FINAL STAFF REPORT
for the
KLAMATH RIVER TOTAL MAXIMUM DAILY LOADS (TMDLs) ADDRESSING TEMPERATURE, DISSOLVED OXYGEN, NUTRIENT, and MICROCYSTIN IMPAIRMENTS IN CALIFORNIA
the
PROPOSED SITE SPECIFIC DISSOLVED OXYGEN OBJECTIVES FOR THE KLAMATH RIVER IN CALIFORNIA,
and the
KLAMATH RIVER and LOST RIVER IMPLEMENTATION PLANS

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This TMDL is dedicated in loving memory to Elmer Dudik and Dr. Ranjit Gill who worked tirelessly in their duties to improve water quality in the Klamath River basin and throughout the North Coast to ensure that California's water resources were pollutant free, and beneficial uses were protected for all to enjoy. Their work to protect and restore water quality is a lasting testament to their dedication to the environment and to the people of California. They are sorely missed.

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List of Abbreviations

5C Program	Five Counties Salmonid Conservation Program
ACS	Aquatic Conservation Survey
Action Plan	Klamath River TMDL Action Plan
af	acre feet
AGR	Agricultural Supply
AIP	Agreement in Principal
AOI	Annual Operating Instructions
AMP	Allotment Management Plan
AQUA	Aquaculture
Basin Plan	Water Quality Control Plan for the North Coast Region
BBN	Bring Back the Natives initiative
BLM	Bureau of Land Management
BGAWG	Blue Green Algae Work Group
BMP	Best Management Practice
BOD	biochemical oxygen demand
BU	beneficial use
BURC	Beneficial Use Risk Category
°C	degrees celcius
CA	California
CA NNE	California Nutrient Numeric Endpoints
CAFO	concentrated animal feeding operation
CalTrans	California Department of Transportation
CAO	clean up and abatement order
CBOD	Carbonaceous Biochemical Oxygen Demand
CDEC	California Data Exchange Center
CDF	California Department of Forestry and Fire Protection
CDFG	California Department of Fish and Game
CDO	cease and desist order
CDWR	California Department of Water Resources
CEQA	California Environmental Quality Act
CFR	Code of Federal Regulations
cfs	cubic feet per second
COLD	Cold Freshwater Habitat
COMM	Commercial and Sport Fishing
Commission	California Fish and Game Commission
COPCO	California Oregon Power Company
CRP	Conservation Reserve Program
C. shasta	*Ceratomyxa shasta*
CSP	Conservation Security Program
CUL	Native American Culture
CVC	California Vehicle Code
CWA	federal Clean Water Act
CWSRF	Clean Water State Revolving Fund

DIN	dissolved inorganic nitrogen
DIRT	Direct Inventory of Roads and Treatments
DMAs	designated management agencies
DO	dissolved oxygen
DPH	Department of Public Health
E	Existing beneficial use
EFDC	Environmental Fluid Dynamics Code
EIR	Environmental Impact Report
EQIP	Environmental Quality Incentives Program
ESA	Endangered Species Act
ETAW	evapotranspiration of applied water
EWP	Emergency Watershed Program
°F	degrees fahrenheit
FBOM	fine benthic organic matter
FEIS	Final Environmental Impact Statement
FERC	Federal Energy Regulatory Commission
FISH	Subsistence Fishing
FLP	Forest Legacy Program
FPOM	fine particulate organic matter
FPP	Farm Protection Program
FPR	Forest Practice Rules
FRPP	Farm and Ranch Lands Protection Program
GIS	Geographic Information System
H	Historical beneficial use
HA	hydrologic area
HCP	Habitat Conservation Plan
HFRP	Healthy Forests Reserve Program
HVTEPA	Hoopa Valley Tribal Environmental Protection Agency
Ich	*Ichthyophthiriasis*
ISS	Inorganic Suspended Solids
KBRA	Klamath Basin Restoration Agreement
KBWQMCG	Klamath Basin Water Quality Monitoring Coordination Group
KFHAT	Klamath Fish Health Assessment Team
KHP	Klamath Hydroelectric Project
KIP	Klamath Irrigation Project
Klamath River TMDLs	Klamath River Total Maximum Daily Loads Addressing Temperature, Dissolved Oxygen, Nutrient and Microcystin
KMZ	Klamath Management Zone
KNF	Klamath National Forest
KRBFTF	Klamath River Basin Fisheries Task Force
KSD	Klamath Straights Drain
KSWCD	Klamath Soil and Water Conservation District
KWI	Klamath Watershed Institute
KWUA	Klamath Water Users Association
LA	Load Allocations
LKNWR	Lower Klamath National Wildlife Refuge

LRDC	Lost River Diversion Channel
LRMP	Land and Resource Management Plan
MAA	Management Agency Agreement
MIGR	Migration of Aquatic Organisms
mg/L	milligrams per liter (equal to parts per million)
MOA	Memorandum of Agreement
MSAE	*Microcystis aeruginosa*
MUN	Municipal & Domestic Supply
MWMT	Maximum Weekly Maximum Temperature
NCCP	Natural Community Conservation Plan
NEPA	National Environmental Policy Act
NIWQP	National Integrated Water Quality Program
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOAA CRP	National Oceanic and Atmospheric Administration Community-based Restoration Program
NOAA Fisheries	National Oceanic and Atmospheric Administration Fisheries
NPCI	National Plant Conservation Initiative
NPDES	National Pollutant Discharge Elimination System
NPS	nonpoint source
NRC	National Research Council of the National Academies
NRCS	National Resource Conservation Service
NTMP	Non-Industrial Timber Management Plan
NWFP	Northwest Forest Plan
OARs	Oregon Administrative Rules
Objectives	Basin Plan Water Quality Objectives
OCS	Oregon Climate Service
ODEQ	Oregon Department of Environmental Quality
OEHHA	Office of Environmental Health Hazard Assessment
OM	organic matter
OR	Oregon
ORI	Open Rivers Initiative
Orleans RAP	The Orleans Roads Analysis and Off-Highway Vehicle Strategy
P	Potential beneficial use
PESP	Pesticide Environmental Stewardship Program
PFMC	Pacific Fishery Management Council
PO4-T	total phosphate
Porter Cologne	Porter Cologne Water Quality Control Act
PTI	Pulling Together Initiative
QA	Quality Assurance
QA/QC	Quality Assurance and Quality Control
RARE	Rare, Threatened, or Endangered Species
RCD	Resource Conservation District
REC-1	Water Contact Recreation
REC-2	Non-Contact Water Recreation

Reclamation	U.S. Bureau of Reclamation
Regional Water Board	North Coast Regional Water Quality Control Board
Restoration and Enhancement Fund	California Klamath Restoration Fund/Coho Enhancement Fund
RM	River Mile
RMA	Resource Management Associates
RME	Reasonable Maximum Exposure
ROD	Record of Decision
RSS	Road and Sediment Source
S1	current conditions modeling scenario
SARE	Sustainable Agriculture Research and Education
SED	Substitute Environmental Document
SHELL	Shellfish Harvesting
SOD	sediment oxygen demand
SONCC ESU	South Oregon/Northern California Coast Evolutionary Significant Unit
SOPs	Standard Operating Procedures
SPWN	Spawning, Reproduction, and/or Early Development
SRWC	Scott River Watershed Council
State NPS Policy	Policy for Implementation and Enforcement of the Nonpoint Source Pollution Control Program
State Water Board	California State Water Resources Control Board
STP	Sewage Treatment Plant
Strategy	Recovery Strategy for California Coho Salmon: Report to the California Fish and Game Commission
SWPPP	Stormwater Pollution Prevention Plan
T1BSR	Natural conditions baseline scenario
T4BSRN	With-dam TMDL scenario
TCD2RN	California allocation scenario
TOD2RN	Oregon allocation scenario
Thermal Plan	Water Quality Control Plan for Control of Temperature in the Coastal and Interstate Waters and Enclosed Bays and Estuaries of California
THP	Timber harvest plan
TLNWR	Tule Lake National Wildlife Refuge
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
TRRP	Trinity River Restoration Program
TSS	Total Suspended Solids
TU	Trout Unlimited
μg/L	micrograms per liter (equal to parts per billion)
UKL	Upper Klamath Lake
USBR	U.S. Bureau of Reclamation
USCB	U.S. Census Bureau
USDA	U.S. Department of Agriculture

USEPA	U.S. Environmental Protection Agency
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VSS	Volatile Suspended Solids
WDR	Waste Discharge Requirement
WHIP	Wildlife Habitat Incentives Program
WHO	World Health Organization
WLA	Waste Load Allocations
WLPZ	Watercourse Lake Protection Zone
WMA	Weed management area
WQMP	Water Quality Management Plan
WRIMS	Water Right Information Management System
WWTP	Waste Water Treatment Plant
YTEP	Yurok Tribe Environmental Program

CHAPTER 1. INTRODUCTION

1.1 Overview

The purpose of this report is to present the Total Maximum Daily Loads (TMDLs) calculated by California to protect and restore beneficial uses of water in the Klamath River downstream of the Oregon border and in portions of the Klamath River watershed in California. The purpose is also to present the recalculated Site Specific Objectives (SSOs) for dissolved oxygen (DO) for the mainstem Klamath River in California (see Appendix 1). The California Klamath TMDLs are comprised of two distinct parts: the Staff Report and the Action Plan. This document is the Staff Report that contains information and findings to support the recommended Action Plan to the North Coast Regional Water Quality Control Board (Regional Water Board). It also contains, in Appendix 1, the staff report for the proposed Basin Plan Amendment to incorporate into the Water Quality Control Plan for the North Coast Region (Basin Plan) the recalculated SSOs for DO.

The Klamath River basin[1] is 12,680 square miles in area. The Klamath River originates in southern Oregon and flows through northern California to meet the Pacific Ocean at Requa in Del Norte County, California. Forty-four percent of the watershed lies within the boundaries of Oregon, while the remaining 56% of the basin lies within the boundaries of California. Figure 1.1 is a map of the Klamath River basin.

The Klamath River basin is of vital economic and cultural importance to the states of Oregon and California, as well as the Klamath Tribes in Oregon; the Hoopa, Karuk, and Yurok Tribes in California; the Quartz Valley Indian Reservation in California, and the Resighini Rancheria in California. It provides fertile lands for a rich agricultural economy in the upper basin. Irrigation facilities known as the Klamath Project owned by the U.S. Bureau of Reclamation support this economy as does hydroelectric power provided via a system of five dams operated by PacifiCorp. The basin is the home spawning grounds of a once vast Tribal, sport, and commercial fishery and provides other aquatic resources of cultural significance to the local Indian Tribes. The watershed supports an active recreational industry, including activities that are specific to the Wild and Scenic portions of the river designated by both the state and federal governments in both Oregon and California. Finally, the watershed continues to support what were once more significant mining and timber industries.

A decline in the fisheries has signaled deep impacts on the ecology of the basin. Congress passed Public Law 99-552 (Klamath Act) in 1986 to establish the Klamath River Basin Conservation Area Restoration Program with the intention of rebuilding the river's dwindling fish resources. Since that time, however, several of the fish species endemic to the basin have been listed by federal and state agencies as threatened or endangered. Impairments to water quality have been identified as one of the factors

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1 For the purposes of this report, the terms "basin" and "watershed" are synonymous and will be used to refer to the area that drains flows to the Pacific Ocean at Requa.

contributing to the continued decline of native fish populations. This has led to water quality assessments by the States of Oregon and California and the listing of the Klamath

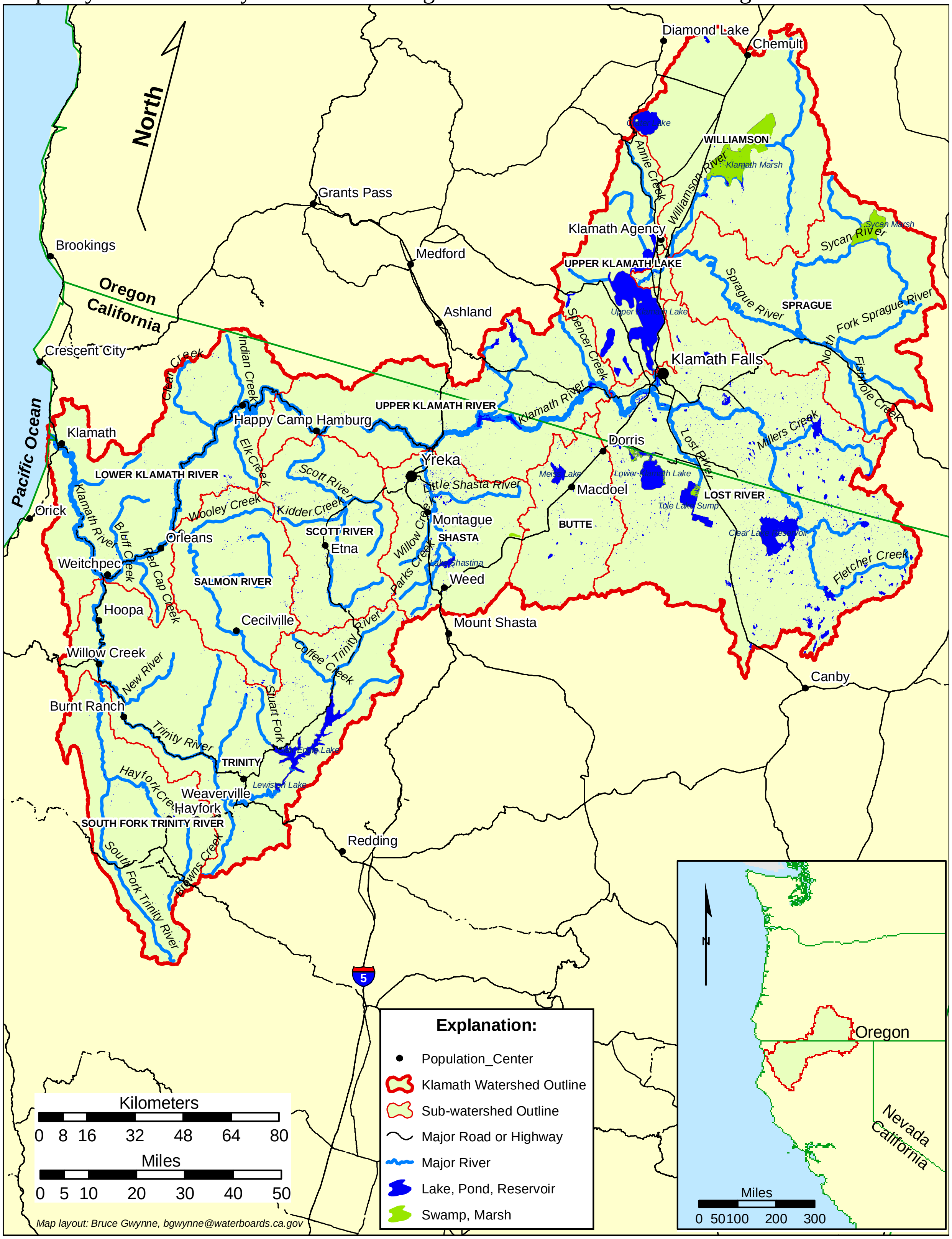

Figure 1.1: Klamath River basin showing rivers, lakes and reservoirs, population centers, and major roads

River as impaired under section 303(d) of the federal Clean Water Act (CWA). It has also led to the recalculation of the SSOs for DO in the mainstem Klamath River as contained in the Basin Plan.

The Oregon Department of Environmental Quality (ODEQ) and the Regional Water Board are working cooperatively to develop TMDLs for the water quality impaired waterbodies in the Klamath Basin, including the Lost River and the Klamath Straits Drain, and the Klamath River from Link River to the Pacific Ocean. The States of Oregon and California are responsible for calculating the TMDL of each of the pollutants of concern that can be discharged to the river while still protecting the fisheries and other beneficial uses of the waters within their respective jurisdictions. California has recalculated the SSOs for DO using data generated by the TMDL development team.

California has listed the portions of the Klamath River within its jurisdiction (from the CA/OR Stateline to the mouth) for impairments due to elevated water temperatures, elevated nutrients, and organic enrichment/low dissolved oxygen. In addition, the portion of the Klamath River watershed downstream of the Trinity River, partially within the Yurok Reservation, is listed for sedimentation/siltation impairment. Finally, in March 2008, the U.S. Environmental Protection Agency (USEPA) added the reach of the Klamath River that incorporates Copco 1 and 2 and Iron Gate Reservoirs to the 303(d) List for the blue-green algae toxin microcystin. Table 1.1 and Figure 1.2 summarize the waterbody-pollutant combinations for the Klamath River in California as identified on the current (2006) section 303(d) List[2]. The Klamath River TMDLs reported here address the water quality impairments and geographic areas summarized in Table 1.1, with the exception of sedimentation/siltation in the Klamath Glen HSA. Table 1.2 summarizes the status of the TMDLs for the entire Klamath River basin in California.

A consent decree entered into by the USEPA in March 1997 (*Pacific Coast Federation of Fishermen's Associations et al. v. Marcus*) establishes the date by which TMDLs for 17 California northcoast watersheds must be completed. The Klamath River TMDLs for the listed temperature and nutrient impairments were scheduled for completion by 2007. Negotiations between USEPA and the plaintiffs resulted in an extension of that deadline to 2010.

The current TMDLs for the Klamath River in California reported here, address temperature, dissolved oxygen, nutrient, and microcystin water quality impairments for the Klamath River Hydrologic Unit, Middle HA (Oregon to Trinity River) and Lower HA, Klamath Glen HSA (Trinity River to Pacific Ocean). These TMDLs do not explicitly address the sedimentation/siltation impairments in the Lower HA, Klamath Glen HSA. Addressing DO in the mainstem Klamath River required not only the development of a TMDL but, the recalculation of the SSOs for DO, as well. The SSOs for DO in the mainstem Klamath River have been recalculated because conditions of barometric pressure, salinity and natural receiving water temperatures at equilibrium

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[2] Figure 1.2 identifies the water quality impairments for the entire Klamath River basin in California, as depicted in the 2006 Clean Water Act Section 303(d) List.

(e.g., 100% DO saturation) do not consistently allow for attainment of the existing SSOs for DO. Further, the *Klamath TMDL model*, as described in detail throughout the rest of this report, indicates that under natural conditions, the DO concentrations achieved in the mainstem Klamath are periodically less than the existing SSOs for DO, particularly during the summer months. For a detailed analysis of DO conditions in the mainstem Klamath River, including the recalculation of the SSOs, please see Appendix 1.

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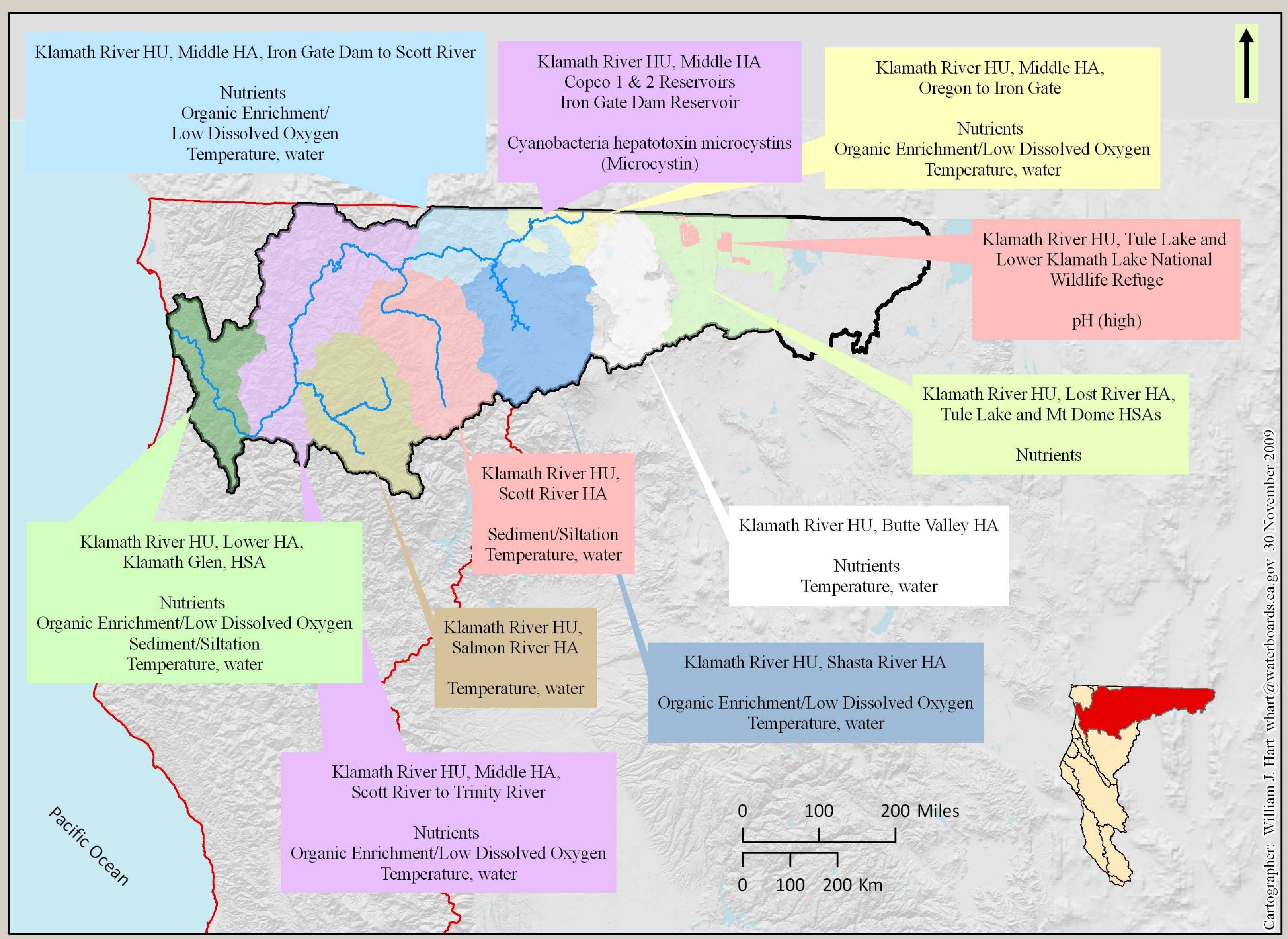

Figure 1.2: 2006 Clean Water Act Section 303(d) List of water quality limited segments in the Klamath River hydrologic unit in California

Table 1.1: Klamath River water quality impairments in California from the 2006 Clean Water Act Section 303(d) List

Hydrologic Area (HA)[3]	**CalWater Watershed**	**Pollutant/Stressor(s)**	**Hydrologic Sub Areas (HSAs[2]) Included in Listing**
Middle HA, Oregon to Iron Gate	10530000	Temperature Nutrients Organic enrichment/ low dissolved oxygen	Iron Gate HSA 115.37 Copco HSA 105.38
Middle HA, Copco 1 and 2 and Iron Gate Reservoirs	NA	Microcystin	N/A
Middle HA, Iron Gate Dam to Scott River	10530000	Temperature Nutrients Organic enrichment/ low dissolved oxygen	Beaver Creek HSA 105.35 Hornbrook HSA 105.36
Middle and Lower HAs, Scott River to Trinity River	10500000	Temperature Nutrients Organic enrichment /low dissolved oxygen	Orleans HSA 105.12 Ukonom HSA 105.31 Happy Camp HSA 105.32 Seiad Valley HSA 105.33
Lower HA, Klamath Glen HSA, Trinity River to Pacific Ocean	10511000	Temperature Nutrients Organic enrichment/ low dissolved oxygen Sedimentation/Siltation	Klamath Glen HAS 105.11

Table 1.2: Status of TMDLs in the Klamath River basin in California.

Subwatershed	**TMDL(s)**	**Year**	**Agency**
Upper Lost River	Temperature, nutrients	Delisted, 2006	-
Lower Lost River	Nutrients	Technical TMDL, 2008	USEPA
	Temperature	Delisted, 2006	-
Shasta River	Temperature, dissolved oxygen	Final Technical TMDL and Implementation Plan, 2007	Regional Water Board
Scott River	Temperature, sediment	Final Technical TMDL and Implementation Plan, 2006	Regional Water Board
Salmon River	Temperature	Final Technical TMDL, 2005	Regional Water Board
	Nutrients	Delisted, 2006	-
Trinity River	Sediment	Final Technical TMDL, 2001	USEPA
South Fork Trinity River	Sediment	Final Technical TMDL, 1998	USEPA
Klamath River	Nutrients, temperature, organic enrichment/low dissolved oxygen, microcystin	TMDL in progress	Regional Water Board

Oregon and California have formed a technical team in conjunction with USEPA and its contractor Tetra Tech, Inc. to develop a uniform water quality model of the basin and conduct joint analyses to ensure compatible TMDLs. However, the states will establish

[3] Hydrologic Area (HA) is the terminology used in the CalWater watershed delineation system to identify a sub-unit of a watershed. Similarly, Hydrologic Sub Area (HSA) identifies a smaller hydrologic unit within a HA.

independently the TMDLs for those portions of the basin within their respective jurisdiction. Oregon is not bound by the deadlines associated with the above referenced consent decree. Further, California proposes the recalculation of the SSOs for DO as contained in the Basin Plan, as an additional action not applicable in Oregon.

California has listed separately several of the major tributaries to the Klamath River as impaired; these are identified in Table 1.2. Each tributary watershed is listed for its own site-specific list of pollutants but generally include: elevated water temperature, elevated nutrients, depressed dissolved oxygen levels and excess sediment. Either technical TMDLs or TMDLs with Action Plans have been developed and approved for each of the major tributary watersheds.

1.2 Report Organization

As noted above, this document is the Staff Report supporting the Action Plan. Appendix 1 includes a separate staff report for the recalculation of the SSOs for DO in the mainstem Klamath River. This report contains several standard elements (summarized below) including:

- Chapter 1 – Introduction
- Chapter 2 – Problem Statement
- Chapter 3 – Analytic Approach
- Chapter 4 – Pollutant Source Analysis
- Chapter 5 – Klamath River TMDLs - Allocations and Numeric Targets
- Chapter 6 – Implementation Plan
- Chapter 7 – Reassessment Monitoring Program
- Chapter 8 – Antidegradation Analysis
- Chapter 9 – California Environmental Quality Act (CEQA) Environmental Analysis
- Chapter 10 – Economic Analysis
- Chapter 11 – Public Participation

Chapter 1 describes the regulatory framework for the Klamath River TMDLs and recalculation of the SSOs for DO in the mainstem Klamath River, and presents an overview of the Klamath River basin. Chapter 2 provides the assessment framework for the TMDL and recalculation of the SSOs for DO; assesses water quality conditions in the basin; and documents impairments. Chapter 3 describes the TMDL model and its use in developing the source analysis and allocations for the TMDL as well as its use in the recalculation of the SSOs for DO. Chapter 4 assesses the sources of water quality impairment in the basin and their relative contribution to the overall load of pollutants. Chapter 5 assigns pollutant load and waste load allocations and establishes numeric targets consistent with water quality standards. Chapter 6 describes a program of implementation and includes measures necessary to achieve the Klamath River TMDLs and recalculation of SSOs for DO in California. Chapter 7 describes the monitoring necessary to assess the degree of success associated with the TMDLs, the recalculation of the SSOs for DO and their implementation. Chapter 8 briefly describes the state and federal antidegradation policies and how they apply to the Action Plan. Chapter 9 describes the steps Regional Water Board staff have taken to comply with CEQA, and presents the findings of the CEQA analysis. Chapter 10 analyzes the potential economic benefits and costs that may result from the adoption and implementation of the proposed Action Plan. Chapter 11 describes some of the opportunities that have been made available to the public for comment on and participation in the development of the Klamath River TMDL Staff Report and Action Plan. See Appendix 1 for a discussion of the opportunities for public review associated with the Proposed Site Specific Dissolved Oxygen Objectives for the Klamath River in California (Klamath River DO Staff Report).

1.3 TMDL Development and Adoption Process

Regional Water Board staff submitted a Peer Review Draft Staff Report to outside scientific peer reviewers for review of the technical elements associated with the TMDL. (See Appendix 1 for discussion of the peer review process associated with the Klamath River DO Staff Report). Staff prepared a response to the peer review comment document and revised the Staff Report accordingly. Staff released a Public Review Draft Staff Report for public review and comment in June 2009. The Staff Report accompanied a TMDL Action Plan that summarizes the findings of the TMDLs and describes in detail the proposed plans for implementation, monitoring, and adaptive management. During the summer 2009 public review period, staff conducted public and Board Workshops to present the TMDL and receive oral comments. In December 2009, a revised Staff Report and TMDL Action Plan was released, incorporating revisions based on public comments. Finally, the Staff Report and Action Plan are presented before the Regional Water Board at a public hearing for the purpose of adopting the Action Plan as an amendment to the Basin Plan. Once the Regional Water Board has adopted the TMDL Action Plan, the State Water Resources Control Board (State Water Board) holds a workshop and hearing to confirm the decision of the Regional Water Board. California's Office of Administrative Law provides a final legal review before the TMDL Staff Report and Action Plan are forwarded to USEPA. USEPA approves only the technical TMDL, not the implementation plan components.

1.4 Regulatory Framework and Purpose of the TMDL

The quality of surface and ground waters in the North Coast Region of California is governed by the Water Quality Control Plan for the North Coast Region (Basin Plan) as developed and implemented by the Regional Water Board. The North Coast Region is defined as those waters draining into the Pacific Ocean from the California-Oregon state line to the southern boundary of the watershed of the Estero de San Antonio and Stemple Creek in Marin and Sonoma Counties. The Basin Plan identifies the existing and potential beneficial uses of water within the North Coast Region and the water quality objectives necessary to protect those uses. Together water quality objectives, beneficial uses, and the anti-degradation policy are known as water quality standards. The Basin Plan also prohibits certain activities and requires certain other activities as necessary to achieve water quality standards.

With respect to the Klamath River basin, the Basin Plan prohibits point source waste discharges to surface waters. Point sources are sources of pollutants discharged through a known conveyance, such as an outfall pipe. This prohibition does not apply to point source waste discharges to land, such as discharges to evaporation or percolation ponds. Similarly, the prohibition does not apply to nonpoint source discharges which are the more dispersed flow of pollutants through stormwater runoff.

Under section 303(d) of the CWA, states are required to develop a list of water bodies where legally required pollution control mechanisms are not sufficient or stringent enough to meet water quality standards applicable to such waters. The 303(d) List also includes the pollutant/stressor causing the impairment and a time schedule for addressing the water quality impairment. Placement of a water body on the 303(d) List triggers the development of a TMDL, for each water body-pollutant/stressor combination. The specific requirements for TMDLs are described in the United States Code of Federal Regulations (CFR) Title 40, sections 130.2 and 130.7 (40 CFR § 130.2 and 130.7), and section 303(d) of the federal CWA.

A TMDL is in essence a planning and management tool intended to identify, quantify, and control the sources of pollution within a given watershed such that water quality objectives are achieved and the beneficial uses of water are fully protected. A TMDL is defined as the sum of individual waste loads allocated to point sources, load allocations assigned to non-point sources, and loads assigned to natural background conditions. Loading from all pollutant sources must not exceed the loading or assimilative capacity (TMDL) of a water body. To account for uncertainty, CWA section 303(d) requires that TMDLs are established with a margin of safety.

The USEPA has federal oversight authority for the CWA section 303(d) program and may approve or disapprove TMDLs developed by the states. Under the terms of the consent decree (*Pacific Coast Federation of Fishermen's Association, et. al. v. Marcus*), if USEPA disapproves the Klamath River TMDLs as developed by the Regional Water Board, then USEPA must itself establish the TMDLs by the date specified in the decree.

The Regional Water Board, under the state's Porter-Cologne Water Quality Control Act, has the obligation to establish an Action Plan by which TMDLs are implemented. Action Plans are adopted by the Regional Water Board and incorporated as an amendment into the Basin Plan. USEPA, on the other hand, does not have this obligation. TMDLs developed by USEPA include the technical analysis only, and are then forwarded to the Regional Water Board for implementation. The States of Oregon and California utilize their authority to implement TMDLs by different methods. See <http://www.oregon.gov/DEQ/WQ/index.shtml> for information on Oregon's TMDLs and implementation planning methods.

The purpose of the Klamath River TMDLs is to estimate the assimilative capacity of the system with respect to the total loads of nutrients and organic matter that can be delivered to the Klamath River without causing an exceedance of the water quality objectives for nutrients and dissolved oxygen. The TMDLs must also establish the amount of protection from solar radiation and cold water withdrawals necessary to meet water quality objectives for water temperature.

Assessing the assimilative capacity of the system begins with an estimate of water quality under natural baseline conditions. Having simulated the natural baseline conditions, anthropogenic sources of nutrient and organic matter loads are incrementally added back into the models until that point at which water quality objectives are just being met. A somewhat different but similar approach is used for temperature to assess the assimilative capacity of the river for solar radiation and cold water withdrawals. This then forms the basis for the TMDLs. The geographic scope of these TMDLs includes the entire Klamath River hydrologic area[4] (HA) in California, not including those reaches of the Klamath River that lie within the Hoopa Valley Indian Reservation and Yurok Reservation.

1.5 Other Ongoing Regulatory Processes in the Klamath River Basin

TMDLs must consider other ongoing regulatory processes in the basin. Already described is the recalculation of the SSOs for DO in the mainstem Klamath River. Of additional relevance to water quality are:

- The Tribal Trust responsibilities of the United States government to Tribes and individual Indians.
- The need for consultation under the federal Endangered Species Act with the National Oceanic and Atmospheric Administration Fisheries (NOAA Fisheries) and U.S. Fish and Wildlife Service on projects affecting listed species occurring in the Klamath River and its watershed, and
- The relationship between the TMDL process and the water quality certification process under section 401 of the CWA associated with the relicensing application submitted by PacifiCorp to FERC for the operation of hydroelectric facilities on the Klamath River mainstem.

1.5.1 Tribal Trust Responsibilities

The United States has a trust responsibility to protect and maintain rights reserved by, or granted to, federally recognized Tribes and individual Indians, by treaties, statutes, and executive orders. The trust responsibility requires that federal agencies take all actions reasonably necessary to protect trust assets, including the fishery resources of the Indian Tribes in the Klamath River basin. The Regional Water Board must consider federal Tribal Trust responsibilities in the Klamath River basin since TMDLs are subject to the approval of the USEPA. The Regional Water Board will assist USEPA in fulfilling Tribal Trust responsibilities by adopting an Action Plan that restores and maintains pollutant levels that are protective of anadromous fish and other beneficial uses related to

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[4] Hydrologic Area is the terminology used in the CalWater watershed delineation system to identify a sub unit of a watershed, involving a major river.

the Tribes of the Klamath River in California, including the Hoopa, Karuk, Quartz Valley, and Yurok Tribes and the Resighini Rancheria to the degree that natural conditions allow.

1.5.2 ESA Consultation

The USEPA and Regional Water Board initiated an informal consultation process with the United States Fish and Wildlife Service (USFWS) and NOAA Fisheries on the Klamath River basin TMDLs in California. USEPA and Regional Water Board staff have used this process to provide information and updates on the TMDLs in the Klamath River basin (e.g., the Salmon, Scott, Shasta, Lower Lost, and Klamath River TMDLs). USEPA has an obligation to consult with federal wildlife agencies on any action that may affect the wildlife trust responsibilities of these agencies. The Regional Water Board must consider the federal wildlife trust responsibility in the Klamath River basin since TMDLs are subject to USEPA approval. The Regional Water Board will assist USEPA in fulfilling wildlife trust responsibilities by adopting an Action Plan that restores and maintains pollutant levels that are protective of threatened or endangered species including anadromous fish, and other cold water species, and their habitat.

1.5.3 Water Quality Certification

PacifiCorp currently operates hydroelectric facilities on the Klamath River in southern Oregon and northern California. On February 23, 2004, PacifiCorp transmitted its application for a new 50-year license for the Klamath Hydroelectric Project to the Federal Energy Regulatory Commission (FERC). Associated with its application for a new license is the obligation to submit documentation under section 401 of the CWA to the State Water Board and ODEQ that demonstrates compliance of the proposed project with state water quality standards. The State Water Board then reviews the documentation and issues its water quality certification (401Certification) if the information indicates that water quality standards will be met. The certification can include conditions in order to ensure that water quality standards are met. A certification is denied if water quality standards will not be met by the project as proposed.

As a result of its review of the submitted documents, the State Water Board issued a letter on February 26, 2007 indicating that PacifiCorp had not adequately documented its assertion that water quality will be protected by the relicensing of the hydroelectric facilities. Additional studies of several areas of concern are required before 401 Certification can be issued. In addition, an environmental impact review under the CEQA is required before a certification can be issued. A key question under consideration in the certification review process is whether or not the proposed project will meet the TMDLs.

1.5.4 Klamath Basin Restoration Agreement, Agreement in Principal, and Klamath Hydroelectric Settlement Agreement

The Klamath Basin Restoration Agreement (KBRA) is a negotiated settlement agreement between as many as 26 different parties designed to settle long-standing disputes in the Klamath River basin. It focuses on water allocations in the upper basin, provides for fisheries restoration and is structured around the central assumption that an agreement to remove the lower four Klamath River Dams will be reached. On November 13, 2008, an Agreement in Principle (AIP) to remove four Klamath River dams was announced after negotiations between the federal government, representatives from the state of California, the state of Oregon, and PacifiCorp. Regional Water Board staff were not a party to the KBRA or AIP negotiations. On September 30, 2009, a draft Klamath Hydroelectric Settlement Agreement (KHSA) was released. The final KBRA and KHSA agreements may affect the TMDL implementation schedule, which relies on the FERC relicensing process and subsequent water quality certification by the State Water Board. As currently drafted, the KHSA contemplates federal legislation that would allow PacifiCorp to remain on annual licenses from FERC, thereby indefinitely delaying the 401 certification and Clean Water Act compliance. See Chapter 6 for additional discussion.

1.6 Physical Setting

It is useful to orient the reader to the physical setting within which the TMDLs for the Klamath River basin are developed as a way of establishing the background conditions influencing pollutant levels in the system. The topography of the basin, the bedrock geology, soils, vegetation and climate each play a role in shaping the particular surface water and ground water hydrology of the basin. Similarly, these factors play a role in the fate and transport of instream pollutants. More detailed descriptions of the physical setting of the Klamath River basin have been reported extensively in numerous available publications including:

- Federal Energy Regulatory Commission. 2007. Final Environmental Impact Statement for the Klamath Hydroelectric Project. Docket No. P-2082-027. November 18, 2007. U.S. DOE, FERC, Washington D.C.
- National Research Council of the National Academies (NRC). 2004. Endangered and Threatened Fishes in the Klamath River Basin. Washington, D.C. National Academies Press.

1.6.1 Population and Land Ownership

The human population in the Klamath River basin was estimated in the 2000 US Census to be about 114,000 (United States Census Bureau [USCB] 2000). The largest population concentrations lie in the upper Klamath agricultural area, the Shasta River Valley, and Scott Valley. The largest population center is Klamath Falls in Oregon (19,462 people in 2000) followed by Yreka, California (7,290 people). The Klamath River basin can generally be characterized as a rural watershed with limited population-related water quality issues.

More than two thirds of the Klamath River watershed is in federal ownership. Figure 1.3 shows, among other things, federal lands managed as National Forests, National Wildlife Refuges, and National Parks, in addition to Bureau of Land Management (BLM) land. The largest blocks of private ownership are agricultural areas in the upper Klamath watershed and agricultural and timber properties in the Shasta and Scott Valleys and adjacent areas of the mainstem. Also, much of the Klamath River Valley near the mouth of the river is privately owned.

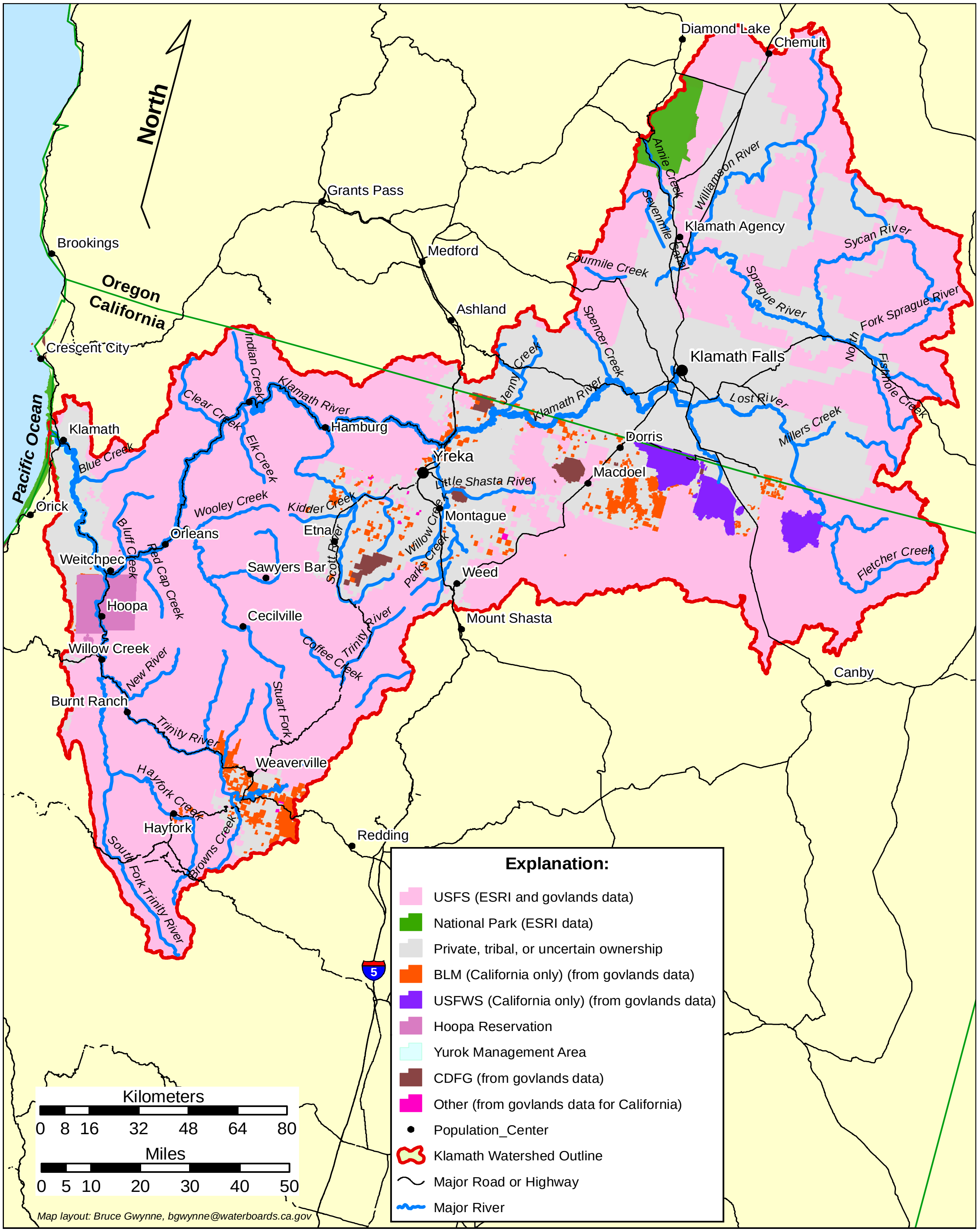

Figure 1.3: Land ownership in the Klamath River basin

The Hoopa Valley Tribe owns land, 12 miles by 12 miles, primarily in the Trinity River watershed but intersecting the Klamath River at Saints Rest Bar upstream of the confluence with the Trinity. The Yurok Reservation's lands extend from 1 mile on each side from the mouth of the Klamath River and upriver for a distance of 44 miles. The Karuk Tribe owns 800 acres of tribal trust land along the Klamath River between Orleans and Happy Camp, and in Yreka, California. The Quartz Valley Indian Reservation is located near Fort Jones and encompasses 174 acres along the Scott River. The Resighini Rancheria spans 228 acres along the south shore of the mouth of the Klamath River.

1.6.2 Topography, Geology and Soils

Topography in the Klamath River watershed varies between steep mountains and flat and rolling valley bottoms with little in between (Figure 1.4). Elevations range from sea level at the river mouth to 14,179 feet (4,322 meters) feet at the summit of Mount Shasta. The Klamath River watershed crosses four recognized geomorphic provinces, each of which is defined and shaped by its unique geologic history. From east (upstream) to west (downstream) these provinces are the Modoc Plateau, Cascade Range, Klamath Mountains, and Coast Ranges (Figure 1.5). These geomorphic provinces, defined by Oakshott (1978), are the result of the different structure and composition of the underlying rocks and different times of uplift and volcanism.

Headwaters of the Klamath gather in the Modoc Plateau, an area of geologically young lava flows (Pliocene and Pleistocene – less than fifteen million years) and flat valleys punctuated by volcanic cones. The rolling valley bottoms are at about 4000 to 5000 feet (1219 to 1524 meters) elevation and the volcanic cones rise a thousand feet higher. While drainage in this young landscape is through-flowing, many depressions contain shallow lakes, most of which have been augmented by dams. Although rainfall is low, the flat and rolling valley bottoms of rich volcanic and organic soils combine with abundance of water entering from higher surrounding country to create historically vast freshwater wetlands. Much of these have been converted to farmland. The volcanic soils are naturally rich in phosphorus, a nutrient of concern in these TMDLs. Similarly, the conversion of wetlands to farmland and other land uses has exposed the nutrient and organic rich soils to oxidation, resulting in the release to the water column of nitrogen and phosphorus previously stored in the soil and wetland vegetation (Snyder and Morace, 1997).

The transition between the Modoc Plateau and Cascade Range provinces is not sharp, so that a line on a map is by necessity a bit arbitrary (Figures 1.5, 1.6). The Cascade Range province is a belt of mainly volcanic rocks that are younger than rocks of most of the Modoc Plateau and form higher relief. The Cascade Range is defined by a chain of active and potentially active volcanoes that stretches from Mount Lassen, east of Redding, northward through Oregon and Washington into Canada. The most prominent mountain in the Klamath region is Mount Shasta, a composite volcano that rises at the head of Shasta Valley, and which last erupted about 1786. Crater Lake, in the northeast, fills the collapse crater of a volcano that erupted cataclysmically about 7,000 years ago.

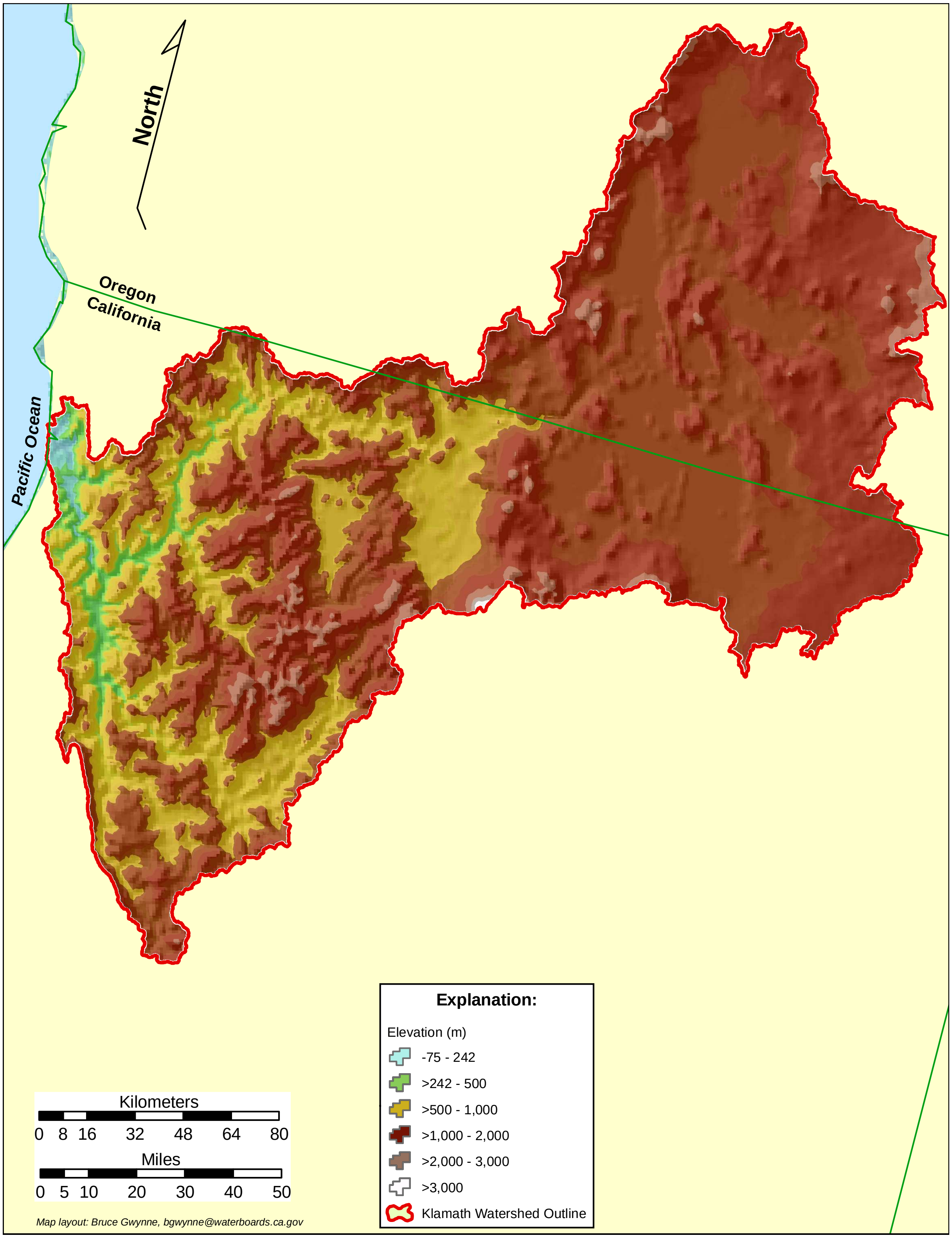

Figure 1.4: Land elevation in the Klamath River basin

Figure 1.5: Geomorphic provinces in the Klamath River basin - Source: Oakshott 1978

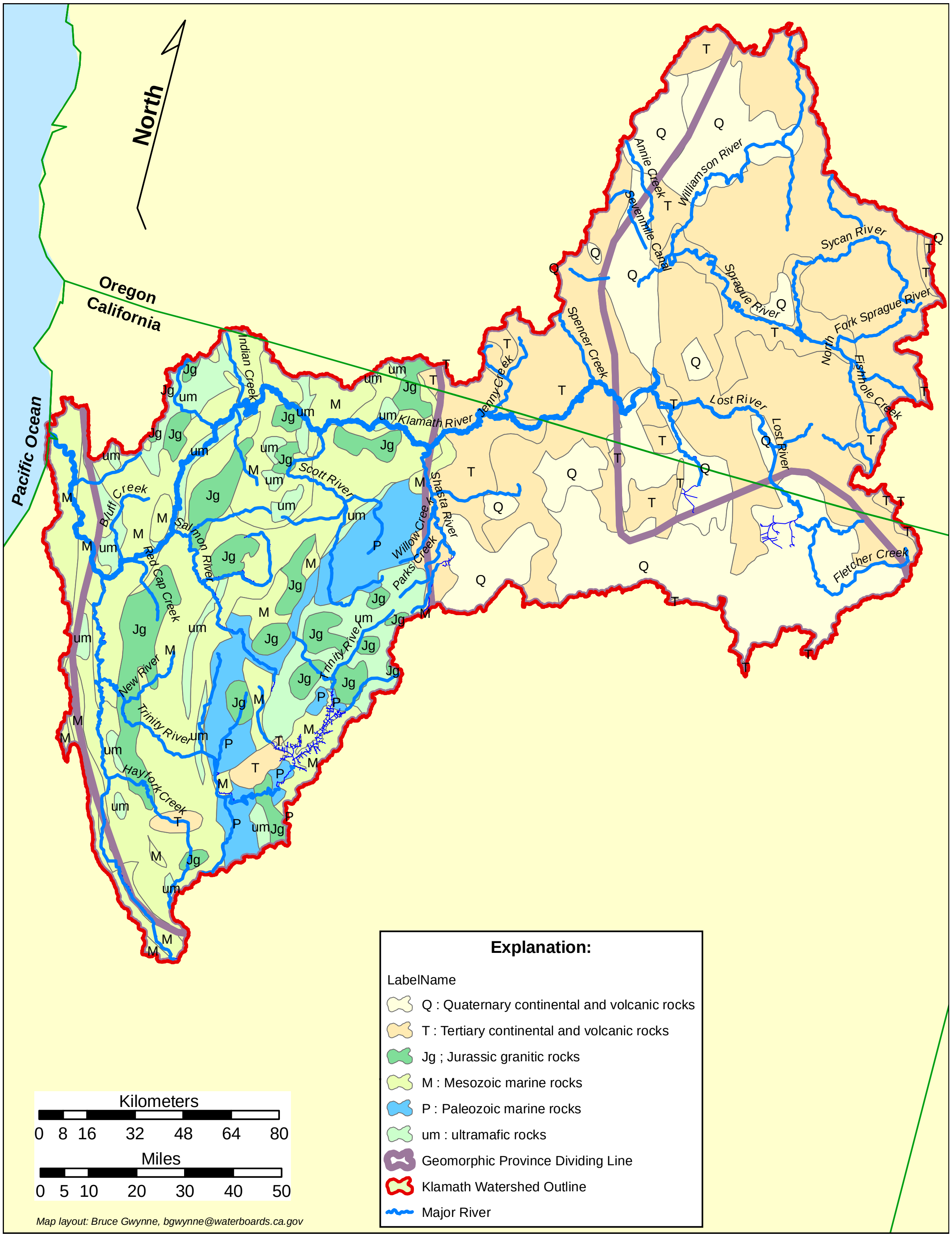

Figure 1.6: Geologic map of the Klamath River basin
Source: Modified from Schruben et al. (1997)

The border between the Cascade province and the Klamath Mountains province is spanned by Shasta Valley and covered by a unique deposit. Most of the floor of this valley is disrupted rolling topography of small hillocks and closed depressions. Crandell (1989) recognized this landscape as the deposits formed by a huge avalanche and debris flow, or series of such events, shed off the north flank of Mount Shasta more than 300,000 years ago.

The Klamath Mountains province is very steep and rugged for the most part and in the Klamath River watershed consists of several irregularly oriented ranges – the Trinity Alps, Scott Bar Mountains, Siskiyou Mountains, and Marble Mountains. Shasta and Scott Valleys have broad flat valley bottoms that support agriculture, but other valleys are narrower and steeper and therefore less developed. Most of the land in the Klamath Mountains province is in federal ownership (Figure 1.3), and this rugged landscape lends itself more to timber harvest and cattle grazing than to crops.

The bedrock geology of the Klamath Mountains province is extremely varied and complex (Figure 1.6) and largely made up of ocean-floor igneous and sedimentary rocks of a large range in ages. Most of the igneous rocks in this province are dark colored mafic and ultramafic rocks of both intrusive and extrusive origin, most of which have been partly or wholly altered to serpentine and otherwise metamorphosed. Younger, light colored granitic rocks have been intruded in some places. Recent uplift has created a landscape of rapidly downcutting streams and steep slopes that are subject to rapid erosion and landsliding. The granitic rocks in particular weather to form loosely consolidated material that sloughs and ravels easily when disturbed.

The Coast Ranges province, the westernmost province (Figure 1.5), forms about 20 miles of the lower Klamath River valley and part of the west side of the valley of the lower Trinity River and South Fork Trinity River. These rivers have exploited the fault zone that forms the geologic boundary between the Klamath Mountains province and the Coast Ranges province. The Coast Ranges are steep, but are generally more rounded and not as high as the mountains of the Klamath Mountains province. Bedrock is the Franciscan Complex, which is structurally deformed and highly varied. The mix of sedimentary rocks includes sandstone, siltstone, shale, conglomerate, greywacke, and chert. Parts of the complex have been metamorphosed and include blueschist and greenschist as well as low grade mica schist. Some areas are mélange, which is geologic terrain that has been deformed and mixed by prolonged and complex tectonic movement, and lacks continuity of structure, rock type, or age.

The gradient profile of the Klamath River is anomalous for a large river in that it is generally low gradient in the headwaters in the Modoc Plateau and steeper farther downstream (Figure 1.4). This unusual gradient is largely the result of geologic uplift in the upstream portion of the river basin in recent geologic time.

1.6.3 Vegetation

Vegetation in the Klamath varies greatly with elevation, precipitation, and degree of disturbance. Figure 1.7 shows the major classifications of vegetation (Thematic Mapper

GIS database). Conifers dominate in the steep mountains and the higher elevations. Hardwood forest and shrubs are more abundant in the lower country, which tends to be warmer and dryer. In many parts of the region a transition zone of mixed conifer and hardwood separates areas classified as conifer forest and hardwood.

1.6.4 Climate

The great geographic extent and topographic relief of the Klamath River watershed combine to produce a wide variety of climate conditions (Figure 1.8). On average, the climate is characterized by dry summers with high daytime temperatures and wet winters with moderate to low temperatures. About three quarters of the annual precipitation falls between October and March, producing a snowpack in the higher mountain ranges that feeds streamflow in many lower areas through the summer. As major storms move in from the Pacific Ocean, the moisture-laden air rises over the coastal mountain ranges and condenses as rain and snow (California Department of Water Resources [CDWR] 1986). Further inland, in the valleys of major tributaries and over the lower terrain of the upper Klamath basin, a rain shadow effect is created, and less moisture falls (Figure 1.8).

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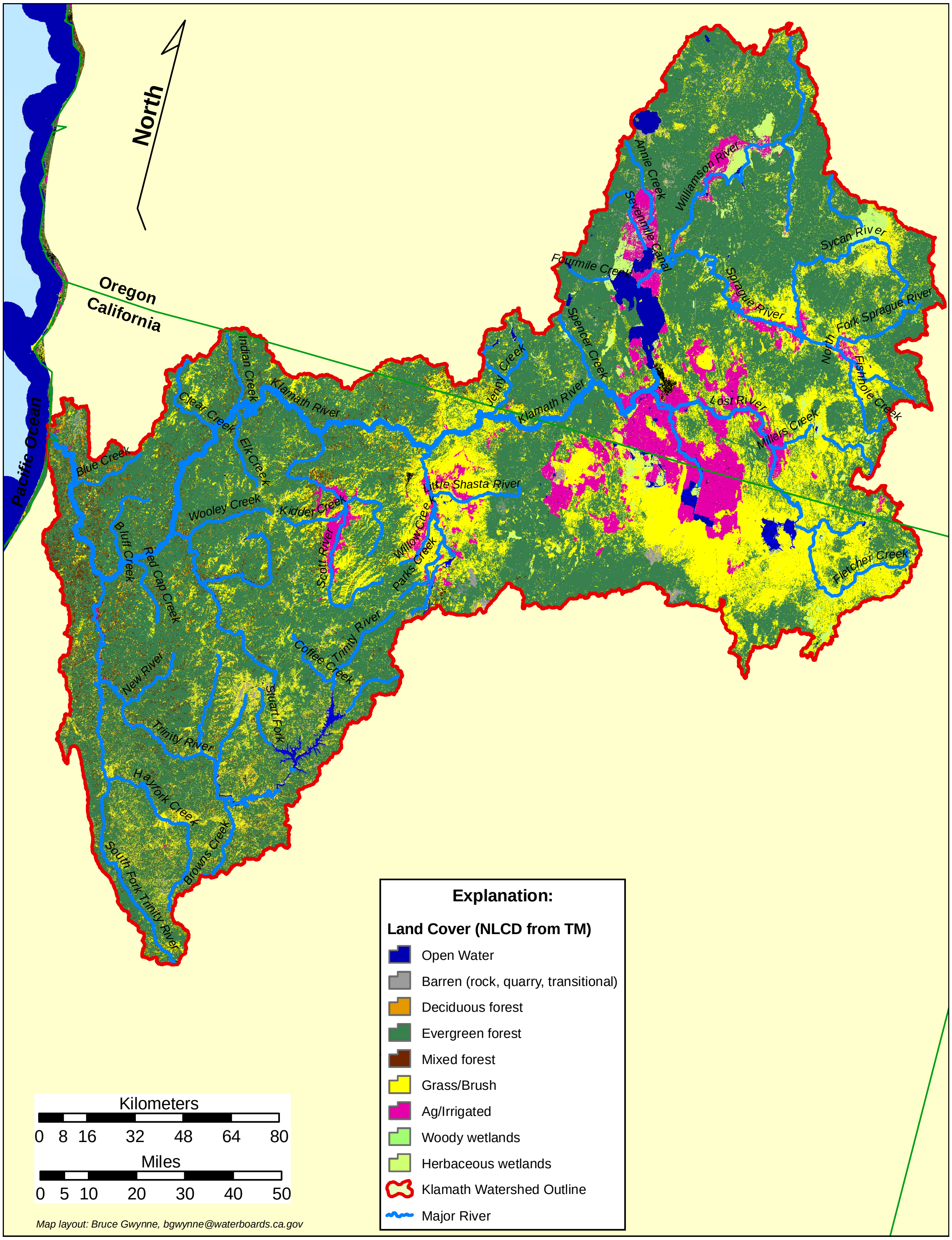

Figure 1.7: Vegetation and land cover of the Klamath River basin

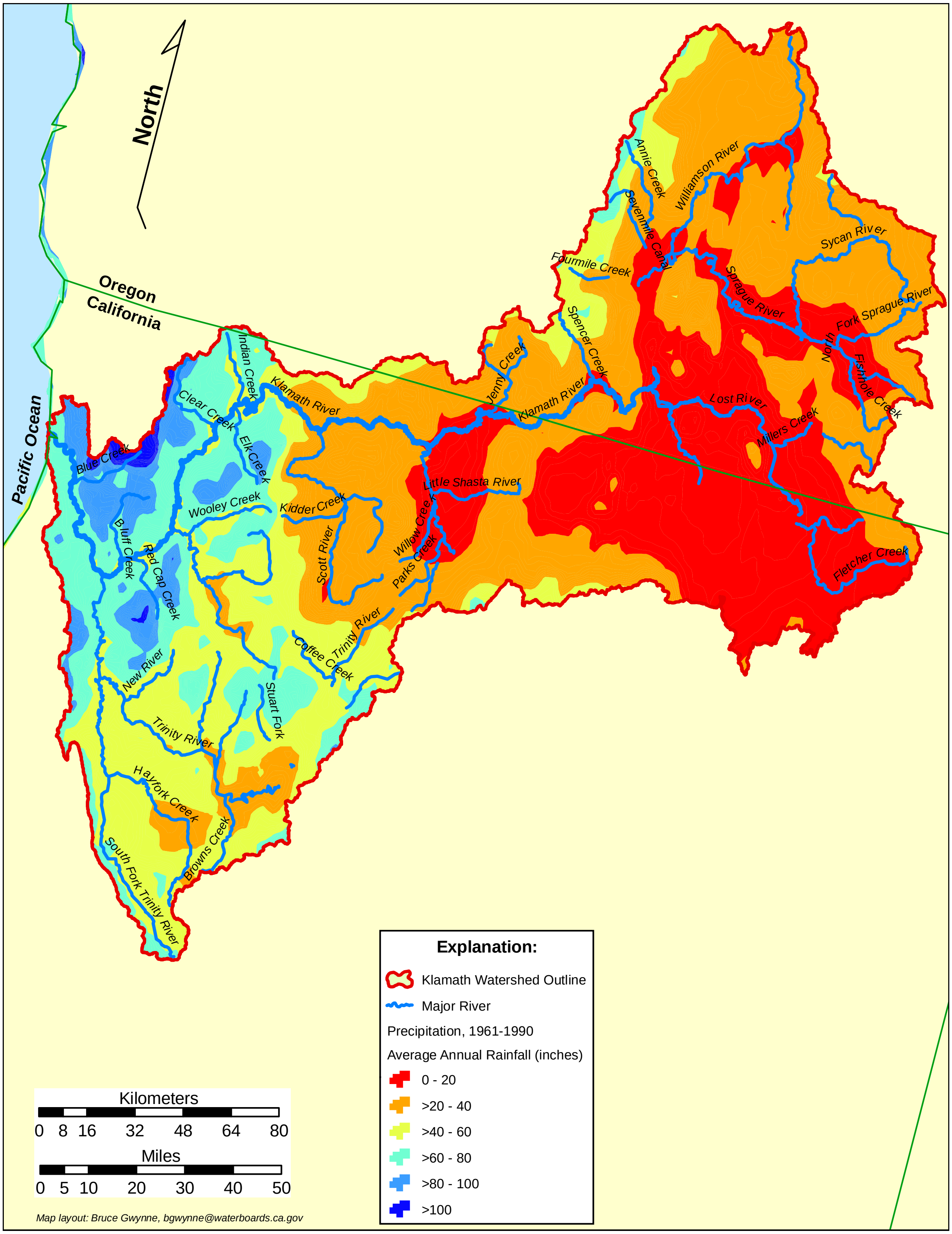

Figure 1.8: Average annual rainfall in the Klamath River basin
Source: United States Department of Agriculture (USDA) Undated

Figure 1.9 provides a comparison of monthly precipitation values from Orleans, California in the mountainous country of the lower Klamath basin and Klamath Falls, Oregon in the broad valley of the upper Klamath basin as an illustration of rainshadow effect. The mean annual precipitation in the Klamath River watershed is about 32 inches (CDWR 1986); but, local averages range from more than 80 inches in the high elevations to 10 inches in the broad inland valleys (CDWR 1986; United States Forest Service [USFS] 1996).

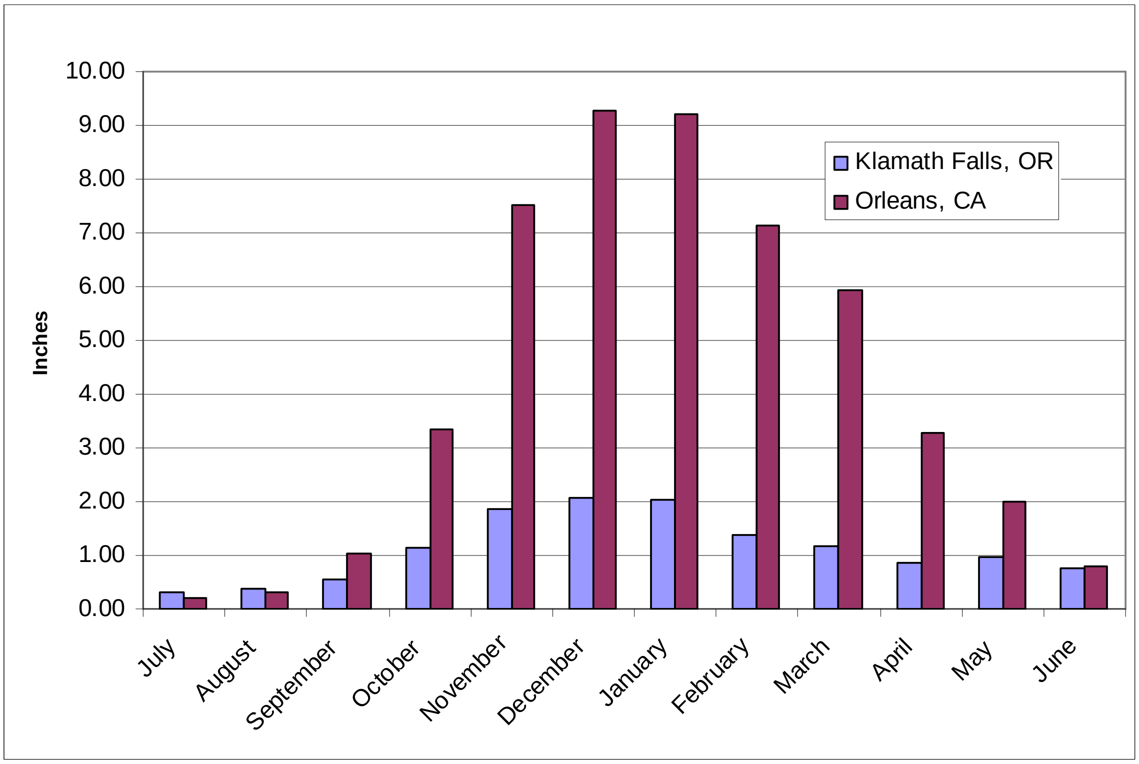

Figure 1.9: Average Monthly Precipitation, 1905-2003, in Klamath Falls, Oregon and Orleans, California
Source: California Data Exchange Center [CDEC] 2006; Oregon Climate Service [OCS] 2006

In the 20th century the Klamath River watershed was characterized by a pattern of floods and droughts. This pattern is discussed by The Klamath River Basin Fisheries Task Force [KRBFTF] (1991, p. 2-3 to 2-7). During a drought in 1976-77, precipitation was only 20 percent of normal in the Scott River watershed and 40 percent of normal in the upper Klamath River basin. The largest floods occurred when relatively warm storm systems melted a pre-existing snow pack such as occurred in 1861, 1955, 1964, 1974 and 1997 (USFS 2000, p.3-3). Many areas of the Klamath River watershed, mostly in the middle third of the basin, are susceptible to these rain-on-snow events.

Klamath Basin air and water temperature data indicate that air and water temperatures have been steadily increasing since at least the 1960s. Bartholow (2005) analyzed air and water temperature records distributed throughout the Klamath basin and evaluated water temperatures simulated using a computer-based water temperature model. The results of Bartholow's analysis strongly suggest a trend of water temperature increases of approximately 0.5 ^{o}C per decade since the 1960s.

1.6.5 Hydrology

Drainage density in the Klamath River watershed is affected by infiltration capacity, tectonics, and underlying bedrock. Figure 1.10 shows dense drainage networks in the steep, recently uplifted ranges to the west and in the volcanic mountains to the east. The lower, flatter country in the upper Klamath, in the region of Klamath Falls, has a much lower drainage density and is punctuated by lakes and wetlands associated with local tectonic subsidence.

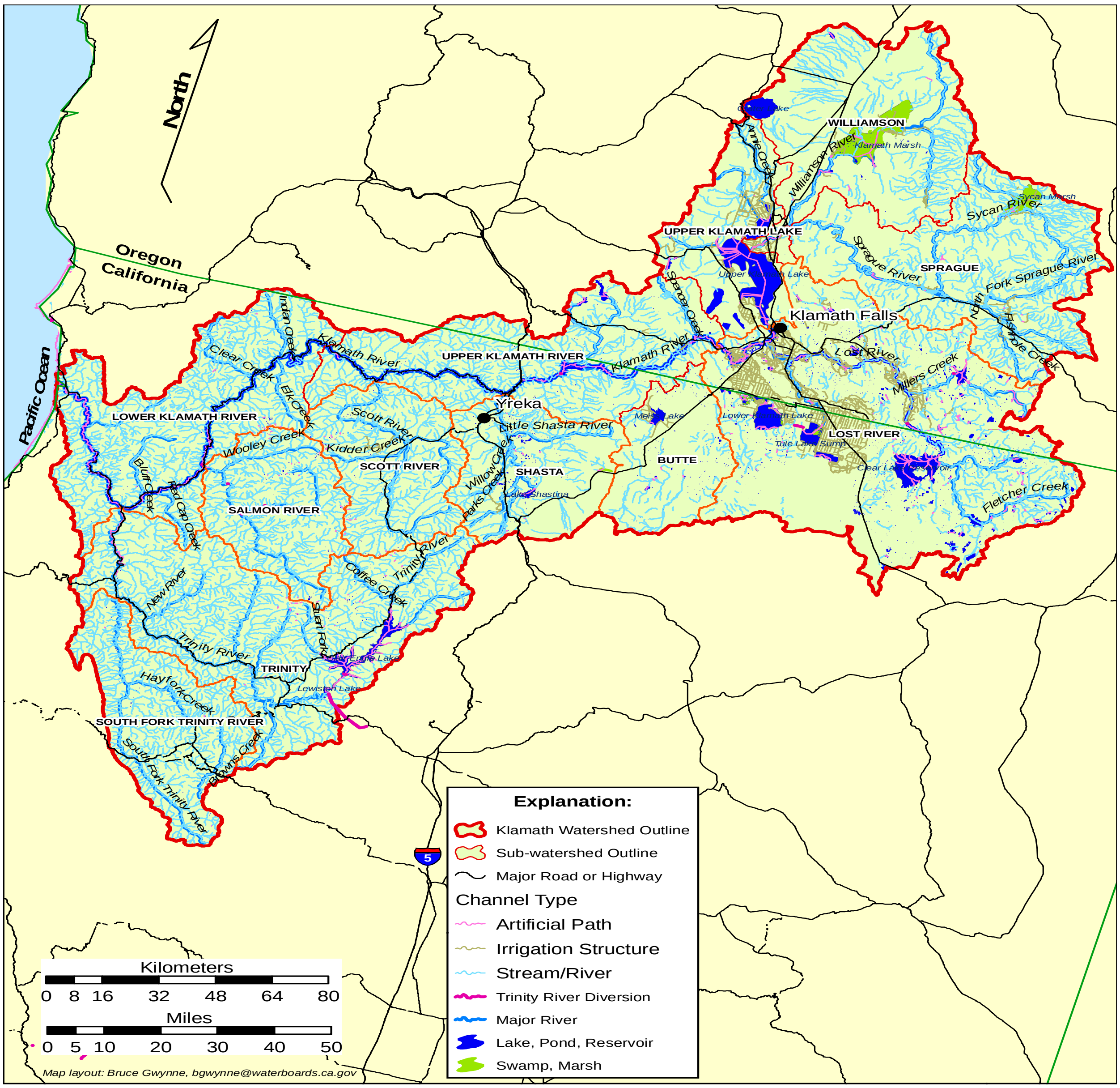

Figure 1.10: Map of Klamath River basin emphasizing subbasins and surface drainage

Water yield in the Klamath basin varies by watershed setting. As illustrated in Figure 1.11, approximately half of the February flow measured in the lower watershed at Klamath, California is drained from that portion of the basin from Orleans, California to Klamath, California, representing about a third of the basin's area. Conversely, only 7 percent of the flow originates in the upper one third of the basin. This pattern is not as dramatic in the summer months when water yield is more generally proportional to drainage area. It is important to recognize that the data presented in Figure 1.11 shows the pattern of flow associated with a history of consumptive use (e.g., Klamath Project in the upper basin) and altered flow timing (e.g., controlled releases from Upper Klamath Lake). However, these factors do not affect the above observations with respect to winter flows.

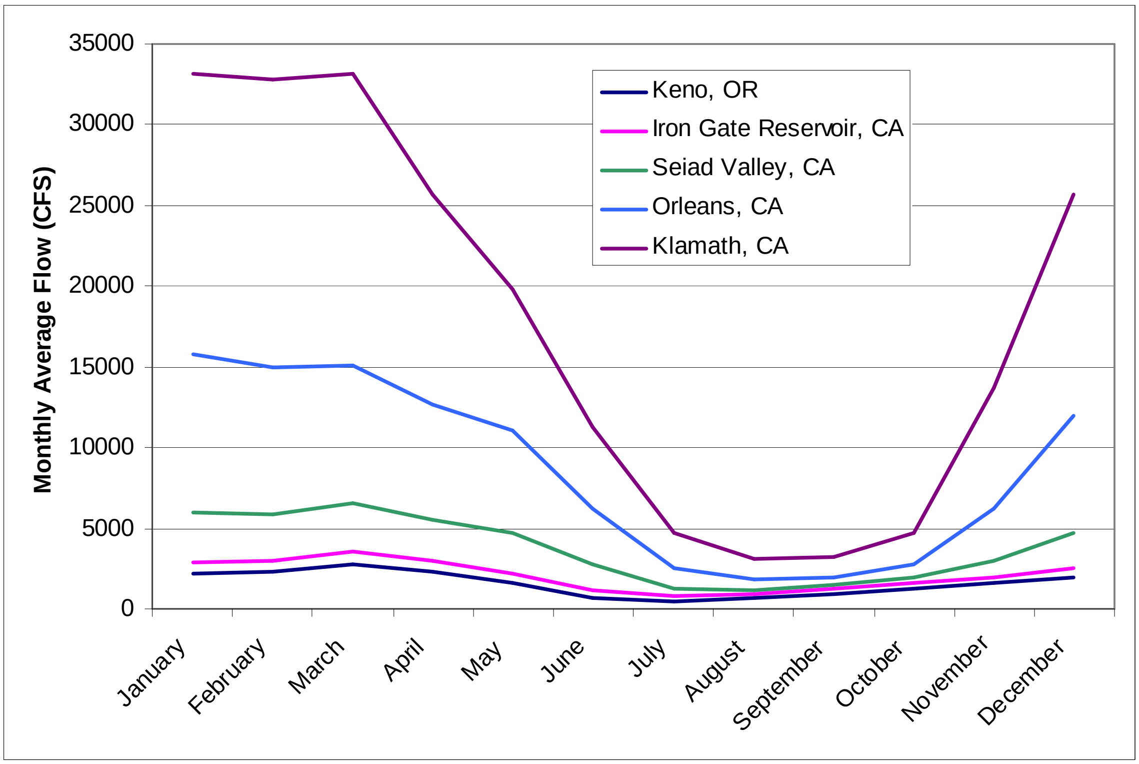

Figure 1.11: Monthly average flows at five Klamath River locations, water years 1963-2005
Source: United States Geological Survey [USGS] 2006

1.6.6 Water Use

There exist in the Klamath River basin numerous dams and diversions associated with power generation and irrigation. The histories of many of these are well documented and the effects on water yield quantified. The effects of diversions granted under riparian rights and groundwater withdrawals, however, are not well understood. Beginning around 1850, small dams and diversion ditches were built on smaller tributaries for use in mining and irrigation. Starting out small and temporary in nature, some became more fixed as established use persisted. As early as 1930, these more permanent diversion structures were creating barriers to fish migration (KRBFTF 1991, p.2-40, 2-62). Among the mining dams, some were left in place after cessation of mining, creating additional barriers (KRBFTF 1991, p.2-62).

Beginning in the 1890s, hydroelectric power facilities were installed, first on the Shasta River, then on the Link River. California Oregon Power Company (COPCO) built Copco Number 1 Dam and Copco Number 2 Dam between 1917 and 1925. These comprise the first major hydroelectric facilities built on the mainstem of the Klamath River (KRBFTF 1991, 2-62 to 2-64).

Prohibitions on the construction of any obstructions in the Klamath River downstream from the mouth of the Shasta River were enacted as a result of Proposition 11 passed in a statewide election of 1924 (KRBFTF 1991, p. 2-64). This effectively ended the prospective efforts to build major hydroelectric and diversion projects in the Klamath River below the mouth of the Shasta River; though no such protections were afforded the flows above the confluence with the Shasta. In 1958, J.C. Boyle (Big Bend) Dam went online just upstream of the California state line.

In 1962 Iron Gate Dam was built below Copco 1 and 2 at river mile 190. From this point to the ocean the river is protected as free flowing under the National Wild and Scenic Rivers System. Iron Gate Dam was originally built to attenuate flow variations caused by the operations of Copco 1 and 2 Dams. These dams are operated as peak demand generation facilities.

Most of the Klamath River water is used in the Klamath River basin, including the use of water for crop and pasture irrigation within the Williamson River, Sprague River, Lost River, Shasta River, Scott River, and South Fork Trinity River. Facilities built to support consumptive uses in California include the U.S. Bureau of Reclamation Klamath Project (construction began in 1906, first water delivered in 1907) and Lake Shastina (created by the construction of Dwinnell Dam on the Shasta River in 1928). A total of 240,412 acres of irrigable lands, including 235,667 acres of farmland, and 4,745 acres of residential, commercial, and industrial lands, are served by Klamath Project infrastructure.

In addition to in-basin use, however, there are also significant diversions out of the basin maintained for agriculture and power generation: The Lewiston and Trinity Dams were completed in 1964 on the Trinity River to enable a significant transfer of flow out of the Klamath watershed and into the Sacramento River system. An additional, smaller, out-of-basin diversion occurs from the upper tributaries in the Jenny Creek watershed in Oregon and into the Rogue River watershed in Oregon.

The pattern of water use, on the other hand, is nearly the opposite of the pattern in drainage density and water yield. That is, the majority of the diversions in the basin are upstream of Seiad Valley where the least amount of the water is produced. As demonstrated by Figure 1.12, some of the effects of this pattern of water use are to:

- Move the timing of the peak spring flows from mid-April to mid-March;
- Make steeper the decline in the spring hydrograph, thus reducing flows by roughly 65-70% in June and July, 45% in May, 20-25% in April, and 35-40% in August;
- Lower the minimum summer flows; and
- Move the timing of the minimum summer flow from mid-September to mid-July

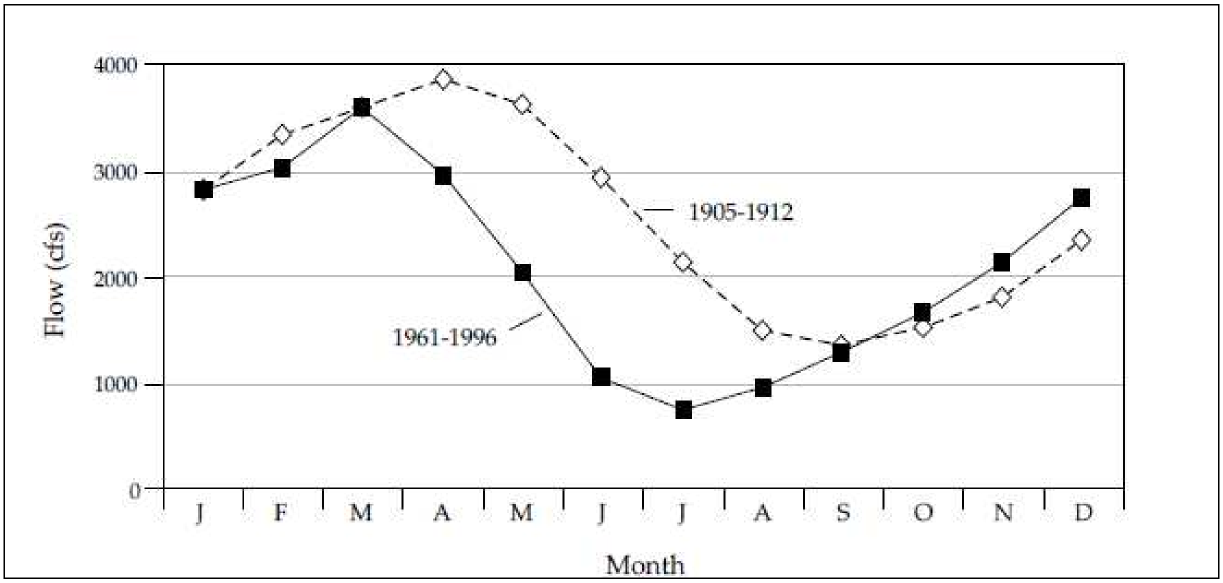

Figure 1.12: Mean monthly flows at Iron Gate Dam in 1961-1996 compared with reconstructed flows for 1905-1912
Source: NRC 2004

The estimated unimpaired flows represented in Figure 1.12 illustrate the magnitude and pattern of flows that would be expected without diversions upstream of Keno, Oregon.

<u>1.6.6.1 Water Rights of the Klamath River Basin, California</u>
Water rights within the State of California are administered by the State Water Resources Control Board, Division of Water Rights (Division of Water Rights) based on three general principles:

- All water belongs to the people of the state;
- Water rights are a right to the use of water;
- Water use must be reasonable and beneficial.

Generally, the appropriative use of surface water after 1914 requires a permit through the Division of Water Rights. Permits identify the maximum amount of water allowed to the user, the timing of permitted use, and the place and purposes of the use. In times of water shortage users with the oldest permits have the first priority to use. Permitting of water rights within the Klamath River basin in California began in June 1916. For the Klamath Basin within California, there are a total of 1614 permitted water rights listed with the Division of Water Rights.

Once all the water within a stream or river has been permitted by the Division of Water Rights for withdrawal, the stream is declared fully appropriated either year-round or during specified months. Table 1.3 lists all the fully appropriated tributaries to the Klamath River in California and below Iron Gate dam, as well as the season during which they are determined fully appropriated. Additionally, the Klamath River itself is determined to be fully appropriated during the entire year.

Table 1.3: Fully appropriated Klamath River reaches and tributaries to the Klamath River in California below Iron Gate Dam

Stream	Tributary	Season Begin-End	Critical Reach
Klamath River	Pacific Ocean	01/01-12/31	From the mainstem about 100 yards below Iron Gate Dam to the Pacific Ocean.
Trinity River	Klamath River	01/01-12/31	The mainstem from 100 yards below Lewiston Dam to the river mouth at Weitchpec.
Salmon River	Klamath River	01/01-12/31	The Salmon River from Cecilville Bridge to the river mouth near Somes Bar.
Scott River	Klamath River	01/01-12/31	The Scott River from the mouth of Shackleford Creek west of Fort Jones to the river mouth near Hamburg.
Shasta River	Klamath River	05/01-10/31	From the confluence of the Shasta River and the Klamath River upstream.
Willow Creek	Klamath River	04/01-11/30	From the York Road Bridge located within Section 8, T46N, R5W, MDB&M upstream.
Seiad Creek	Klamath River	07/01-10/31	From the confluence of Seiad Creek and the Klamath River upstream.
McKinney Creek	Klamath River	03/01-11/30	About 1 ½ miles downstream from the point of diversion on McKinney Creek upstream.
Douglas Creek	Klamath River	06/01-10/31	From a point on Douglas Creek located within the NE 1/4, Section 19, T15N, R7E, MDB&M upstream.

Source: State Water Board 1998, p.8, 13, 56, 57, 58, 64.

The right to use water can under some circumstances be legal without a permit from the Division of Water Rights. Land owners with property adjacent to a waterbody have what is known as a “riparian right” by which they can use water on their river front parcel, so long as the use is reasonable with respect to other users of the waterbody. Groundwater use is also allowed without a permit from the Division of Water Rights if not within the underflow of the river. All water use in California is subject to a constitutional prohibition against waste and unreasonable use or method of diversion.

Table 1.4 summarizes permitted water rights within the Klamath River basin in California, based on the Division of Water Rights, Water Right Information Management System (WRIMS). Table 1.4 groups water rights into reaches of the Klamath River in California including all tributaries. The Shasta, Scott, Salmon, and Trinity Rivers are summarized individually. Summer season (May through August) and winter season (September through April) water rights are summarized and the primary summer season water use is identified. Diversions for the purpose of storage are included in Table 1.4. Uses for stored water include domestic, fire protection, fish culture, irrigation, industrial, incidental power, municipal, power, recreation, stockwatering, and fish and wildlife protection and/or enhancement. The season that water is diverted for the purpose of storage varies from permit to permit. Months of diversion for storage generally occur during the period of November through June. A small portion of permits include the right to divert water throughout the year and only a few allow diversion for storage during the summer months. All values represent the maximum permitted water use.

Table 1.4: Summary of water rights in the Klamath River basin in California below Iron Gate Dam

Reach	Number of Permits	Primary Summer Use	Summer Totals (cfs)	Winter Totals (cfs)	Storage Totals (af)
Klamath River					
Iron Gate to Shasta River	50	Fish Culture	65	49	81
Shasta River to Scott River	76	Domestic	9.6	8.6	0
Scott River to Salmon River	143	Power	25	17	10
Salmon River to Trinity River	66	Domestic	0.006	0.006	160
Trinity River to Pacific Ocean	40	Power	2	2	0
Tributaries					
Tributaries to Iron Gate & Copco	34	Irrigation	72	16	0
Shasta River Watershed	121	Irrigation	982	82	9406
Scott River Watershed	272	Irrigation	255	157	387
Salmon River Watershed	86	Domestic	44	39	6
Trinity River Watershed	726	Municipal	818	593	4442

Source: WRIMS 2006
Note: Summer season is May through August and winter season is September through April.

Dates of permitted water use vary from permit to permit. Table 1.4 groups permitted water rights into summer and winter seasons. Water use permitted during the months of May through August are grouped into the summer totals. Water use permitted during the months of September through April is grouped into the winter totals. Water uses permitted for the entire year are accounted for once in the summer total and again in the winter total.

CHAPTER 1. REFERENCES

Bartholow, J. 2005. Recent Water Temperature Trends in the Lower Klamath River, California. North American Journal of Fisheries Management. 25: 152-162.

California Data Exchange Center (CDEC). 2006. Historical Data: Klamath River at Orleans. Accessed August 1, 2006. Available at: <http://cdec.water.ca.gov/cgi-progs/staMeta?station_id=OL>.

California Department of Water Resources (CDWR). 1986. Shasta/Klamath Rivers water quality study. 26 pp. Accessed August 25, 2006. Available at: <http://www.krisweb.com/biblio/klamath_cadwr_clawsonetal_1986.pdf#search=%22%20%22shasta%2Fklamath%20rivers%20water%20quality%22%22>.

Crandell, D.R. 1989. Gigantic Debris Avalanche of Pleistocene Age from Ancestral Mount Shasta Volcano, California, and Debris-Avalanche Hazard Zonation. United States Geological Survey Bulletin 1861. 32pp.

Klamath River Basin Fisheries Task Force (KRBFTF). 1991. Long Range Plan for The Klamath River Basin Conservation Area Fishery Restoration Program. Assistance from William M. Kier Associates. 403pp.

National Research Council of the National Academies (NRC). 2004. Endangered and Threatened Fishes in the Klamath River Basin. Washington, D.C. National Academies Press.

Oakshott, G.B. 1978. California's Changing Landscapes: A Guide to the Geology of the State. New York, NY. McGraw Hill, Inc.

Oregon Climate Service (OCS). 2006. Climate Data Archives: Klamath Falls 2 SSW (354506), Klamath Falls Ag-Stn (354511). Accessed January 8, 2007. Available at: <http://www.ocs.oregonstate.edu/page_links/climate_data_zones/monthly_precip/zone7_tpcp.html>.

Schruben, P.G., R.E., Arndt, and W.J., Bawiec. 1997. Geology of the conterminous United States at 1:2,500,000 scale – a digital representation of the 1974 P.B. King and H.M. Beikman map. United States Geological Survey Digital Data Series 11, Release 2. Accessed January 11, 2007. Available at: <http://pubs.usgs.gov/dds/dds11/>.

Snyder D.T. and J.L. Morace. 1997. Nitrogen and Phosphorus Loading from Drained Wetlands Adjacent to Upper Klamath Lake and Agency Lakes, Oregon. U.S. Geologic Survey. Water-Resources Investigations Report. 97-4059. 69 pp.

State Water Resources Control Board (State Water Board). 1998. Declaration of Fully Appropriated Stream Systems. Exhibit A. Water Right Order 98-08. November 19, 1998.

United States Bureau of Reclamation (USBR). 2005. Natural Flow of the Upper Klamath River – Phase I. 115pp. Accessed January 8, 2007. Available at: <http://www.usbr.gov/mp/kbao/docs/undepleted_klam_fnl_rpt.pdf>.

United States Census Bureau (USCB). 2000. Your Gateway to Census 2000. American Fact Finder and State and County Quick Facts. Accessed January 5, 2007. Available at: <http://www.census.gov/main/www/cen2000.html>.

United States Department of Agriculture (USDA). Undated. Processed Annual Precipitation. Vector dataset provides derived average annual precipitation according to a model using point precipitation and elevation data for the 30-year period of 1961-1990. USDA, National Cartography & Geospatial Center.

United States Forest Service (USFS). 1996. Clear Creek Watershed Analysis. Happy Camp Ranger District. Klamath National Forest.

United States Forest Service (USFS). 2000. Lower Scott Ecosystem Analysis. Klamath National Forest. Scott River Ranger District. United States Department of Agriculture, Pacific Southwest Region.

United States Geological Survey (USGS). 2006. USGS Surface-Water Data for California. Accessed August 1, 2006. Available at: <http://waterdata.usgs.gov/ca/nwis/sw>.

Water Right Information Management System (WRIMS). 2006. Water Rights Information for the Klamath River basin in California. State Water Resources Control Board, Division of Water Rights. Data downloaded October 3, 2006.

CHAPTER 2. PROBLEM STATEMENT

2.1 Introduction

In the Klamath River in California increased water temperatures, elevated nutrient levels, low dissolved oxygen concentrations, elevated pH, potential ammonia toxicity, increased incidence of fish disease, an abundance of aquatic plant growth, high chlorophyll-a levels (both planktonic and periphytic algae), and high concentrations of potentially toxinogenic blue-green algae, particularly in the impounded reaches, decrease the quality and quantity of suitable habitat for fish and aquatic life, and have disrupted traditional cultural uses of the river by resident Tribes. These conditions contribute to the non-attainment of beneficial uses, including the most sensitive beneficial uses: those associated with cold water fish and fisheries (including in particular the salmonid fishery) in California, those related to cultural uses and practices, and those related to recreation.

The purposes of the California Klamath River basin TMDL problem statement are to:

- Provide an overarching assessment framework for the TMDL;
- Present a summary assessment of current water quality conditions; and
- Document beneficial use impairments.

The Klamath River numeric and narrative water quality objectives and beneficial uses that are the comparative benchmarks for the problem statement assessment are described in the Regional Water Board's *Water Quality Control Plan for the North Coast Region* **(**Basin Plan). Section 2.2 of the problem statement, Water Quality Standards, consists of a summary description of the Basin Plan and Tribal water quality standards, objectives, and beneficial uses addressed in the TMDL. The Basin Plan and Tribal water quality standards provide the regulatory context for the assessment that follows. Section 2.3, Numeric Targets, presents the numeric water quality targets that represent attainment of applicable water quality objectives used in this TMDL.

Section 2.4, Water Quality Conceptual Models Overview, describes the technical approach used in the problem statement assessment. To ensure a comprehensive assessment and decision framework, the Regional Water Board has adopted the technical approach from the California Nutrient Numeric Endpoints (CA NNE) framework (Tetra Tech 2006). The CA NNE is used to assess and describe the water quality impacts associated with nutrient and organic enrichment and temperature alteration. The approach involves the development of conceptual models that illustrate how key factors and processes link the primary stressors (nutrients and organic enrichment, and altered temperature regime) with impacts on beneficial uses. In addition, the conceptual models can be used to identify key uncertainties and data gaps, provide lines of evidence for numeric targets and allocations, and are useful tools for adaptive management. The conceptual models for the Klamath River focus on water quality related impacts and provide perspective on other factors that contribute to impairment of beneficial uses within the Klamath River basin.

Section 2.5, Evidence of Water Quality Objective and Numeric Target Exceedances, as the title suggests, presents evidence of exceedances of water quality objectives. The Regional Water Board has compiled water quality monitoring data from several sources to support this analysis (e.g., dissolved oxygen, temperature, pH, nutrient enrichment) and CA NNE indicators (e.g., benthic algal biomass, chlorophyll-a, diurnal dissolved oxygen [DO] and pH patterns). The purpose of the analysis of water quality objectives and CA NNE indicators is to evaluate the risk of impairment to beneficial uses. The Section 2.5 analysis uses data from eleven stations along the length of the Klamath River from the Oregon border to its mouth at the Pacific Ocean. (See Appendix 1 for the Klamath River DO Staff report and a discussion of the recalculation of the SSOs for DO in the mainstem Klamath River as currently contained in the Basin Plan).

As detailed in Section 2.6, Evidence of Beneficial Use Impairment, many designated beneficial uses are not being supported in the Klamath River. The purpose of Section 2.6 is to describe how poor water quality conditions are impairing beneficial uses in the Klamath River. The focus is on the status of the elements that are essential to each beneficial use. For example, to evaluate the Cold Freshwater Habitat (COLD) beneficial use, the historical and current status of cold-water fish populations and the associated fishery is compared to demonstrate a significant degradation of cold water fish and fishery related beneficial uses.

Section 2.7, Problem Statement Synthesis, presents the problem statement conclusions regarding the status of Klamath River beneficial uses and the necessity for fully implementing the TMDL in a timely manner. The problem statement conclusions provide the focus for the TMDL pollutant allocations and implementation.

2.1.1 Non-TMDL Factors and Other Regulatory Processes

It is important to recognize that in the Klamath River basin there are factors that affect the condition of beneficial uses that are not directly addressed through the TMDL process. Klamath River beneficial uses are also impacted by other factors including but not limited to:

- The presence of dams which impede passage of anadromous fish;
- Altered flow conditions that affect habitat conditions;
- The presence of hatchery raised fish with the potential for disease and genetic effects;
- Ocean and in-river fisheries harvest rates; and
- Global climate change.

The problem statement description is a required component of any TMDL, but in this case it takes on added importance because of other ongoing regulatory processes and collaborative settlement discussions (i.e., Klamath Hydroelectric Settlement Agreement and Klamath Basin Restoration Agreement) occurring within the Klamath Basin that must be kept clearly distinct from the TMDL process. The other ongoing regulatory processes include:

- The 50-year Federal Energy Regulatory Commission (FERC) relicense for the four mainstem dams included in the Klamath Hydroelectric Project; and
- Endangered Species Act (ESA) consultation for several native species that have special federal and or state status, including but not limited to Coho salmon, shortnose sucker, Lost River sucker, and Bull trout.
- Tribal Trust responsibilities of the USEPA to Tribes and individual Indians.

The mention of these other non-TMDL factors affecting water quality and other ongoing regulatory processes that will address some of these factors is meant to underscore the need for a comprehensive solution to restore ecosystem integrity to the Klamath River basin. The TMDL process described in this document is only one component of a restoration and management program that must be implemented in the next few years to preserve and restore Klamath River water resource related uses.

2.2 Water Quality Standards

The USEPA describes a water quality standard as consisting of four basic elements: 1) designated uses of the water body, 2) water quality criteria to protect designated uses, 3) an antidegradation policy to maintain and protect existing uses and high quality waters, and 4) general policies addressing implementation issues. More information is available at <http://www.epa.gov/waterscience/standards/about/>.

The Porter Cologne Water Quality Control Act (Porter Cologne)[1] modifies USEPA's language to refer to designated uses as "beneficial uses" and water quality criteria as "water quality objectives", which includes the state anti-degradation policy (Resolution 68-16). Porter Cologne also requires a "program of implementation" (Water Code section 13050(i)) for water quality protection in California. A "program of implementation" includes actions necessary to achieve objectives, a time schedule for the actions to be taken, and surveillance to determine compliance with objectives (see Water Code section 13242).

The Regional Water Board has adopted the Basin Plan in which it establishes the region's water quality standards, including the standards that apply to that portion of the Klamath River basin that falls under the jurisdiction of the state of California. The Basin Plan has been approved by the State Water Board and by USEPA and is in full force and effect. Appendix 1 of this staff report includes the Proposed Site Specific Dissolved Oxygen Objectives for the Klamath River in California, a staff report supporting the recalculation of the existing SSOs for DO in the mainstem Klamath River.

Similarly, the Hoopa Valley Tribe has adopted the *Water Quality Control Plan for the Hoopa Valley Indian Reservation* that has been approved by USEPA and is in full effect.

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[1] The Porter-Cologne Water Quality Control Act (Water Code §§ 13000 et seq.) is the act governing the water quality protection activities of the State Water Resources Control Board (State Board) and the nine regional boards within the state of California.

The Hoopa's standards apply to those portions of the Trinity and Klamath Rivers under the jurisdiction of the Hoopa Valley Tribe[2].

The Yurok and Karuk Tribes have also adopted water quality standards, as has the Resighini Rancheria. These water quality plans and standards have not yet been approved by USEPA, however, and the Regional Water Board will consider their content and use for guidance, as appropriate.

The Quartz Valley Tribe, located along the Scott River, is in the process of developing a document on water quality standards for approval by its Tribal government.

2.2.1 Water Quality Control Plan for the North Coast Region

The Basin Plan (Regional Water Board 2007) is divided into 6 chapters. Of concern to this discussion are Chapter 2 (Beneficial Uses), Chapter 3 (Water Quality Objectives), Chapter 4 (Implementation Plans), and Chapter 5 (Plans and Policies).

2.2.1.1 Beneficial Uses

Chapter 2 of the Basin Plan identifies 28 beneficial uses of water within the North Coast region. Within the Klamath River basin, the following beneficial uses are identified as existing uses:

- MUN—Municipal and domestic supply
- AGR—Agricultural supply
- IND—Industrial service supply
- PRO—Industrial process supply
- GWR—Groundwater recharge
- FRSH—Freshwater replenishment
- NAV—Navigation
- POW—Hydropower generation
- REC1—Water contact recreation
- REC2—Non-contact water recreation
- COMM—Commercial and sport fishing
- CUL—Native American Culture
- WARM—Warm freshwater habitat
- COLD—Cold freshwater habitat
- WILD—Wildlife habitat
- RARE—Rare, threatened, or endangered species
- MAR—Marine habitat
- MIGR—Migration of aquatic organisms
- SPWN—Spawning, reproduction, and/or early development
- SHELL—Shellfish harvesting
- EST—Estuarine habitat
- AQUA—Aquaculture

Of particular importance are those uses that are currently not fully supported due in part to degraded water quality. As detailed in Section 2.5, 17 of the 23 designated beneficial uses for the Klamath River are impaired including: Native American Culture; Subsistence Fishing; Cold Freshwater Habitat; Warm Freshwater Habitat; Rare, Threatened, or Endangered Species; Migration of Aquatic Organisms; Spawning, Reproduction, and/or Early Development; Water Contact Recreation; Non-Contact Water Recreation;

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[2] The Hoopa Valley Tribe is a sovereign nation with land, 12 miles by 12 miles, primarily in the Trinity River watershed but intersecting with the Klamath River at Saints Rest Bar upstream of the confluence with the Trinity (www.Hoopa-nsn.gov).

Municipal & Domestic Supply; Shellfish Harvesting; Estuary Habitat; Marine Habitat; Aquaculture; Agricultural Supply; Commercial and Sport Fishing; and Wildlife Habitat. Subsistence fishing (FISH) is also listed in the Basin Plan as a beneficial use of the waters in the region. Although the specific areas in which this use exists have not yet been designated in the Basin Plan, this does not alter the need to protect this existing beneficial use.

2.2.1.2 Water Quality Objectives

Chapter 3 of the Basin Plan identifies the water quality objectives deemed necessary to protect beneficial uses. Of concern to this TMDL are the water quality objectives concerning temperature, dissolved oxygen and nutrients. These are the parameters for which instream water quality data indicate exceedances and for which the Klamath River is listed on the 303(d) list as impaired[3]. Additionally, pH is discussed because high pH can be directly stressful to salmonids and it also influences nutrient related parameters such as ammonia toxicity. Toxicity is also discussed as nutrient and temperature impairment contributes to the presence of blue-green algae blooms and associated presence of algal toxins.

Temperature

The Basin Plan contains two separate water quality objectives for temperature. The first objective is the intrastate temperature objective. This objective applies to all waters of the state.

The intrastate temperature objective is a narrative objective with associated numeric criteria and reads:

> The natural receiving water temperature of intrastate waters shall not be altered unless it can be demonstrated to the satisfaction of the Regional Water Board that such alteration in temperature does not adversely affect beneficial uses.
>
> At no time or place shall the temperature of any COLD water be increased by more than 5°F above natural receiving water temperature.
>
> At no time or place shall the temperature of WARM intrastate waters be increased more than 5°F above natural receiving water temperatures.

The second water quality objective for temperature is the interstate temperature objective contained in the state wide *Water Quality Control Plan for Control of Temperature In the Coastal and Interstate Waters and Enclosed Bays and Estuaries of California* (Thermal Plan). The Thermal Plan, as adopted by the State Water Board, is incorporated by reference in the Basin Plan (see Appendix 3 of the Basin Plan). The plan designates the

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[3] The Klamath River downstream of the Trinity River is also on the 303(d) list for Sedimentation/Siltation, and Copco and Iron Gate Reservoirs are on the 303(d) list for the microcystin toxin.

Klamath River as a “Cold Interstate Water”. The “Cold Interstate Waters” objective is as follows:

> Elevated temperature waste discharges into cold interstate waters are prohibited.

“Elevated Temperature Waste” is defined as:

> Liquid, solid, or gaseous material including thermal waste discharged at a temperature higher than the natural temperature of receiving water. Irrigation return water is not considered elevated temperature waste for the purpose of this plan.

The interstate objective applies to waters that cross or define the state border. The interstate temperature objective augments, but does not supersede, the intrastate temperature objective.

The federal Clean Water Act (CWA) imposes a criterion for setting loads in addition to the water quality standards defined by the State. For waters impaired by temperature, CWA section 303(d)(1)(D) requires that states estimate “the total maximum daily thermal load required to assure protection and propagation of a balanced, indigenous population of shellfish, fish, and wildlife.”

<u>Dissolved Oxygen</u>

The Basin Plan includes two sets of DO objectives. The first set of objectives included on page 3-4.00 are minimum DO levels for various beneficial uses. These DO objectives are based on the life cycle requirements of aquatic species occupying warm water and marine habitat, as well as habitat of inland saline seas, and the life cycle requirements of aquatic species occupying cold water habitat, as well as the spawning and incubation requirements of cold water species. These are given as ambient water quality objectives applicable as instantaneous minimum requirements.

The second set of objectives is included in Basin Plan Table 3-1 of the Basin Plan and describes the background conditions in individual waterbodies as defined by grab sampling studies conducted in the 1950s and 1960s. In the existing Basin Plan (Regional Water Board 2007) the Site Specific Objectives (SSOs) contained in Table 3-1 supersede the life cycle requirements for those waterbodies listed in Table 3-1 with SSOs DO.

For the Klamath River, numeric objectives are assigned in Table 3-1 of the Basin Plan for the following hydrologic areas: 1) upstream of the Iron Gate Dam, 2) downstream of Iron Gate Dam, 3) on tributaries of the Middle Klamath River, and 4) on tributaries of the Lower Klamath River. The Klamath River DO impairment applies only to the mainstem of the Klamath River.

Upstream of the Iron Gate Dam, the instantaneous minimum concentration of DO required is 7.0 mg/L. Half of the monthly mean DO values for the year must be 10.0 mg/L or greater.

Downstream of the Iron Gate Dam, the instantaneous minimum concentration of DO required is 8.0 mg/L. Half of the monthly mean DO values for the year must also be 10.0 mg/L or greater.

Staff has assessed the Basin Plan Table 3-1 DO objectives for the Klamath River, and determines that revised SSOs DO for the Klamath River are warranted and appropriate. Staff proposes the adoption of Basin Plan language in which the Table 3-1 DO objectives for the mainstem Klamath River are eliminated and replaced by percent DO saturation criteria based on natural receiving water temperatures.

Proposed Basin Plan language is as follows:

Table 3.1a[1]

Location[2]	**Percent DO saturation based on natural receiving water temperatures3**	**Time period**
Stateline to the Scott River	90%	October 1 through March 31
	85%	April 1 through September 30
Scott River to Hoopa	90%	Year round
Downstream of Hoopa-California boundary to Turwar	85%	June 1 through August 31
	90%	September 1 through May 31
Upper and Middle Estuary	80%	August 1 through August 31
	85%	September 1 through October 31 and June 1 through July 31
	90%	November 1 through May 31
Lower Estuary	For the protection of estuarine habitat (EST), the dissolved oxygen content of the lower estuary shall not be depressed to levels adversely affecting beneficial uses as a result of controllable water quality factors.	

[1] States may establish site specific objectives equal to natural background (USEPA, 1986. Ambient Water Quality Criteria for Dissolved Oxygen, EPA 440/5-86-033; USEPA Memo from Tudor T. Davies, Director of Office of Science and Technology, USEPA Washington, D.C. dated November 5, 1997). For aquatic life uses, where the natural background condition for a specific parameter is documented, by definition that condition is sufficient to support the level of aquatic life expected to occur naturally at the site absent any interference by humans (Davies, 1997). These DO objectives are derived from the natural conditions baseline scenario (T1BSR) run of the Klamath TMDL model and described in Appendix 7 - *Modeling Scenarios: Klamath River Model for TMDL Development.*

[2] These objectives apply to the maximum extent allowed by law. To the extent that the State lacks jurisdiction, the Site Specific Dissolved Oxygen Objectives for the Mainstem Klamath River are extended as a recommendation to the applicable regulatory authority.

[3] Corresponding DO concentrations are calculated as daily minima, based on site-specific barometric pressure, site-specific salinity, and natural receiving water temperatures as estimated by the natural conditions baseline scenario of the Klamath TMDL model and described in Appendix 7 - Modeling Scenarios: Klamath River Model for TMDL Development. The estimates of natural receiving water temperatures used in these calculations may be updated as new data or method(s) become available. After opportunity for public comment, any update or improvements to the estimate of natural receiving water temperature must be reviewed and approved by Executive Officer before being used for this purpose.

Appendix 1 (*Proposed Site-Specific Dissolved Oxygen Objectives for the Klamath River in California* [Mangelsdorf 2009]) presents Regional Water Board staff's scientific justification for the selection of this proposed site-specific DO objective for the Klamath River in California.

Nutrients

The nutrient objective is a narrative objective for controlling biostimulatory substances. Biostimulatory substances include nitrogen and phosphorus. The objective reads:

> Waters shall not contain biostimulatory substances in concentrations that promote aquatic growths to the extent that such growths cause nuisance or adversely affect beneficial uses.

Nutrient-Related Water Quality Objectives

The cycling of nutrients in an aquatic environment is strongly influenced by several factors. Depending on these factors, there is the potential for impacts to beneficial uses from secondary indicators of biostimulation such as algal biomass, chlorophyll-a, DO, and pH.

The Basin Plan does not contain numeric water quality objectives for algal biomass or chlorophyll-a. The Basin Plan does contain a set of numeric objectives for pH in the

Klamath River. Minimum pH levels shall not drop below 7.0 and maximum pH shall not be raised above 8.5.

Other impacts closely related to excessive nutrient inputs, but qualitatively different are ammonia toxicity and microcystin[4] toxicity. The Basin Plan does not include numeric objectives for ammonia toxicity or microcystin.

The Basin Plan includes a narrative objective for toxicity that reads:

> All waters shall be maintained free of toxic substances in concentrations that are toxic to, or that produce detrimental physiological responses in human, plant, animal, or aquatic life.

2.2.1.3 Antidegradation Policies

There are two applicable antidegradation policies pertinent to water quality in the North Coast Region – a state policy and a federal policy. The state antidegradation policy is titled the *Statement of Policy with Respect to Maintaining High Quality Waters in California* and is commonly known as "Resolution 68-16." The federal antidegradation policy is found at 40 CFR section 131.12. Both policies are incorporated in the Basin Plan for the North Coast Region. Although there are some differences in the state and federal policies, both require that whenever surface waters are of higher quality than

[4] Microcystin is a toxin produced by a species of blue-green algae.

necessary to protect the designated beneficial uses, such existing quality shall be maintained unless otherwise provided by the policies.

The state antidegradation policy applies to groundwater and surface water whose quality meets or exceeds water quality objectives, which may limit its direct applicability in impaired waterbodies. The state policy establishes a two-step process to determine if discharges that will degrade water quality are allowed. The federal antidegradation policy applies to both surface waters that meet or exceed water quality objectives, and those that do not meet the applicable water quality objectives (i.e., impaired waters). Under the federal policy, an activity or discharge would be prohibited if the activity would lower the quality of surface water including where that surface water currently does not meet water quality standards (i.e., the water quality is not sufficient to support designated beneficial uses) with limited exceptions set forth in federal regulations.

2.2.1.4 <u>Program of Implementation</u>
Chapter 4 of the Basin Plan describes the program of implementation by which the beneficial uses and water quality objectives are applied and enforced. This chapter includes all the prohibitions, schedules of compliance, action plans, policies, and guidelines adopted by the Regional Water Board for that purpose.

Chapter 6 of this TMDL staff report describes the proposed Implementation Plan for the TMDL, and will serve as the basis for the for the Klamath River TMDL Action Plan to be considered by the Regional Water Board as an amendment to Chapter 4 of the Basin Plan.

2.2.2 Tribal Water Quality Standards
The four Tribes in California with land along the mainstem Klamath River are the Hoopa Valley Tribe, the Karuk Tribe, the Resighini Rancheria, and the Yurok Tribe. As stated earlier, only the Hoopa Valley Tribe's water quality standards have been approved by the USEPA at this time. The water quality standards developed by the Yurok and Karuk Tribes and Resighini Rancheria will be used as guidance in developing the TMDL as appropriate.

2.2.2.1 <u>Hoopa Valley Tribe Beneficial Uses</u>
The *Water Quality Control Plan for the Hoopa Valley Indian Reservation* (Hoopa Valley Tribal Environmental Protection Agency [HVTEPA] 2008) identifies nine existing (E), four potential (P), and one historical (H) beneficial uses of water within their jurisdictional reach of the Klamath River. Figure 1.2 identifies the location and boundaries of the Hoopa Valley Indian Reservation, as well as the Yurok Indian Reservation.

- AGR—Agricultural supply(P)
- COLD—Cold freshwater habitat(E)
- CUL—Ceremonial and Cultural Water Use(H)
- GWR—Groundwater recharge(E)
- IND—Industrial service supply(P)
- MGR—Fish Migration(E)
- MUN—Municipal and domestic supply(P)
- PROC—Industrial process supply(P)

- REC1—Water contact recreation(E)
- REC2—Non-contact water recreation(E)
- SPWN—Spawning, reproduction,
- and/or early development(E)
- T&E— Preservation of Threatened and Endangered Species(E)
- W&S—Wild and Scenic(E)
- WILD—Wildlife habitat
- and Endangered Species(E)

2.2.2.2 Hoopa Valley Tribe Water Quality Criteria
The Hoopa Valley Tribe has established DO and nutrients criteria for the Klamath River as described below. The Tribe has not developed temperature criteria for the Klamath River.

Dissolved Oxygen
The existing dissolved oxygen (DO) criterion consists of a 7-day moving average of the daily minimum DO concentrations.

In areas of the Klamath River designated as COLD (year-round), the 7-day moving average of the daily minimum DO concentration required in the water column must be 8.0 mg/L or greater. Areas of the Klamath River designated as SPWN (whenever spawning occurs, has occurred in the past or has potential to occur) must have a 7-day moving average of the daily minimum DO concentration in the water column of the Klamath River of 11.0 mg/L or greater. The intragravel 7-day moving average of the daily minimum DO concentration required in the Klamath River areas designated as SPWN (whenever spawning occurs, has occurred in the past or has potential to occur) must be 8.0 mg/L or greater. In the event that these 7-day moving averages of the daily minimum DO standards "are not achievable due to natural conditions, then the COLD and SPWN standard shall instead be DO concentrations equivalent to 90% saturation under natural receiving water temperatures." This later element is contained in the Hoopa Water Quality Control Plan but has not been approved by USEPA. USEPA requires that a method for determining that the DO objectives are not achievable due to natural conditions be developed and presented. Staff believe the *Klamath TMDL model* as described in this staff report provides the tool necessary to establish natural conditions for comparison to DO objectives.

Nutrients
Nutrient criteria consist of several narrative criteria for controlling biostimulatory substances, nitrate and nitrite levels, and phosphate levels. Additionally, there are numeric objectives for nitrate, total nitrogen, ammonia, and total phosphorus.

The narrative criteria for biostimulatory substances reads:

> Waters shall not contain bio-stimulatory substances in concentrations that promote aquatic growths to the extent that such growths cause nuisance or adversely affect beneficial uses.

The narrative criteria for nitrates applies to all waterbodies except those designated as municipal or domestic supply (which have their own numeric criteria) and reads:

> …levels of nitrate shall not be increased by human related activity above the levels consistent with preservation of the specified beneficial uses.

The narrative criteria for nitrites reads:

> Levels of nitrites shall not be increased, in any body of water, by human related activity above the levels consistent with preservation of the specified beneficial use corresponding to that water body.

The narrative criteria for phosphates reads:

> In order to preserve the existing quality of water within the reservation boundaries from existing and to avoid potential eutrophication of phosphorous in any water body shall not be increased by human related activity above levels consistent with preservation of the specified beneficial uses. <sic>

Numeric nutrient criteria for the Hoopa Valley Tribe reaches of the Klamath River are displayed below in Table 2.1. "If total nitrogen and total phosphorus standards are not achievable due to natural conditions, then the standards shall instead be the natural conditions for total nitrogen and total phosphorus (HVTEPA 2008, p.53)." As stated in a footnote within the Hoopa's Basin Plan, "Through consultation, the ongoing TMDL process for the Klamath River is expected to further define these natural conditions (HVTEPA 2008, p.53)."

Table 2.1: Hoopa Valley Tribe numeric nutrient criteria

	Nitrate (mg/L)	**Total N (mg/L)**[1]	**Ammonia (mgN/L)**	**Total P (mg/L)**[1]
All Streams	-	0.2	-[2]	0.035
Domestic/Municipal supply	10	-	-	-

Source: HVTEPA 2008
[1] 30-day mean of at least two samples per 30-day period.
[2] Maximum one-hour and 30-day average concentrations linked to pH by a formula. Formula can be found in HVTEPA 2008.

Nutrient-Related Water Quality Criteria

In addition to the above narrative and numeric criteria for nutrients, the *Water Quality Control Plan for the Hoopa Valley Indian Reservation* contains narrative criteria for toxicity and Cyanobacterial scums, as well as numeric criteria for parameters which are closely related to excessive nutrient inputs and influence toxicity.

The toxicity narrative reads:

> All waters shall be maintained free of toxic substances in concentrations that produce detrimental physiological responses in human, plant, animal or aquatic life.

The Cyanobacterial scums narrative reads:

> There shall be no presence of cyanobacterial scums.

Table 2.2 displays numeric criteria for algal biomass, pH, blue-green algae, and Microcystin.

Table 2.2: Hoopa Valley Tribe numeric nutrient and toxicity related criteria

	Periphyton	**Hydrogen Ion (pH)**		**Total Potentially Toxinogenic BGA Species**[1]	***Microcystis aeruginosa* and Microcystin**			
	Max annual periphyton mg chl-a per m^2	**Max**	**Min**	**Recreation Water**	**Drinking Water**		**Recreation Water**	
				cells/mL	**cells/mL**	**Microcystin (µg/L)**	**cells/mL**	**Microcystin (µg/L)**
All Streams	150	8.5	7.0	<100,000	<5000	<1	<40,000	<8

Source: HVTEPA 2008
[1] Includes: *Anabaena, Microcystis, Planktothrix, Nostoc, Coelosphaerium, Anabaenopsis, Aphanizomenon, Gloeotrichia,* and *Oscillatoria*.

2.2.2.3 Karuk Tribe, Resighini Rancheria, and Yurok Tribe Beneficial Uses

The Karuk Tribe[5], Resighini Rancheria[6], and Yurok Tribe[7], have identified the following existing, potential, and historical beneficial uses within their respective reaches of the Klamath River:

- AGR—Agricultural Supply [6, 7, 8]
- ASQ—Aesthetic Quality [6]
- BIOL—Preservation of Areas of Special Biological Significance[6, 7]
- COL/COLD—Cold Freshwater Habitat [6, 7, 8]
- COMM—Commercial and Sport Fishing [8]
- CUL—Cultural [7,8]
- CUL-1—Cultural Contact Water [6]
- CUL-2—Cultural Non-Contact Water [6]
- EST—Estuarine Habitat [8]
- FC—Fish Consumption [6]
- FRSH—Freshwater Replenishment [6, 8]
- GW—Groundwater Recharge [6, 7, 8]
- IND—Industrial Service Supply[7]
- LIV—Livestock Watering [6]
- MGR/MIGR—Migration of Aquatic Organisms [6, 8]
- MGR—Fish Migration [7]
- MUN—Municipal and Domestic Supply [7, 8]
- NAV—Navigation [6, 8]
- PROC—Industrial Process Supply [7]
- PWR/POW—Hydropower Generation [7, 8]
- RARE/T&E—Rare, Threatened, or Endangered Species [6, 7, 8]
- REC-1—Water Contact Recreation [6, 7, 8]
- REC-2—Non-Contact Water Recreation [6, 7, 8]
- SPAWN—Fish Spawning [7]
- SPN/SPWN—Spawning, Reproduction, and/or Early Development [6, 8]
- WARM—Warm Freshwater Habitat[8]
- WLD/WILD—Wildlife [6, 7, 8]

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5 Beneficial Uses designated by the Karuk Tribe
6 Beneficial Uses designated by the Resighini Rancheria
7 Beneficial Uses Designated by the Yurok Tribe

2.2.2.4 Karuk Tribe, Resighini Rancheria, and Yurok Tribe, Water Quality Objectives and Criteria

The Karuk and Yurok Tribes have established narrative water quality objectives for temperature, DO and nutrients. Additionally, the Tribes have created narrative objectives for toxicity and pH. The Resighini Rancheria has established narrative water quality criteria for temperature and nutrients, as well as toxicity. These narrative water quality standards are quoted in Table 2.3.

Table 2.3: Karuk Tribe, Resighini Rancheria, and Yurok Tribe narrative objectives and criteria for the Klamath River in California

KARUK	
Objective	**Description**
Temperature	The natural receiving water temperature of intratribal waters shall not be altered unless it can be demonstrated to the satisfaction of the Department of Natural Resources that such alteration in temperature does not adversely affect beneficial uses. At no time or place shall the temperature of any cold freshwater habitat (COLD) water be increased by more than 5 degrees F above natural receiving water temperature.
Dissolved Oxygen	Dissolved Oxygen Concentrations shall not at any time be depressed more than 10 percent from that which occurs naturally.
Nutrients	Biostimulatory Substances: Waters shall not contain biostimulatory substances in concentrations that promote aquatic growths to the extent that such growths cause nuisance or adversely affect beneficial uses.
Toxicity	All waters shall be maintained free of toxic substances in concentrations that are toxic to, or that produce detrimental physiological responses in human, plant, animal or aquatic life. Where appropriate, additional numerical receiving water standards for specific toxicants will be established as sufficient data become available, and source control of toxic substances will be encouraged.
pH	Changes in normal ambient pH levels shall not exceed 0.5 units within the range specified in fresh waters with designated COLD or WARM beneficial uses.
RESIGHINI RANCHERIA	
Objective	**Description**
Temperature	The natural receiving water temperature of intrastate waters shall not be altered unless it can be demonstrated to the satisfaction of the Business Council that such alteration in temperature does not adversely affect beneficial uses. At no time or place shall the temperature of any water be increased by more than 5 degrees F above natural receiving water temperature.
Nutrients	Biostimulatory Substances: Waters shall not contain biostimulatory substances in concentrations that promote aquatic growths to the extent that such growths cause nuisance or adversely affect beneficial uses.
Toxicity	All waters shall be maintained free of toxic substances in concentrations that are toxic to, or that produce detrimental physiological responses in human, plant, animal or aquatic life.
YUROK	
Objective	**Description**
Temperature	The temperature of waters within the Yurok Indian Reservation shall not be increased by human caused activity by more than 5 degrees Fahrenheit above the background level at any time or place. If a background level has not been determined, the temperature upstream of a project impacting the receiving water will be considered the background level.

Table 2.3 (cont.): Karuk Tribe, Resighini Rancheria, and Yurok Tribe narrative objectives and criteria for the Klamath River in California

YUROK (cont.)	
Objective	**Description**
Dissolved Oxygen	Dissolved oxygen concentrations shall not be altered by human caused activities that could cause a barrier to salmonid fish migration or adversely affect the water to support specified beneficial uses.
Nutrients	Ammonia: Levels of ammonia shall not be increased, in any body of water, by human related activity that could cause a nuisance or adversely affect the water to support specified beneficial uses. Biostimulatory Substances: Waters shall not contain biostimulatory substances in concentrations that promote aquatic growths to the extent that such growths cause nuisance or adversely affect beneficial uses. Nitrites: Levels of nitrites shall not be increased, in any body of water, by human related activity that could cause a nuisance, or adversely affect the water to support specified beneficial uses. Phosphates: Levels of phosphorous in any water body shall not be increased by human related activity above the levels that could cause a nuisance, or adversely affect the water to support specified beneficial uses.
Toxicity	All waters shall be maintained free of toxic substances in concentrations that are toxic to, or that produce detrimental physiological responses in human, plant, animal, or aquatic life.
pH	Changes related to human caused activities in normal pH levels shall not exceed 0.5 pH units.

Sources: Karuk Tribe of California 2002, Resighini Rancheria Environmental Department 2006, and Yurok Tribe Environmental Program (YTEP) 2004

In addition to the narrative criteria, the Karuk Tribe, Resighini Rancheria, and Yurok Tribe have established numeric criteria for water quality parameters including temperature, DO, nutrients, and other criteria related to nutrients and toxicity as displayed in Table 2.4, Table 2.5, and Table 2.6.

Table 2.4 Karuk Tribe numeric water quality objectives

	Temperature (°C)		**Dissolved Oxygen (mg/L)**		**Hydrogen Ion (pH)**	
	MWAT[1]	**Max**	**Min**	**50% lower limit**[2]	**Max**	**Min**
All Streams	15.5	21	-	-	8.5	7.0
Klamath River	-	-	8.0	10.0	-	-
Other Streams	-	-	7.0	9.0	-	-

Sources: Karuk Tribe of California 2002
[1] MWAT is the maximum 7-day average temperature within a given time period.
[2] 50% lower limits represent the 50 percentile values of the monthly means for a calendar year. 50% or more of the monthly means must be greater than or equal to the lower limit.

Table 2.5 Resighini Rancheria numeric water quality criteria

	Dissolved Oxygen (mg/L)	Hydrogen Ion (pH)		*Microcystis aeruginosa* and Microcystin			
				Drinking Water		Recreation Water	
	7-DAMin[1]	Max	Min	cells/mL	Microcystin (µg/L)	cells/mL	Microcystin (µg/L)
COLD water column	8.0	-	-	<5000	<1	<50,000	<10
SPAWN intergravel	8.0	8.5	7.0	-		-	
SPAWN water column	11.0	8.5	6.5	-		-	

Source: Resighini Rancheria Environmental Department 2006
[1] 7-DAMin is the minimum 7-day average dissolved oxygen concentration within a given time period.

Table 2.6: Yurok Tribe numeric water quality objectives

	Temperature (°C)		Dissolved Oxygen (mg/L)		Nutrients		Hydrogen Ion (pH)	
	MWAT[1]	Max	Min	50% lower limit[2]	Nitrate (mg/L)	Ammonia (mgN/L)	Max	Min
All Streams	15.5	21.0	7.0	9.0	-	-[3]	8.5	6.5
Domestic/Municipal supply	-	-	-	-	10	-	-	-

Source: Yurok Tribe Environmental Program (YTEP) 2004
[1] MWAT is the maximum 7-day average temperature within a given time period.
[2] 50% lower limits represent the 50 percentile values of the monthly means for a calendar year. 50% or more of the monthly means must be greater than or equal to the lower limit.
[3] Maximum one-hour and 30-day average concentrations linked to pH by a formula. Formula can be found in YTEP 2004.

2.3 Numeric Targets for the Klamath River basin TMDLs

Numeric targets are the numeric water quality conditions that represent attainment of the applicable water quality objectives for a TMDL. In some cases numeric targets can equal a numeric water quality objective. In other cases, numeric targets are a numeric interpretation of the conditions that meet a narrative water quality objective. In all cases numeric targets are used in the calculation of a TMDL. Presented here are the numeric targets applied in the development of these Klamath River TMDLs.

The Regional Water Board considers several factors in selecting the appropriate numeric target values for the selected indicators. The most important factor is to select indicator values that will provide supporting conditions for the most sensitive beneficial uses. Another consideration is ensuring that the target values for the selected indicator(s) are consistent with the desired trophic status of the waterbody, and that the desired trophic status is appropriate for the waterbody. Although trophic classification is a tool to simply characterize the factors that define the productivity of a waterbody, often values defining thresholds between various trophic states (e.g., mesotrophic, eutrophic, or hypereutrophic) are based on ranges. Moreover, systems can be either more or less productive even within a trophic state. Thus, the Regional Water Board considered the following information regarding the trophic status conditions within the Klamath basin in selecting numeric values for selected indicators.

In the case of Upper Klamath Lake (UKL), the transition from a naturally productive condition to its current productivity condition dominated by near-monocultures of *Aphanizomenon* (Eilers et al. 2004) has had profound water quality implications and has resulted in impairment of beneficial uses within the UKL and in downstream waters. As described by Eilers et al. (2004), there have been clear shifts in UKL sediment and nutrient accumulation and species composition in the past 100 years, consistent with large scale land disturbance activities. In addition, this issue has been previously addressed in the technical report from the Upper Klamath Lake TMDL (ODEQ 2002):

> The term eutrophic is often associated with adverse water quality condition (pollution), whereas in reality, a body of water may be both ecologically "healthy" and eutrophic. Historically UKL [Upper Klamath Lake] was a productive (eutrophic) and diverse ecosystem. It is presently a hypereutrophic system that frequently experiences such poor water quality as to be lethal to its native species (Saiki and Monda 1993). Thus statements such as UKL [Upper Klamath Lake] has always been a eutrophic system" should not be used as an excuse for inaction nor construed to mean that the system was polluted or unhealthy. The argument that it is useless to reduce nutrient loading because the lake will still be eutrophic indicates a misunderstanding of trophic level classifications. - Gearheart et al. 1995

Given that UKL is the source water for the Klamath River downstream of UKL, river productivity was also likely to be historically productive with a change to even more productive conditions as UKL began to export massive biomass of blue-green algae. That is, productivity is not fixed and can change based on environmental conditions. Reducing pollutant loading in the upper basin is critical to restoring conditions in the upper Klamath River, currently eutrophic and hypereutrophic, to a range more consistent with pre-disturbance conditions of lower productivity. In addition to the risk co-factor of excessive loading of nutrients and organic matter, another contributing factor (significant risk co-factor – see section 2.4.1) affecting the trophic balance in the Klamath River is the Klamath Hydropower Project (KHP) dams. KHP dams in California have created environmental conditions that have further shifted the trophic status of these portions of the river. The TMDL numeric targets are intended to set restoration goals that are consistent with the formerly supporting trophic status for the reaches now occupied by the reservoirs.

2.3.1 Temperature

The Klamath TMDL water temperature allocations and targets are consistent with water quality standards, which are set to protect all beneficial uses of water. Establishing load allocations and targets based on natural conditions is the best possible means of achieving a balanced indigenous population and fully complies with both state water quality standards and the Clean Water Act's requirement for thermal TMDLs. The protection of all beneficial uses ensures a balanced indigenous population of aquatic life.

The numeric temperature targets are expressed as monthly average temperatures and are calculated from the estimated natural temperature regime of the Klamath River. The approach and assumptions applied in estimating the natural temperatures and calculating the numeric targets at select compliance locations are detailed in Chapter 3. The specific numeric temperature targets for select TMDL compliance locations are presented in Chapter 5.

2.3.2 Dissolved Oxygen and Nutrient-Related

The numeric DO targets are expressed as monthly average and monthly minimum DO concentrations calculated at 85% DO saturation under natural temperatures for most of the river; 90% DO saturation from October through April upstream of the Hoopa-California boundary; and 80% DO saturation during the month of August in the Middle and Upper Estuary. The approach and assumptions applied to estimating the natural temperatures and associated DO concentrations are detailed in Chapter 3. The specific numeric DO targets for select TMDL compliance locations are presented in Chapter 5.

The DO targets are the primary target associated with the nutrient and organic matter TMDLs and associated load allocations. However, additional numeric targets are associated with these TMDLs, and are used to reflect compliance with the narrative biostimulatory substances and toxicity objectives. These additional numeric targets are set for benthic algae biomass, suspended algae chlorophyll-a, *Microcystis aeruginosa* cell density and microsystin concentration. Because the Klamath River alternates between free-flowing reaches and impounded conditions it is necessary to have algal indicators appropriate to both environments: for free-flowing reaches – benthic algal biomass; and for quiescent reaches chlorophyll-a.

2.3.2.1 <u>Benthic Algae Biomass</u>

The benthic algae biomass numeric target is 150 mg chlorophyll-a/m^2. During the summer season, dense mats of attached algae form on the rocky substrate of many reaches of the Klamath River. This vegetative mass is referred to variously in the literature as periphyton, macroalgae, macrophytes, and attached benthic algal biomass. For this assessment we have adopted the term benthic algal biomass. Because of the limited amount of benthic algae data that has been collected in the Klamath River, Regional Water Board staff used various lines of evidence to develop a numeric target for this assessment. The lines of evidence include:

- The California Nutrient Numeric Endpoints (CA NNE) framework (Tetra Tech 2006) sets a benthic algal biomass target for the boundary between Beneficial Use Risk Category II (potentially impaired) and III (presumptively impaired) for streams with a cold-water fishery use (COLD) at 150 mg chlorophyll-a/m^2, interpreted as a maximum biomass in time averaged over a reach (i.e., it does not apply to single point measurements). The CA NNE boundary target is based on a review of both regional and international studies and the recommendation of university and regional experts. The CA NNE also recommends the evaluation of other lines of evidence for each waterbody to ensure the appropriateness of this boundary condition. Because of the natural continuum of conditions from the Klamath headwaters (eutrophic) to its mouth (mesotrophic), the Regional Water Board considered other information for benthic algae biomass target determination. In addition, the analysis of diurnal water chemistry impacts, within reaches of the Klamath River where the benthic algal biomass likely exceeds the proposed target, indicates extreme DO and pH conditions that present stressful conditions to resident fish.

- A recent study sponsored by the U.S. Fish and Wildlife Service -Arcata Office on an assessment of community metabolism and associated kinetic parameters in the Klamath River (Ward and Armstrong 2009 in press) concludes that the Klamath River below Iron Gate dam is mesotrophic. The target of 150 mg chlorophyll-a/m^2, interpreted as a maximum biomass in time averaged over a reach, is consistent with mesotrophic conditions.
- The Regional Water Board and EPA Region IX sponsored a *Nutrient Numeric Endpoint Analysis for the Klamath River, CA* (Appendix 2) in 2008. The study made use of the CA NNE scoping tools (described in Chapter 3) to assess benthic algal biomass targets under both existing conditions and the natural conditions baseline scenarios (described in Chapter 3 and Appendix 7). The scoping tool predicted benthic algal biomass levels very similar to those measured in the field using average current nutrient concentrations and information about other factors (e.g., accrual period). When estimates of natural background nutrient concentrations were applied at four locations along the mainstem Klamath River below Iron Gate Dam, the scoping tool estimated reach-averaged maximum benthic algal biomass densities of 109 to 157 mg chlorophyll-a/m^2, with a mean across the four stations of 141 mg chlorophyll-a/m^2.
- The Hoopa Valley Tribe Basin Plan includes a criterion of 150 mg chlorophyll-a/m^2 for the reach of the Klamath River within the Hoopa Valley Indian Reservation.

Based on these considerations, a benthic algal biomass numeric target of 150 mg chlorophyll-a/m^2 is set for this TMDL. This is a growing season (June – September) reach-average benthic algal biomass target.

The reach average is for the summer growing season and should be measured at a minimum of three points during the growing season (e.g., June, August, September) using the protocols described in: *Standard Operating Procedures for Collecting Stream Algae Samples and Associated Physical Habitat and Chemical Data for Ambient Bioassessments in California* (Fetscher et al. 2009). Sampling locations should be in close proximity to TMDL compliance points.

2.3.2.2 Suspended Algae Chlorophyll-a, *Microcystis aeruginosa*, and Microcystin Toxin

In addition to the benthic algae biomass target, the following nutrient-related numeric targets are set for the Klamath River TMDLs:

- Suspended algae chlorophyll-a = 10 μg/L (as a growing season mean -May to October)
- *Microcystis aeruginosa* cell density = 20,000 cells/mL; and
- Microcystin = 4 μg/L.

Monitoring requirements to assess these targets for each reservoir with recreational uses are: a minimum of one sample per month at each of 3 near shore reservoir entry areas and 1 open water reservoir sample, collected in accordance with *Standard Operating Procedures, Environmental Sampling of Cyanobacteria for Cell Enumeration, Identification and Toxin Analysis* (June 2099) or other protocol as approved by the Regional Water Board. Interpretation of monitoring data for these targets will conform to World Health Organization guidance for low probability of adverse health effects, from the *Guidelines for Safe Recreational Water Environments* (Table 8.3), or superseding guidance. (WHO guidelines are also summarized in *Cyanobacteria in California Recreational Water Bodies*, *Blue-Green Algae Work Group of the State Water Resources Control Board, Department of Public Health, and Office of Environmental Health and Hazard Assessment* (Sept 2008).

The selection of each of these targets is discussed below.

As an indicator for the Klamath River reservoirs, chlorophyll-a is a surrogate measure of suspended algal (phytoplankton) biomass. Chlorophyll-a is a response variable to both water quality stressors (e.g., nutrients) and to impoundment conditions. High levels of suspended algae (chlorophyll-a) indicate an aquatic ecosystem subject to biostimulatory effects due to physical conditions and/or high concentrations of nutrients. Consistently high or episodic chlorophyll-a concentrations indicate the potential occurrence of algal blooms, which can be harmful to aquatic organisms (Welch and Jacoby 2004) and negatively impact several beneficial uses. Prolonged conditions of high levels of chlorophyll-a are typical of eutrophic to hyper-eutrophic water bodies.

Water quality impacts associated with high chlorophyll-a concentrations in the Klamath River reservoirs include:

- Extreme diurnal variation in DO and pH;
- Low DO conditions due to the decay of organic matter resulting from algal blooms;
- Aesthetic impacts, both visual and aroma (olfactory), due to nuisance algal blooms; and
- Increasing likelihood of dominance of toxigenic blue-green algal species at higher concentrations of chlorophyll-a.

The CA NNE framework sets a suspended algae growing season mean chlorophyll-a target of 10 μg/L as the boundary between Beneficial Use Risk Category II (potentially impaired) and Beneficial Use Risk Category III (presumptively impaired) for support of the COLD beneficial use (Tetra Tech 2006). This concentration target was selected in part due to the rapidly increasing likelihood of nuisance algal blooms when chlorophyll-a concentrations are above this concentration (Walker 1985). In addition, as chlorophyll-a levels increase above 10 µg/L, blue-green algal species tend to begin to dominate the algal species assemblage (Downing et al. 2001). That is, the likelihood of blue-green algal biomass dominance rapidly increases as chlorophyll-a concentrations move above the target threshold. With blue-green algal dominance there is an increased probability of algal toxin production under elevated biomass of various toxicogenic blue-green algae, creating a potential public risk hazard for people, livestock, and wildlife.

The chlorophyll-*a* target is primarily for the reservoir environments but also applies to quiescent waters (backwater eddies and the estuary) of the Klamath River. For reasons stated above (increased likelihood of nuisance blooms and associated toxin production), a value of 10 µg/L of chlorophyll-a provides an appropriate target for the quiescent waters of the Klamath River. Under background free-flowing conditions the target value of 10 µg/L of chlorophyll-a would be inappropriately high and unnecessary. However the presence of the reservoirs requires the development of this numeric target due to its effect on increasing suspended algal concentrations. The river upstream rarely exceeds 10 µg/L of chlorophyll- a, despite the currently eutrophic condition of the system. Monitoring data show that mean chlorophyll-a was below 10 µg/L at Shovel Creek above the reservoirs, but above 10 ug/L below the reservoirs at the Hatchery Bridge. This has most recently been illustrated for 2008 in (Table 6 and Figure 6 in Raymond 2009: *Phytoplankton Species and Abundance Observed During 2008 in the vicinity of the Klamath Hydroelectric Project.*) These results are consistent with earlier 2005-2007 data analyzed by Asarian et al (2009); see Figures 2.22, 2.23, and 2.25 below. The reservoirs as controllable factors have created conditions more susceptible to nuisance algal blooms dominated by blue-green algal species.

The CA NNE impairment boundary value of 10 µg/L of chlorophyll-a was developed from studies that included information from a large number of reservoirs from temperate climate locations (Walker 1985). Because a large amount of data has been collected at several stations along the Klamath River including Iron Gate and Copco Reservoirs, it is possible to evaluate the site-specific relationship between high concentrations of chlorophyll-a and blue-green algal dominance (Kann and Corum 2009).

Klamath River monitoring since 2005 has documented elevated levels of the blue-green algae (a.k.a. cyanobacteria) *Microcystis aeruginosa* (MSAE) and the blue-green algae toxin microcystin. Microcystins are a class of toxic chemicals produced by some strains of the blue-green algae *Microcystis aeruginosa.* Microcystins can be found associated with algal cells and are also released into waters when blue-green algal cells die or cell membranes degrade. These chemicals are a human health risk, capable of inducing skin rashes, sore throat, oral blistering, nausea, gastroenteritis, fever, and liver toxicity (World Health Organization [WHO] 2003). Microcystin toxins have also been shown to produce effects on animals including acute livestock poisoning and tumor production in fish guts and liver (de Figueiredo et al. 2004, Lehman et al. 2005, and Xie et al. 2005). Microcystin can thus potentially impair a number of beneficial uses of a waterbody.

The targets for low risk exposure to *Microcystis aeruginosa* and microsystin come from the World Health Organization (WHO) and are 20,000 cells/mL and 4 µg/L respectively (WHO 2003).

When health advisories are issued by agencies concerned that cyanotoxins are present in waterbodies at levels that may pose a health risk, they are often issued based on "guidelines" or "risk levels." These guidelines are derived from analytic thresholds and field observations, and are established by the WHO. The WHO guidelines are largely accepted by nations and territories world-wide (WHO 1999, p. 171-175; WHO 2003, pp. 149-154). The presence of extensive blue-green algal water discolorations and scum accumulations are often used as triggers to assess the relative health risk to humans and other organisms from possible cyanotoxin exposures.

The Regional Water Board has not established numeric water quality objectives for microcystin toxins. However, the Basin Plan narrative objective for toxicity does apply. There are numeric translators for the narrative criteria for both *Microcystis aeruginosa* and microcystin that can be used as the basis for an impairment assessment and to develop numeric targets for the TMDL. The primary source for numeric assessment endpoints comes from the Blue Green Algae Work Group of the State Water Board, Department of Public Health (DPH), and Office of Environmental Health and Hazard Assessment (OEHHA) (Blue Green Algae Work Group), who developed guidance that is described in *Cyanobacteria in California Recreational Water Bodies: Providing Voluntary Guidance about Harmful Algal Blooms, Their Monitoring, and Public Notification* (State Water Board 2008). From this guidance the Regional Water Board has developed the following 303(d) impaired waters listing criteria:

Tissue Listing Criteria:

For the protection of human health from tissue contaminated with microsystin:

- Composite of three or more individual samples with microcystin edible tissue concentration $\geq$ 26 ng/g wet weight (OEHHA 2008)

Water Column Impairment Listing Criteria:

The following values are not the TMDL target values. TMDL target values are set to protect against beneficial use impacts and were therefore set at the level of low probability of health effects. The values below are used to take action (public health posting or listing) when impairment is occurring and represent a moderate level of health effects. From grab sample or fixed station trend monitoring sites, three or more samples that exceed any of the following numeric listing criteria for the protection of human health and aquatic life:

- Microsystin concentrations ≥ 8 µg/L
- *Microcystis aeruginosa* cell densities ≥ 40,000 cells/mL
- **Or** if a waterbody is posted based on photographic documentation of surface scums containing *Microcystis aeruginosa*. The photographic record must be compiled as part of a monitoring program that has an approved Quality Assurance Program and staff that have been trained in recognizing *Microcystis aeruginosa* scums, as per the posting guidelines established by the Blue Green Algae Work Group (State Water Board 2008).

The data illustrated in Figures 2.1 through 2.6 were collected by the Yurok Environmental Program, Karuk Tribe of California, and PacifiCorp in 2005, 2006, and 2007 (Kann and Corum 2009). The relationships depicted in the figures use chlorophyll-a, which indicates total algal biomass, as a means of assessing potential health effects. Using chlorophyll-a as a public health guidance value for toxic cyanobacteria is common throughout the world and in the literature. For example, the World Health Organization (WHO) uses chlorophyll-a to assess the probability of health effects; and indicates that chlorophyll-a values of 10 µg/L or greater are associated with a moderate probability of acute health effects (Graham et al. 2009). Similarly, Lindon and Heiskary (2009) combined microcystin and chlorophyll-a classes to provide a basis for describing the risk of encountering microcystin as a function of bloom intensity (chlorophyll-a). Bingham et al. (2009) reported on a survey of toxic algal [microcystin] distribution in Florida lakes. This study also provides an analysis of the probability that microcystin concentrations will exceed WHO guidance values as a function of chlorophyll, and conclude that as chlorophyll increases the probability of encountering elevated microcystin concentrations increases. Thus, chlorophyll-a provides a reasonable and robust variable to estimate the potential risk of encountering microcystin or *Microcystis* levels that pose a risk with respect to public health. The relationships depicted in the figures are consistent with these results, and show that when chlorophyll-a is elevated in the Copco/Iron Gate systems during the months presented, the probability for chlorophyll-a to be comprised of *Microcystis* increases.

The relationship illustrated in Figure 2.1 indicates that as chlorophyll-a concentrations reach 10 µg/L and above, there is a sharp increase in *Microcystis aeruginosa* cell density above 20,000 cells/mL. That is, within the Klamath River and Iron Gate and Copco Reservoirs the dominance of toxigenic blue-green algal species rapidly increases above the CA NNE target of 10 µg/L. Figure 2.2, which uses the same data as 2.1, demonstrates that the same relationship exists between chlorophyll-a and microcystin. As chlorophyll-a concentrations exceed 10 µg/L concentrations of microcystin rapidly increase above 4 µg/L. Taken together these relationships provide site-specific support for the use of the CA NNE impairment boundary target of 10 µg/L of chlorophyll-a.

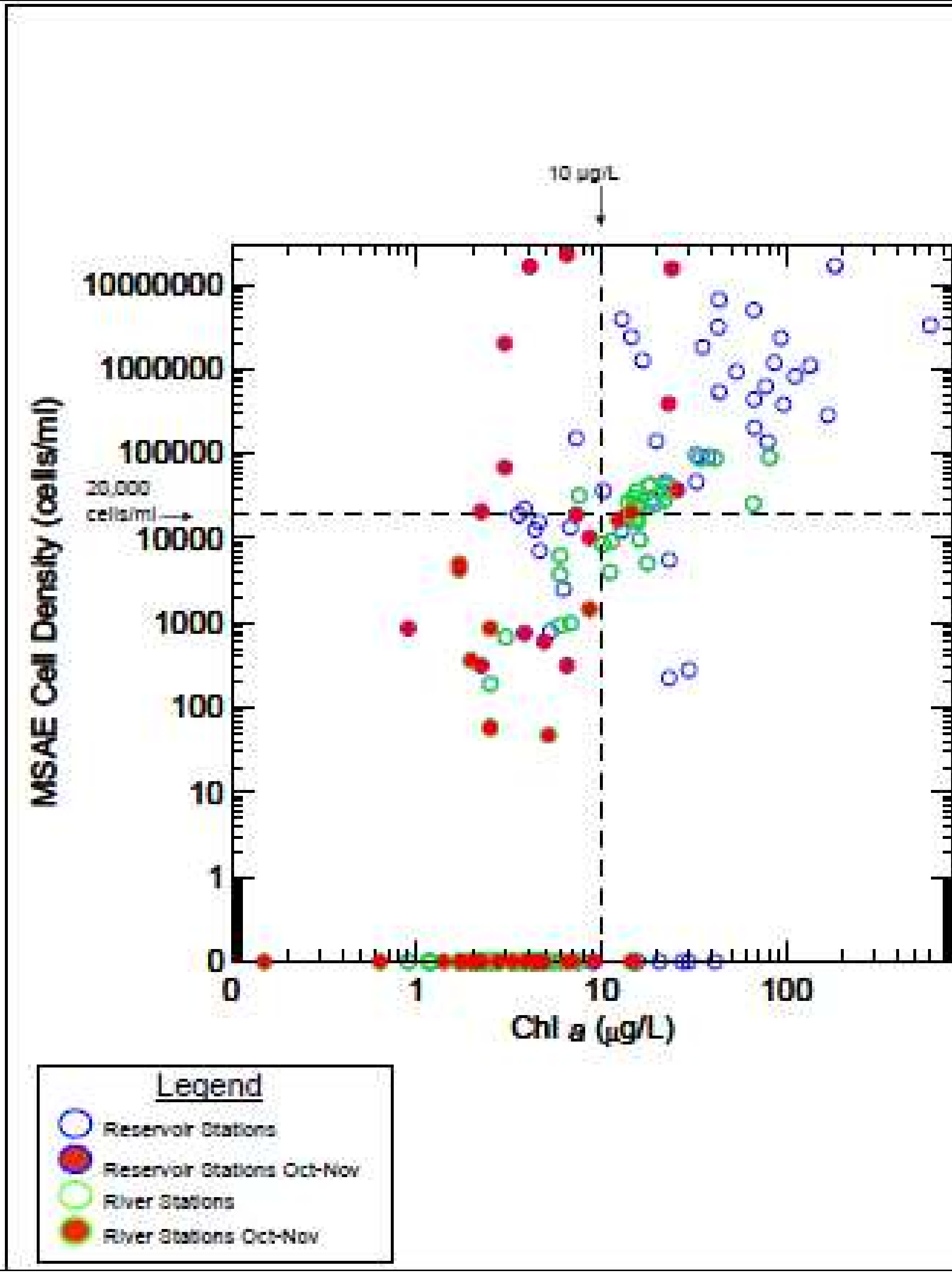

Figure 2.1: Relationship of chlorophyll-a and *Microcystis aeruginosa* (MSAE) cell density at monitoring stations along the Klamath River (2005-2007) from above Copco Reservoir to Orleans.
Source: Kann and Corum 2009

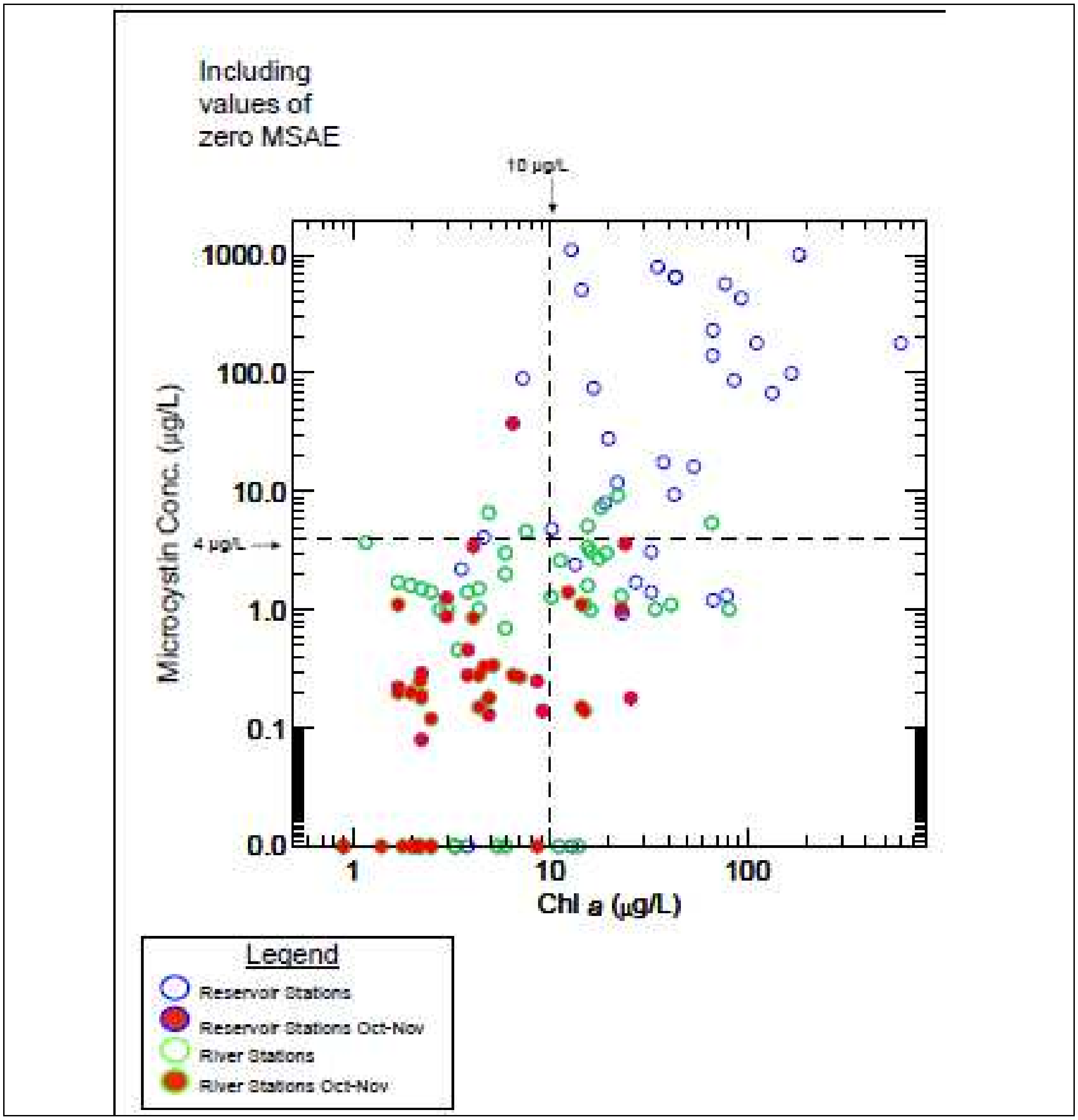

Figure 2.2: Relationship of chlorophyll-a and microcystin at monitoring stations along the Klamath River (2005-2007) from above Copco Reservoir to Orleans.
Source: Kann and Corum 2009

The probability of exceeding three critical *Microcystis aeruginosa* cell density levels at the chlorophyll-a target of 10 µg/L can be computed from nonparametric cross-tabulation probability models developed for Iron Gate and Copco Reservoirs (Kann and Corum 2009 – the computational methodology is explained in Kann and Smith 1999). The probability plots from this analysis are illustrated in Figure 2.3 using *Microcystis aeruginosa* cell density critical values of 20,000 cells/mL (red), 40,000 cells/mL (blue), and 100,000 cells/mL (green). The probability of *Microcystis aeruginosa* cell density exceeding 20,000 cells/mL (red), 40,000 cells/mL (blue), and 100,000 cells/mL (green) at a chlorophyll-a concentration of 10 µg/L (dashed line) are approximately 32%, 13%, and 10% respectively. The exceedance probabilities for the critical values increases rapidly above 10 µg/L. For Iron Gate and Copco Reservoirs the chlorophyll-a target of 10 µg/L is a reasonable threshold to protect against conditions predisposing growth of unacceptable *Microcystis aeruginosa* cell densities.

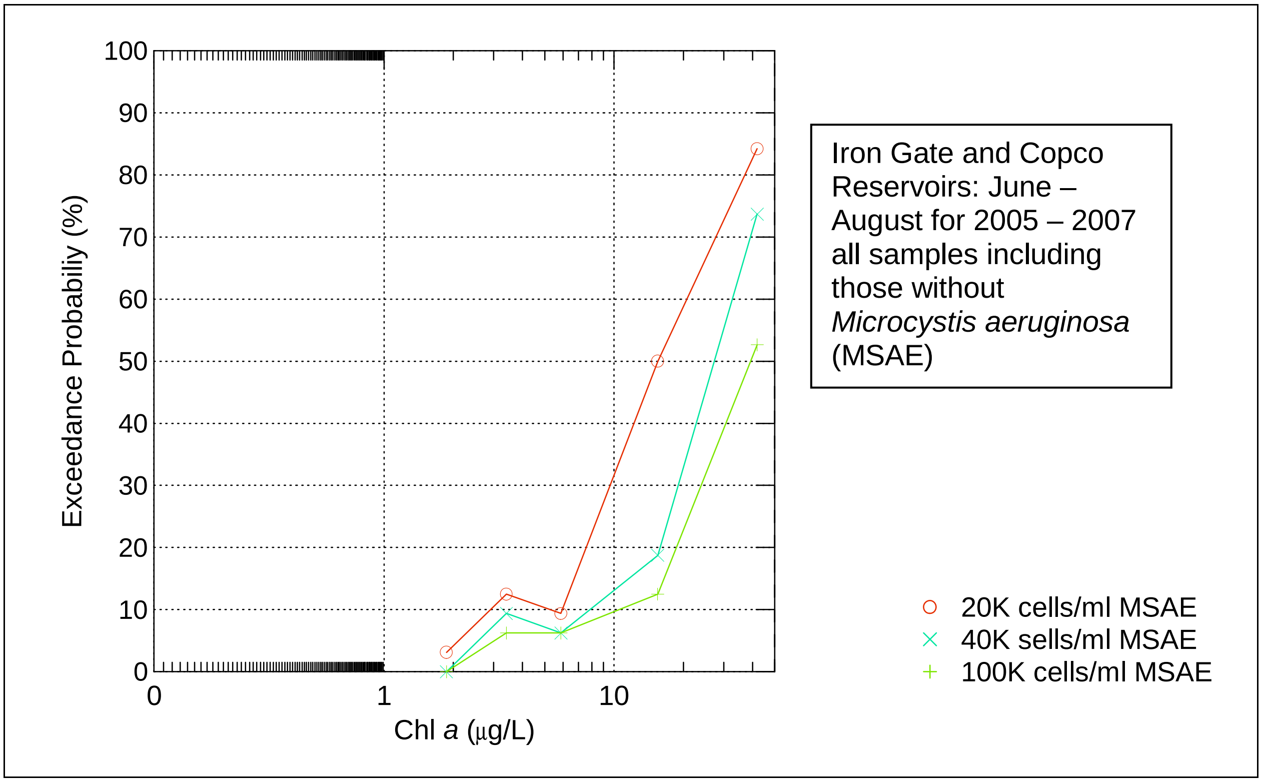

Figure 2.3: *Microcystis aeruginosa* (MSAE) cell density exceedance probability plotted as a function of chlorophyll-a concentration (10 µg/L) for Iron Gate and Copco Reservoirs using data collected by the Karuk Tribe of California for the years 2005, 2006, and 2007 during peak growing season (June – August). The probability plot includes all samples, including those with no *Microcystis aeruginosa* present.
Note: 20K = 20,000, 40K = 40,000, and 100K = 100,000
Source: Kann and Corum 2009

The same plots can be generated for the growing season (June – September) relationship between surface and/or 1 m chlorophyll-a and microcystin for Iron Gate and Copco Reservoirs for the period 2005-2007 with data collected by the Karuk Tribe of California Natural Resources Department. The probability plots from this analysis are illustrated in Figure 2.4 using microcystin concentrations critical values of 4 µg/L (red), 8 µg/L (blue), and 20 µg/L (green). The probabilities of microcystin concentrations exceeding the critical values of 4 µg/L (red), 8 µg/L (blue), and 20 µg/L (green) at a chlorophyll-a concentration of 10 µg/L (dashed line) are approximately 24%, 15%, and 10% respectively. The exceedance probabilities for the critical values increase rapidly above 10 µg/L. For Iron Gate and Copco Reservoirs the chlorophyll-a target of 10 µg/L is a reasonable threshold to protect against conditions with unacceptable microcystin concentrations.

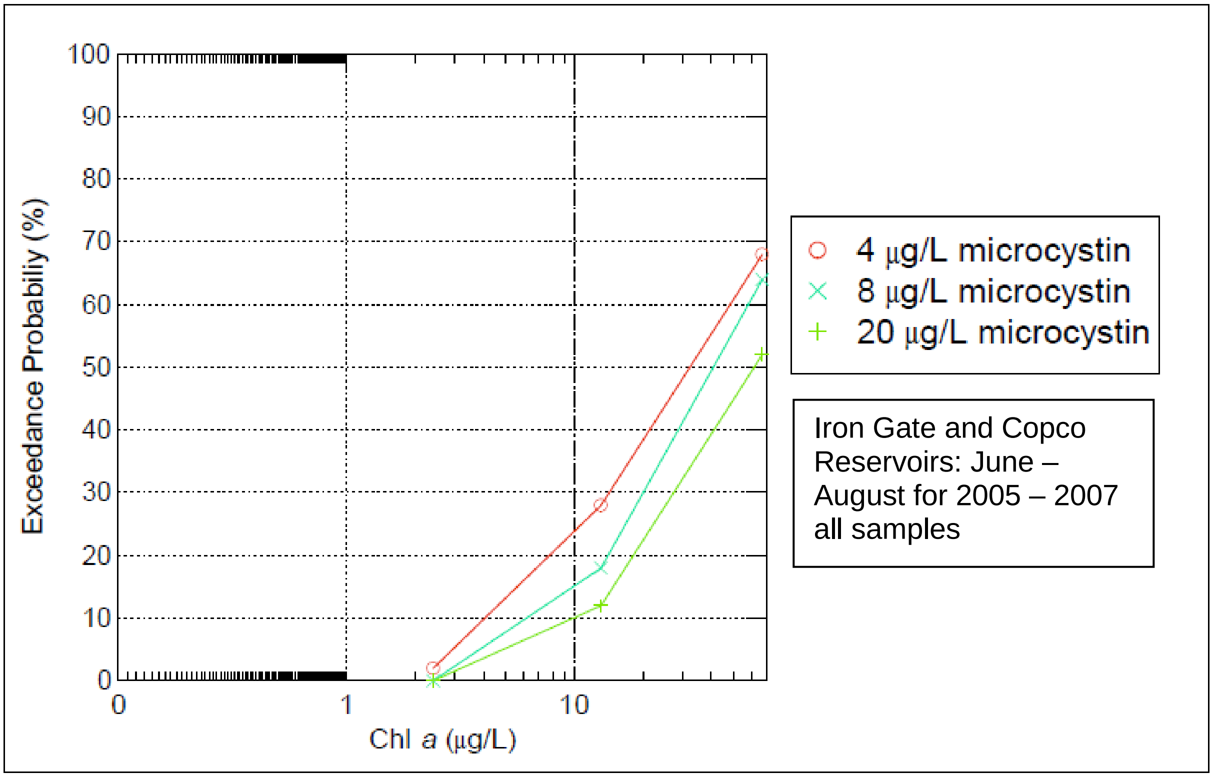

Figure 2.4: Probability of exceeding various WHO public health *Microcystis aeruginosa* (MSAE) cell density levels at varying Chl-a concentration (a), and probability of exceeding various WHO public health microcystin toxin levels at varying Chl-a concentration (b) in Copco and Iron Gate Reservoirs and the Klamath River, 2005-2007. Exceedance probability is computed using nonparametric cross-tabulation method described in Kann and Smith (1999).
Source: Kann and Corum 2009

Figure 2.5 illustrates *Microcystis aeruginosa* cell density during 2006-2007 for all stations from upper Copco through the lower estuary on the X axis with their associated microcystin concentrations on the Y axis. The measurements in the upper right hand quadrant in the chart are those measurements where cell count exceeds 20,000 cells/mL and the microcystin concentration exceeds 4 µg/L of microcystin. In regards to the relationship being evaluated, measurements in this quadrant of the graph are often referred to as true positives. The lower right hand quadrant includes those measurements that would be labeled false positives. For false positives microcystin concentrations are expected to be higher than the threshold criteria of 4 µg/L because they are associated with observed *Microcystis aeruginosa* cell densities above the threshold criteria of 20,000 cells/mL. False positives (samples in the lower right hand quadrant) with concentrations below 4 µg/L **do not** represent a risk to public health.

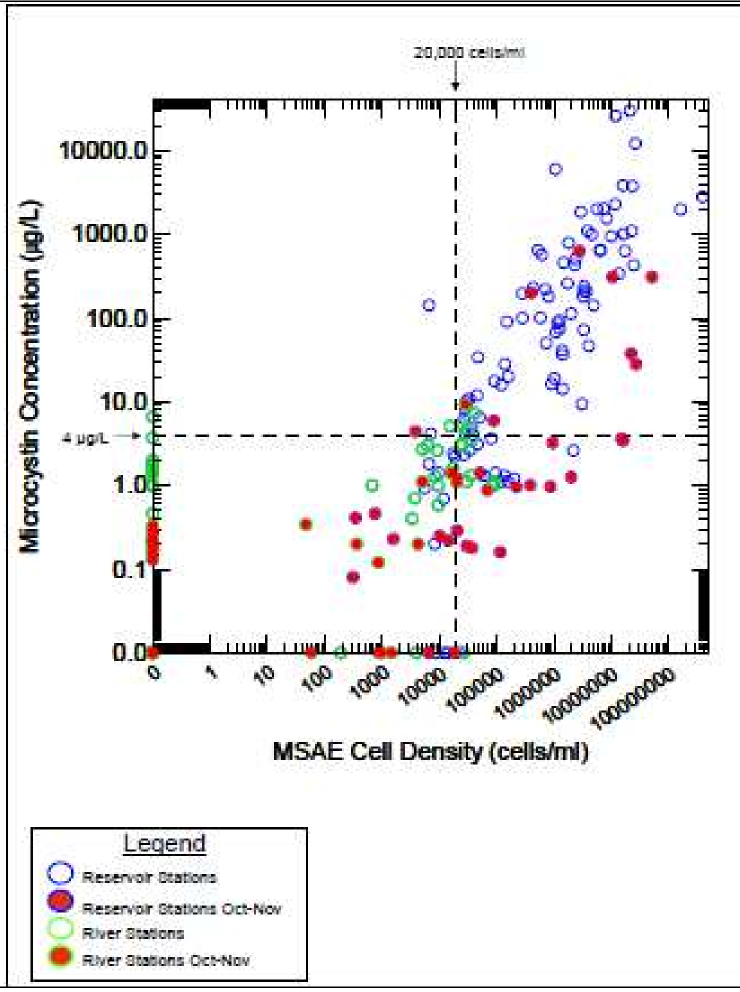

Figure 2.5: Relationship of *Microcystis aeruginosa* (MSAE) cell density and microcystin concentrations for stations along the Klamath River from above Copco Reservoir to the lower Klamath River estuary for the years 2006 and 2007 (Kann and Corum 2009). Data from Yurok Environmental Program, Karuk Natural Resources, and PacifiCorp.
Source: Kann and Corum 2009

The lower left hand quadrant represents the true negative results. That is, the true negative observations in the lower left quadrant have *Microcystis aeruginosa* cell densities less than 20,000 cells/mL and microcystin concentrations less than 4 µg/L. Measurements in the upper left hand quadrant are the false negative measurements. This is the quadrant that would represent the risk to public health with adoption of a numeric target of 4 µg/L of microcystin and a cell density of 20,000 cells/mL of *Microcystis aeruginosa.* False negative observations have concentrations of microcystin that exceed the threshold criteria of 4 µg/L, which is higher than would expected with a *Microcystis aeruginosa* cell density of less than 20,000 cells/mL. Because 4 µg/L of microcystin represents a WHO low effects level and given the few number of measurements in the false negative quadrant, the proposed numeric target represents a reasonable level of protection. The high level of correlation between cell count and microcystin concentration makes it possible to calculate the percent probability that a desired level of microcystin concentration will be exceeded at a particular cell density.

The probability of exceeding three critical level microcystin concentrations at a *Microcystis aeruginosa* cell density level of 20,000 cells/mL can be computed from nonparametric cross-tabulation probability models developed for Iron Gate and Copco Reservoirs (Kann and Corum 2009). The probability plots from this analysis are illustrated in Figure 2.6 using microcystin concentrations of 4, 8, and 20 µg/L as critical values. These concentrations represent WHO health effects levels of low, moderate, and high respectively. The probability of microcystin exceeding the critical values of 4 µg/L (red), 8 µg/L (light blue), and 20 µg/L (green) at a *Microcystis aeruginosa* cell density of 20,000 cells/mL (dashed line) are approximately 47%, 8%, and 0% respectively. Therefore at a cell density target of 20,000 cells/mL there is less than a 50% probability that microcystin concentrations will exceed the low health effects threshold of 4 µg/L.

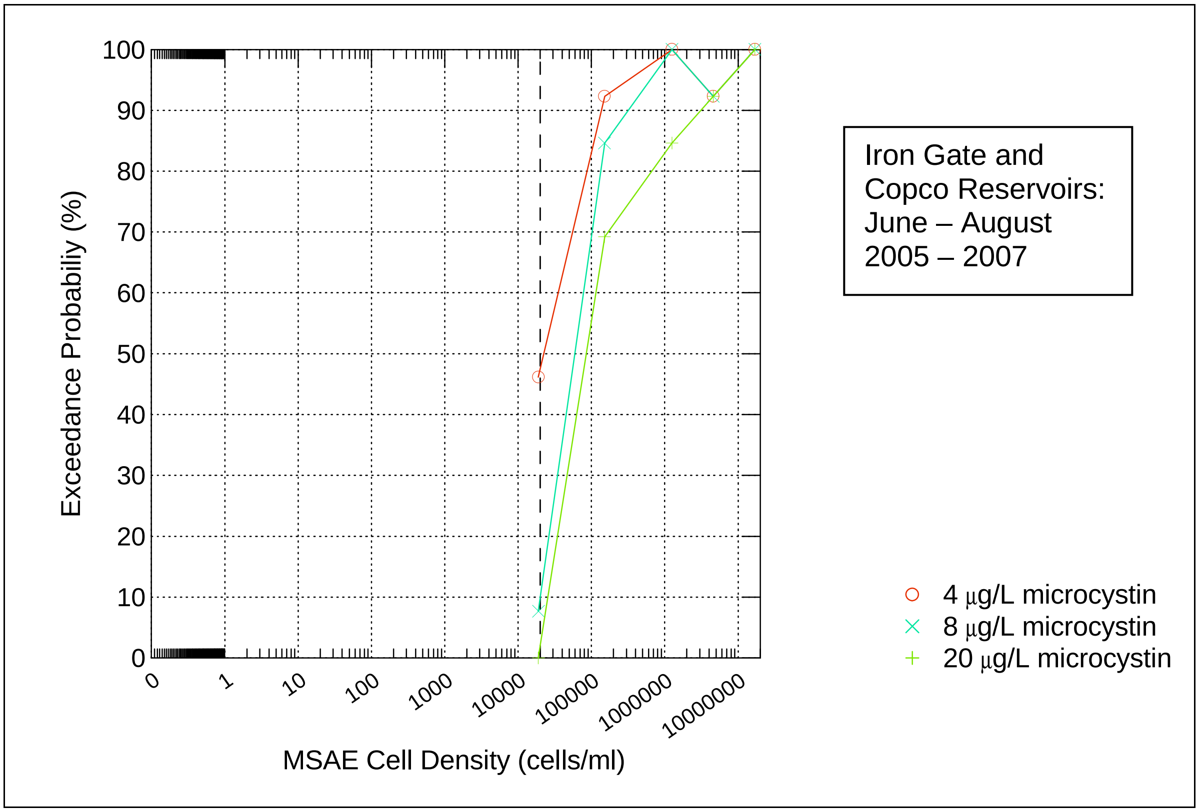

Figure 2.6: Microcystin exceedance probability plotted as a function of *Microcystis aeruginosa* cell density for Iron Gate and Copco Reservoirs using data collected by the Karuk Tribe of California Natural Resources Department and PacifiCorp for the years 2005, 2006, and 2007 during peak growing season (June – August).
Source: Kann and Corum 2009

In addition to these numeric water quality targets, monitoring targets are also identified and included in the Monitoring Plan (Chapter 7) and in Chapter 5.

The probability plots provided in Figures 2.3, 2.4, and 2.6 illustrate an increase in response variable probabilities at the recommended numeric target concentration and cell density for chlorophyll-a concentrations and Microcystis *aeruginosa* respectively. However, the probability models show exceedances of guideline levels below either the

TMDL targets or the State Water Board (2008) guidance on cyanobacteria in public recreational waters for public health. However, as noted by Kann and Corum (2009), this is because the plotted probabilities represent an interval around the median of the independent variable and thus includes values above and below any chosen value.

The probability plots are a good tool for illustrating the relationship between the independent variables (i.e., chlorophyll-a concentrations and Microcystis *aeruginosa* cell densities) and the dependent variable (microcystin concentration). However the plots require an averaging algorithm that limits an evaluation of the probability of exceedance at a specific threshold. It is possible to calculate the exceedance probability at a specific level for the independent variables. The exceedance probability for the microcystin thresholds for several specific values of the independent variables are presented in Table 2.7. The point specific evaluation demonstrates that when chlorophyll-a was less than 10 µg/L that the exceedance frequencies of the public health thresholds for *Microcystis aeruginosa* density or microcystin concentration were less than 10%.

Table 2.7: Percent exceedance for MSAE cell densities and microcystin toxin concentrations at threshold chlorophyll-a of 10 µg/L, and percent exceedance for microcystin toxin concentrations at threshold MSAE cell density of 20,000 cells/ml; Klamath River, California 2005-2007.

	MSAE cell density percent exceedance for Chl<10 µg/L			**MSAE cell density percent exceedance for Chl≥10 µg/L**		
	20,000 cells/ml	**40,000 cells/ml**	**100,000 cells/ml**	**20,000 cells/ml**	**40,000 cells/ml**	**100,000 cells/ml**
all stations all months	8.2	5.2	4.1	69.6	49.3	34.8
reservoirs only; Jun-Aug	7.1	7.1	7.1	66.7	59.3	55.6
	Microcystin conc. percent exceedance for Chl<10 µg/L			**Microcystin conc. percent exceedance for Chl≥10 µg/L**		
	4 µg/L	**8 µg/L**	**20 µg/L**	**4 µg/L**	**8 µg/L**	**20 µg/L**
all stations all months	7.4	2.9	2.9	47.4	40.4	29.8
reservoirs only; Jun-Aug	insufficient sample size			89.5	84.2	68.4
	Microcystin conc. percent exceedance for MSAE<20,000 cells/ml			**Microcystin conc. percent exceedance for MSAE≥20,000 cells/ml**		
	4 µg/L	**8 µg/L**	**20 µg/L**	**4 µg/L**	**8 µg/L**	**20 µg/L**
all stations; Jun-Sep	7.6	1.3	1.3	78.5	70.1	58.9
all stations; Jun-Aug	10.4	0.0	0.0	88.6	75.7	65.7
reservoirs only; Jun-Sep	14.3	7.1	7.1	86.7	81.1	70.0
reservoirs only; Jun-Aug	14.3	0.0	0.0	94.9	86.4	78.0
	Microcystin conc. percent exceedance for MSAE<40,000 cells/ml			**Microcystin conc. percent exceedance for MSAE≥40,000 cells/ml**		
	4 µg/L	**8 µg/L**	**20 µg/L**	**4 µg/L**	**8 µg/L**	**20 µg/L**
reservoirs only; Jun-Sep	37.5	16.7	4.2	88.8	87.5	78.8
reservoirs only; Jun-Aug	46.2	7.7	0.0	96.2	94.3	86.8

Source: Kann and Courm 2009

Likewise, when *Microcystis aeruginosa* cell density was less than 20,000 cells/ml, maximum exceedance frequencies were 14.3% and 7,1% for 4 µg/L and 8 µg/L microcystin. Frequency of exceedance for 8 µg/L microcystin when MSAE cell density was below 40,000 cells per ml was 16.7% (June-September) and 7.7% June-August (Table 2.7). The higher frequency for the computation period that includes September may be due to a tendency towards increased aqueous versus cell-bound toxin during the fall months.

The threshold analysis presented in Table 2.7 supports the numeric targets proposed by the Regional Water Board for chlorophyll-a (10 μg/L), *Microcystis aeruginosa* cell density (20,000 cells / mL), and microcystin (4 μg/L).

2.4 Water Quality Conceptual Models Overview

There are numerous overlapping physical, chemical, and biological factors that are currently contributing to impairment of water quality standards in the Klamath River. The purpose of this section is to describe these factors and discuss how they are contributing to impairment.

The challenge associated with the Klamath River TMDL problem statement is to develop a clear roadmap between the TMDL listing parameters of nutrients, temperature, and DO and their impacts on beneficial uses. There are several issues that must be addressed as part of this challenge. Nutrients and temperature often interact together and with other watershed factors to influence processes within the aquatic ecosystem that then impact ecological elements associated with Klamath River beneficial uses. With multiple factors impacting multiple ecosystem components, impacts on beneficial uses can be cumulative and involve effects from several different pathways. The Klamath River problem statement is based on a process that clearly identifies and evaluates impacts on beneficial uses from multiple concurrent stressors.

This process evaluates the likelihood that adverse ecological impacts may occur in response to one or more stressors by identifying (1) the pathways by which stressors cause ecological effects and (2) informative and representative assessment endpoints. Assessment endpoints are the link between scientifically measurable endpoints and the objectives of stakeholders and resource managers (Suter 1993). Endpoints should be ecologically relevant, related to environmental management objectives, and susceptible to stressors (USEPA 1998). For the Klamath River problem statement evaluation, nutrients and temperature are the primary stressors and separate conceptual models have been developed for each. Assessment endpoints in the conceptual models are comprised of A – Driver/Stressor, B – Environmental Conditions, D – Response/Outcome, and E – Beneficial Use (BU) Impairment. There are a total of thirty-nine assessment endpoints included in the Klamath River nutrient conceptual model, and thirty-five assessment endpoints in the temperature conceptual model. The Klamath River problem statement evaluation includes DO as a secondary indicator in the pathway analysis. The management objective for the Klamath River conceptual models is to assess conditions that are contributing to the impairment of beneficial uses designated to the Klamath River in the Basin Plan.

A conceptual model is a graphical and narrative description of the physical, chemical and biological stressors within a system, their sources, and the pathways by which they are likely to impact multiple ecological resources (Suter 1999) and contribute to beneficial use impairment. The conceptual model is important because it links exposure characteristics such as water quality conditions with the ecological endpoints important for describing the beneficial uses.

Conceptual models consist of two general components (USEPA 1998): (1) a description of the hypothesized pathways between human activities (sources of stressors), stressors, and assessment endpoints; and (2) a diagram that illustrates the relationships between human activities, stressors, and direct and indirect ecological effects on assessment endpoints. The conceptual model consolidates available information on ecological resources, stressors, and effects, and describes, in narrative and graphical form, relationships among human activities, stressors, and the effects on valued ecological resources (Suter 1999). A conceptual model provides a visual representation for the cases where multiple stressors contribute to water quality problems. With the conceptual model, some attribute or related surrogate (termed an "indicator" in both the watershed approach [USEPA 1995] and the TMDL program) provides a measurable quantity that can be used to evaluate the relationship between pollutant sources and their impact on water quality (USEPA 1999a).

2.4.1 Klamath River Nutrient and Temperature Conceptual Models

Figure 2.7 and Figure 2.8 present the nutrient and temperature conceptual models developed for the Klamath River TMDL problem statement. The components of the Klamath River nutrient and temperature conceptual models are described below.

- Driver/Stressor (A) – The primary risk element being evaluated (nutrients and temperature). There is one element, increased nutrient loading, included in this category for the nutrient conceptual model, and five elements in this category for the temperature conceptual model.

- Environmental Conditions (B) – Water quality processes directly impacted by the stressor. These conceptual model “elements” are linked to response/outcome ecosystem elements (e.g., fish populations) that are more directly linked to aspects of the beneficial use. Environmental Condition elements are secondary indicators, providing an intermediate measure (prior to primary impact) of beneficial use condition. There are 12 elements in this category for both the nutrient and the temperature conceptual models respectively.

- Risk Cofactors (C) – In the nutrient conceptual model, these are related conditions or stressors that affect how nutrients are processed in the ecosystem. The nutrient risk cofactors listed in category C can magnify or mitigate the negative impacts linked to nutrients as biostimulatory substances. In the temperature conceptual model, the risk cofactors are processes or factors which are affected by the environmental conditions (category B) caused by an altered

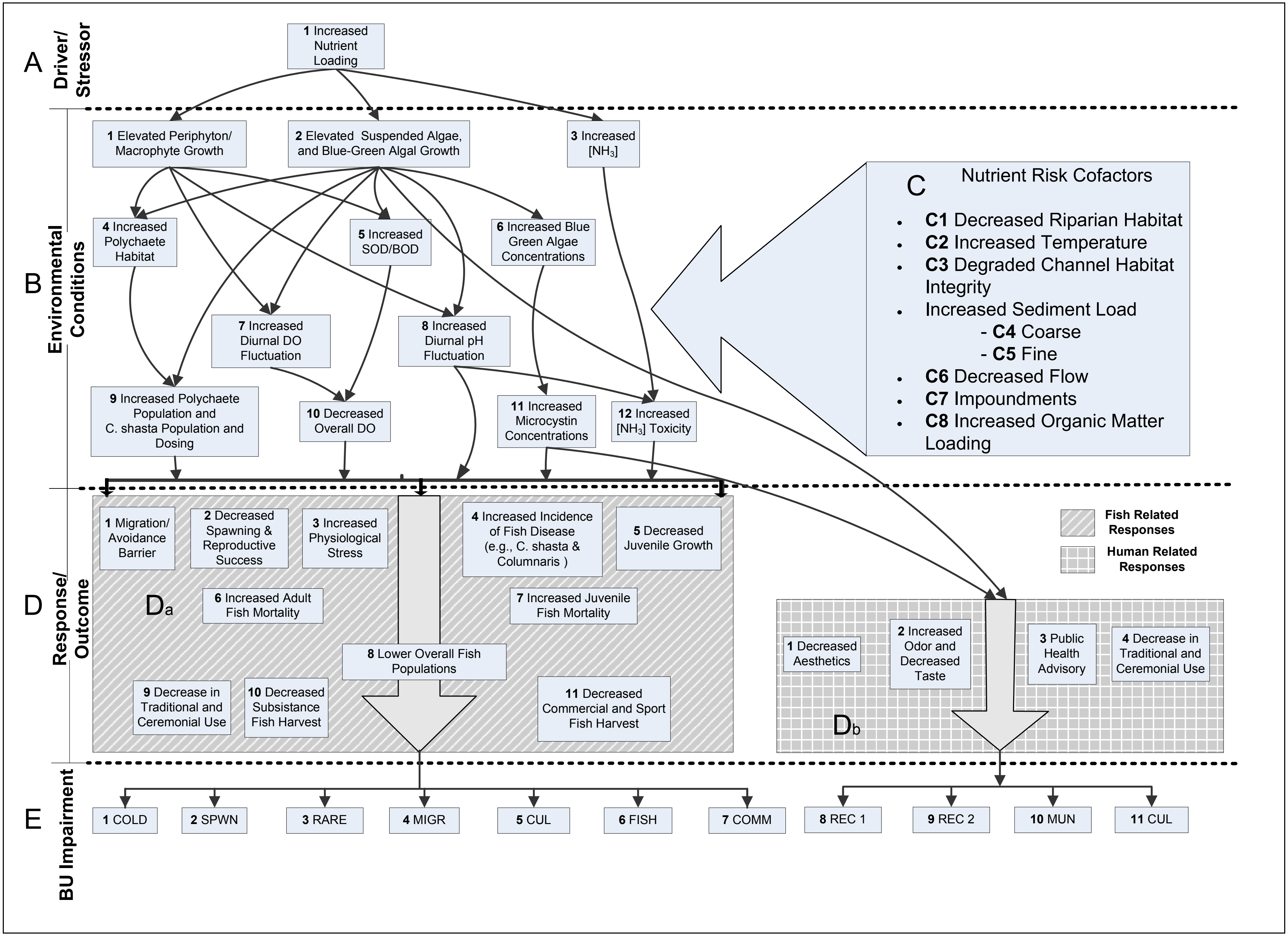

Figure 2.7: Nutrient conceptual model for the Klamath River in California

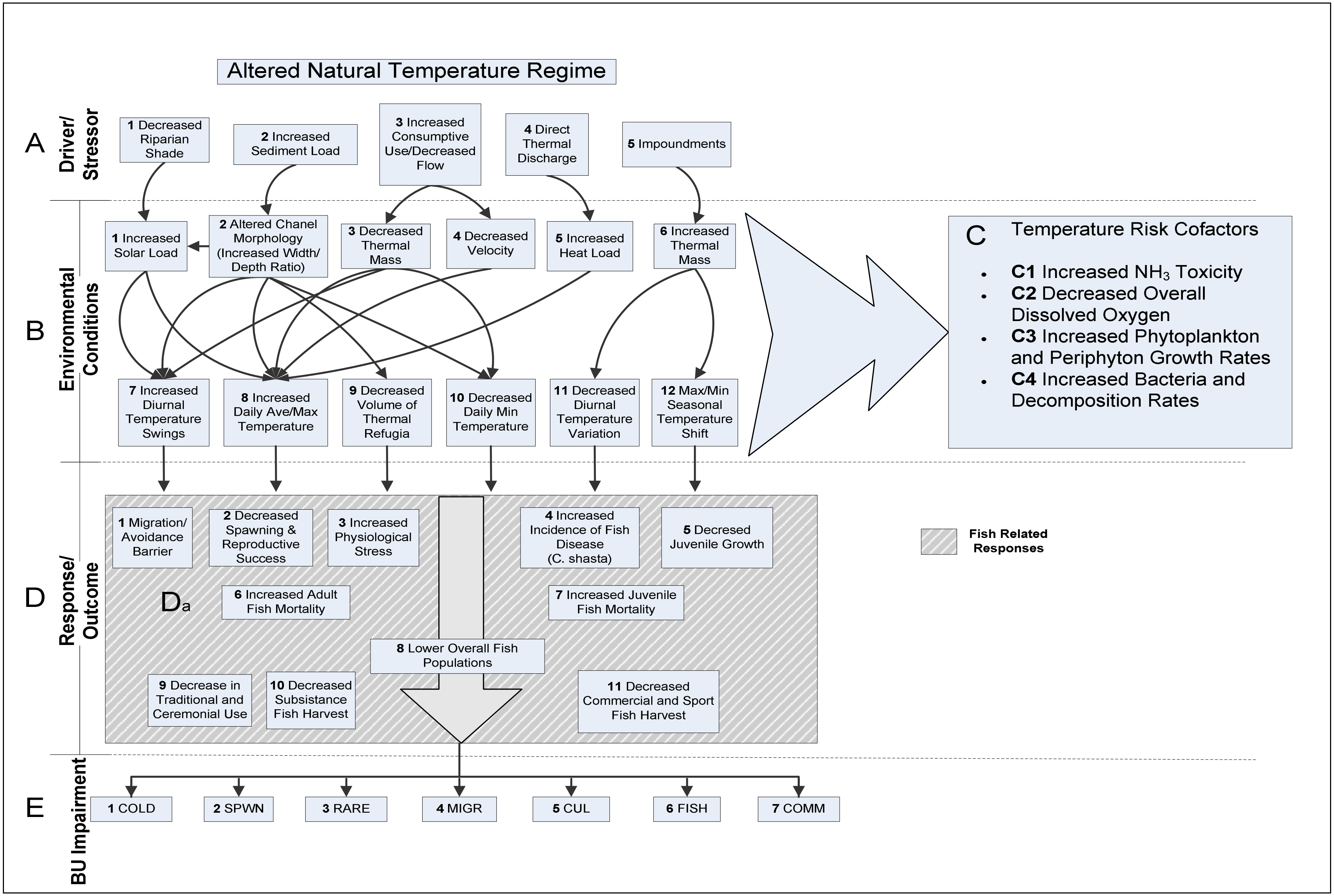

Figure 2.8: Temperature conceptual model for the Klamath River in California

natural temperature regime. There are eight nutrient risk cofactors and four temperature risk cofactors identified.

- Response/Outcome Fish and Aquatic Life (D_a) – The elements included in Category D_a involve some measure of the health of the Klamath River cold water fish populations and associated impacts to Native American culture and commercial and sport fishing. Other forms of aquatic life could be included in this category, but the cold water fish are considered most sensitive to water quality conditions resulting from increased nutrient loading and altered temperature regimes. There are 11 elements in this category for both the nutrient conceptual model and temperature conceptual models.

- Response/Outcome - Human Health and Aesthetics (D_b) – Beneficial uses linked to the human related assessment endpoints are included in category D_b. Risk related to close human contact or conditions that prohibit contact are potentially impacting long standing ceremonial practices of Tribes along the Klamath River and disruption of recreational activities. There are four assessment endpoints for this category.

- Beneficial Use Impairment (E) – Category E includes the beneficial uses that the Regional Water Board has determined to be impacted by water quality conditions in the Klamath River basin, and whose restoration will be the primary focus of the TMDL implementation plan. There are 11 beneficial uses identified as impacted in the nutrient model and seven beneficial uses identified in the temperature conceptual model.

It is not the purpose of the conceptual models developed for the Klamath River TMDL to provide a comprehensive description of all ecosystem elements and pathways. Rather the focus is on identifying assessment endpoints that either should be managed or measured as indicators of water quality condition for attaining and maintaining water quality standards in the Klamath River. The following sections describe the assessment endpoints and the linkages between the assessment endpoints that contribute to impairment of water quality standards in the Klamath River.

In the following sections, components of the nutrient conceptual model will be referenced with the letter "N", and components of the temperature conceptual model will be referenced with the letter "T". For example, a discussion related to the environmental condition of increased SOD/BOD from the nutrient conceptual model is referenced as "NB5", and a discussion of the environmental condition of increased solar loading in the temperature conceptual model is referenced as "TB1".

2.4.2 Nutrient Conceptual Model Environmental Conditions and Cofactors

The Klamath River prior to anthropogenic impacts was a highly productive ecosystem, in part driven by relatively high background loading of nutrients. More recently, anthropogenic impacts have resulted in increased levels of nutrient and organic loading and altered nutrient dynamics that have amplified the risk associated with **increased nutrient loading (NA1)** throughout the basin.

2.4.2.1 Nutrient Related Effects on Productivity

Increased nutrient loading (NA1) can result in increased primary productivity in waterbodies. Ecologically, an increase in primary production can increase the production of invertebrates and fish in streams (MacDonald et al. 1991). However, **elevated periphyton[8] and suspended algae growth (NB1, NB2)** result in high levels of algal biomass, and through algal respiration and photosynthesis can significantly **increase diurnal DO and pH swings (NB7, NB8)** and result in **decreased overall DO (NB10)** (Welch and Jacoby 2004). In their investigation of water quality conditions on the North Umpqua River, Anderson and Carpenter (1998, p.12) describe the process that occurs in rivers that have significant periphyton communities:

> Photosynthesis, a light driven process (Graham et al., 1982; Wooton and Power, 1993), consumes carbon dioxide (CO_2) and produces oxygen (Equation 1). Respiration by aquatic plants and animals, which occurs at all times, consumes oxygen and produces CO_2. Diel changes in pH are caused by shifts in the carbonate equilibrium (equation 2) as the algae utilize CO_2. (or bicarbonate, HCO3-) during photosynthesis (Wetzel 2001) faster than atmosphere inputs can equilibrate. Streams with significant periphyton communities often have supersaturated DO concentrations and high pH values late in the day and minimum DO and pH values in the early morning (for examples see Kuwabara, 1992 or Tanner and Anderson, 1996). However the solubility of DO is inversely proportional to the water temperature, which rises in response to solar radiation and thereby decreases DO solubility during daylight hours, and is also impacted by physical reaeration. In effect, stream temperature, reaeration, photosynthesis and respiration compete for control of DO and pH in streams.

Equation 1: $$6CO_2 + 6H_2O \underset{\textit{Respiration}}{\overset{\textit{Photosynthesis}}{\rightleftharpoons}} C_6H_{12}O_6 + 6O_2$$

Equation 2: $$CO_2 + H_2O \longleftrightarrow HCO_3^- + H^+ \longleftrightarrow CO_3^{2-} + 2H^+$$

The Klamath River has relatively low alkalinity (<100 mg/L) which means that it is a weakly buffered system that is susceptible to photosynthesis driven changes in pH. DO is incorporated into the Klamath River nutrient conceptual model as an assessment endpoint, and not included as a driver/stressor, because DO is an intermediate parameter that responds to the stressors. The actual concentration of DO in water depends not only

8 For the purposes of the Klamath River TMDL Problem statement the term periphyton refers primarily to plants that are attached to the substrate (mainly benthic algae). However also included are heterotrophic organisms that are also attached to stream substrate such as bacteria and other benthic macroinvertebrates.

on saturation concentration (temperature and barometric pressure dependent) but also on oxygen sinks and sources. Two of the primary oxygen sinks are **sediment oxygen demand (SOD) and biochemical oxygen demand (BOD) ($_N$B5)** of substances in the water. When organic matter, such as periphyton and suspended algae, are broken down by microorganisms in the stream this process consumes oxygen and results in **decreased DO concentrations ($_N$B10)**.

The pathways that have resulted in major documented fish mortalities in the Klamath River in the last several years are illustrated as follows: **increased nutrient loading ($_N$A1) → elevated periphyton/macrophyte growth ($_N$B1)** and **elevated suspended algae and blue-green algal growth ($_N$B2) → increased polychaete habitat ($_N$B4) → increased polychaete population and *Ceratomyxa shasta (C. shasta)* population and dosing ($_N$B9)**. This pathway is not complete without consideration of the combination of increased parasite densities with stressful water quality conditions (e.g., high temperatures, low DO) which results in an increased incidence of disease and mortality.

Ceratomyxa shasta (*C. shasta*) is thought to be indigenous to the Klamath River, and is the primary fish health issue in the Klamath River (Bartholomew et al. 2007). The lifecycle of *C. shasta* is complex because the parasite changes form and the lifecycle involves two hosts, a freshwater polychaete (worm) and a salmonid (Figure 2.9).

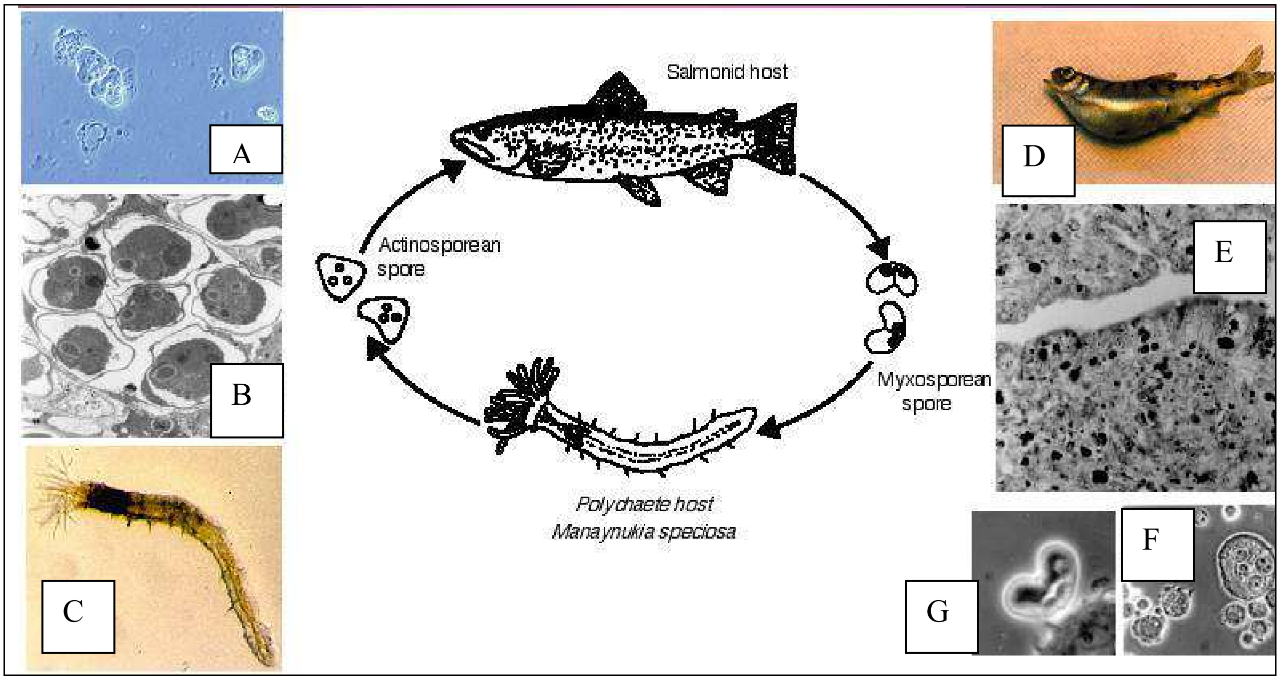

Figure 2.9: Life cycle of *C. shasta* showing release of the myxospore stage from the infected fish, the polychaete alternate host, and release of the alternate actinospore stage from the polychaete. A: released actinospores, B: electron micrograph of actinospores in the polychaete, C: polychaete, D: infected fish, E: histological section of infected intestine, F: trophozoite stages, G: myxospore
Source: Bartholomew et al. 1997 as cited by Stocking and Bartholomew 2004

One of the limiting factors for the presence of *C. shasta* appears to be the presence and abundance of the polychaete in the Klamath River (Bartholomew and Bjork 2007).

In 2003 a study by Stocking and Bartholomew (2004) found the highest densities of the polychaete living in periphyton (commonly made up of *Cladophora*). Study results from 2006 at sites located between Iron Gate Dam and Interstate-5 in California revealed that polychaete populations at habitat locations identified in 2004 and 2005 were not present in 2006, or were present in numbers too low to be considered significant (Stocking and Bartholomew 2007). According to Stocking and Bartholomew (2007), the substrate at these locations was new in 2006 and devoid of periphyton (*Cladophora)*, most likely due to scour caused by winter flushing flows. It appears that the lack of available habitat for the polychaete in 2006 led to their absence from these locations in the Klamath River.

Studies have found that the primary habitat of the polychaete also includes sand and periphyton embedded with fine particulate organic matter (FPOM) (Stocking 2006). FPOM is derived from the breakdown products of particulate organic matter, including periphyton and suspended algae.

Regional Water Board staff have consulted with Dr. Jerri Bartholomew and Mr. Richard Stocking, the principal investigators in the following studies - Bartholomew and Bjork (2007), Stocking and Bartholomew (2004), Stocking and Bartholomew (2007), and Stocking (2006) - to evaluate the presence and abundance of the polychaete that is the intermediate host for *C. Shasta* and the linkage to elevated nutrient concentrations. The conceptual model linkage is initiated with the high levels of FPOM released from the reservoirs (from upstream and within-reservoir sources) during the summer months. The FPOM is retained quite well by *Cladophora*, which grows in high densities in the river reaches below I-5, where the average river gradient decreases along with channel substrate characteristics (PacifiCorp 2004c) which are then more favorable for periphyton colonization. These high levels of FPOM appear to be a critical factor determining distribution and abundance of *M. speciosa*. According to Stocking and Bartholomew the large populations of polychaetes have been identified in the fine sediment rich inflow areas of the reservoirs, but the highest densities occur in their river samples. While the habitat is an important factor it is also likely that the populations are food limited. Published research indicates that FPOM makes up a significant portion of the Fabriciinae diet and personal observations (Stocking and Bartholomew 2007) show that *M. speciosa* (Sabellidae: Fabriciinae) is no exception. Based on discussions with Mr. Stocking the following observations support the following conceptual model linkage:

> Sparse amounts of Cladophora found near Saints Rest Bar (above the confluence with the Trinity River) possessed almost no organic matter and very low polychaete densities. Cladophora found near I-5 was saturated with FPOM and polychaetes (Stocking, 2009). Data results of numerous polychaete populations between these two locations indicate a solid trend. To the extent that project reservoirs have altered the distribution and abundance of organic matter in the Klamath River, there can be no doubt that it has also altered the abundance of C. shasta's polychaete host. (Stocking, 2009)

Based on the above information, there may be a linkage between the proliferation of *C. shasta* in the mainstem Klamath River and elevated nutrient concentrations. **Elevated nutrient concentrations (NA)** result in **increased periphyton ($_{N}$B1) and increased suspended algae and blue-green algal growth ($_{N}$B2)** in the river, which have been identified as prime habitat for the polychaete. **Increased habitat ($_{N}$B4)** leads to an **increased abundance of the polychaete ($_{N}$B9)**, which in turn leads to a high infectious spore load in the river. This results in a high probability that adult and juvenile salmonids migrating and rearing in the river will be infected by *C. shasta*.

An additional factor that is potentially shifting the balance toward increased parasite concentrations is the **elevated suspended algae and blue-green algal growth ($_{N}$B2)** in Iron Gate Reservoir, which contributes to **increased polychaete populations ($_{N}$B9)** in the mainstem Klamath River below the reservoir. The polychaetes are filter feeders and feed on fine organic detritus, as well as various forms of suspended algae. **Elevated nutrient loading ($_{N}$A)** leads to prolific amounts of phytoplankton growth in the reservoir. The phytoplankton are released into the Klamath River as water flows out of Iron Gate Dam, thus creating an abundant food source for the polychaete, which may contribute to increasing their numbers (USFWS 2006).

Figure 2.10 was presented at the 2008 Klamath River Fish Health Conference to illustrate how the balance between parasite, hosts, and the environment has shifted to favor the increased abundance of parasites. There is an emerging consensus among those conducting research on these relationships in the Klamath River basin that the changes in the environmental conditions identified in the nutrient conceptual model, in association with other risk cofactors, provides a reasonable explanation of the shift to an increasing abundance of parasites (and spores) and higher levels of infection among salmonids in the Klamath River.

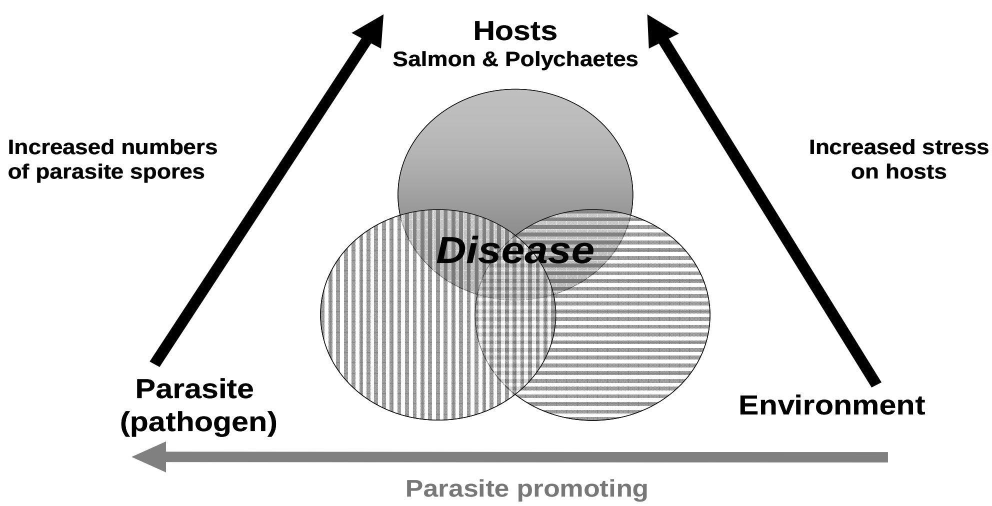

Figure 2.10: Severity of *Ceratomyxosis* in Klamath River suggests a shift in the host/parasite balance towards *C. shasta*
Source: Bartholomew personal communication 2008

The increase in the prevalence of parasite infection and related mortality is a very complex issue and it is likely that other environmental factors are also contributing to the proliferation of *C. shasta*. For example, the existing near-constant summer flow regime has eliminated extreme low flows which could cause the desiccation of the periphyton and resident polychaete populations. In addition, reduced peak flows and the elimination of small gravel from the sediment load has reduced impingement on attached periphyton reducing the amount of scouring that would normally occur, also contributing to increased periphyton densities. An example of the parasite promoting factors included in the conceptual model above is that high densities of salmonids trapped in the reach below Iron Gate lead to increased shedding of the myxosporean spore which then infects the polychaete population in the dense periphyton present downstream of the dam in the reach between Shasta and Scott Rivers. While these potential factors are not addressed explicitly in the conceptual model, they should be included in any comprehensive assessment and mitigation plan to address this issue.

In addition, the prevalence of parasite infection within the lower Klamath River downstream of Iron Gate may be due in part to the presence of the dam, which concentrates the numbers of spawners in this reach. Dense spawning redds and salmon carcasses can be found below Iron Gate Dam (Toz Soto, Karuk Tribal Fisheries Biologist, Personal Communication 2009). This observation is reinforced by U.S. Fish and Wildlife Service data (Grove 2002, as cited in FERC 2007) indicating that ~40% of the fall chinook redds observed within the 82-mile mainstem survey reach (Iron Gate Dam to Indian Creek) in 1993-2002 were located in the first 3.3 miles below Iron Gate Dam (Iron Gate to Cape Horne Creek) and another ~10% in the next 10.2 miles (Cape Horne Creek to Shasta River). There are also dense populations of the polychaete host in this same reach (Stocking and Bartholomew 2007). According to Stocking (Stocking, 2009), it appears that the prevalence of C. *shasta* in the lower Klamath River below Iron Gate may be explained by an emerging understanding of the biology of these animals (both hosts and parasite). As salmon near their spawning grounds, their immune system begins to shut down and all energy is directed towards reproduction. The parasite, *C. shasta*, takes advantage of its hosts weakened immune response and begins to proliferate within the hosts tissues in preparation for the next step in its life-cycle: infecting the polychaete host. The parasite is released from a decomposing salmon carcass, swept up in passing currents, and is deposited within a downstream population of polychaetes.

The Klamath River basin has also been subject to **excessive suspended algae and blue-green algae growth (NB2**). Blue-green algae grow and thrive in slow-moving to stagnant waterbodies such as ponds, lakes, and low gradient river reaches that usually have high nutrient loads accompanied by adequate sunlight (Hudnell 2009, and Paerl 2008). These conditions are found in Copco and Iron Gate Reservoirs, coupled with elevated nutrient concentrations, which promote nuisance **blooms of blue-green algae (NB6)**; the most common are *Microcystis aeruginosa*, *Anabaena flos-aquae, Anabaena flos-aquae,* and *Gleotricia echinulata*.

All four of these species are capable of producing cyanotoxins; however, the strain of *Aphanizomenon flos-aquae* found in Upper Klamath Lake, and subsequently transported downstream to the Klamath River, has not yet been shown to produce any toxins (Carmichael et al. 2000; Li et al. 2000). Cyanotoxins produced by these blue-green algae include dermatotoxins (cause contact dermatitis and stomach-intestinal disorders), neurotoxins (cause nervous system poisoning), and hepatotoxins (cause liver poisoning) (WHO 1999, p. 57). **Microcystin (NB11)** is a hepatotoxin produced by *Microcystis aeruginosa*, which has been measured in Copco and Iron Gate and detected in slow moving portions of the river downstream of Iron Gate dam, as well as in Klamath River fish tissue (Fetcho 2006, Kann 2006).

2.4.2.2 Nutrient Related Effects on Ammonia Toxicity

Nutrient loading to a waterbody can contribute directly to **increased ammonia concentrations (NB12)** through the addition of nitrogen to the system. The pH of the water column influences the concentration of un-ionized ammonia (NH_3) and ammonium ion (NH_4^+). As pH increases, un-ionized ammonia concentrations increase and ammonium ion concentrations decrease. These speciation relationships are important to ammonia toxicity because un-ionized ammonia is much more toxic to aquatic species than ammonium ions (USEPA 1999b). The **increased diurnal pH (NB8)** swings result in higher pH levels in the water column, and can result in **increased ammonia toxicity (NB12)**. The analysis of the potential for ammonia toxicity in the Klamath River is described below in Section 2.5.7.

2.4.2.3 Nutrient Risk Cofactors

Generally, nutrient concentrations alone do not impair beneficial uses. Rather, in combination with other factors nutrients cause indirect impacts through aquatic plant growth, low DO, high pH, and other related impacts. Nutrients are one factor in the impairment equation that must be present with other risk cofactors to express an impairment. Each of these risk cofactors contributes to the degraded conditions that exist in the Klamath River basin today. Any watershed scale recovery plan must address the potential effect of the following nutrient risk cofactors:

- **Reduced riparian habitat (NC1)** and associated reductions in shading by vegetation increases the amount of sunlight that reaches the stream and that can, in turn, drive photosynthesis of both suspended algae and periphyton. The increased solar radiation also causes **increased temperature (NC2)** of the water column which reduces oxygen saturation potential, and accelerates SOD and BOD processes. Also, reduced riparian habitat can impede riparian functions such as filtering and uptake of pollutants in runoff. These conditions are often associated with **degraded stream bank and stream channel conditions (NC3).**

- **Degraded Channel Habitat Integrity (NC3)** through sediment filling, incidental anthropogenic channel disturbance (e.g. grazing), channelization, or diking repairs can impair natural river processes that retain or remove permanently from the water column nutrients through denitrification, growth of attached algae, and the settling of organic matter. The result of these types of impacts in the upper Klamath River basin is higher downstream nutrient loading than would have occurred historically. Bernot and Dodds (2005) describe several restoration techniques for reversion to historical channel sinuosity, channel complexity, and connectivity to riparian wetlands with the objective of restoring nitrogen retention and removal characteristics.

- **<u>Increased sediment load (NC4, NC5)</u>** includes both the fine and coarse components that can originate from different sources (e.g. roads, mass wasting debris flows), but both have similar impacts on the stream ecosystem. Increased sediment load can result in stream channel aggradation, filling in pools and deeper portions of the stream channel (i.e. thalweg), creating a shallow concave channel cross-section that facilitates accelerated growth rates of periphyton and suspended algae. The transport of sediment into the water column is also a primary mechanism for nutrient loading.

- **<u>Altered flow conditions (NC6)</u>** covers a wide range of potential flow-related impacts, including: reduced flow that is more susceptible to high temperature drivers; persistent flow during normally dry conditions reducing the effect of desiccation and thus promoting excessive macrophyte and algal growth and accrual; and, for the Klamath River below Iron Gate Dam, altered sediment transport leading to reduced impingement (impact from small gravel) on periphyton due to reduced gravel transport downstream, which can increase periphyton accrual time.

- **<u>Impoundments (NC7)</u>** are a significant nutrient risk cofactor. The effect of impoundments on nutrient dynamics in the Klamath River are discussed in Section 4.2.2.2. The Klamath River impoundments are a risk cofactor for nutrients because of multiple factors:

  - Empirical data and model predictions indicate that the Copco 1 and 2 and Iron Gate Reservoirs (impoundments) have a net annual retention of nutrients (PacifiCorp 2006; PacifiCorp 2008; PacifiCorp 2009; Appendix 2 of Staff Report, Asarian et al. 2009).
  - Impoundments spread out event-driven spikes in upstream nutrient loads (PacifiCorp 2006).
  - Iron Gate and Copco Reservoirs are capable of generating their own pulses of nutrients downstream of Iron Gate Dam during intense algae blooms (see for example September 2007 conditions in Figure 14 in Asarian et al. 2009).
  - The effect of reservoir nutrient retention on downstream water quality likely varies by reach.
  - Impoundments create an environment that is more favorable to nuisance blooms of both green and blue-green algae (Kann and Corum 2009, Paerl 2008, Welch and Jacoby 2004, Kann and Asarian 2005, Wetzel 2001).

    As described in more detail in section 2.4.2.1, the Klamath River impoundments alter habitat conditions and increase fine particulate organic matter concentrations downstream of Iron Gate Dam, which may contribute to the high density of the polychaetes below Iron Gate Reservoir (which in turn supports high densities of the parasite *C. shasta*) (Stocking and Bartholomew 2007).

  - Dams typically halt the downstream transport of gravel, resulting in more coarse substrates (Biggs 2000). FERC (2007) concluded that the Klamath Hydroelectric Project reservoirs cause streambed armoring and reduce the frequency of bed-mobilizing flows. below Iron Gate Dam.. Larger substrates like cobble and boulder require higher flows to scour them than smaller substrates like gravel and sand. These coarse substrates are more stable, increasing the amount of periphyton and aquatic macrophytes that can grow (Biggs, 2000; Anderson and Carpenter 1998). In addition, the effect of reduced gravel transport and altered flows reduces the amount of impingement which is an important element contributing to dislodging attached algae (also discussed above in altered flows).

- **Increased Organic Matter Loading (NC8)** is a risk cofactor in a direct manner by contributing additional nutrients to the Klamath system and by exacerbating stressful DO conditions through SOD and BOD. The increased loading of organic matter is also a risk cofactor in a less direct manner due to its contribution to the formation of anoxic conditions that will alter nutrient dynamics increasing the abundance of dissolved inorganic nutrients contributing to increased algal productivity.

2.4.3 Temperature Conceptual Model Environmental Conditions and Cofactors

2.4.3.1 Thermal Processes Related to Solar Loading

Direct solar radiation is the primary factor influencing stream temperatures in summer months. The energy added to a stream from solar radiation far outweighs the energy lost or gained from evaporation or convection (Beschta et al. 1987; Johnson 2004; Sinokrot and Stefan 1993). At a given location, incoming solar radiation is a function of position of the sun, which in turn is determined by latitude, day of the year, and time of day. During the summer months, when solar radiation levels are highest and streamflows are low, shade from streamside forests and vegetation can be a significant control on direct solar radiation reaching streams (Beschta et al. 1987). Because shade limits the amount of direct solar radiation reaching the water, it provides a direct control on the amount of heat energy the water receives. At a workshop convened by the state of Oregon's Independent Multidisciplinary Science Team, 21 scientists reached consensus that solar radiation is the principal energy source that causes stream heating (Independent Multidisciplinary Science Team 2000).

Shade is created by vegetation and topography; however, vegetation typically provides more shade to rivers and streams than topography. The shade provided to a water body by vegetation, especially riparian vegetation, has a dramatic, beneficial effect on stream temperatures. The removal of vegetation **decreases shade (TA1)**, which **increases solar radiation levels (TB1)**, which, in turn, **increases both average and maximum stream temperatures (TB8)**, and leads to **large daily temperature variations (TB7)**. Additionally, the removal of vegetation increases ambient air temperatures, can result in bank erosion, and can result in changes to the channel geometry to a wider and shallower stream channel, all of which also increase water temperatures.

2.4.3.2 Thermal Processes Related to Sediment Load

Increased sediment loads (TA2) and associated changes in channel morphology can affect stream temperature conditions in multiple ways. These effects can manifest at both large (watershed-wide) and small (individual reach) scales. Sediment is defined as any inorganic or organic earthen material, including but not limited to: soil, silt, sand, clay, and rock (Regional Water Board 2007). The sizes of sediment that present a temperature concern are those that may result in pool filling, increased width, decreased depth, and/or a reduction of intergravel flow.

Increases in sediment loads may **alter channel morphology (TB2)**, leading to a wider and shallower wetted channel. In a study of stream channel geometry at twelve gauging stations throughout northwest California, Lisle (1982) described channel widths increasing by as much as one hundred percent, bars becoming smaller, and pools filling in response to increases in sediment supply. Channel widening associated with increased sediment loads can also result in the destruction of riparian canopy and consequent **increases in solar loading (TB1)** by increasing shear forces on channel margins (Lisle 1982). Riparian vegetation may also be removed or buried by sediment, trees, and other debris transported in debris flows. A US Forest Service report documenting the effects of the 1997 flood on Klamath National Forest resources identified the following:

> Riparian vegetation was damaged or removed from some stream segments. Temperature increases in the summer of 1997 were documented at Elk Creek, and may have occurred in the Walker, Indian, Tompkins, Portuguese, and Ukonom Creeks, as well as the South Fork of the Salmon River. Large logs were mobilized in many streams, and re-positioned within the channels. Many of the accumulations are above the bank-full channel. Additionally, channel widening undermined large trees in lower stream reaches, causing them to topple into the channel where many remain at the present time. (De la Fuente and Elder 1998, p.6, Appendix E)

Increased Width-to-Depth Ratios

A wider and shallower channel gains and loses heat more readily than a narrow and deep channel. This principal is true for any stream. A stream's width-to-depth ratio influences stream heating processes by determining the relative proportion of the wetted perimeter in contact with the atmosphere versus the streambed. Water in contact with the streambed exchanges heat via conduction. Conductive heat exchange with the streambed has a moderating influence, reducing daily temperature fluctuations. However, wide and shallow channels have a greater surface area per unit of volume in contact with the atmosphere than a narrower, deeper channel. Water in contact with the atmosphere exchanges heat via evaporation, convection, solar radiation, and long-wave radiation. Heat exchange from solar radiation far outweighs heat exchange from evaporation, convection, and long-wave radiation, unless the stream is significantly shaded. The net effect of changes in width-to-depth ratios is that streams that are wide and shallow heat and cool faster than streams that are narrow and deep (Poole and Berman 2001).

The effects of a wider and shallower channel are similar to the effects of increased solar loading. Both changes lead **to increases in daily average and maximum temperatures (TB8)**, **increased diurnal fluctuations (TB7)**, **and may lead to decreased daily minimum temperatures (TB10).**

Decreased Hyporheic Exchange

Increased sediment loads may also reduce heat exchange associated with hyporheic processes through simplification of the bed topography and reduced permeability due to increases in fine sediment deposition. Hyporheic exchange occurs when surface waters infiltrate into the interstitial spaces of stream beds. As surface water passes through the porous sediment, heat is lost (or gained) through conduction with the sediments. In some settings, streambed conduction can be a significant heat sink that buffers daily maximum temperatures in the summer season (Loheide and Gorelick 2006).

Several published studies describe mechanisms of heat transfer dependent on permeability of bed sediments, effects of sediment on stream channel morphology, and stream channel characteristics related to thermal refugia. Vaux (1968) demonstrated that hyporheic exchange is dependent on the topographic complexity of the bed surface and permeability of the sediments. Lisle (1982) reported a simplification of streambed complexity associated with aggradation at stream gauge sites following the 1964 flood. He observed that gauging sites went from a pool-like form prior to aggradation, to a riffle-like form with flat cross-sectional profiles following aggradation. Wondzell and Swanson (1999) similarly evaluated the effects of large events on channel form. They specifically evaluated changes in the hyporheic zone resulting from large flood events and demonstrated that simplification of stream channel geometry decreases intra-gravel exchange rates. Furthermore, they suggested that loss of pool-step sequences related to channel disturbances could result in decreased intra-gravel exchange.

More recently, researchers have quantified the reduction in surface stream temperatures attributable to hyporheic exchange. In a study of Deer Creek in northern California, Tompkins (2006) found that reduced daily maximum water temperatures in hyporheic seeps on the order of 3.5 ^{o}C (6.3 ^{o}F) created thermal refugia for salmonids. In a study similar to Tomkins', Loheide and Gorelick (2006) documented daily maximum temperature reductions on the order of 2 ^{o}C (3.8 ^{o}F) in study of a 1.7 km (1.1. mi) stream reach of Cottonwood Creek in Plumas County, California.

Morphological changes associated with increased sediment loads can also eliminate or result in a **decreased volume of thermal refugia (TB9)** in a stream or river and impede access to thermal refugia provided by tributaries. Refugial volume can be reduced or eliminated when deep pools fill with sediment, when side channels are buried, or when cold tributary flows percolate into aggraded tributary deltas or gravel bars before entering the river. Similarly, access to refugial tributaries can be reduced or eliminated when sediment loads result in aggradation and cause a tributary to percolate before entering the mainstem and thus become disconnected from the mainstem or become too shallow for fish to swim. Aggradation has impacted the mouths of Hunter, Turwar, Independence, Walker, Oneil, Portuguese and Grider Creeks, as well as 14 of 17 small Lower Klamath tributaries surveyed by the Yurok Tribe (De La Fuente and Elder 1998; Kier Associates 1999). Finally, refugia can be eliminated when tributary temperatures increase beyond salmonid thresholds due to the other effects of increased sediment loads discussed above.

2.4.3.3 Thermal Processes Related to Flow

Surface water diversions (TA3) decrease the volume of water in the stream, and thereby decrease a stream's capacity to assimilate heat. When water is removed from a stream the **thermal mass (TB3)** and **velocity (TB4)** of the water is decreased. Thermal mass refers to the ability of a body to resist changes in temperature. Basically, less water heats or cools faster than more water. Decreases in velocity increase the time required to travel a given distance, and thus increases the time heating and cooling processes can act on the water. These principles are true for any stream, and work in concert with other heat exchange processes to determine the overall temperature of a stream.

The increase in the rate of heating that accompanies a decrease in the volume of flow in a stream can have significant temperature effects. A decrease in thermal mass results in **higher daily high and lower daily low temperatures (TB7, TB8, TB10)**, as well as **higher daily average temperatures (TB8)**. Reduced velocities also result in **higher daily average temperatures (TB8)**.

2.4.3.4 Thermal Processes Related to Direct Thermal Discharges

Direct thermal discharge (TA4) is the discrete addition of heat to a waterbody. Direct thermal discharges occur when water is used in a cooling process, such as in power generation or industrial settings, or when warm materials are placed in a waterbody. In the Klamath basin the main source of direct thermal discharges is related to irrigation tailwater return flows.

Flood irrigation is a common irrigation practice in parts of the Klamath basin, including the Klamath Project area and the Shasta River watershed. When irrigation water is applied to a field in this manner, it generally flows across the field as a thin sheet or in shallow rivulets. As the irrigation water runs across the ground it absorbs heat. When irrigation flows return to a stream, they carry with them the **increased heat load (TB5)** added as they pass through the irrigated lands. Regional Water Board staff deployed temperature monitoring devices at several Shasta Valley locations with irrigation return flows. Upon review of the monitoring results, it was very difficult to determine when the temperature monitoring probes were exposed to irrigation return flow versus when they were exposed to the air, indicating that the temperature of the tailwater return flows was generally at equilibrium with the air temperature. The net effect of direct thermal discharges is an **increase in both daily average and maximum temperatures (TB8)**.

2.4.3.5 Thermal Processes Related to Impoundments

The water stored behind a **dam (TA5)** functions as **thermal mass (TB6)**, storing heat. Because larger volumes of water heat and cool slower than smaller volumes, the large volume of water behind an impoundment acts as a temperature buffer, **reducing daily**

temperature variations downstream (TB11). Similarly, large volumes of water resist **seasonal changes in temperature (TB12)**, and thus delay seasonal temperature changes, resulting in colder temperatures in the spring and warmer temperatures in the fall. In the Klamath River, these effects may extend downstream to the Pacific Ocean under certain conditions (Bartholow et al. 2005). The effects are most pronounced immediately downstream of Iron Gate Dam, diminishing in the downstream direction.

The expected biological implications of the changes in diurnal temperature patterns caused by dams are mixed. The **decreased diurnal temperature variation (TB11)** associated with dams lead to reduced peak temperatures, thereby reducing the most acutely harmful temperatures. Conversely, the increased daily low temperatures associated with dams could reduce the time available for fish to leave thermal refugia to feed. Also, higher daily low temperatures may lead to higher temperatures at the bottom of thermally stratified pools (Nielsen et al. 1994).

The **seasonal temperature changes (TB12)** caused by the dams may also have biological implications. Bartholow et al. (2005) evaluated the thermal effects of the Klamath River dams on downstream reaches and determined that the dams delay the seasonal temperature patterns by approximately 18 days on an annual basis. The physical implication of an 18 day shift in the seasonal temperature pattern is that the river is cooler in the springtime when juvenile salmonids are migrating to the ocean, and warmer in the fall when adults are migrating upstream and spawning, and eggs are incubating in the gravels. Cooler temperatures are known to reduce juvenile salmonid growth rates; however this effect may be mitigated by the benefit gained by reduced incidence of stressfully high temperatures during outmigration. Warmer temperatures in the summer period may reduce the nocturnal feeding opportunities of juvenile salmonids that persist at thermal refugia, thereby reducing their ability to withstand stressfully high daytime temperatures (National Research Council of the National Academies [NRC] 2004). Warmer temperatures in the fall may delay adult migration or lead to stressfully high temperatures when adults are present or eggs are incubating in gravels. More discussion of this topic can be found in Section 2.5.2.1.

2.4.3.6 Temperature Risk Cofactors

Adverse temperature conditions may combine with other factors to further impair beneficial uses beyond the primary effects of high temperatures. Temperature is a physical factor that affects chemical concentrations and biological growth rates of other factors that affect habitat and water quality. These factors are described below. Each of these risk cofactors contribute to the degraded conditions that exist in the Klamath River basin today. Any watershed scale recovery plan must address the potential effect of the following temperature risk cofactors:

- **Increased NH_3 Toxicity (TC1)** – The concentration of un-ionized ammonia (NH_3) in water increases with higher temperature, higher pH, and higher concentration of ionized ammonia (NH_4^+). In waterbodies that have high concentrations of ionized ammonia and frequent excursions of high pH an increase in temperature can result in the formation of un-ionized ammonia, which is toxic to fish and other organisms.

- **Decreased Overall Dissolved Oxygen (TC2)** – The concentration of DO in water is partly a function of the temperature of the water. Colder water can absorb more DO than warm water, if all other factors are equal. Higher temperatures reduce the DO saturation concentration, increasing the risk that other factors that cause a decrease in DO will result in concentrations less than the criteria concentrations needed to support beneficial uses.

- **Increased Suspended Algae and Periphyton Growth Rates (TC3) –** Algal growth rate is partially dependent on the temperature at which they grow. Generally, higher temperatures result in higher rates of growth (up to a limiting temperature), if all other factors are equal.

- **Increased Bacteria and Decomposition Rates (TC4)** – The rate at which bacteria grow and decay is partially dependent on the temperature of the water they are in. Higher temperatures result in higher rates of growth and decay, if all other factors are equal, resulting in greater oxygen demand within the surrounding water column.

2.4.4 Responses/Outcomes

The driver/stressors and environmental conditions discussed in the previous sections have resulted in the response/outcomes identified in Section D of the Nutrient and Temperature Conceptual Models. Many of these have been well documented and are discussed in the following sections, which describes impacts to Klamath River beneficial uses. The current conditions of many of the indicators described in this section will be presented in Section 2.5 to better assess their actual impact on beneficial uses within the Klamath River basin. Additional information on the effects of an altered natural temperature regime and the secondary effects of elevated nutrient levels on salmonids is available in Appendix 4, *Effects of Temperature, Dissolved Oxygen/Total Dissolved Gas, Ammonia, and pH on Salmonids.*

2.4.4.1 Migration/Avoidance Barrier (D_a1)

High water temperatures can inhibit or block upstream migration of adult salmonids. One study specific to the Klamath River was conducted by Strange (2007) and evaluated the association between water temperature in the mainstem Klamath River and adult fall Chinook migration. Utilizing radio telemetry to track the movements and monitor the internal body temperatures of adult fall Chinook salmon during their upriver spawning migration in the Klamath basin, Strange (2007) found that fall Chinook will not migrate upstream when mean daily temperatures are ≥22°C. Strange also noted that adult fall Chinook in the Klamath basin will not migrate upstream if temperatures are 21°C or above and rising, but will migrate at temperatures as high as 23°C if temperatures are rapidly falling.

The upstream migration by adult salmonids is typically a stressful endeavor. Sustained swimming over long distances requires high expenditures of energy and therefore requires adequate levels of DO. Migrating adult Chinook salmon in the San Joaquin River exhibited an avoidance response when DO was below 4.2 mg/L, and most Chinook waited to migrate until DO levels were at 5 mg/L or higher (Hallock et al. 1970). The swimming performance of migrating salmonids is also impacted by reduced concentrations of DO (Bjornn and Reiser 1991).

2.4.4.2 Decreased Spawning and Reproductive Success (D_a2)

There is evidence that fish that over-summer in stressfully high temperatures and low DO concentrations experience reduced reproductive success (Coutant 1987). A study by Coutant (1987) demonstrates that fish experiencing the combination of high temperatures and low DO are subject to physiological harm that persists well after the fish are exposed to these water quality conditions. Persistent effects of high temperature and low DO include a reduction in female spawning success and poor embryo survival.

2.4.4.3 Increased Physiological Stress (D_a3)

Increased temperature and the secondary effects of nutrient loading can result in physiological stress on salmonids. The metabolic processes of salmonids are directly related to temperature. When water temperatures are above the optimal metabolic range for salmonids, the resting metabolic rate increases dramatically. This results in reduced feeding rates, swimming speed, growth, reproduction, and resistance to environmental extremes (USEPA 2001, p.39). Also, if temperatures are high, much of the energy assimilated from food is lost as excessive metabolism (USEPA 2001, p.85). High incubation temperatures may create a metabolic energy deficit for pre-emergent salmon that increases mortality (Heming 1982, as cited by USEPA 2001, p.31). Further, the stressful impacts of water temperatures on salmonids are cumulative and positively correlated to the duration and severity of exposure. The longer the salmonid is exposed to thermal stress, the less chance it has for long-term survival (Ligon et al. 1999).

As the metabolic rates of salmonids increase there is an increased physiologic demand for oxygen. Low DO concentrations (<4-5 mg/L) result in decreased size of newly hatched salmonids (WDOE 2002a, p.14), as well as decreased juvenile salmonid growth and food consumption (Bjornn and Reiser 1999, p.118; Herrmann et al. 1962; and USEPA 1986, p.5-8), and decreased food conversion efficiency (ODEQ 1995, p.A-6). When DO levels are extremely low (2-3 mg/L) weight loss can occur due to decreased food consumption (Herrmann et al. 1962). Low DO concentrations also adversely affect swimming performance in both adult and juvenile salmonids (Bjornn and Reiser 1999, pp.85, 118, 119; WDOE 2002a, p.46).

Concentrations of ammonia acutely toxic to fishes may cause loss of equilibrium, hyperexcitability, increased breathing, cardiac output and oxygen uptake, and, in extreme cases, convulsions, coma, and death. At sub-acute concentrations, ammonia has many effects on fishes, including a reduction in hatching success, reduction in growth rate and morphological development, and pathologic changes in tissues of gills, livers, and kidneys (USEPA 1986, p.17).

The pH of freshwater streams, lakes, and reservoirs is also important for adult and juvenile salmonid development, and is influenced by the respiration of benthic algae and suspended algae. Chronic effects from low pH can occur at levels that are not toxic to adult fish but that impair reproduction including altered spawning behavior, reduced egg viability, decreased hatchability, and reduced survival during early life stages when salmonid development is most vulnerable to low pH (Jordahl and Benson 1987). Chronic high pH levels in freshwater streams can decrease activity levels of salmonids, create stress responses, decrease or cease feeding, and lead to a loss of equilibrium (Murray and Ziebell 1984; Wagner et al. 1997). Additionally, high temperatures can exacerbate the effects of high pH levels on salmonids, and if pH reaches extremely low or high levels, death can occur (Wagner et al. 1997).

2.4.4.4 Increased Incidence of Fish Disease (*Ceratomyxa shasta* and Columnaris) (D_a4)

The USFWS California-Nevada Fish Health Center has identified *C. shasta* as the primary fish health issue in the Klamath River, and Columnaris is the second biggest fish health threat (Foott 2005). Disease has been cited as the ultimate cause of death in most of the adult and juvenile fish kills which have occurred in the Klamath River from Iron Gate Dam to the mouth (CDFG 2000; CDFG 2004; Deas 2000; Engbring 2004; Foott 2000; Foott et al. 2002; Hannum 1997; Hendrickson 1997; KFHAT 2005; Klamt and Carter 2004; USFWS 1997; USFWS 2003a; USFWS 2003b; Williamson and Foott 1998). On more than one occasion the outbreak of disease was termed an "epizootic" (the equivalent of an epidemic in humans), and in all cases the disease outbreaks were exacerbated by a combination of poor water quality conditions including high water temperatures, low DO levels, sediment deposition, and high ammonia concentrations (CDFG 2000; CDFG 2004; Deas 2000; Engbring 2004; Foott 2000; Foott et al. 2002; Foott 2005; Hannum 1997; Hendrickson 1997; KFHAT 2005; Klamt and Carter 2004; USFWS 1997; USFWS 2003a; USFWS 2003b; Williamson and Foott 1998).

The USEPA (2003) and Washington Department of Ecology (WDOE 2002b, p.115) report that as water temperatures increase, the risk and severity of a disease outbreak increases. The infectivity of *C. shasta* and Columnaris increases with increasing temperature, and the lifecycle of these diseases shorten with increasing temperature, making outbreaks more likely. WDOE (2002b) expresses the temperature thresholds that are likely to prevent or exacerbate disease outbreaks as a Maximum Weekly Maximum Temperature (MWMT), which is the maximum seasonal or yearly value of the daily maximum temperatures over a running seven-day consecutive period. The Washington Department of Ecology (WDOE 2002b, p.115) conducted a review of studies on disease outbreak in salmonids and estimated that an MWMT of less than or equal to 14.4°C (midpoint of 12.6-16.2 range) will virtually prevent warm water disease effects. According to WDOE (2002b, p.115), to avoid serious rates of infection and mortality the MWMT should not exceed 17.4°C (midpoint of 15.6-19.2 range), and that severe infections and catastrophic outbreaks become a serious concern when the MWMTs exceed 21.0°C (midpoint of 18.6-23.2 range). In a summary of temperature considerations, USEPA (2003) states that disease risks for juvenile rearing and adult migration are minimized at temperatures from 12°C to13°C, elevated from 14°C to 17°C, and high at temperatures from 18°C to 20°C. Additionally, the crowding of salmonids in thermal refugia increases the likelihood of fish-to-fish transmission of Columnaris.

When the infectious spore load of *C. shasta* in the Klamath River is low, or juvenile salmonids are exposed for less than 24 hours, they can successfully rear at temperatures as high as 21°C (Foott 2006). However, if the infectious spore load in the river is high, or juvenile salmonids are exposed for long periods of time (2-4 days), mortality occurs at temperatures as low as 16°C (Foott 2006).

As discussed in Section 2.4.2.1 there may be a linkage between the proliferation of *C. shasta* in the mainstem Klamath River and elevated nutrient concentrations. Elevated levels of nutrients and organic matter allow for the proliferation of prime polychaete habitat (periphyton and pockets of fine benthic organic matter) and thus large numbers of polychaetes and high infectious spore load in the river. This can lead to an increased probability of *C. shasta* infections.

2.4.4.5 Decreased Juvenile Growth (D_a5)
Low dissolved oxygen levels and elevated temperatures can result in decreased juvenile fish growth, including growth of salmonids.

> Hutchins (1973 [as cited by WDOE 2002a]) reported that at 15°C, growth of juvenile coho salmon fed to repletion and held at velocities between 1.2 and 3.6 l/sec (lengths per second) at an oxygen level of 3 mg/L for 10 to 12 days was reduced by 20 and 65 percent from that of a control salmon held at respective velocities in air-saturated water (9.5 mg/L). At the intermediate oxygen concentration of 5 mg/L, growth rates of salmon were reportedly reduced by 0 and 15 percent over controls, respectively.
>
> Herrmann et al. (1962 [as cited by WDOE 2002a]) found that juvenile coho salmon (age class 0) held at 20°C and fed to repletion twice daily experienced declines in growth with reduction of oxygen from a mean of about 8.3 to 6 and 5 mg/L, and declined more sharply with further reduction of oxygen concentration, suggesting further that concentrations near 4 or 5 mg/L can be exceedingly detrimental. The authors estimated a reduction of both percent weight gain and the rate of food consumption by about 11 percent with reduction of oxygen concentration from 8.3 to 5.0 mg/L, and by at least twice as much with reduction of oxygen concentration to 4 mg/L.

Elevated water temperature has a detrimental effect on juvenile salmonid growth. Banks et al. (1971 as cited by WDOE 2002b) found that growth was similar at 15.6°C and 18.3°C, however temperatures above 19°C were associated with reduced feeding and growth, as well as increased problems with disease. Marine and Cech (2004) found that growth was substantially reduced at 21-24°C when compared to 13-16°C.

2.4.4.6 Increased Fish Mortality and Lower Overall Populations (D_a6, D_a7, D_a8)
The effects of altered temperature, decreased DO, and increased nutrient loading can have a significant impact on salmonids. In the Klamath River basin, the impacts of high water temperature directly, and in combination with other factors, has likely resulted in both adult and juvenile fish mortality and contributed to lower overall fish populations.

Bartholow (1995, p.19) states, "…water temperatures in the Klamath basin are marginal at best for anadromous salmonids, squeezing their thermal resources in both space and time." The National Research Council of the National Academies (NRC) state that various factors including decreased flows and increased water temperatures in the Klamath River basin have contributed to declining salmonid populations during the 20th century (NRC 2004, p.284). Salmonid populations in the Klamath River basin have declined sharply since the early 1900's. In 1931, Snyder (1931, p.9, 121) wrote that the fishery of the Klamath River basin is very important because with proper management it can be maintained, although he also states that depletion of the Klamath salmon is apparent and occurring at an "alarming rate" which artificial propagation alone may not remedy. The NRC (2004, p.284) reports that virtually all Klamath River basin populations of salmonids have declined considerably from their historical abundances, and note the significant link between the decline in coho, spring Chinook, and summer steelhead to the "verge of extinction" and their dependence on cool summer water temperatures. The NRC also notes that the Klamath River has become inhospitable to juvenile coho due to high water temperatures, and although the Klamath River is still important for rearing Chinook and steelhead, further increases in temperatures may make it unsuitable even for those species (NRC 2004, p.284). NRC (2004, p.268) state that in some respects, "…it is remarkable that fall-run Chinook salmon in the Klamath River are doing as well as they seem to be. Both adults migrating upstream and juveniles moving downstream face water temperatures that are bioenergetically unsuitable or even lethal." In 1991, the Klamath River Basin Fisheries Task Force (KRBFTF) identified increased stream temperatures in the lower Klamath River as impeding the recovery and posing threats to coho, winter steelhead, and late run fall Chinook (KRBFTF 1991, p.4-29). A discussion of how temperature and other water quality factors are contributing to fish mortality and salmonid population decline can be found in Section 2.6.1.

2.4.4.7 Impacts to Cultural and Harvest-Related Activities (D_a9, D_a10, D_a11)
The reduction of overall salmonid populations impacts the availability of fish for commercial, sport, and subsistence fish harvesting, as well as traditional and ceremonial uses. All of these activities require robust fish populations for long-term sustainable use of the resource. Thus, water temperatures, DO, pH, and ammonia toxicity outside the range of salmonid suitability can significantly impact these activities. Evidence of temperature and nutrient related impairment to harvest related activities is presented in Sections 2.6.2 and 2.6.4.

2.4.4.8 Impacts to Municipal Supply, Recreation, and Traditional/Cultural Use (D_b1, D_b2, D_b3, D_b4)
Elevated nutrient concentrations in the Klamath River basin have contributed to nuisance blooms of the blue-green algae *Microcystis aeruginosa*, which produces the cyanotoxin

microcystin. Exposure routes of cyanotoxin poisoning can be via direct water contact, ingestion of contaminated water, breathing of aerosolized toxin bearing water, and possibly secondarily through the ingestion of infected fish or other vertebrates, invertebrates, and plant matter. As detailed in Section 2.5.4 this toxin has been detected in Copco and Iron Gate Reservoirs at levels which are considered dangerous for contact or consumption, leading to the posting of public health warnings at the reservoirs and various locations along the river.

The Klamath River Tribes utilize the river for traditional and ceremonial uses including bathing, plant gathering, ingestion, and other activities discussed in Section 2.6.2. The presence of microcystin in the lower river presents a potential human health risk for the Tribes. Further, mats of suspended algae in the reservoirs and river are an aesthetic nuisance impacting the public's ability to enjoy the natural beauty of these waters leading to impacts on the Rec-1 and Rec-2 uses. Additionally, taste and odor problems are associated with high densities of blue-green algae, and these compounds are difficult and costly to remove from water supplies (Welch and Jacoby 2004, p.172).

2.5 Evidence of Water Quality Objective and Numeric Target Exceedances

This section presents observed water quality conditions and evaluates the data with respect to the relevant water quality objectives or surrogate thresholds.

2.5.1 Temperature and Nutrient Data Sources

Stream temperature data used for this analysis were provided by the US Forest Service, Yurok Tribe, Karuk Tribe, Forest Science Project, US Fish and Wildlife Service, Salmon River Restoration Council, and PacifiCorp. In addition, Regional Water Board staff collected temperature data.

For the DO and nutrient analyses, Regional Water Board staff compiled monitoring data from several sources including the US Fish and Wildlife Service, US Geological Survey, PacifiCorp, Karuk Tribe, Yurok Tribe, Regional Water Board, and the US Environmental Protection Agency Environmental Monitoring and Assessment Program.

2.5.2 Temperature

Regional Water Board staff conducted a literature review to evaluate stream temperature requirements for the various life stages of steelhead trout (*Oncorhynchus mykiss*), coho salmon (*Oncorhynchus kisutch*), and Chinook salmon (*Oncorhynchus tschawytscha)* as a means for interpreting the narrative temperature objective in the Basin Plan (Regional Water Board 2007). As a result of this literature review, Regional Water Board staff selected chronic and acute temperature thresholds for evaluating Klamath River basin temperatures. These temperature thresholds are used for assessing the suitability of current Klamath River basin temperatures for fully supporting salmonids. These thresholds are *not* numeric water quality targets used for calculating the Klamath River temperature TMDL. The numeric temperature targets are discussed in Section 2.3.1 and the specific temperature targets are presented in Chapter 5.

Chronic temperature thresholds were selected from the USEPA document *EPA Region 10 Guidance for Pacific Northwest State and Tribal Temperature Water Quality Standards* (2003), and are presented in Table 2.8. The Region 10 guidance is the product of a three-year interagency effort, and has been reviewed by both independent science review panels and the public. Lethal temperature thresholds were selected based upon best professional judgment of the literature, and are presented in Table 2.9. Although some studies of southern California steelhead suggest the possibility of higher temperature tolerances of salmonids occupying the southern end of the species range (Spina 2007), available studies from northern California indicate that the thresholds expressed in USEPA's guidance (2003) are appropriate for the north coast region (Welsh et al. 2001; Hines and Ambrose undated).

Table 2.8: MWMT chronic effects temperature thresholds

Life Stage	**MWMT (°C)**
Adult Migration	20
Adult Migration plus Non-Core Juvenile Rearing [1]	18
Core Juvenile Rearing [2]	16
Spawning, Egg Incubation, and Fry Emergence	13

Source: USEPA 2003

[1] The Adult Migration plus Non-Core Juvenile Rearing designation is recommended by USEPA (2003) for the "protection of migrating adult and juvenile salmonids and moderate to low density salmon and trout juvenile rearing during the period of summer maximum temperatures," usually occurring in the mid to lower part of the basin. The phrase "moderate to low density" is not specifically defined.

[2] The Core Juvenile Rearing designation is recommended by USEPA (2003) for the "protection of moderate to high density summertime salmon and trout juvenile rearing" locations, usually occurring in the mid to upper reaches of the basin. The phrase "moderate to high density" is not specifically defined.

Table 2.9: Lethal temperature thresholds

Lethal Threshold[1] (°C)			
Life Stage	**Steelhead**	**Chinook**	**Coho**
Adult Migration and Holding	24	25	25
Juvenile Growth and Rearing	24	25	25
Spawning, Egg Incubation, and Fry Emergence	20	20	20

Source: Appendix 4

[1] The lethal thresholds selected in this table are generally for chronic exposure (greater than seven days). Although salmonids may survive brief periods at these temperatures, they are good benchmarks from the literature for lethal conditions. See Appendix 4 for further discussion.

These freshwater temperature thresholds are applicable during the time of year when the life stage of each species is present in the Klamath River basin. Where life history, timing, and/or species needs overlap, the lowest of each temperature metric applies. A discussion of the distribution and periodicity of salmonids in the Klamath River basin is available in Appendix 5, *Fish and Fishery Resources of the Klamath River Basin*. Additional information on the effect of temperature on salmonids and a brief discussion of temperature metrics are available in Appendix 4.

2.5.2.1 <u>Mainstem Klamath River</u>

Temperature data from the Klamath River mainstem indicate that seasonal maximum temperatures are not supportive of beneficial uses. Figure 2.11 shows that MWMT values at all sites from the Oregon-California state line to the estuary are well above the suitable temperature range for full support of salmonids as described by USEPA (2003). These data clearly demonstrate that the river has no capacity to assimilate increased heat loads during the hottest critical periods without adversely affecting the beneficial uses COLD, RARE, and MIGR.

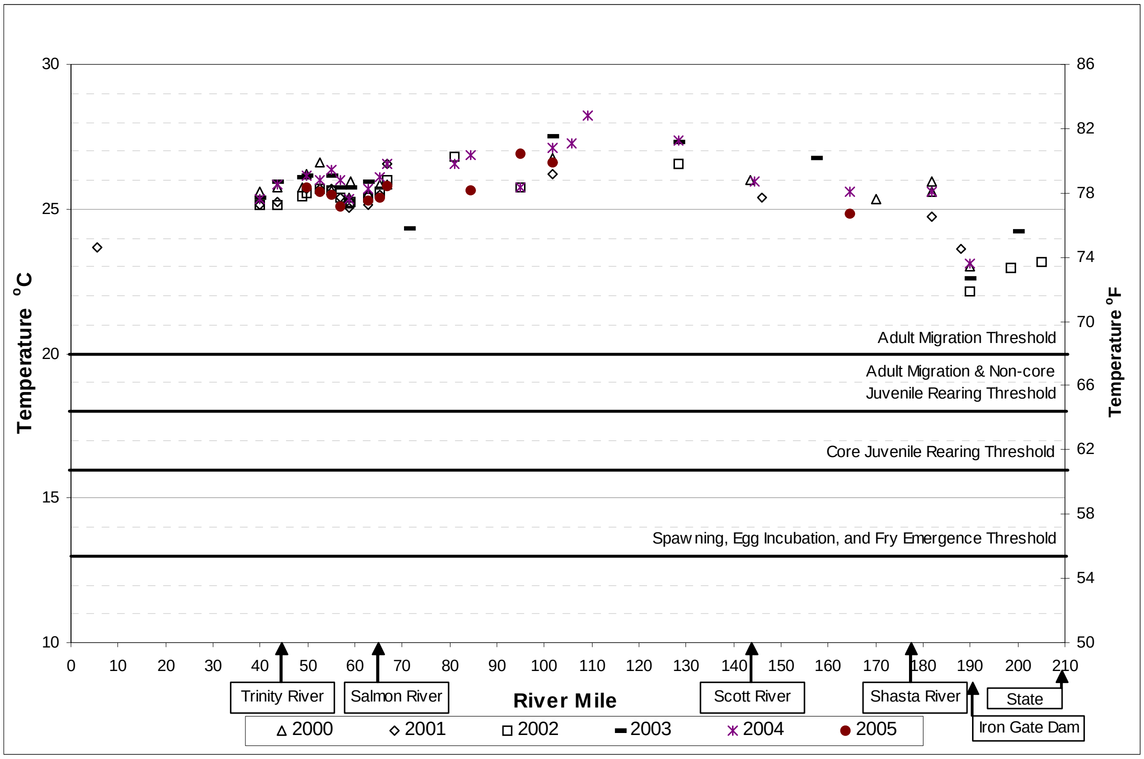

Figure 2.11: Measured Klamath River MWMTs, 2000-2005.
Note: MWMTs typically occur in late July.

The reduced diurnal temperature variation associated with the impoundments seen in Figure 2.12 also results in adverse impacts to coho salmon. The National Research Council report clearly summarizes the effects of elevated daily low mainstem temperatures on coho salmon:

> Overall, it appears that the bioenergetic demands of juvenile coho prevent them from occupying the main stem. Even with abundant food, the thermal refugia (the pools at mouths of tributaries) are inadequate: nighttime temperatures stay too high for them, and the energy costs of interactions with Chinook and steelhead, both of which are much more abundant in the pools, are probably high. Coho juveniles in the pools during June and July may die by late summer. (NRC 2004, p.220).

The results of water quality modeling completed for this TMDL process indicate that human activities have significantly altered the temperature regime of the mainstem Klamath River. The application of the water quality models is described in Chapter 3. These results indicate that the combined effects of human activities in the basin commonly result in temperature alterations in excess of 5 °F, and these alterations can be as much as 18 °F. Figure 2.12 presents simulated natural and current Klamath River temperatures, and the calculated difference, at the site of maximum temperature alteration in California.

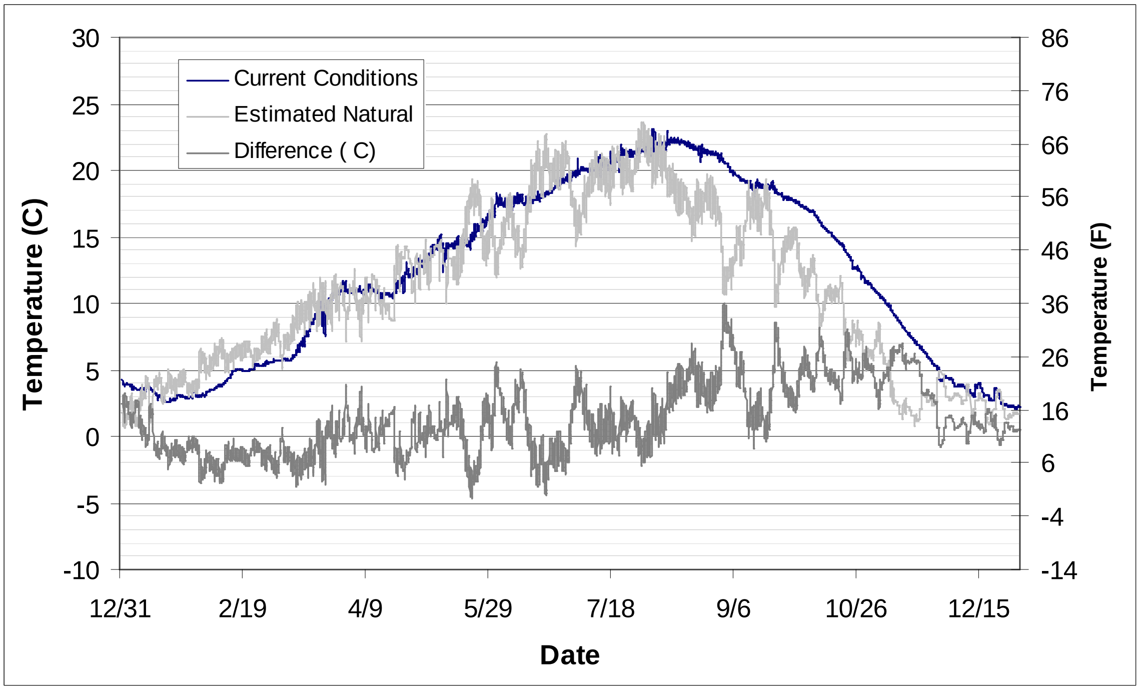

Figure 2.12: Current and estimated natural temperatures downstream of Iron Gate Dam, with difference in temperature, 2000
Note: Model results presented at 1-hour time step.

The results of the water quality modeling completed for this TMDL process are consistent with results of an analysis of temperature effects caused by the Klamath Hydroelectric Project in the 5 years from 2000-2004 (Dunsmoor and Huntington 2006). The results of that analysis are presented in Figure 2.13 and were developed using an earlier version of the modeling system used in this analysis.

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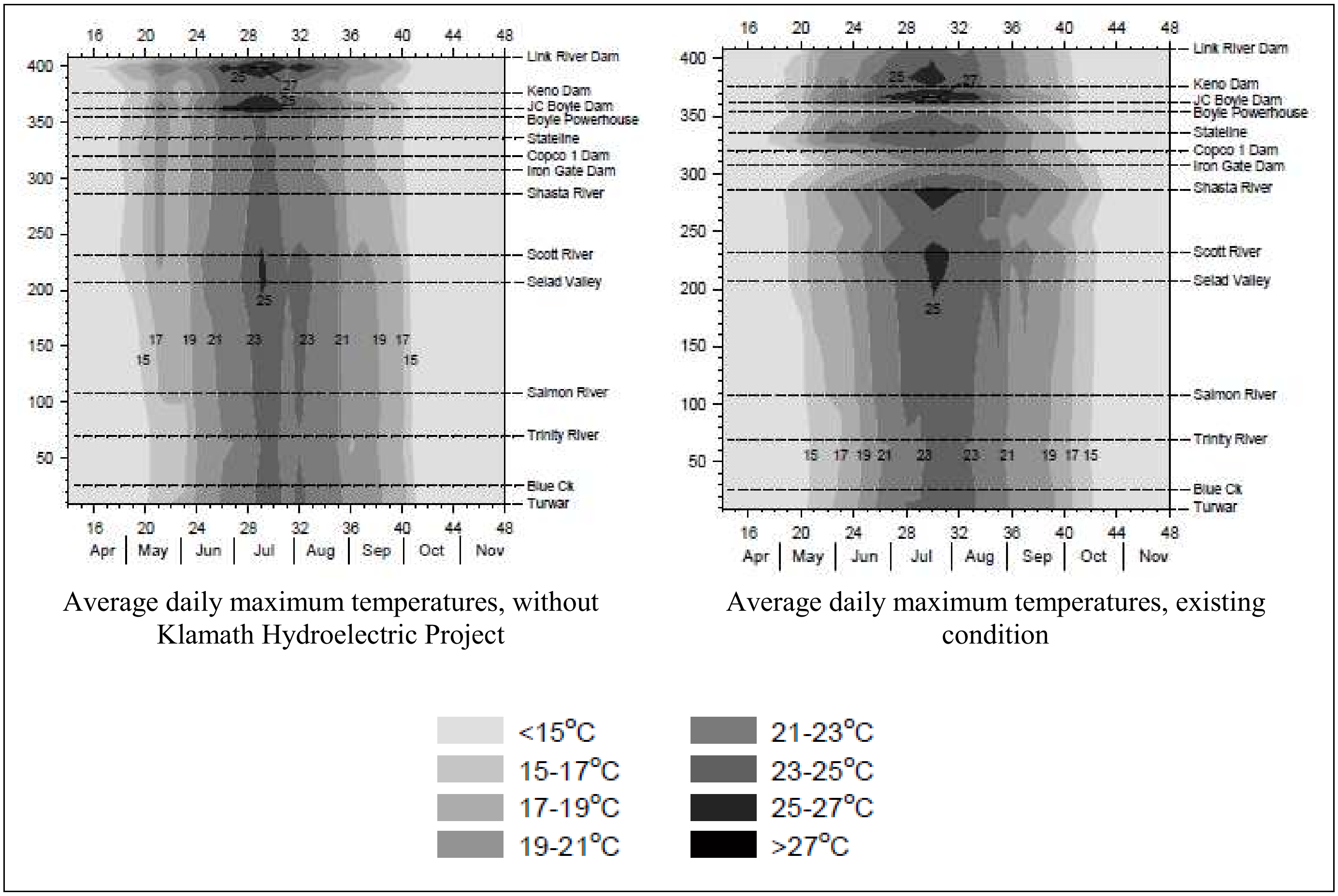

Figure 2.13: Simulated Klamath River temperatures, by week, 2000-2004.
Source: Dunsmoor and Huntington 2006

The temperature modeling indicates human impacts are responsible for the elevated temperatures that are above biological temperature thresholds for rearing juvenile salmonids and reproductive success of adult salmonids. Under current conditions, the seasonal increase in temperatures during the winter and spring months is delayed in comparison to estimated natural temperatures. Similarly, the seasonal decline in temperatures during the fall months is also delayed in comparison to estimated natural temperatures. Dunsmoor and Huntington (2006) evaluated the effects of the delay in the seasonal fall temperature decline on salmonids due to the Klamath Hydropower Project. They evaluated Pacificorp's model output data for the years 2000-2004. Their analysis of temperature alteration during the fall months indicates impaired spawning conditions resulting from the presence of the Klamath Hydropower Project, and is summarized in Table 2.10, below.

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Table 2.10: Summary of fall temperature effects resulting from human alteration at Iron Gate Dam.

	Pacificorp Model, 2000-2004 (Dunsmoor and Huntington, 2006)		**Klamath TMDL Model, 2000**	
Time Period	**Existing Condition**	**Without Project Condition**	**Existing Condition, MWMT (C)**	**Natural Conditions, MWMT (C)**
Sept. 10-23	Stressful or worse 90% of days	Stressful 9% of days	19.2	18.7
Sept. 24 – Oct. 7	Suboptimal or worse 100% of days	Suboptimal 37 % of days	18.1	15.5
Oct. 8 – Oct. 21	Suboptimal 70% of days	Suboptimal 1% of days	16.1	11.4
Oct. 22 – Nov. 4	Optimal 100% of days	Optimal 100% of days	12.9	8.2

Bartholow et al. (2005) concluded that in comparison to the expected temperatures resulting from a natural flow regime, the Klamath River dams create temperature conditions more favorable to migrating juveniles in the spring and less favorable to adults migrating and spawning in the fall. They suggested that the increased temperatures occurring later in the spring may increase growth rates. However, juvenile fish migrating down the Klamath River in the spring suffer high mortality rates due to C. Shasta, which is more virulent at temperatures that typically occur that time of year (see section 2.4.4.4 and Appendix A). Bartholow et al. (2005) further speculated that the changes in seasonal temperature patterns may have affected the timing of the Chinook salmon run since the dams were constructed.

The growth of juvenile salmonids is partially dependent on temperature (USEPA 2003). The optimal temperature range for juvenile salmonids is 10-15 ^{o}C, with a lower limit of 4 ^{o}C (USEPA 2003). The ability of salmonids to survive the ocean phase of their life cycle is partially dependent on their size upon entering the ocean. Thus, the delay in warming that occurs in the late winter may reduce the growth rates of salmonids rearing in the Klamath River, and may ultimately reduce the survival rate of salmonids in the ocean.

USEPA (2001) reviewed multiple literature sources and concluded that optimal protection of salmonids from fertilization through initial fry development requires that temperatures be maintained below 9-10°C, and that daily maximum temperatures should not exceed 13.5-14.5°C. Under current conditions, these temperatures are not reached until late October or November. However, the current Chinook spawning season begins in mid-September and peaks in late October (see Appendix 5 for more details).

In summary, the temperature alterations presented in Figure 2.12 result in adverse effects to salmonids. The comparison of estimated natural and current temperatures for the year 2000 at the location downstream of Iron Gate Dam clearly shows that the water quality objective for temperature is regularly exceeded. This conclusion is based on the observation that current temperatures are regularly more than 5^{o}F above the estimated natural temperatures, and the fact that there is no capacity to assimilate increased heat loads during the hottest critical periods without adversely affecting the beneficial uses.

2.5.2.2 Tributaries to the Klamath River

Tributaries are important habitat for Klamath River salmonids. Tributaries provide the majority of available rearing habitat for juvenile salmonids (NRC, 2004). In addition, many tributary mouth pools provide a refuge from higher mainstem temperatures for chinook salmon and steelhead (*Ibid*). Temperature data from the mouths of Klamath tributaries indicate that the seasonal maximum temperatures of the majority of the tributaries are not supportive of beneficial uses. The MWMT values at most of these sites are well above the non-core (low density rearing habitat) juvenile rearing threshold for salmonids suggested by USEPA (2003), as illustrated in Figure 2.14.

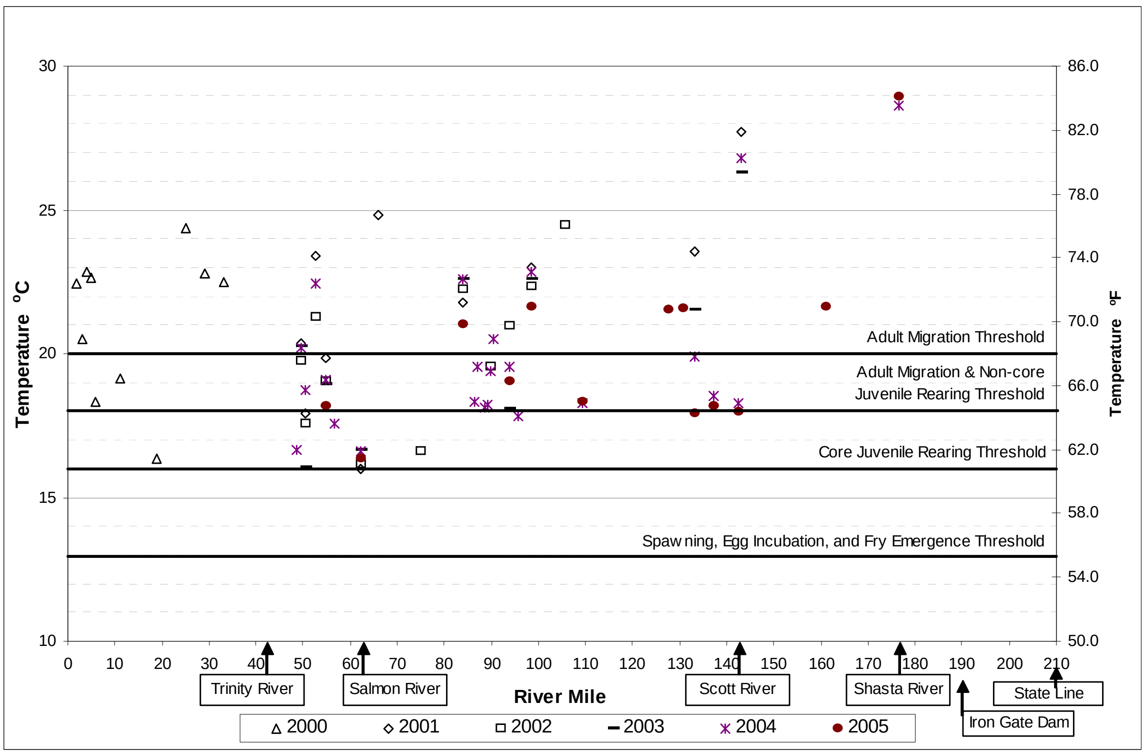

Figure 2.14: Klamath River tributary mouth MWMTs stream temperatures 2000-2005
Note: MWMTs typically occur in late July.

Of the twenty-two tributaries monitored in 2004 (the year with the most tributaries monitored), eighteen had MWMT values in excess of the adult migration and non-core juvenile rearing thresholds for salmonids suggested by USEPA (2003). These data clearly demonstrate that these tributaries have no capacity to assimilate increased heat loads during the hottest critical periods without adversely affecting beneficial uses.

The Shasta, Scott, and Salmon Rivers, three of the largest Klamath River tributaries, have been listed on the 303(d) list for temperature impairment separately. TMDL analyses developed for these tributaries have confirmed the temperature impairments, as well as the human contribution to elevated temperatures in these basins.

Although the temperatures are high relative to the temperature requirements of salmonids (USEPA 2003), the high temperatures do not exceed the water quality objective for temperature unless they are elevated due to human activities, such as riparian vegetation removal and altered channel morphology. However, it is well documented that the erosion associated with the 1997 flood in the Klamath River basin resulted in widespread stream channel alteration, loss of riparian vegetation, and shade reductions (further discussed in Section 2.5.8) and that a significant amount of the erosion was caused or exacerbated by human activities (De La Fuente and Elder 1998). Similarly, it is well known that historic mining, road building, and silvicultural practices have resulted in riparian disturbances and consequent reductions of stream shade in many tributaries (Elder et al. 2002; KNF 1999; KNF 2002). Therefore, Regional Water Board staff conclude that enough information exists to confirm impairment and justify TMDL development and implementation.

2.5.2.3 Reservoirs

The available Iron Gate and Copco Reservoir temperature and DO profile data indicate that during summer stratified conditions, temperatures are only suitable for cold water species, including salmonids, rearing at depths where the DO concentrations are near lethal levels. Redband/rainbow trout are currently present in both Copco and Iron Gate Reservoir (PacifiCorp 2004b, p.4-53 - 4-55, 4-58). A representative example of typical summer conditions is illustrated in the vertical profiles of DO concentration and temperature that are presented in Figure 2.15 for Iron Gate Reservoir.

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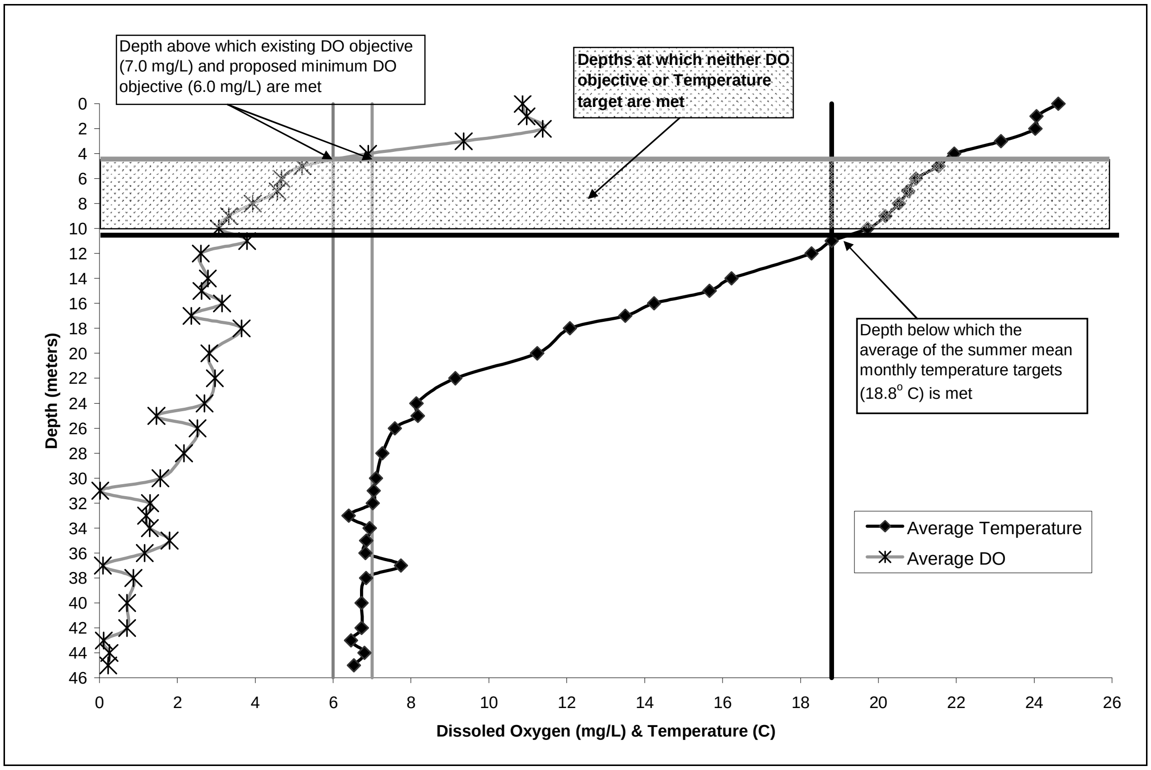


Figure 2.15: Dissolved oxygen and temperature depth profiles in Iron Gate Reservoir – average for July and August 2000 – 2005

The same pattern exists for Copco and for other years. The reservoirs become thermally stratified in the summer months. The stratification of the reservoirs prevents mixing of the low temperature/low DO waters with the high temperature/high DO waters, and thus there are no depths in the reservoirs at which the most sensitive beneficial uses are supported. Given that the stratification and the absence of suitable habitat is due to the presence of the reservoirs, Regional Water Board staff have concluded that the reservoirs contribute to exceedances of the temperature and DO water quality objectives.

2.5.3 Nutrients and Indicators of Nutrient-Related Impairment

Except in extreme cases, nutrients alone do not impair beneficial uses. Rather, they cause indirect impacts through their biostimulatory effect on algal growth, low DO, and extreme pH conditions among others that can impair uses. The water quality objectives with distinct numeric limits include DO and pH. The California Nutrient Numeric Endpoints (CA NNE) framework (Tetra Tech 2006) indentifies indicators for biostimulatory effects that can impair beneficial uses, including benthic algal biomass, planktonic chlorophyll-a concentrations, and diurnal DO and pH fluctuations. Other indicators included here are toxic blue-green algae (*Microcystis*) concentrations, and un-ionized ammonia.

2.5.3.1 <u>Nutrient Concentrations</u>

The primary driver for the nutrient conceptual model is the increased loading of nutrients to the Klamath River ecosystem. High levels of nutrient loading and elevated water column concentrations do not alone result in biostimulatory conditions, but excess nutrients are an essential precondition to this finding. Therefore the first step in evaluating impairment due to biostimulatory conditions is to determine whether existing nutrient loading and water column concentrations exceed natural baseline conditions. If it is determined that nutrient levels above natural baseline concentrations are present in the system, then the CA NNE secondary endpoints are evaluated to determine whether they have exceeded the Beneficial Use Risk Category Level III boundary for impaired waters. It is when both natural baseline nutrient levels and CA NNE Level III indicator boundaries have been exceeded that a finding of impairment due to biostimulatory conditions can be supported.

Several sources within the Klamath and Lost River watersheds contribute nutrient loads. Some of the key sources include irrigated agriculture return flows, internal nutrient cycling from nutrient enriched sediments (especially within UKL), nutrients released as a result of wetland conversion, sediments from external sources derived from land disturbance activities, and to a much lesser extent, point sources. The analysis of Klamath River nutrients involves a comparison of estimated natural baseline water column concentrations of several nutrient species to existing conditions concentrations. Natural baseline conditions are estimated based on TMDL model simulations (described in Chapter 3). These estimates are not interpreted literally but only as approximations of conditions that may have existed under natural conditions. The natural baseline conditions modeling scenario provides an estimate of nutrient loads and concentrations generated from a landscape with minimal anthropogenic disturbance. The existing conditions values come from the mean concentration of composite grab samples taken during the summer (June 1 to September 30) at twelve stations by various organizations from 1996 to 2007. Each station has at least three samples for each summer season over five years. Several stations have a much greater sampling density. The assumption for this analysis is that the annual and daily variability converges to an average over the course of a large number of samples that represent typical conditions during the summer growing season.

The purpose of the comparison is to evaluate whether nutrients have been increased by human related activities above the levels that could cause a nuisance, or adversely affect the ability of water to support specified beneficial uses. This approach does not allow for a complete mass balance comparison for the river since winter flows and concentrations have not been monitored. Rather, the information serves to provide a relative comparison of the mean summer concentrations of total nitrogen and total phosphorus to which aquatic life respond under current and natural baseline conditions (Figures 2.16 and 2.17). The left side of Figures 2.16 and 2.17 present existing conditions from stateline to the estuary, while the right side of the figure presents concentrations under natural baseline conditions. At most stations the existing summer mean concentrations for both total phosphorous and total nitrogen exceed the natural baseline conditions. Frequently the existing summer mean concentrations are more than double the natural background summer mean concentrations and can be up to five times higher than concentrations under the natural conditions baseline scenario. It is important to note that the summer mean for natural baseline conditions is based on two years of model runs versus 12 for existing (current) and that this may underestimate variability in natural conditions. These results suggest that human activities have increased nutrient loads to the Klamath River.

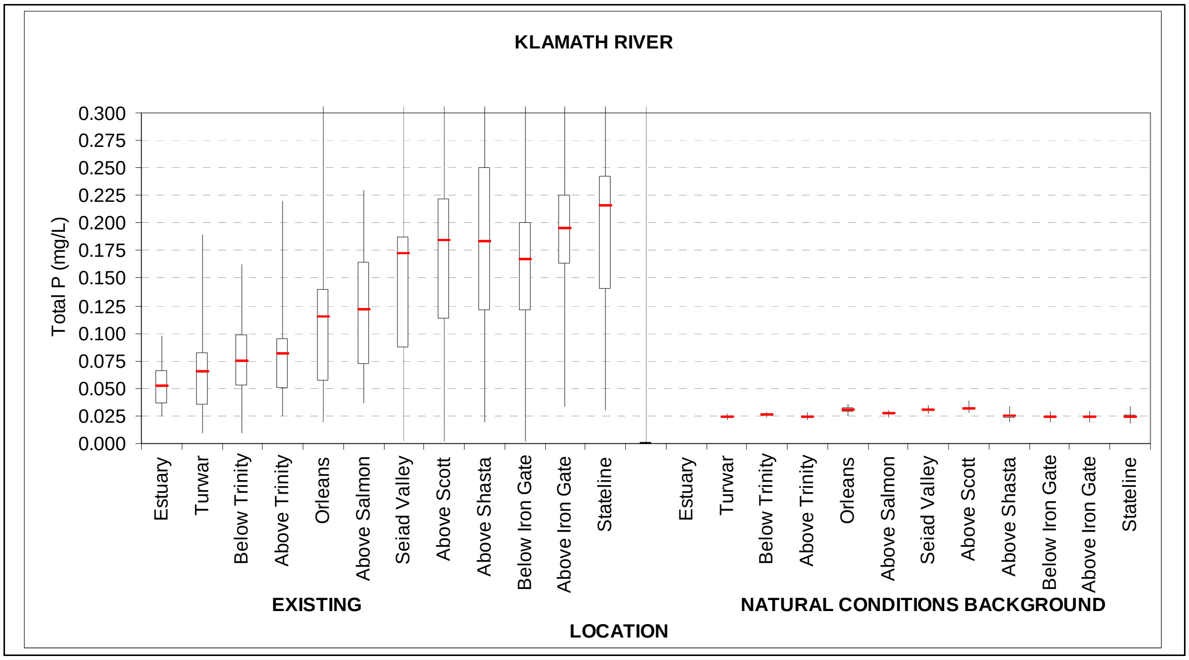


Figure 2.16: Comparison of total phosphorous concentrations for existing conditions (consolidated monitoring data 1996-2007) with estimated (TMDL model) natural baseline conditions at Klamath River monitoring stations in California.

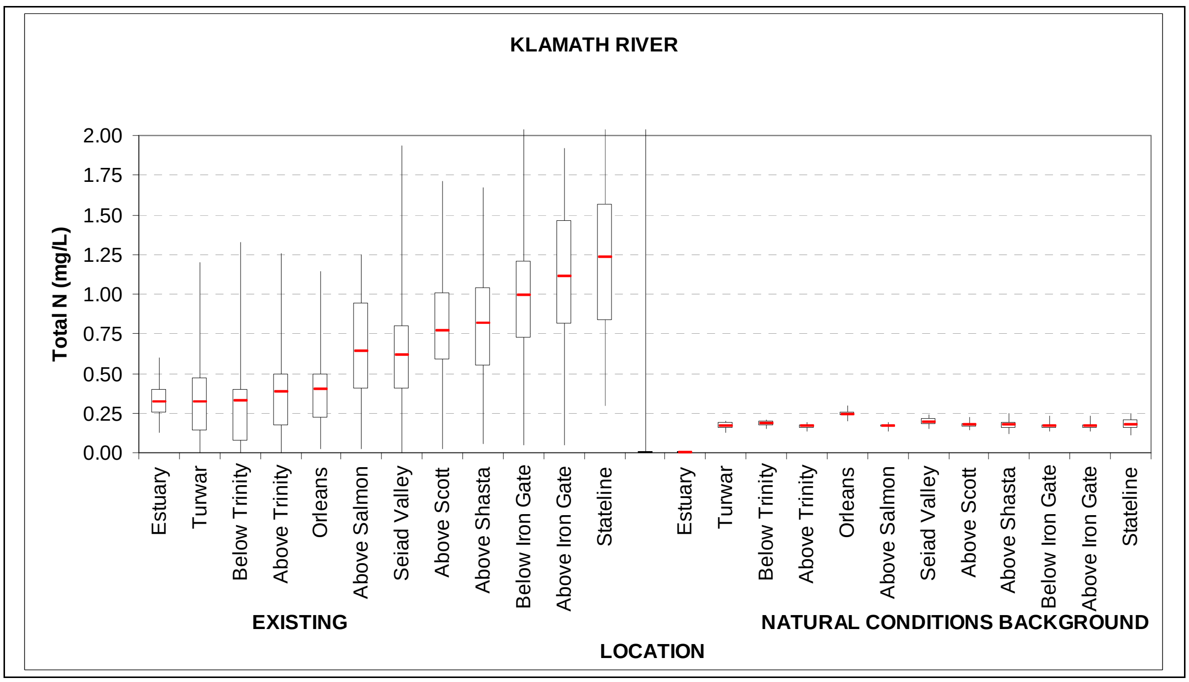


Figure 2.17: Comparison of total nitrogen concentrations for existing conditions (consolidated monitoring data 1996-2007) with estimated (TMDL model) natural baseline conditions at Klamath River monitoring stations in California.

2.5.3.2 Benthic Algal Biomass

Figure 2.18 presents the results of composited benthic algae biomass monitoring samples collected during summer months in 2003, 2004, 2006, and 2007.

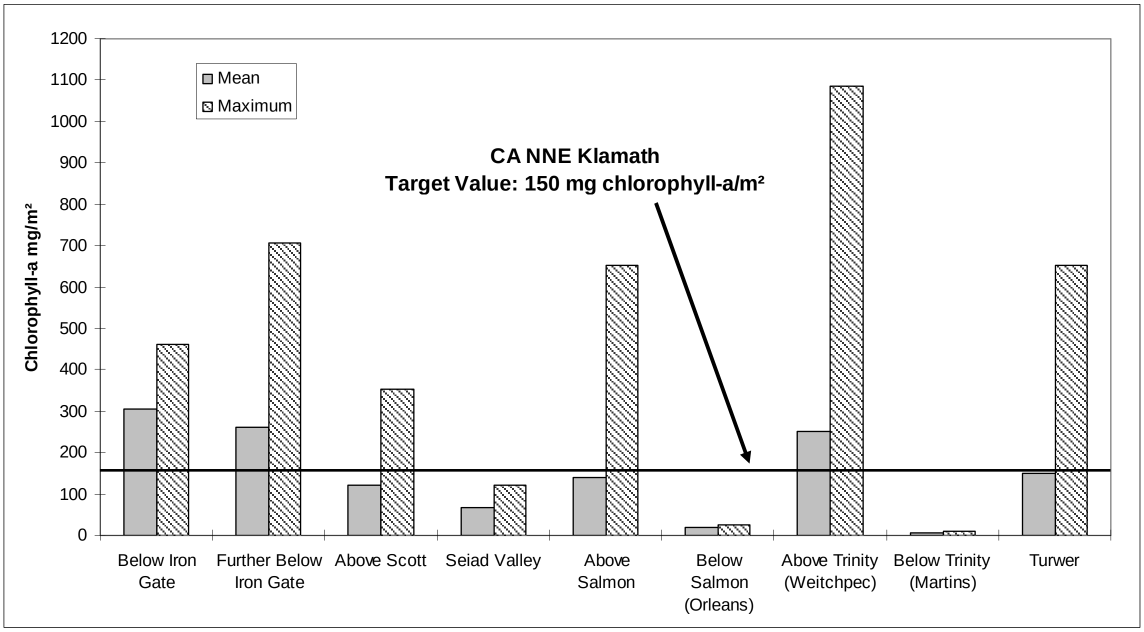


Figure 2.18: Consolidated benthic algal biomass monitoring results (summer mean and maximum) for 2003-2007 with CA NNE/TMDL numeric target.

There are a total of fifty samples for nine stations. The spatial and temporal sampling density is not ideal, but does indicate that during the summer months Klamath River benthic algae biomass in California exceed the CA NNE and TMDL numeric target of 150 mg chl-a/m^2 at several stations.

As demonstrated in the following sections, these benthic algae conditions have a direct impact on water quality via algal photosynthesis and respiration. In addition, the benthic algal biomass densities also provide habitat for polychaetes that serve as a host and source for the fish parasite *C. shasta.* In summary, existing benthic algal biomass conditions strongly suggest impairment.

2.5.3.3 Diurnal DO and pH

For several stations along the Klamath River the diurnal photosynthesis and respiration cycle is strongly influenced by dense colonies of benthic algal biomass which result in extreme diurnal cycles for DO and pH. The water quality conditions of frequent and chronic low DO and high pH illustrated in Figures 2.19 through 2.21 create chronic stressful conditions for fish populations.

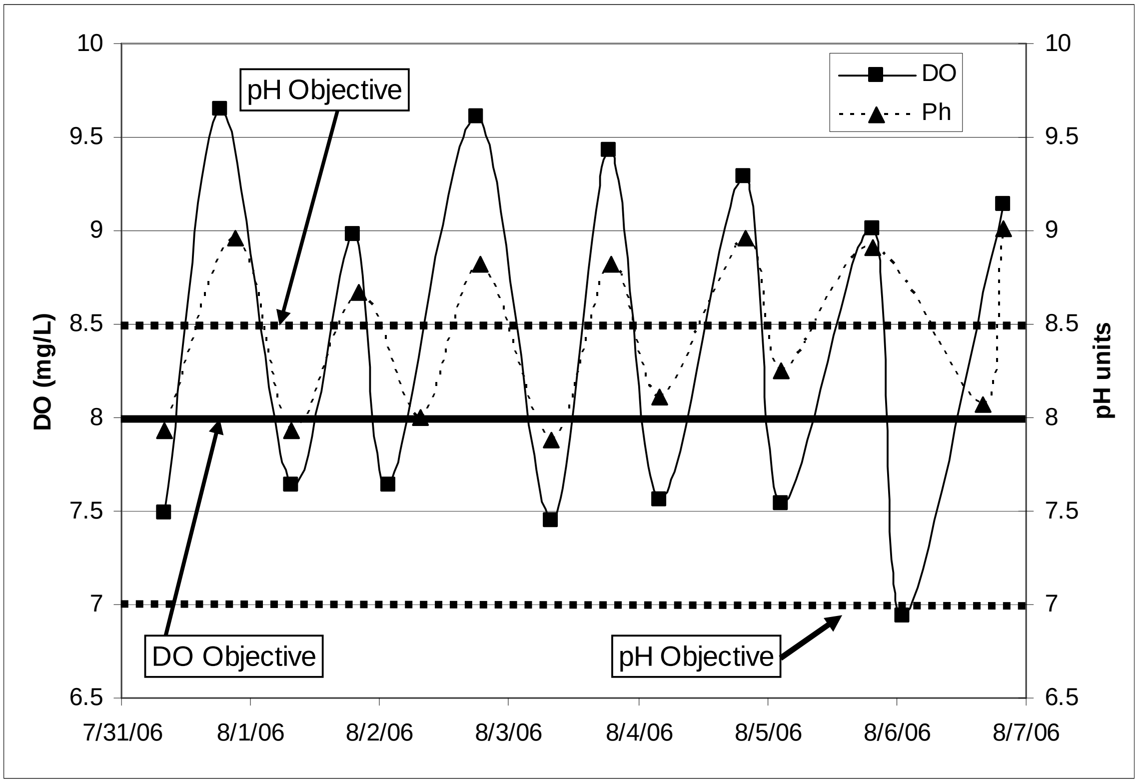


Figure 2.19: Example diurnal DO and pH cycle below Iron Gate Dam, summer 2006

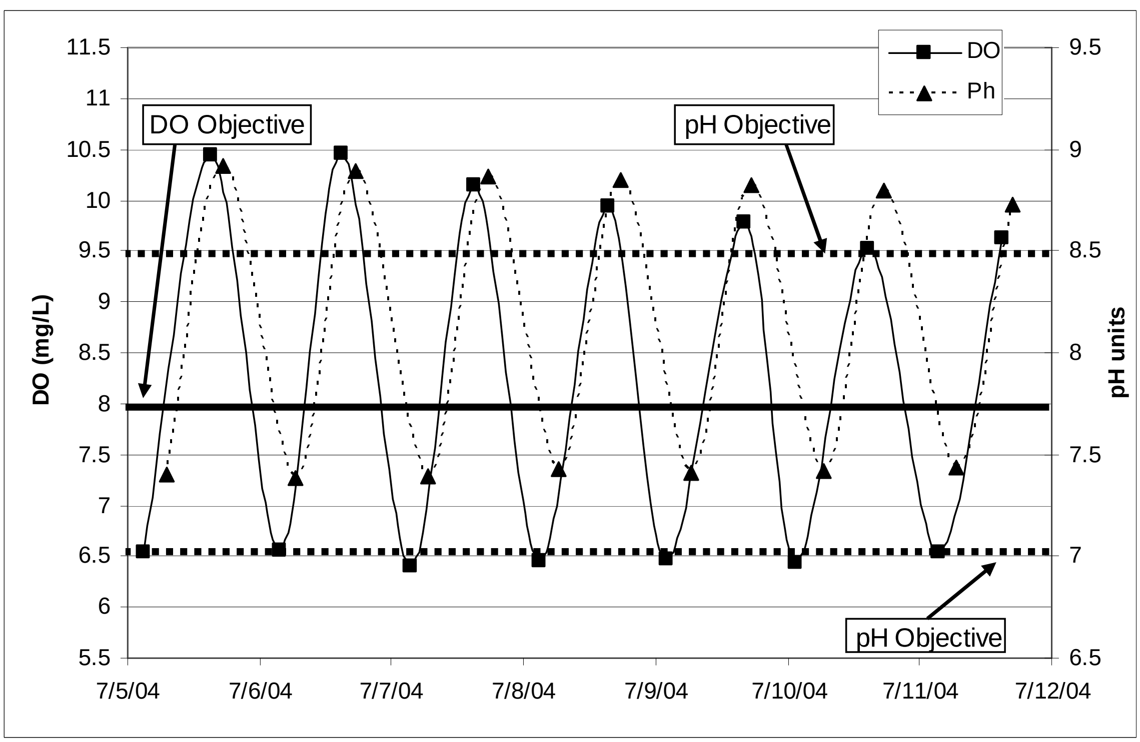


Figure 2.20: Example diurnal DO and pH cycle above the Shasta River, summer 2004

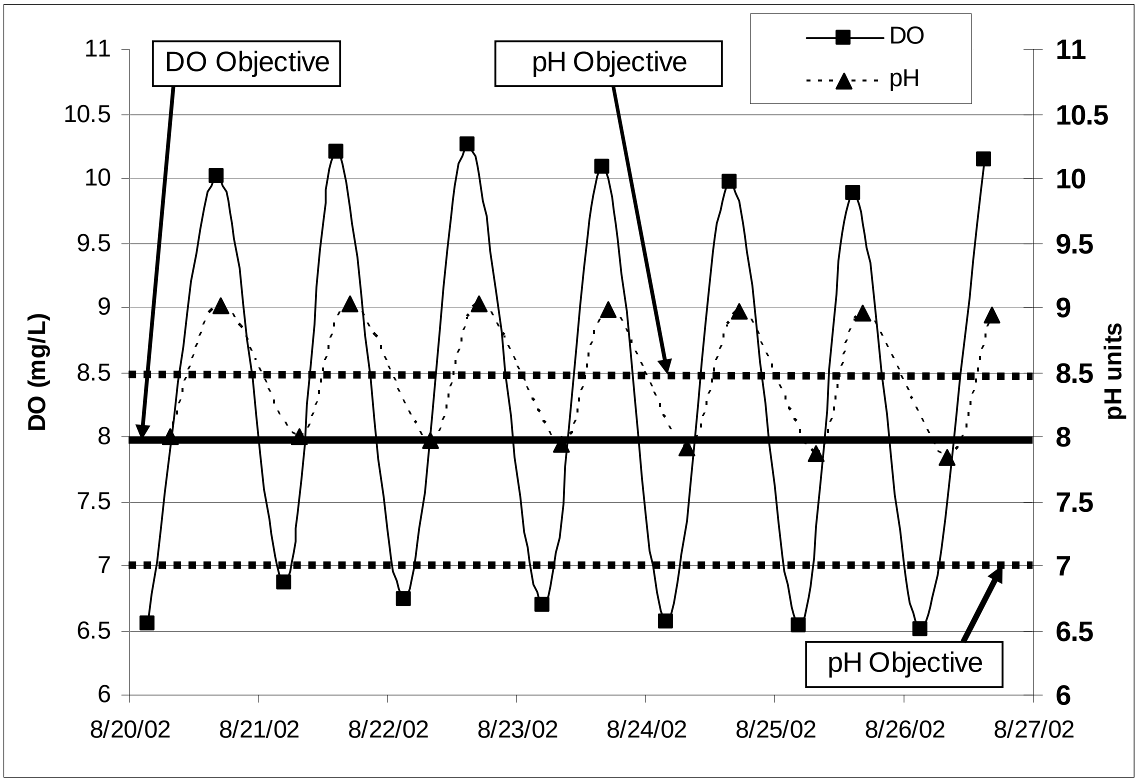
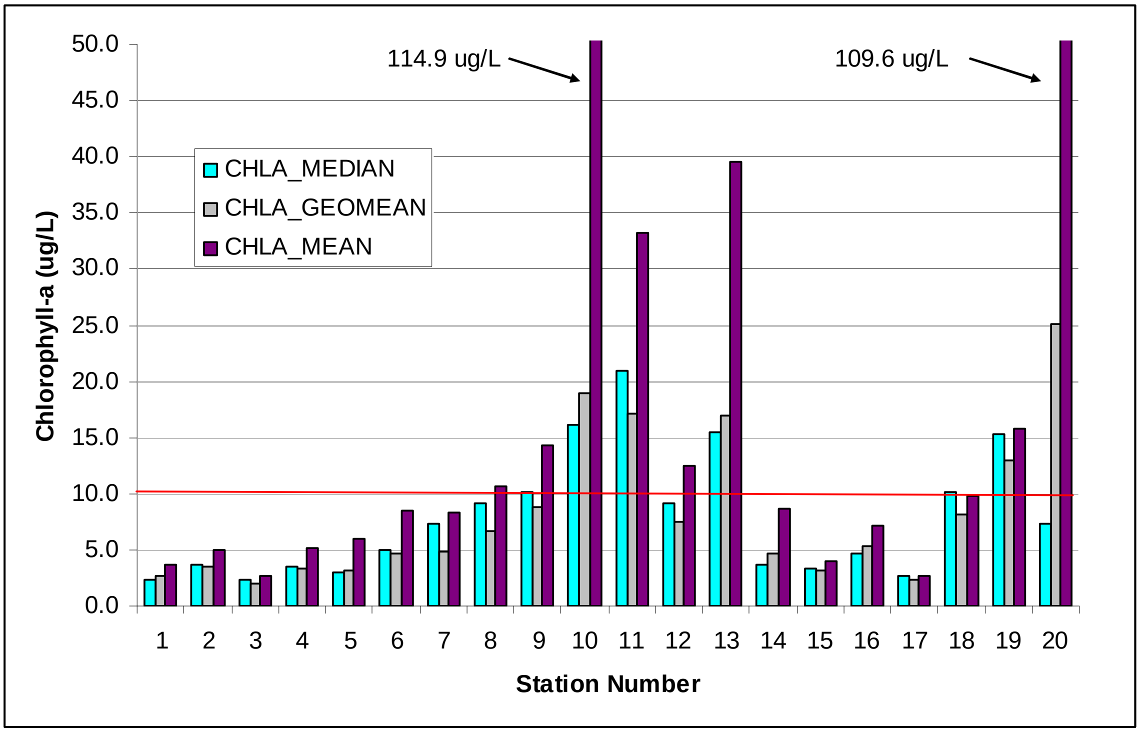


Figure 2.21: Example diurnal DO and pH cycle at Seiad Valley, summer 2002

While the three plots present monitoring data from single stations, the observed pattern is consistent with summer months for other years when diurnal data has been collected and for other stations along the Klamath River. Both the existing DO objective (>8 mg/L) and pH objective (not greater than 8.5 and not less than 7.0) for the Klamath River downstream of Iron Gate Dam are exceeded on a regular basis. The extreme magnitude and regular frequency of these excursions indicate impairment from biostimulatory substances (i.e., nutrients).

2.5.3.4 Chlorophyll-a – Reservoirs

Figure 2.22 compares various measures of central tendency (mean, geometric mean, and median) of the chlorophyll-a data from samples collected during the summer period (May – September) of 2005, 2006, and 2007 by the Yurok Environmental Program, Karuk Tribe of California Natural Resources Department, and PacifiCorp at twenty stations along the Klamath River.



Station List:

1 - Lower Estuary (n=11)
2 - Turwar (n=19)
3 - Below Weitchpec (n=17)
4 - Weitchpec (n=19)
5 - Orleans (n=19)
6 - Seiad Valley (n=26)
7 - Walker Bridge (n=13)
8 - I-5 (n=16)
9 - Below Iron Gate Dam (n=61)
10 - Iron Gate Res. Lower (n=49)
11- Iron Gate Res. Upper (12)
12 - Copco Res. outflow (n=37)
13 - Copco Res. Lower (n=49)
14 - Copco Res. Upper (n=11)
15 - Above Shovel Creek (n=40)
16 - Below JC Boyle Dam (n=9)
17 - JC Boyle Res.(n=3)
18 - Above JC Boyle Res.(n=17
19 - Keno Dam (n=20)
20 - Link Mouth (n=7)

Figure 2.22: Comparison of central tendencies of summer (May – September) chlorophyll-a measurements for 2005, 2006, and 2007 at twenty monitoring stations along the Klamath River. Data from Yurok Tribe Environmental Program, Karuk Tribe of California Natural Resources Department, Regional Water Board, and PacifiCorp.

It is important to note that the data presented are from samples collected by different entities using similar but not identical protocols and the number and timing of samples vary from station to station. Presentation of the mean, geometric mean, and median values of a data set provides a useful way to assess the spread of the data. A close similarity between median and mean values is an indication that the data set is normally distributed. The geometric mean[9] is a useful measure of central tendencies when the data is log normally distributed. All three measures of central tendencies for each station are illustrated in Figure 2.22 allowing a station by station comparison of the three measures. Figure 2.23 presents the same data in box and whisker diagrams. The shoulders of the

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9 To calculate a geometric mean of the distribution values (i.e., chlorophyll-a concentrations) the following steps are taken: 1) log transform the data; 2) calculate the mean of the logged values; and 3) then antilog (raise to 10th power) the mean.

box and whisker diagram represent the 75th and 25th percentile of the distribution of measurements; the median (50th percentile) is the solid line across the box.

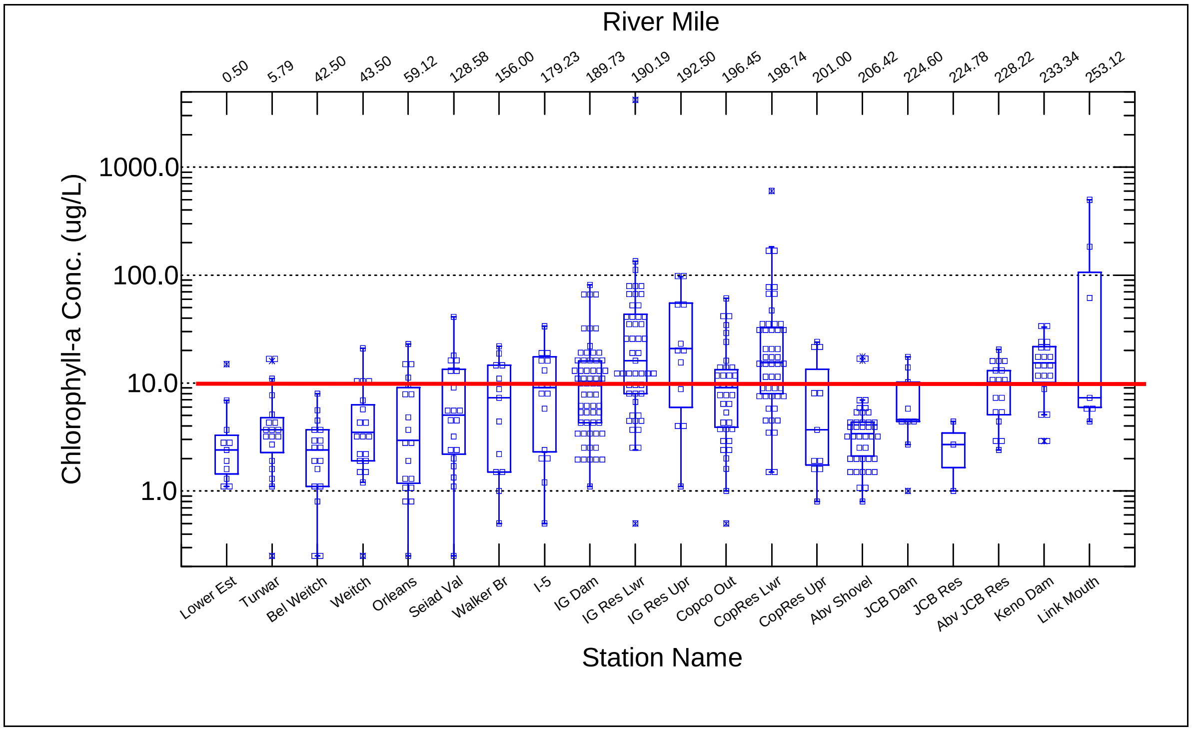

Figure 2.23: Longitudinal analysis of summer (May through September) chlorophyll-a concentrations from 2005 – 2007 along the Klamath River.
Data from Yurok Tribe Environmental Program, Karuk Tribe of California Natural Resources Department, Regional Water Board, and PacifiCorp

Each of the central tendency measures of chlorophyll-a for the Klamath River reservoir stations in California (Copco and Iron Gate) exceed the numeric target of 10 µg/L. There are also high concentrations of chlorophyll-a at Link Mouth, and at Keno Dam and above JC Boyle Reservoir. The high concentrations at these three stations are due in large part to residual algal biomass from Upper Klamath Lake. At most stations the median and the geometric mean are relatively similar, and the mean is higher than both the median and geometric mean. At the California reservoir stations (stations 10-14) however, the mean is significantly higher than either the median or the geometric mean. The very high means can be attributed to the nuisance algae bloom events during the late summer months.

The longitudinal analysis illustrated in Figures 2.22 and 2.23 demonstrates the effect of quiescent waters and the susceptibility of reservoirs on the Klamath River to nuisance algal blooms. Within Upper Klamath Lake and within the reservoirs summer mean and median chlorophyll-a concentrations are substantially higher than at the stations located in the free-flowing sections of the river. Chlorophyll-a concentrations rapidly attenuate downstream of Upper Klamath Lake and the reservoirs.

Nuisance algal blooms within Iron Gate and Copco Reservoirs are well documented in the regular blue-green algae monitoring program reports by the Karuk Tribe of California Natural Resources Department and PacifiCorp. As illustrated in Figure 2.24 the summer (May – September) mean concentrations of chlorophyll-a at all of the reporting stations for the reservoirs are at or above the summer mean numeric target of 10 µg/L. The summer mean concentrations at three of the four stations are more than double the target and the maximum concentrations are generally an order of magnitude higher.

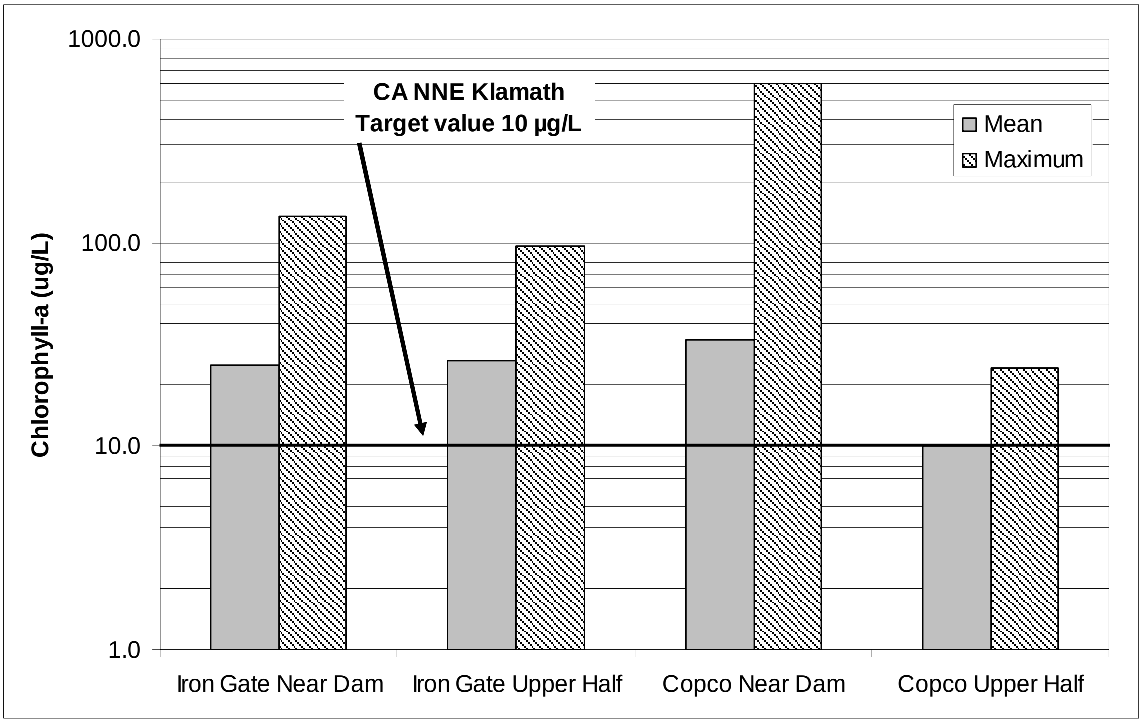

Figure 2.24: Summer (May – September) mean and maximum concentrations of chlorophyll-a (2000 – 2007) at four stations within the Iron Gate and Copco Reservoirs.

Figure 2.25 presents Regional Water Board staffs' seasonal analysis of PacifiCorp 2007 and 2008 data. The data shows an increase in total phytoplankton biovolume below Iron Gate Dam (Station KRBI) compared with above Copco Reservoir (Station KRAC). Normality tests performed on stations above and below the reservoirs showed non-normal distribution. Normality notwithstanding, the Figure 2.25 time series graphs show a distinct seasonal (June -September) increase in total algal biomass (biovolume) below the reservoirs in 2007 and 2008. Two nonparametric tests of the June - September 2007-2008 data show that the distribution of total algal biovolume is significantly greater below the reservoirs than above (Kolmogorov-Smirnov Two-Sample Test [p=0.034] and Kruskal-Wallis Mann-Whitney U Test [p=0.08]).

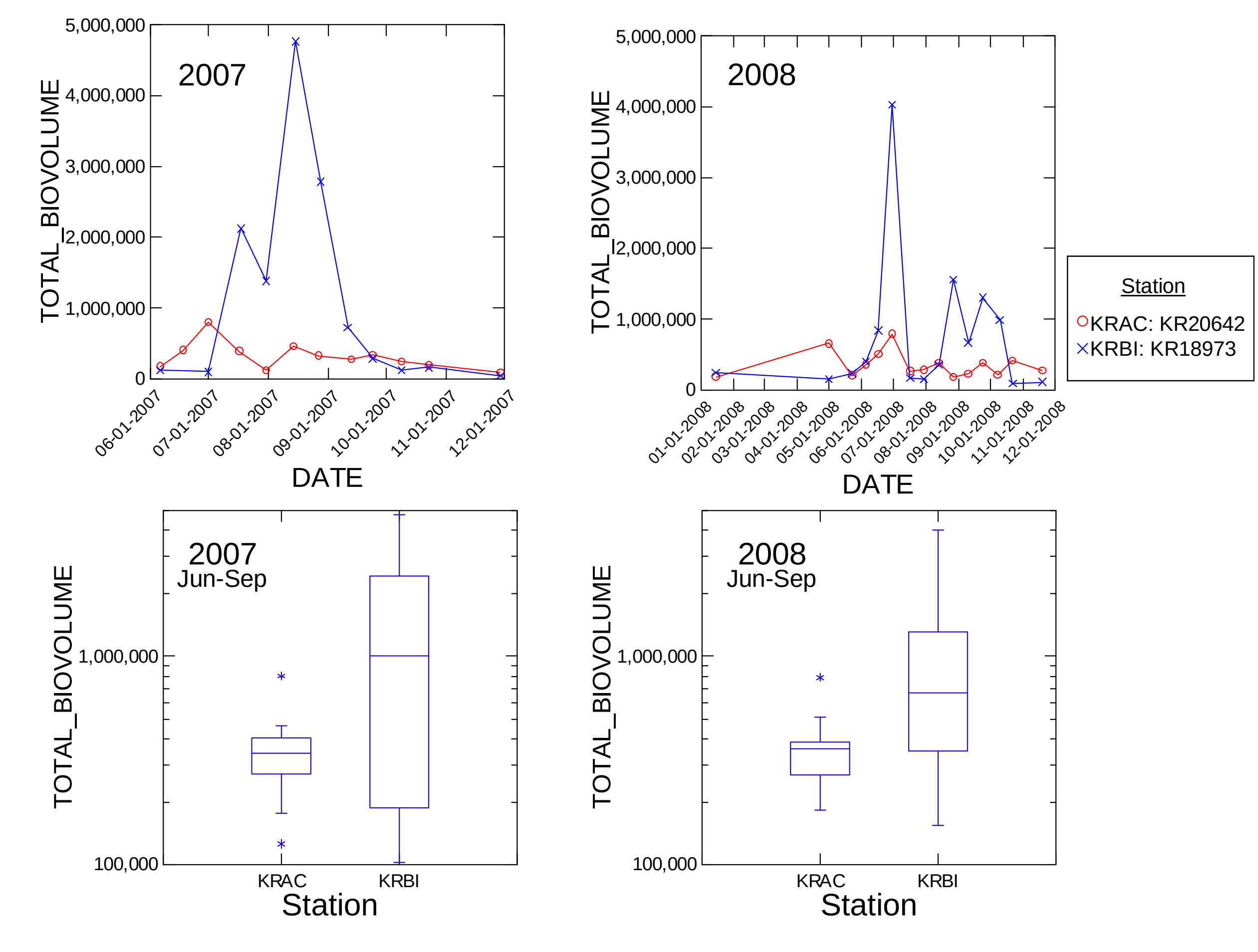

Figure 2.25. Comparison of above Copco Reservoir (Station KRAC; KR20642) and below Iron Gate Dam (Station KRBI; KR18973) biovolume for the summer 2007 and 2008. Data collected by PacifiCorp (http://www.pacificorp.com/es/hydro/hl/kr.html#).

The high concentrations of chlorophyll-a in the reservoirs have water quality impacts downstream. Suspended algae (and their breakdown products) entrained in water released from Iron Gate Reservoir may become available as a food source for polychaetes in the river reaches below the dam. In addition, these algal biomass can be deposited in the river bottom sediments, enhancing habitat conditions for polychaetes which contribute to higher levels of *C. shasta* parasite spores, and therefore contribute to higher rates of infection (Bartholomew et al. 2007; Bartholomew and Bjork 2007). The available data is insufficient to determine how the reservoirs alter the amount and form of particulate organic matter. Therefore, the net effect of fine particulate organic matter exported from the reservoirs on polychaete populations in the river downstream is unclear.

As discussed in more detail in Section 2.5.4, the reservoirs do impact the river below Iron Gate by serving as a source of blue-green algae to downstream water that can continue to grow in backwater and slower sections within the river reaches below the dams (Kann and Corum 2009, Kann and Asarian 2005). The export of algal biomass (including blue-green algae) has been documented by monitoring data showing that both *Microcystis* and microcystin are substantially higher within and below the reservoirs than they are directly upstream. For example, see Raymond (2009; *Phytoplankton Species and Abundance Observed During 2008 in the vicinity of the Klamath Hydroelectric Project* (Report prepared for CH2MHILL and PacifiCorp) which clearly illustrates (Figures 13 and 15) an increase of both *Microcystis* and microcystin toxin within the reservoirs and downstream.

In summary, the available chlorophyll-a and biovolume data suggest that the Iron Gate/Copco Reservoir complex significantly increases the quantity of algal biomass supplied to the river below Iron Gate Dam **and are a net sources of live algae to the river during the algae growing season.** Included in this algal biomass is blue-green algae **that** potentially serves as an in**n**oculant contributing to **nuisance conditions** in downstream backwater habitats. **However, the available data is insufficient to determine the net downstream effect of the reservoirs as a source of dead and decaying particulate organic matter.**

2.5.4 Blue-Green Algae and Microcystin Toxin

An important aspect of the nuisance algae conditions within Copco and Iron Gate Reservoirs is the periodic dominance of toxic blue-green algal species during the summer season. There are many forms of blue-green algae, both toxic and non-toxic. This discussion focuses primarily on *Microcystis aeruginosa* since it has become the dominant species of concern on the Klamath River in California. The frequent documented occurrence of seasonally high concentrations of *Microcystis aeruginosa* and microcystin in reaches of the Klamath River within California in each of the last several years has resulted in the documented impairment of beneficial uses including Native American Culture (CUL), Subsistence Fishing (FISH), Water Contact Recreation (REC-1), Non-Contact Water Recreation (REC-2), Municipal & Domestic Supply (MUN), Shellfish Harvesting (SHELL), Aquaculture (AQUA), Agricultural Supply (AGR), and Commercial and Sport Fishing (COMM), as discussed below. Ongoing research may also demonstrate a direct effect on the health of aquatic organisms from exposure to high levels of microcystin which would lead to the addition of other beneficial uses to this list (de Figueiredo et al. 2004).

Routine public health monitoring of blue-green algae in the Klamath River basin began in 2005. Every year since 2004 *Microcystis aeruginosa* counts and microcystin concentrations on the Klamath River have exceeded the Blue Green Algae Work Group action levels for harmful algal blooms. Table 2.11 summarizes the blue-green algal monitoring data for the years 2006, 2007, and 2008 with respect to the Blue Green Algae Work Group action levels. Data presented in the table is summarized by reach: *Reach 1*) Oregon to Iron Gate Dam; *Reach 2*) Iron Gate Dam to Scott River; *Reach 3*) Scott River to Trinity River; and *Reach 4*) Trinity River to Estuary. The blue-green algae listing criteria are most frequently exceeded in Reach 1, which is primarily composed of sample sites within Copco and Iron Gate Reservoirs. Late summer conditions are typically characterized by dense blue-green algae blooms that form thick viscous scums in parts of the reservoirs. The bloom conditions at times span much of the open water areas within the reservoirs. The reservoirs have been posted with public health advisory signs as a result of these summer blooms in 2006, 2007, and 2008.

Table 2.11: Summary of blue-green algae and microcystin monitoring data for 2006, 2007, and 2008

Reach Name	Reach #	Year	# of monitoring samples that exceed thresholds and targets		
			MSAE Cells ≥ 40,000 ml/L	microcystin ≥ 8 ug/L	Tissue ≥ 26 ng/g
Oregon to Iron Gate Dam	1	2006	27	29	*
Iron Gate Dam to Scott River	2	2006	1	1	*
Scott River to Trinity River	3	2006	2	0	*
Trinity River to Estuary	4	2006	0	0	*
Oregon to Iron Gate Dam	1	2007	47	35	41
Iron Gate Dam to Scott River	2	2007	2	0	1
Scott River to Trinity River	3	2007	4	0	4
Trinity River to Estuary	4	2007	2	0	*
Oregon to Iron Gate Dam **	1	2008	**	14	0 ***
Iron Gate Dam to Scott River	2	2008	4	2	*
Scott River to Trinity River	3	2008	9	4	*
Trinity River to Estuary	4	2008	1	1	*

* Data not collected during this period

** Not all data from monitoring programs available at time of report publication.

*** Tissue samples taken prior to bloom to determine baseline conditions, samples were not taken during bloom.

Data sources: Yurok Environmental Monitoring Program Blue-Green Algae Annual Reports: 2006, 2007, and 2008; Karuk Tribe of California Natural Resources Department Blue Green Algae Monitoring Annual Reports: 2006, 2007, and 2008; and PacifiCorp Blue-Green Algae Monitoring Program annual Reports: 2006, 2007, and 2008.

Table 2.11 also shows high concentrations of *Microcystis aeruginosa* downstream of the Iron Gate Dam in reaches 2, 3, and 4. Some reaches of the Klamath River mainstem were posted with public health advisory signs during the summers of 2008 and 2009. Algae related sampling protocols in the Klamath River have evolved since routine sampling began in 2004. Before 2008 most samples on the Klamath River mainstem were taken from the river at higher velocity areas near the channel mid-point. Until 2008 few samples had been taken in near shore backwater areas where scums have been frequently reported and photographed. Data collected in 2008 showed frequent exceedance of both 8 µg/L microcystin and 40,000 cells/ml *Microcystis aeruginosa* in various river-edge habitats between Iron Gate Dam and Seiad Valley (Figure 6: Kann and Corum 2009). The revised September 2008 Blue Green Algae Work Group report recommends that monitoring for public health should include samples of the Reasonable Maximum Exposure (RME) conditions in areas in which people and animals are most likely to contact water (State Water Board 2008).

2.5.5 Dissolved Oxygen

This section evaluates observed DO conditions relative to the existing and proposed Basin Plan water quality objectives for DO.

The US Fish and Wildlife Service (USFWS), in cooperation with the Karuk and Yurok Tribes, monitored DO conditions with datasondes at several stations along the Klamath River from 2001 to 2006. For the purposes of this assessment measured DO concentrations from the three most recent years (2004 – 2006) are evaluated in comparison to the existing and proposed DO objective. USFWS conducted an in-depth quality control review of the DO data (Ward and Armstrong 2006). Final data- sonde results have been summarized by station by evaluating the percent of total measurements during the summer season that fall below the current Basin Plan DO Objective of 8.0 mg/L. The datasondes recorded water quality conditions at 30-minute increments, for a total of forty-eight daily measurements.

In 2005 greater than ten percent of the DO measurements were less than 8.0 mg/L at six of the nine stations along the Klamath River (Table 2.12 and Figure 2.26). For the period 2004, 2005, and 2006 several of the Klamath mainstem stations (below Iron Gate, above Shasta River, above Scott River, and at Seiad Valley) had conditions where more than 40% of the measurements are less than the current Basin Plan objective indicating serious dissolved oxygen impairment for large sections of the river.

Table 2.12: Percent of DO measurements below Basin Plan water quality objective of 8.0 mg/L for 2004 – 2006 at nine stations along the Klamath River

	2004		**2005**		**2006**	
% Measurements below 8 mg/L	**n**	**%**	**n**	**%**	**n**	**%**
At Iron Gate	2706	64	4498	45	5391	61
Above Shasta River	5478	50	5533	49	-	-
Above Scott River	2966	58	4457	47	-	-
At Seiad Valley	3381	57	4713	45	5526	40
At Orleans	4057	37	4533	23	5349	15
Above Trinity	-	-	5535	5	5739	3
At Weitchpec	4142	48	5400	7	5332	6
Below Weitchpec	5500	16	3529	11	5293	4
At/above Turwar	5066	30	5543	6	-	-

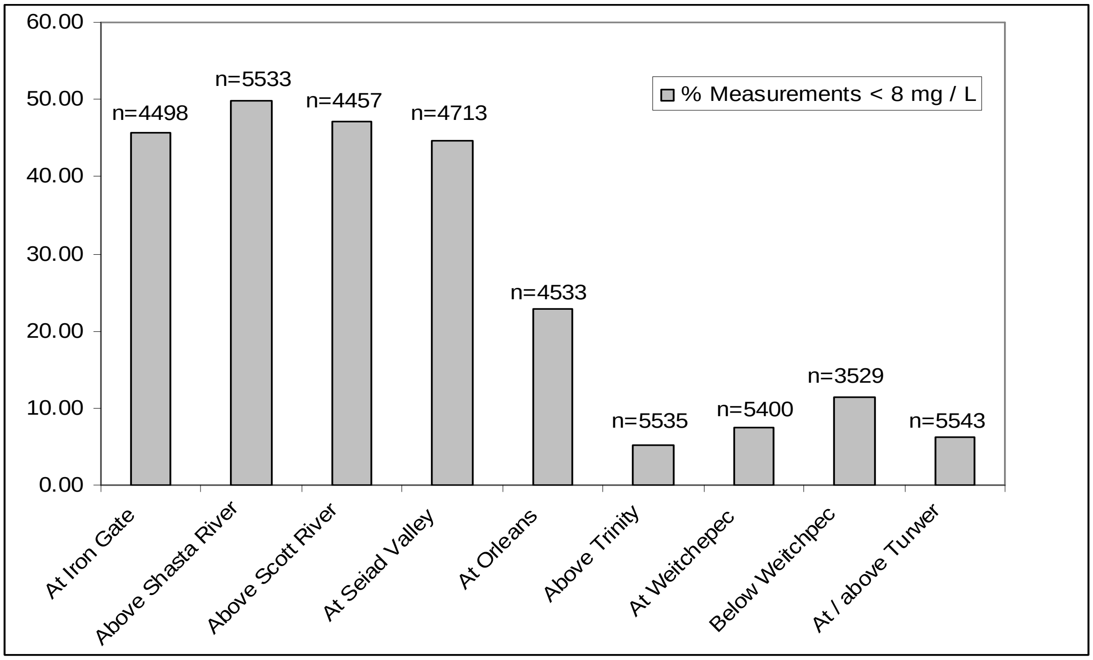

Figure 2.26: Percent of DO measurements below the Basin Plan water quality objective of 8.0 mg/L for 2005 at nine stations along the Klamath River

The analysis presented below addresses the revised DO objective being proposed (see Section 2.2.1.2. and Appendix 1). The revised objective requires that in those waterbodies identified as COLD but unable to meet the salmonid life cycle requirements (instantaneous minimum of 7.0 mg/L upstream of Iron Gate dam and 8.0 mg/L downstream of the dam, with half the monthly mean DO values for the year 10 mg/L or greater) due to natural conditions, a minimum 85% DO saturation limit throughout the mainstem, 90% DO saturation limit from October through April upstream of the Hoopa-California boundary and 80% DO saturation during August in the Middle and Upper Estuary be applied. These percent DO saturation criteria are to be calculated based on natural water temperatures.

In order to compare the USFWS measured DO data to the proposed DO objective assumptions related to temperature and barometric pressure were made. Percent DO saturation was calculated based on measured water temperatures and using a seasonal average barometric pressure. These assumptions make for a very conservative estimate of the percent of measurements below the proposed objective of 85% DO saturation at natural water temperatures. For simplicity, the analysis looks only at the 85% criteria. Estimates of natural water temperatures have not been predicted for the years 2004-2006 using the TMDL model. The results of the analysis are presented in Table 2.13 and Figure 2.27. In 2004, six of the nine stations had more than 10% of the DO measurements below 85% DO saturation.

Table 2.13: Percent of calculated percent DO saturation estimates below the proposed Basin Plan water quality objective of 85% saturation for 2004 – 2006 at nine stations along the Klamath River

% Measurements below 85% saturation at median of pressure range	**2004**		**2005**		**2006**	
	n	**%**	**n**	**%**	**n**	**%**
At Iron Gate	2706	10	4498	6	5391	18
Above Shasta River	5478	25	5533	24	-	-
Above Scott River	2966	35	4457	20	-	-
At Seiad Valley	3381	14	4713	11	5526	0
At Orleans	4057	6	4533	0	5349	0
Above Trinity	-	-	5535	0	5739	0
At Weitchpec	4142	19	5400	0	5332	0
Below Weitchpec	5500	0.1	3529	0	5293	0
At/above Turwar	5066	12	5543	0	-	-

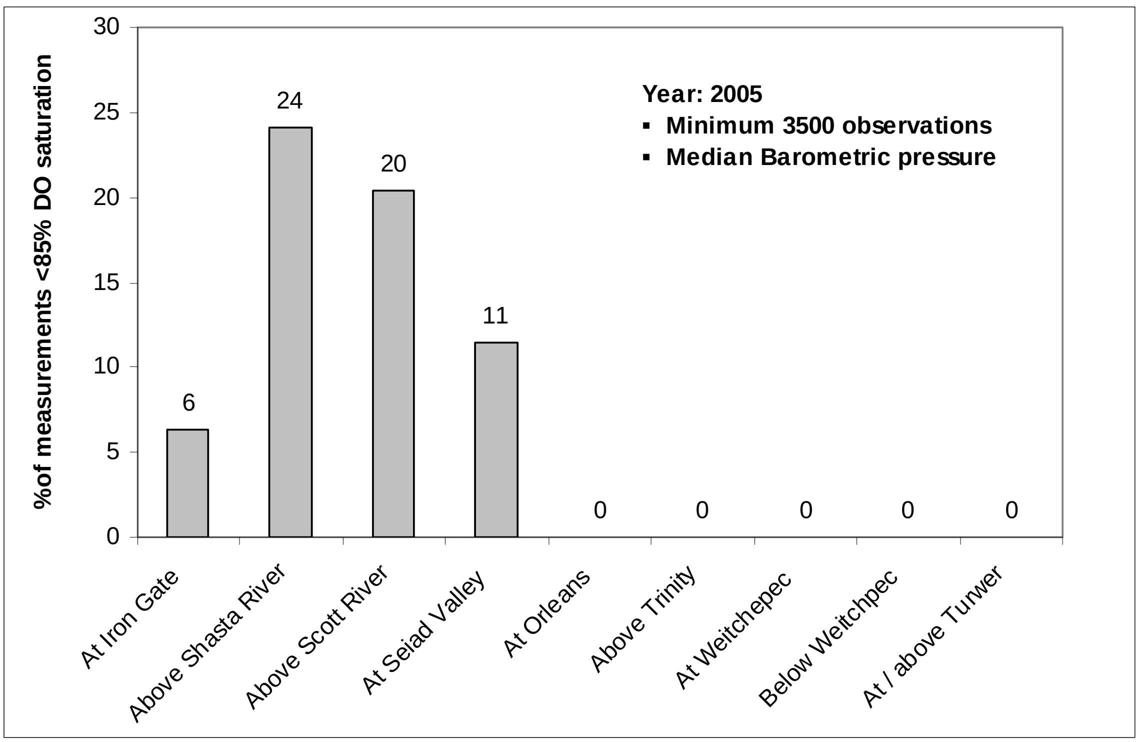

Figure 2.27: Calculated percent DO saturation at nine stations on the Klamath River for 2005 based on data sonde measurements made by U.S. Fish and Wildlife Service, Yurok Tribal Environmental Program, and Karuk Tribe Department of Natural Resources

2.5.6 pH

This assessment includes an evaluation of pH conditions along the Klamath River independent of the diurnal variation driven by photosynthesis that was addressed in Section 2.5.3.3. The data for this analysis also comes from the USFWS, Karuk and Yurok Tribes datasonde measurements. The same years (2004 – 2006) used in the DO analysis were also selected for the pH assessment. The Basin Plan water quality objective for pH is a maximum of 8.5 and a minimum of 7.0.

Five of the stations have more than 20% noncompliant measurements. The highest rate of noncompliant measurements is 48% recorded at Orleans in 2006 (Table 2.14). In the three year sample all nine stations exceeded a noncompliant measurement rate of greater than 10 percent at least once. The rate of noncompliance for the minimum pH of 7.0 is less than 0.05% at all stations. Therefore a sampling station summary table and plot have not been prepared for minimum pH.

Table 2.14: Percent of pH measurements above 8.5 for 2004 – 2006 at nine stations along the Klamath River.

Percent of Measurements above 8.5	2004		2005		2006	
	n	%	n	%	n	%
At Iron Gate	5192	32	4680	3	5486	30
Above Shasta River	5762	37	5847	40	-	-
Above Scott River	3834	28	3821	19	-	-
At Seiad Valley	3808	1	5838	1	5576	32
At Orleans	4844	0	5608	0	5442	48
Above Trinity	-	-	5826	23	5746	18
At Weitchpec	4449	33	5765	29	5823	27
Below Weitchpec	5823	1	5469	23	5125	42
At/above Turwar	4712	16	5835	23	-	-

For 2005 (Figure 2.28) at six of the nine Klamath River stations the Basin Plan objective of 8.5 is exceeded in more than 15% of the samples taken.

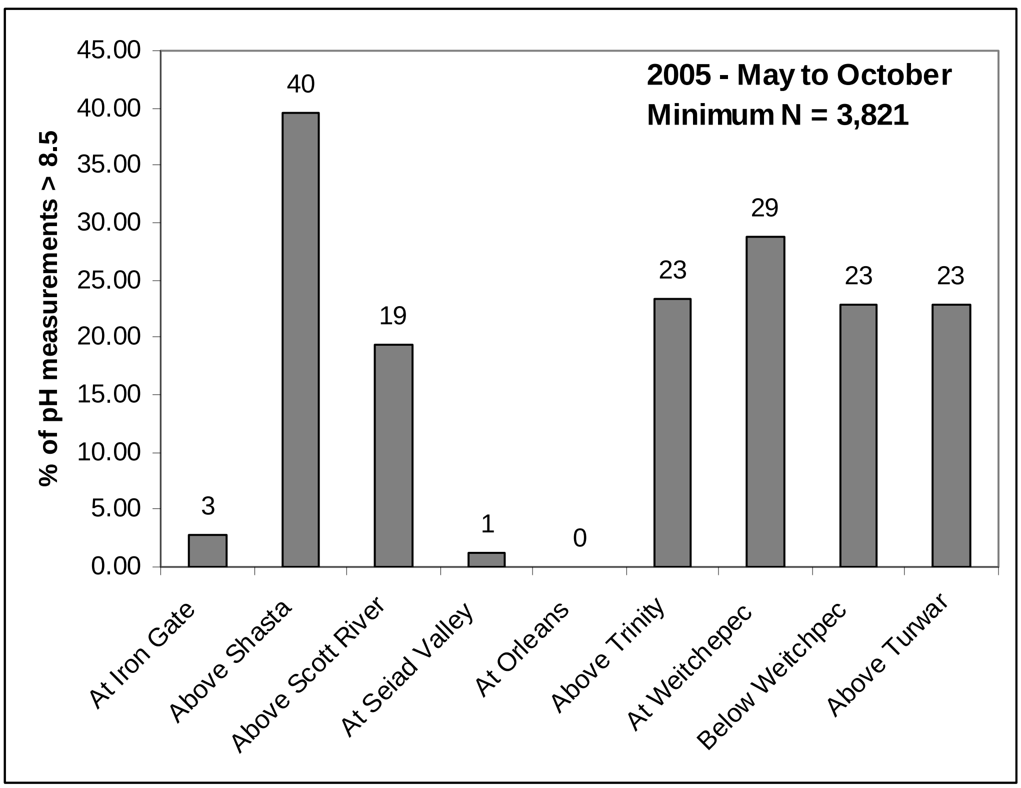

Figure 2.28: Percent of 2005 pH measurements in the Klamath River that exceed 8.5

2.5.7 Ammonia Toxicity

Regional Water Board staff evaluated all the data within our compiled Klamath River datasets in which all 3 parameters (pH, NH3, and temperature) were collected at the same time. Based upon the evaluation, there were no documented times in which acute or chronic aquatic life criteria for ammonia toxicity was exceeded.

To take this one step further, staff evaluated all the available pH and temperature data to determine what the concentration of ammonia would need to be in order for toxicity (acute or chronic) to be present. The results of that effort showed that acute toxicity probably does not occur on the Klamath River in California. However, the results showed that there are probably times when the chronic criteria are exceeded, but only for short durations of perhaps a few hours in a day a few days in a year. EPA guidance suggests that chronic criteria for the protection of aquatic life should be addressed over an averaging period of 4 days. Regional Water Board staff concludes that based on the available data, acute ammonia toxicity has not occurred in the times/years when data is available, and excursions of the chronic ammonia criterion probably only occur for short durations on a few days in a year and, if so, do not constitute an impairment of beneficial uses.

2.5.8 Sediment

The New Years Day flood of 1997 provided an example of some of the ways in which increased sediment loads affect stream temperatures in the Klamath River basin. A report by Klamath National Forest personnel (De La Fuente and Elder 1998) documenting the flood impacts within the Klamath National Forest reported 446 miles (20%) of channels that were significantly altered (i.e. with significant scouring, excessive sediment deposition, or riparian vegetation removal) by the flooding and associated sediment pulses of the 1997 flood. The report stated that “there appeared to be a considerable reduction in size, volume, and depth of pools in Elk, Indian, Beaver, Grider, Tompkins, South Fork Salmon, and Walker Creeks, and there is a larger proportion of fine sediment in the substrate. Alluvial reaches were made shallower and wider due to the sedimentation”. The report found that approximately 30% to 60% of riparian vegetation was lost in the alluvial reaches of the most affected tributaries. These effects of increased sediment loads were observed in Elk, Indian, Ukonom, Independence, Grider, Oneil, Portuguese, Beaver, Horse, and Walker Creeks, as well as numerous other streams throughout the Klamath basin after the flood of 1997 (Figure 2.29) (De La Fuente and Elder 1998; Kier Associates 1999). The conclusions of the Klamath National Forest assessment are consistent with Regional Water Board staff observations.

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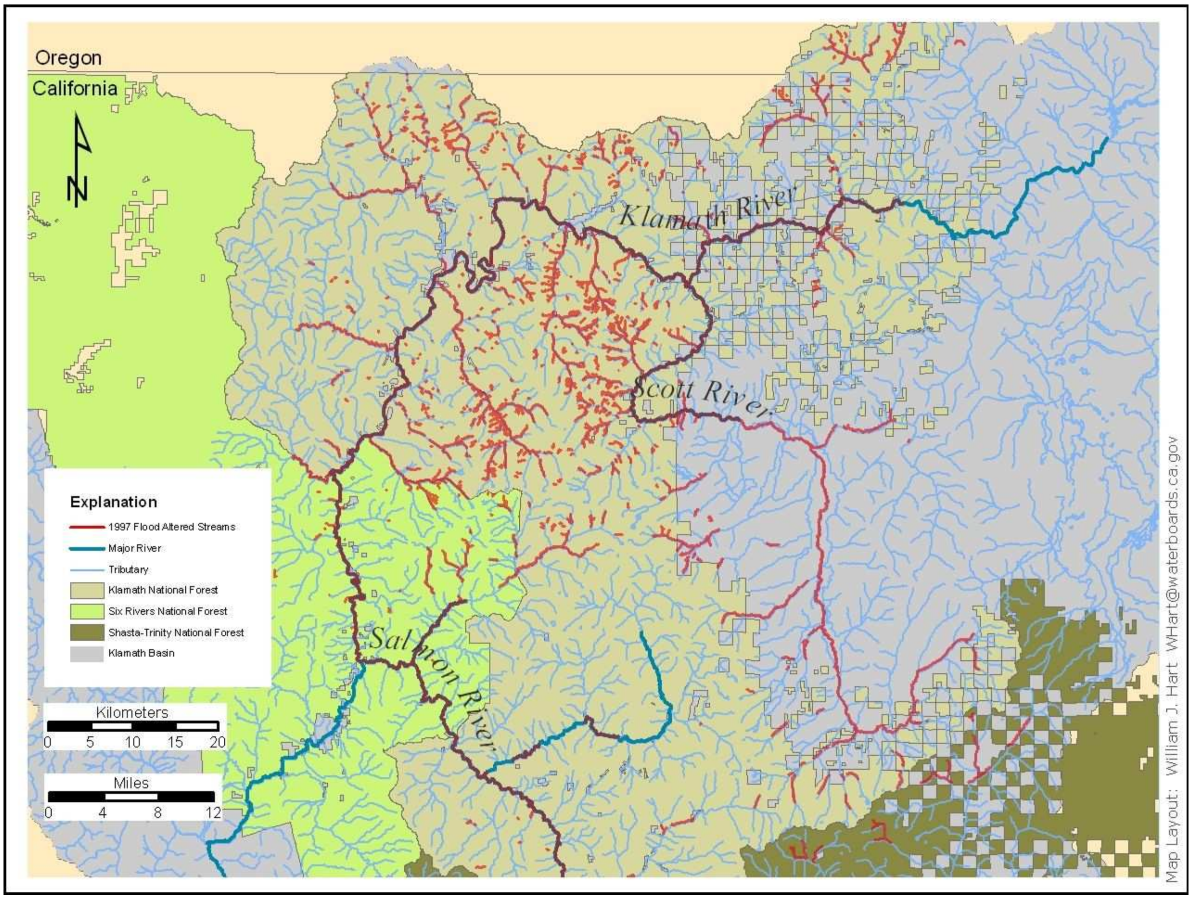

Figure 2.29: Mapped extent of stream channels substantially altered by sediment loads associated with the 1997 flood.
Source: De la Fuente and Elder 1998

The substantial changes in stream shade and channel dimensions that occurred as a result of the 1997 storm are believed to have significantly affected Klamath River tributary temperatures where they occurred. Unfortunately, little pre- and post-flood temperature comparisons are available to evaluate the changes in temperatures that resulted from the flood effects. However, a pre- and post-flood data set exists for one tributary, Elk Creek. De la Fuente and Elder presented a comparison of Elk Creek temperature data before and after the flood. The data showed that in the summer after the flood, the peak temperature was the highest of seven years of record, and was 3.8°F higher than the average from 1990-1995. Likewise, the diurnal variation increased to12.5°F, 4.9°F higher than the 1990-1995 average. Furthermore, comparison of average air temperatures for the seven years show that 1997 was warmer (74.6 °F) than all years except 1994 (76.0 °F). The recorded low flow for 1994 was 16.1 cfs, whereas 1997 had the highest low flow of all the years measured (49.3 cfs). Despite higher air temperatures and lower flows in 1994, the instantaneous maximum temperature, 7-day maximum average, 31-day maximum average, and 31-day average diurnal variation were all lower compared to 1997 temperature data, as they were in all other years between 1990 and 1995 (no data are available for 1996). The fact that the season following the major changes in morphology and effective shade associated with the

1997 flood had higher temperatures, expressed in a variety of metrics, than the six years monitored prior to the flood, including a year with higher air temperatures and a fraction of the flow, strongly suggest that the temperature increase was a result of the effects of the flood.

The Final *Staff Report for the 2008 Integrated Report for the Clean Water Act Section 305(b) Surface Water Quality Assessment and the 303(d) List of Impaired Waters* (Regional Water Board 2009) was adopted by the Regional Water Board on June 3, 2009 and includes listings for sediment in 11 tributaries to the Klamath River in the area downstream of Iron Gate Dam to the confluence of the Trinity River. The portion of the Klamath River watershed from the Trinity River to the mouth of the Klamath is currently on the 2006 303(d) List for sedimentation/siltation impairment.

2.6 Evidence of Beneficial Use Impairment

Section 2.5 demonstrates that temperature, DO, biostimulatory substances, and related water quality objectives are not met at many locations at some times of the year in the Klamath River in California. Exceedance of these water quality objectives contributes to the impairment of a number of existing beneficial uses in the Klamath River. Evidence of impairment of the COLD, RARE, MIGR, SPWN, CUL, FISH, REC-1, REC-2, and MUN beneficial uses is presented in this section. This evidence of beneficial use impairment compels the need to develop TMDLs to address the temperature, DO, and nutrient water quality problems in the Klamath River.

2.6.1 Evidence of Impairment to Cold Freshwater Habitat (COLD), Rare, Threatened, or Endangered Species (RARE), Migration of Aquatic Organisms (MIGR), and Spawning, Reproduction, and/or Early Development (SPWN)

The COLD, RARE, MIGR, and SPWN beneficial uses are currently not fully supported in the Klamath River in California, as demonstrated by the decline of salmonid populations, adult and juvenile fish kills caused by disease outbreaks, migration barriers for adult and juvenile salmonids, and degradation of spawning habitat.

2.6.1.1 <u>Salmonid Population Decline</u>

Although historically there were large runs of salmonids in the Klamath River basin, current data indicate that populations have declined sharply since the early 1900's. Utilizing information from Snyder (1931), the NRC estimated that the annual total catch in the Klamath River during the period from 1916-1927 were probably 120,000 to 250,000 fish, and thus the number of potential spawners and total population numbers was considerably higher (NRC 2004, p.267, 268). In 2007, fall and spring Chinook population estimates were 132,167 and 12,628 respectively (CDFG 2008). No current estimate of steelhead and coho populations has been made, however, it is presumed that populations have declined dramatically from historic numbers (Brown and Moyle 1991, p.8; Brown et al. 1994; Busby et al. 1994 as cited by NRC 2004, p.274; CDFG 2002, p.1; NRC 2004, p.273). More detailed information on the decline of salmonid populations in the Klamath River basin can be found in Appendix 5, and brief summaries are presented below.

Fall Chinook Salmon

Fall Chinook numbers in the Klamath River basin have dramatically declined during the past century (Hardy et al. 2006, p.7). The Klamath River fall Chinook run once totaled as many as 500,000 fish annually (Moyle 2002, p.258). Fall Chinook numbers in the Shasta River basin alone historically numbered 20,000-80,000 fish per year (Regional Water Board 2006, p.1-25). Basin-wide fall Chinook population estimates for the period from 1978-2007 ranged from a high of 239,559 fish in 1987 to fewer than 35,000 fish in 1991 (CDFG 2008).

Spring Chinook Salmon

A population of more than 100,000 spring-run Chinook was once present in the basin, although this estimate is probably low because spring-run fish were the main run of Chinook in the Klamath mainstem in the 1800's (Moyle 2002, p.259). Historic run size estimates in each of the Sprague River, Williamson River, Shasta River, and Scott River alone were at least 5,000 fish (CDFG 1990 as cited by Moyle 2002, p.259). Population estimates for spring Chinook during the period from 1980-2006 ranged from a high of 69,004 fish in 1988 to fewer than 1,945 in 1983 (CDFG 2006).

Steelhead Trout

Hardy et al (2006, p.6) report that historical run sizes for steelhead trout in the Klamath River basin were estimated at "400,000 fish in 1960 (USFWS 1960 as cited by Leidy and Leidy 1984), 250,000 in 1967 (Coots 1967), 241,000 in 1972 (Coots 1972) and 135,000 in 1977 (Boydston 1977)." More recent run sizes are summarized below.

Spring/Summer Steelhead Trout

Annual counts of spring/summer steelhead in holding areas throughout the Klamath River basin ranged from 500 to 3,000 fish (Roeloffs 1983, as cited by Hopelain 1998, p.1). In the 1990's it was estimated that there were 1000-1500 spring/summer steelhead adults divided among eight populations in the basin (Barnhart 1994; Moyle et al. 1995; Moyle 2002 as cited by NRC 2004, p.274). NMFS considers spring/summer steelhead stocks depressed and in danger of extinction (Busby et al. 1994 as cited by NRC 2004, p.274).

Fall Steelhead Trout

The fall steelhead represent the largest of the three steelhead runs, and were estimated to include 55,000-75,000 spawning adults and 150,000-225,000 half-pounders during the period from 1980-1982 (D.P. Lee, CDFG, pers. comm. as cited by Hopelain 1998, p.1).

Winter Steelhead Trout

Run size estimates for Klamath River winter steelhead were 170,000 in the 1960s, 129,000 in the 1970s, and 100,000 in the 1980s (Busby et al. 1994 as cited by NRC 2004, p.273). Current population estimates for winter steelhead have not been conducted, although Hopelain (1998, p.1) estimated a run-size of about 5,000 to 25,000 during 1980-1982. It is presumed that winter steelhead abundance is still declining although estimates, both past and present, are not very reliable (NRC 2004, p.273).

Coho Salmon
It is clear from the information available that coho salmon populations statewide have undergone a dramatic decline from historic levels (Brown and Moyle 1991, p.8; Brown et al. 1994; CDFG 2002, p.1). Maximum estimates for coho spawners in California during the 1940's range from 200,000-500,000 fish (Sagar and Glova 1988 as cited by Moyle 2002, p.250). Brown et al. (1994) state that California coho populations are probably less than 6% of what they were in the 1940s, and there has been at least a 70% decline since the 1960s. In 1994, Brown et al. estimated the coho salmon population in California to be 30,000 fish, with natural spawners comprising 43% of the total population or 13,240 fish.

The Southern Oregon/Northern California Coast Evolutionary Significant Unit (SONCC ESU), which encompasses Klamath River stocks, has been listed as threatened by the State of California and the Federal government. Coho salmon occupy only 61% of the SONCC ESU streams previously identified as historical coho salmon streams (CDFG 2002, p.2).

Historical spawning escapement estimates for the Klamath River basin approximate 15,400-20,000 coho, with 8,000 of these fish originating in the Trinity River (USFWS 1979, App. as cited by Brown et al. 1994). In 1965, CDFG estimated 15,400 coho spawners per year in the basin (CDFG 1965, p.369). In 1994, Brown et al. estimated a total abundance of 18,125 coho in the Klamath River, including 1,860 native and naturalized fish. Current population estimates for coho in the Klamath River basin have not been conducted, although adult coho return numbers to the Iron Gate Hatchery, Trinity River Hatchery, and Shasta River Fish Counting Facility during the last 42 years averaged 5949 fish (Hampton 2004, p.1; Hampton 2005a, p.1; Hampton 2005b; KRIS 2006; Marshall 2005; and Rushton 2005).

2.6.1.2 Juvenile and Adult Fish Kills
Poor water quality conditions in the Klamath River have resulted in both adult and juvenile fish kills reflecting an impairment of the COLD and RARE beneficial uses. Figure 2.30 identifies the mainstem Klamath River reaches in California where adult and juvenile fish kills have been documented.

It is believed that juvenile fish kills are very common in the Klamath River from Iron Gate Dam to the mouth of the river but often go undetected. Direct observation of juvenile fish kills is not common due to the small size of the juvenile fish within the large river system and the generally small number of outmigrant traps that operate in the river (Klamath Fish Health Assessment Team [KFHAT] 2005, p.5, 6).

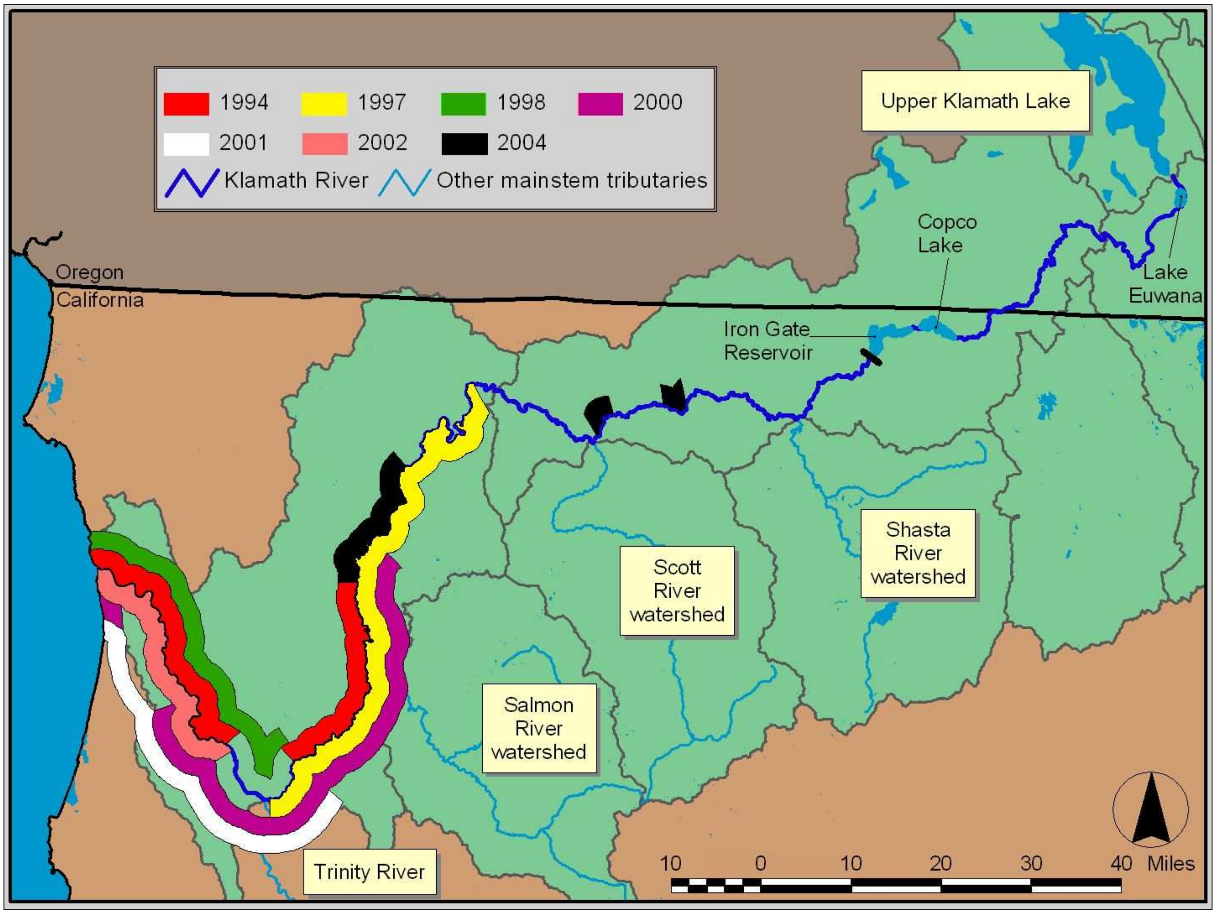

Figure 2.30: Fish kill years and locations in the Klamath River in California

Juvenile fish kills in the Klamath River in California have been documented for the years 1994, 1997, 1998, 2000, 2001, and 2004 (Table 2.15). Estimates of the number of dead fish range from 269-300,000 juvenile salmonids and non-salmonids. Disease was the ultimate cause of death in all juvenile fish kills documented. The effects of disease were exacerbated by poor water quality conditions, including low DO, high water temperature, extreme pH fluctuations, and low flow. Temperatures documented during these fish kills were as high as 25 ^{o}C, well above the lethal threshold for juvenile salmonids. Additionally, DO levels as low as 3.1 mg/L were recorded during these fish kills, which is well below the current Basin Plan objective of 8 mg/L.

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Table 2.15: Juvenile fish kill locations and causes in the Klamath River in California

Year	River Location	Fish	Cause of Death	Exacerbating Factors				Citations
				D.O.	Temp	NH_3	Flow	
1994	middle/ lower	~300 Chinook	None stated		X			Foott (2005) USFWS (1997)
1997	Middle	non-salmonids salmonids	Disease	X	X	X	X	Hannum (1997) Hendrickson (1997) USFWS (1997)
1998	Various	~240,000 Chinook	Disease	X	X		X	Williamson and Foott (1998)
2000	middle/ lower	10,000-300,000 Chinook & steelhead	Disease	X	X			CDFG (2000, p.1, 10, 11), Deas (2000), Foott (2000), USFWS (2003a)
2001		269 Chinook[1]	Disease					Foott et al. (2002)
2004	upper/ middle	>250,000 Chinook	Disease		X			Engbring (2004) KFHAT (2005) Klamt and Carter (2004)

[1] It is likely that the peak of the disease epizootic and associated mortalities of juvenile Chinook likely occurred prior to when KFHAT conducted their reconnaissance surveys, and thus the actual number of dead fish was much higher (KFHAT 2005).

Documentation of adult fish kills in the Klamath River in California is available for 1997 and 2002 (Table 2.16). The 1997 fish kill was determined to be caused by Columnaris and other diseases and was exacerbated by maximum water temperatures around 26°C, low DO levels of 3.1 mg/L, and low flows (Hannum 1997; Hendrickson 1997).

Table 2.16: Adult fish kill locations and Causes in the Klamath River in California

Year	River Location	Fish	Cause of Death	Exacerbating Factors					Citations
				D.O.	Temp	NH_3	Flow	Sediment	
1997	middle	>50/day non-salmonids	Disease	X	X	X	X		Hannum (1997) Hendrickson (1997) USFWS (1997)
2002	lower	>34,000 (including >33,500 salmonids)	Disease		X		X	X	USFWS (2003a) USFWS (2003b) CDFG (2004)

In mid to late September 2002 at least 34,000 fish died in the lower 36 miles of the Klamath River, although actual losses may have been more than double this number (CDFG 2004, p.III). Approximately 98.4% (33,527) of the fish killed were anadromous salmonids, representing 19.2% of the total 169,297 Klamath-Trinity run for 2002 (USFWS 2003b p.ii).

Multiple compounding factors likely contributed to the 2002 fish kill, including an early large run of fall Chinook, low river discharge which did not provide suitable attraction flows to trigger upstream migration, and warm water temperatures which were optimal for disease proliferation (CDFG 2004, p.III, 33, 124; USFWS 2003a, p.ii). Additionally, fish passage through the lower Klamath River may have been impeded by the shallow depth of the water flowing over some riffles, which were created by sediment deposition during high discharge events in the winters of 1997 and 1998 (CDFG 2004, p.III; USFWS 2003a, p.37). The majority of the dead fish examined were infected with the fish diseases *Ichthyophthiriasis* (Ich) and Columnaris, which was identified as the principal cause of death (CDFG 2004, p.III; USFWS 2003a, p.ii). Maximum daily water temperatures recorded at Turwar (RM 7) during September ranged from 18-23°C (CDFG 2004, p.70). Seven-day running averages of the weekly maximum temperature (MWMT) during this period ranged from 19-22.5°C (CDFG 2004, p.70), which exceeds the USEPA (2003) MWMT threshold values of 16°C (adult migration/core juvenile rearing), 18°C (adult migration/non-core juvenile rearing), and 20°C (adult migration). Although these high water temperatures are not unusual for the Klamath River, they are ideal for disease proliferation and thus contributed to a disease epizootic (the equivalent of an epidemic in humans) (CDFG 2004, p.III, 124; USFWS 2003a, p.ii).

2.6.1.3 Adult and Juvenile Salmonid Migration Barriers and Spawning and Rearing Habitat Degradation

Unless otherwise specified, the following information is from CDFG 2004 (p.III, 83), Hardy et al 2006 (p.10, 15, 20), and USFWS 2003a (p.ii, 36).

Poor water quality conditions are contributing to the impairment of migration (MIGR) of aquatic organisms, particularly salmonids. Section 2.4.4.1 summarized findings by Strange (2007) that adult fall Chinook salmon migration is dependent on stream temperature. As shown in Section 2.5.2, Klamath River mainstem and tributary water temperatures during the period of fall Chinook migration are often over the temperatures noted by Strange (2007) that inhibit upstream migration. Thus elevated water temperatures contribute to the impairment of MIGR.

Alterations in flow in the Klamath River basin have contributed to the degradation of salmonid spawning and rearing habitat (SPWN). Principal factors affecting anadromous fish production in the Klamath River from Iron Gate Dam to Weitchpec include impaired flow in some tributaries (particularly the Shasta and Scott Rivers), impaired flows in the mainstem, and alterations to the timing and magnitude of mainstem flows. One of the primary limiting factors for anadromous fish production in the Klamath River from Weitchpec to the mouth is the cumulative effect of impaired flow and alterations in the seasonal hydrograph. These impacts have contributed to the degradation of available spawning gravel from sedimentation (Hardy et al 2006, p.20).

Cumulative impacts resulting in sediment delivery to many tributaries of the Klamath River in California have contributed to the formation and persistence of large delta fans at many tributary confluences, impeding adult and juvenile migration (MIGR). In low flow years, this accumulation of sediment can inhibit or block access to these tributaries, thereby restricting access to habitat and thermal refugia for migrating adult and juvenile salmonids. Salmonids that are unable to enter the tributaries are forced to seek space in the limited areas of thermal refugia in the mainstem Klamath River. Overcrowding of salmonids in mainstem thermal refugia areas, combined with the high water temperatures can exacerbate disease proliferation.

As mentioned in the previous section, there is evidence that conditions inhibiting adult migration may have contributed to the 2002 adult fish kill in the Klamath River. USFWS reported that in 2002 Klamath River flows were too low to trigger upstream migration, causing adults to congregate in the lower river. After the fish kill was underway the U.S. Bureau of Reclamation increased flows, and salmonids responded by migrating out of the lower river. CDFG hypothesized that fish passage may have been impeded by shallow water depth over certain riffles.

> CDFG…reported that in 1997 and 1998 high discharge events occurred in northern California that could have altered the channel of the Klamath River. They suggested that the input of high sediment loads during high discharge events could have resulted in the filling of pools and increased the elevation of riffles in the lower Klamath River. Furthermore, they speculated that discharges that may have been sufficient for fish passage in low discharge years prior to 1997 were inadequate for passage in September 2002 (CDFG 2003b, as cited by USFWS 2003a, p.37).

Additionally,

> USFWS biologists working on the lower Klamath River [in September of 2002] observed low-flow conditions, making it more difficult to traverse shallow riffles in a jet boat than in previous years (Shaw 2002, personal communication). They observed that water depth at Pecwan and Ah Pah riffles appeared shallow enough to be an impediment to adult fish passage. Yurok biologists also observed that fish passage over some riffles was confined to multiple small channels, in which their jet boat with a six-inch draft, would occasionally touch bottom (Belchik 2003, personal communication). A former NMFS fisheries biologist (Gilroy 2003, personal communication) with experience working on the Klamath river suggested when flows are low, fish passage over certain riffles is confined to smaller channels, representing the main thalweg and much of the riffle is too shallow to pass fish. The DFG Fisheries Biologist, who has participated in angler surveys on the Klamath River since 1985, described water levels during September 2002 in the fish-kill area as the lowest she has observed in over 20 years of experience (Borok 2003, personal communication). These anecdotal observations raised concern that shallow water depth over certain riffles might have impaired the ability of salmon and steelhead to migrate upstream (CDFG 2004, p. 87).

Thus, alterations in flow and changes in channel conditions resulting from sedimentation in the mainstem Klamath River in California have contributed to the impairment of MIGR and SPWN.

2.6.2 Impairment of Native American Culture (CUL) and Subsistence Fishing (FISH) Beneficial Uses

The Water Quality Control Plan for the North Coast Region (Basin Plan) includes two Native American Cultural beneficial uses; Native American Culture (CUL) and Subsistence Fishing (FISH). The CUL beneficial use covers "uses of water that support the cultural and/or traditional rights of indigenous people such as subsistence fishing and shellfish gathering, basket weaving and jewelry material collection, navigation to traditional ceremonial locations, and ceremonial uses"; FISH encompasses "uses of water that support subsistence fishing" (Regional Water Board 2007). CUL is designated as an "Existing" use in the Ukonom, Happy Camp, Seiad Valley, Klamath Glen, and Orleans Hydrologic Subareas of the Klamath River. Due to a lack of available information at the time of the last update of the Basin Plan, no waterbodies in the North Coast have been designated as "Existing" or "Potential" use for FISH. Based on the available information, however, Regional Water Board staff consider FISH an existing use within the same Hydrologic Subareas of the Klamath River as those designated CUL.

Given the scope of the CUL and FISH uses within the Klamath River basin in California, support of these uses is closely interrelated with the uses associated with the cold freshwater salmonid fishery (i.e. COMM, COLD, RARE, MIGR, and SPWN), as well as with the water contact and drinking water uses (REC-1 and MUN). The CUL and FISH beneficial uses in the Klamath River in California is currently impaired due to the decline of salmonid populations and degraded water quality resulting in changes to or the elimination of ceremonies and ceremonial practices and risk of exposure to degraded water quality conditions during ceremonial bathing and traditional daily activities. The FISH beneficial use is currently impaired in the Klamath River basin in California due to the decline of salmonid populations and other Tribal Trust fish populations resulting in decreased use, abundance, and value of subsistence fishing locations, altered diet and associated physical and mental health issues, and increased poverty. Additionally, the presence of the toxin microcystin in fish and mussels in the Klamath River has the potential to impair both the CUL and FISH beneficial uses. It is important to note that other beneficial uses, such as COLD and MUN, are linked to the support of the CUL and FISH beneficial uses throughout the year.

2.6.2.1 <u>Decline in Salmonid and Other Fish Populations</u>

The decline of salmon populations, as well as the decline of other Tribal Trust fish species of the Klamath River basin in California including sturgeon, eulachon (candlefish), lamprey (eel) and some species of suckers, has impaired the CUL and FISH beneficial uses. The elimination of the spring Chinook run above the Salmon River has resulted in the elimination of cultural ceremonies associated with the migration of this species through the length of the Klamath River. Declines in fish populations, especially salmonids, has also resulted in decreased use, abundance, and value of subsistence fishing locations, an altered daily diet that has been linked to health issues for Tribal Members, and increased poverty.

An elaborate ceremony, called the First Salmon Ceremony, marks the passing of the first spring Chinook salmon up the Klamath River. This migrating salmon was allowed to pass all the way up the Klamath River to its spawning ground. It was believed that the first spring Chinook migrating upstream would leave its scales at each spawning location for the rest of the salmon run to follow (Roberts 1932 as cited by Sloan 2003, p. 25). This first migrating salmon of the year was considered taboo, and if eaten would cause convulsions and death. Thus, the First Salmon Ceremony allowed this fish to pass safely upstream, thereby lifting the taboo, and allowing the Native People to fish for salmon in the river (Waterman and Kroeber 1938 as cited by Sloan 2003, p.25). The dramatic decline in the spring Chinook run has made it impossible for the Klamath River Tribes to conduct the First Salmon Ceremony. "And how do you perform the Spring Salmon Ceremony, how do you perform the First Salmon Ceremony, when the physical act of going out and harvesting that first fish won't happen?"(Leaf Hillman 2004 as cited by Norgaard 2005, p.35).

The Karuk Tribe historically depended on the abundant populations of fish found in the mainstem Klamath River for subsistence. However, as fish populations have declined the Karuk have shifted their diets to other food sources (Reed 2007a). Ron Reed (2005), traditional dipnet fisherman and cultural biologist for the Karuk Tribe, states that there is only one remaining Tribal fishery location that provides any level of subsistence fishing to the Karuk Tribe, Ishi Pishi Falls. According to Reed (2005), in 2002, about 1,500 fish were caught at Ishi Pishi falls, in 2003 approximately 1,000 fish were caught, and in 2004 only 100 fish were harvested at this location. The limited harvest of fish at Ishi Pishi Falls has meant that even ceremonial salmon consumption is limited (Ron Reed Pers. Comm. as cited by Norgaard 2005, p.4). According to Norgaard (2006), in addition to declining salmonid numbers, the fishery at Ishi Pishi Falls is negatively affected by low flows. When flows are too low the ability to perform dip net fishing is limited and fewer fish are caught (Norgaard 2006).

The importance of fishing to Tribal Members is reflected by the fact that fishing locations are a form of real property (Pierce 2002, p.7-2; Sloan 2003, p.17). They can be owned by individuals, families, or a group of individuals, and can be borrowed, leased, inherited, and bought and sold (Sloan 2003, p.17, 18). The quality, use, and value of these fishing locations has been reduced as changes including increased siltation and decreased salmonid abundance have occurred in the Klamath River and its tributaries (Sloan 2003, p.18, 28).

Historically, the Karuk Tribe had a platform fishery associated with each of their 100 Tribal village sites (Reed 2006). These fisheries were located near the tops of riffles, where eddies were created along the margins of the Klamath River. These areas of low velocity were where the salmon would hold and/or utilize this microhabitat as a migration corridor. According to Reed (2006) these 100 platform fishery locations are no longer as productive as they once were, or are gone. Tribal elders convey that the riffles near these fishing areas have been filled in and flattened out by sediment, contributing to the decline in overall fish populations (Reed 2006), as well as contributing to the loss of a culturally significant way of life.

The decline of salmonids and other Tribal Trust fish populations in the Klamath River basin has altered the diet of each of the Tribes along the river and its tributaries. Historically, traditional consumption of fish by the Karuk Tribe was estimated at 450 pounds per person per year, while in 2003 the Karuk People consumed less than 5 pounds of salmon per person per year, and in 2004 less than ½ pound per person per year was consumed (Norgaard 2005, p.13). In 2005 over 80% of Karuk households surveyed reported that they were unable to harvest adequate amounts of lamprey (eel), salmon or sturgeon to fulfill their family needs (Norgaard 2005, p.4). Furthermore, 40% of Karuk households reported that there are fish species that their family historically caught, which are no longer harvested (Norgaard 2005, p.7).

The decrease in abundance and availability of traditional foods, including salmon, trout, eel, shellfish, sturgeon and riparian plants, is responsible for many diet related illnesses among Native Americans including diabetes, obesity, heart disease, tuberculosis, hypertension, kidney troubles and strokes (Joe and Young 1993 as cited by Norgaard 2005, p.9, 39). These conditions result from the lack of nutrient content in foods consumed in place of the traditional foods such as salmon, as well as from the decrease in exercise associated with fishing and gathering food (Norgaard 2005, p.40). The estimated diabetes rate for the Karuk Tribe is 21%, nearly four times the U.S. average, and the estimated rate of heart disease for the Karuk Tribe is 39.6%, three times the U.S. average (Norgaard 2005, p.40).

In addition to altered diet and increased health issues, declines in fish populations have resulted in a documented increase in poverty rates for some Klamath River Tribes.

> The destruction of the Klamath River fishery has led to both poverty and hunger. Prior to contact with Europeans and the destruction of the fisheries, the Karuk, Hupa and Yurok tribes were the wealthiest people in what is now known as California. Today they are amongst the poorest. This dramatic reversal is directly linked to the destruction of the fisheries resource base.
>
> The devastation of the resource base, especially the fisheries, is also directly linked to the disproportionate unemployment and low socio-economic status of Karuk people today. Before the impacts of dams, mining and over fishing the Karuk people subsisted off salmon year round for tens of thousands of years. Now poverty and hunger rates for the Karuk Tribe are amongst the highest in the State and Nation. The poverty rate of the Karuk Tribe is between 80 and 85% (Norgaard 2005 Exec Summary).

2.6.2.2 Degraded Water Quality

Degraded water quality in the Klamath River basin in California, including the seasonal presence of blue-green algae and algal toxins in the Klamath River and reservoirs (see Section 2.5.4), has impaired the CUL and FISH beneficial use. Known and/or perceived health risks associated with degraded water quality have resulted in the alteration of cultural ceremonies to exclude or limit ingestion of river water. Additionally, known or perceived risk of exposure to degraded water quality conditions during ceremonial bathing and traditional cultural activities such as bathing, gathering and preparing basket materials, and collecting and using plants has resulted in an impairment of CUL.

The presence of blue-green algae and algal toxins in the Klamath River and reservoirs has impaired the cultural practice of subsistence fishing. The Karuk Tribe has only one fishing location available to them and it is flow dependent. Thus, when fish are in the river and the flow is suitable for fishing, Tribal Members must fish even if blue-green algae and algal toxins are present in the river. Susan Corum, Water Resources Coordinator for the Karuk Tribe, states: "It is really not a choice to fish. It is part of their culture which they need to maintain (Corum 2007)."

Microcystin has been identified in the waters of Klamath River, as well as in the liver of salmonids and in mussels from the river. Laboratory analyses detected a trace of microcystin in the liver of an adult steelhead, and 0.54 µg/kg in the liver of a half-pounder steelhead landed in the Klamath River at Weitchpec on October 3, 2005. Although these levels are not above the 250 µg/kg threshold which is advised by Van Buynder et al. (2001) to protect human health, the Yurok Tribe has expressed concern that the mid to late summer blooms of *Microcystis* in the Klamath River generally coincides with increased salmonid upstream migrations and subsequent usage of salmonid meat for recreational, cultural, and sport purposes. Mussels in the Klamath River have also had detectable levels of microcystin found in them. In 2007, a mussel was found in the Klamath River containing >1500 µg/kg microcystin, over the threshold to protect human health advised by Van Buynder et al. (2001). Additionally, upon review of the 2007 data, OEHHA recommended against consuming mussels from the affected sections of the Klamath River and yellow perch from Iron Gate and Copco Reservoirs due to their high concentrations of microcystin (OEHHA 2008). The presence of microcystin in salmonids and mussels of the Klamath River has resulted in an impairment of the cultural practice of subsistence fishing.

The Klamath River Tribes practice their culture through their "World Renewal" ceremonial cycle, such as the "First Salmon Ceremony" and Jump Dance, the Boat Dance, the War Dance, and the White Deerskin Dance (Reed 2007b). Other Tribal ceremonies and rituals include the Brush Dance and the Flower Dance, as wells as other rituals that require a spiritual cleansing process such as for fishing and hunting, funerals, and good luck (Reed 2007b). All of these ceremonies and rituals require Tribal members to be in close proximity to the Klamath River and they are integrally linked to the river and its health (Sloan 2003 p.18).

According to Karuk Cultural Biologist Ron Reed (2006, 2007b), the "World Renewal" ceremonial cycle is held on the Klamath River at Amerikirum (approximately 2 miles below Somes Bar), Clear Creek (Inam), Somes Bar (Katimin), and Orleans (Panamnik) starting in April and continuing through September of each year. The Medicine Man, who leads the ceremony at Clear Creek, walks 14 miles through the ridges and hills along the Klamath River and is joined halfway through his journey by children and adults of the

Tribe who follow him the rest of the way for good luck. Upon reaching the Klamath River at the end of this walk, it was historically tradition to drink water from the river to complete the ceremony. This is no longer done due to health concerns about drinking water directly from the river, though children are still known to jump in and drink the water (Reed 2006).

Ceremonial bathing in the river is an important part of most ceremonies (Curtis 1924 as cited by Sloan 2003, p.28). For example, bathing in the Klamath River and its tributaries is a requirement for participants in the Brush Ceremony (Sloan 2003, P.16). "During the Fish Dam Ceremonies at *Kepel*, young girls were selected by the Medicine Man to participate in the ceremonies. Once selected, they were sent to the river to bathe and then were dressed in full regalia which they would wear during the ceremonies. Then they were sent home to their families, and were required to fast and bathe in the river every day" (Van Stranlen 1942 as cited by Sloan 2003, p. 28). During the World Renewal Ceremonies, the Medicine Man and other participants bathe in the Klamath River for up to 10 days (Reed 2006).

Bathing is also associated with funeral services, subsistence practices, recreational swimming, courtship, and for individual hygiene (Reed 2007a). Bathing associated with funeral rituals occurs year round and includes preparation for burial, and purification after burial (Curtis 1924 as cited by Sloan 2003, p.28). The Karuk Tribe historically bathed freely in the Klamath River, however in more recent years degraded water quality conditions during the summer have forced them to take precautionary steps while bathing in the river (Reed 2007a). The Yurok Tribe has reported that detached algae have been present in the Klamath River in amounts high enough to prevent access and negatively affect the spirituality associated with bathing areas (McKernan 2006).

Willow roots, wild grape, Cottonwood, and Oregon Grape are collected by Tribal Members in the riparian zone of the Klamath River and used to make baskets (Reed 2007a). Traditional collection of these basketry materials often involved wading in the water (Sloan 2007a), and further contact occurs when the material is washed and cleaned in the water (Reed 2007a). Additionally, willow roots are peeled by mouth following cleaning with river water (Reed 2006). In addition, plants are collected for food, medicine, materials, and other cultural functions (Reed 2007a). Gathering plants or plant materials involves wading and contact with the Klamath River (Sloan 2007a; Reed 2007a). Ingestion of water can occur because plants are often cleaned in the river water and water is consumed with medicinal plants (Sloan 2007a). Given degraded water quality conditions, ingestion of water may pose a potential health risk.

Table 2.17 provides a summary of the activities that are encompassed by the CUL and FISH beneficial uses. Table 2.17 also denotes when those activities occur during the year, and the footnotes identify the amount of physical contact with the water associated with each of these activities. This table is not comprehensive, but conveys the magnitude and diversity of activities that are covered under these uses. Based on the information presented, Regional Water Board staff find that the CUL and FISH beneficial uses of the Klamath River in California are not being fully supported.

Table 2.17: Karuk, Yurok, and Quartz Valley Tribes cultural beneficial uses (CUL and FISH) of the Klamath River and tributaries[4]

Resource	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
CUL												
Plants[1,3]	■	■	■	■	■	■	■	■	■	■	■	■
Fish[1]	■	■	■	■	■	■	■	■	■	■	■	■
Fishing[1,2]	■	■	■	■	■	■	■	■	■	■	■	■
Water-drinking, steaming, cooking[1,3]	■	■	■	■	■	■	■	■	■	■	■	■
Rocks[1]	■	■	■	■	■	■	■	■	■	■	■	■
Bathing[2]	■	■	■	■	■	■	■	■	■	■	■	■
Boating[1,2]	■	■	■	■	■	■	■	■	■	■	■	■
Wildlife[1]	■	■	■	■	■	■	■	■	■	■	■	■
Hunting & Trapping[1]	■	■	■	■	■	■	■	■	■	■	■	■
River & Trail Access[1]	■	■	■	■	■	■	■	■	■	■	■	■
Training[2]	■	■	■	■	■	■	■	■	■	■	■	■
Swimming[2]				■	■	■	■	■	■	■		
Prayer & Meditation[1]	■	■	■	■	■	■	■	■	■	■	■	
Fish Dam[1,2]							■	■	■			
Washing[1]	■	■	■	■	■	■	■	■	■	■	■	■
Meditation[1]	■	■	■	■	■	■	■	■	■	■	■	■
Wood Gathering[1]	■	■	■	■	■	■	■	■	■	■	■	■
Tanning Hides[1]	■	■	■	■	■	■	■	■	■	■	■	■
Roots[1,3]	■	■	■	■	■	■	■	■	■	■	■	■
Sticks, Shoots & Bark[1]	■	■	■	■	■	■	■	■	■	■	■	■
Weaving[1]	■	■	■	■	■	■	■	■	■	■	■	■
Shells[1]	■	■	■	■	■	■	■	■	■	■	■	■
World Renewal Ceremonial Cycle[2,3]				■	■	■	■	■	■			
FISH												
Plants[1,3]	■	■	■	■	■	■	■	■	■	■	■	■
Fishing[1,2]	■	■	■	■	■	■	■	■	■	■	■	■
Eeling[1,2]	■	■	■	■	■							
Shellfish[1,2]						■	■	■				
Water-drinking, steaming, cooking[1,3]	■	■	■	■	■	■	■	■	■	■	■	■
Rocks[1]	■	■	■	■	■	■	■	■	■	■	■	■
Bathing[2]	■	■	■	■	■	■	■	■	■	■	■	■
Boating[1,2]	■	■	■	■	■	■	■	■	■	■	■	■
Wildlife[1]	■	■	■	■	■	■	■	■	■	■	■	■
River & Trail Access[1]	■	■	■	■	■	■	■	■	■	■	■	■

Sources: Bowman 2006; Norgaard 2006; Reed 2007a, Reed 2007b; Sloan 2007a, Sloan 2007b

■ Indicates time of use.

1-Wading, 2-Full submersion, 3-Ingestion of water

4-Tributaries utilized by the Tribes of the Klamath River for cultural purposes include many of those from the Scott River down to the mouth of the Klamath river. Additionally, the Quartz Valley Tribe utilized all tributaries which flow into the Scott and Shasta Rivers. Tributaries considered as having cultural beneficial uses include any tributary that provides spawning or rearing, or provides a migration pathway for Tribal Trust species.

Note: This table is not an exhaustive list of all activities covered under the CUL and FISH beneficial uses.

2.6.3 Impairment of Water Contact Recreation (REC-1), Non-Contact Water Recreation (REC-2), and Municipal and Domestic Supply (MUN)

Toxigenic blue-green algae blooms and their associated toxins measured in Copco and Iron Gate Reservoirs and in select reaches of the Klamath River downstream from the reservoirs are periodically impairing the Water Contact Recreation (REC-1) and Non-Contact Water Recreation (REC-2) beneficial uses. Additionally, the toxins have the potential to impair Municipal and Domestic Supply (MUN) beneficial use in the Klamath River.

2.6.3.1 Recreational Impacts

The available data on blue-green algae and toxin concentrations in the Klamath River and reservoirs are presented in Section 2.5.4. Water contact recreation (REC-1) during swimming, diving, and other direct water contact presents a high risk of exposure to inhalation or ingestion of cyanotoxins in waters contaminated with *Microcystis aeruginosa* (or other toxigenic species). Blooms of *Microcystis* and the presence of its cyanotoxin, microcystin, have prompted health advisories by the California Department of Health Services as well as the posting of on-site warnings for the public to avoid contact or use caution during water contact recreational activities in Iron Gate and Copco Reservoirs and some reaches of the river since 2005.

The presence of elevated *Microcystis* and microcystin concentrations in Iron Gate and Copco Reservoirs during August 2005 prompted the Regional Water Board cooperating with the State Water Board, USEPA, and Karuk Tribe to issue a joint press release (State Water Board 2005) warning of the potential adverse health effects to persons recreating in waterbodies of the Klamath River system contaminated with noticeably excessive algal concentrations. The Siskiyou County Health Department also issued a health advisory warning people about elevated toxin levels in Copco Reservoir. Additionally, warning signs were posted at key recreational access facilities around Iron Gate and Copco Reservoirs by the Regional Water Board.

During mid-August 2006, large blooms of *Microcystis aeruginosa* and high concentrations of microcystin led the Regional Water Board, Karuk Tribe, State Water Board, and USEPA to issue another press release, again warning recreational water users and other area residents to use caution when near the reservoirs, or avoid water contact recreation altogether in locations with noticeable blue-green algal blooms in Copco and Iron Gate Reservoirs (State Water Board 2006). The Siskiyou County Health Department also issued a public health advisory for Iron Gate and Copco Reservoirs in 2006 (Siskiyou County Public Health Department 2006). In early September 2006 the Regional Water Board posted warning signs at prominent recreational access points in both reservoirs reiterating the cautionary advisories contained in the earlier press release. In addition to these postings at the reservoirs, the Yurok Tribe posted health advisory signs along the mainstem Klamath River within the reservation borders (Fetcho 2006).

Microcystis scums were present in Iron Gate and Copco Reservoir beginning in mid- to late-June 2007 at concentrations that prompted the Regional Water Board to post precautionary health advisory signs at boat launches, campgrounds, swimming areas, and other high traffic, recreational use access points along the shorelines of the reservoirs. Shortly after the posting of the two reservoirs the USEPA as lead agency, with a number of state agencies, and the Yurok and Karuk Tribes issued a joint press release on July 5, 2007 advising the public to use caution when recreating at the two reservoirs (USEPA 2007). In August 2007, Microcystis cell counts in the mainstem Klamath River exceeded the Blue Green Algae Work Group's guidelines for posting health advisories. Consequently, Regional Water Board staff posted precautionary health advisory signs at 24 locations along the mainstem Klamath River from the sport fishing access point at Iron Gate Hatchery to the Aikens Creek Campground.

2.6.3.2. Health Impacts

Blooms of *Microcystis aeruginosa*, and subsequent releases of its cyanotoxin, microcystin, during the summer and early fall in the mainstem Klamath River have the potential to impair the municipal and domestic supply (MUN) beneficial use. The State Water Board's Department of Water Rights Information Management System (WRIMS 2006) shows numerous existing water rights that utilize in-river water withdrawals for sources of domestic drinking water and other uses. Nearly all of the water rights are located downstream from Iron Gate dam. The location, engineering, and timing of water withdrawals, as well as the magnitude and velocity of streamflow are factors that affect the possibility of entraining blue-green algae and their toxins in water supplies.

There have been no documented human health impacts due to drinking or recreating in Klamath River water during *Microcystis* blooms. However, the presence of the toxin during periods when water withdrawls are occurring and when people are recreating, presents the possibility that human health impacts could occur.

In August of 2007, a dog became very ill a few hours after swimming in Copco Reservoir and drinking the water during a *Microcystis* bloom (Tobler 2007). The sick dog was taken to the vet and tests showed elevated levels of several enzymes indicative of liver disease. Microcystin is a liver toxin, and is capable of producing this type of an enzymatic response.

2.6.3.3. Aesthetic Impacts

Visible scums formed by the presence of *Microcystis aeruginosa* and other blue-green algae in Copco and Iron Gate Reservoirs present an aesthetic nuisance, potentially impacting the aesthetic enjoyment (REC-2) of these reservoirs. A study conducted by CH2M Hill for PacifCorp compiled interviews and survey responses of recreational water users about their experiences at locations along the Klamath River, including Copco and Iron Gate Reservoirs (PacifiCorp 2004a). Interviewees' responses showed that water condition during the summer to early fall seasons has affected the quality and enjoyment of their experiences. The survey did not link responses to a specific time period; however, nearly all of the concerns expressed by respondents pertained to the summer and early fall recreational seasons of 2001 and 2002.

Approximately 70% (n = 89), of the responses to the interview questions stated water quality either detracted a lot or a little from their aesthetic enjoyment of the Klamath River within the geographical boundaries of the survey. By far, the most common complaint related to large amounts of "algae" and odors related to "algae." The survey data show that of the 70% of water uses reporting unfavorable recreational experiences with "algae," approximately 42% (n = 37) of those negative responses directly involved Iron Gate and Copco Reservoirs. Though not stated, presumably the "algae" in question were blue-green algal species that tend to accumulate along shorelines, forming scums and surface films during blooms.

2.6.4 Impairment of Commercial and Sport Fishing (COMM)

The Commercial and Sport Fishing (COMM) beneficial use is currently impaired in the Klamath River in California, as demonstrated by restrictions and closures on the sport and commercial fishing industries in the basin and beyond. Salmonid population decline has resulted in severe reductions in available Chinook salmon for both the in-river and ocean troll commercial fishing communities, and sport fishing community. Additionally, federal regulations have eliminated the right to harvest coho salmon stocks due to their dwindling numbers. Evidence documenting declining numbers of salmonids returning to spawn in the Klamath River basin is discussed in detail in section 2.6.1 and Appendix 5. The apparent disappearance of eulachon (*Thaleicthys pacificus,* also known as candlefish) spawning activity in the Klamath River (Belchik and Larson 1998) has resulted in the cessation of a historically important, commercially valuable non-salmonid fishery that was primarily utilized by Yurok Tribal members.

2.6.4.1 <u>In-River Sport Fishing Impairment</u>

Decreased salmon populations in the Klamath River have resulted in the alteration of fishing regulations further restricting the number of in-river fish harvested recreationally and the length of the recreational salmon in-river fishing season. For the 2006 season, the California Fish and Game Commission (Commission) decreased the number of days that recreational salmon fishing could occur by 11 days in the Klamath River below the Highway 96 bridge at Weitchpec (CFGC 2006). This was done in an attempt to ensure that the quota for in-river recreational harvest would not be met before Labor Day, allowing fishing during the holiday weekend (CFGC 2006).

The documentation of microcystin toxin concentrations in fish tissue of yellow perch from Copco Reservoir above human health thresholds represents an impairment of in-river sport fishing. Table 2.18 presents data from 2005 and 2007 when salmonids were collected in the Klamath River and yellow perch were collected in the reservoirs to test for the presence of microcystin. As the table reflects, microcystin was detected in the liver of a salmonid collected at Iron Gate Hatchery at a level >250 µg/kg, which is over the threshold recommended by Van Buynder et al. (2001) to protect human health. Additionally, four of the yellow perch fish tissue samples and one of the liver samples collected in Copco Reservoir were >250 ug/kg. Yellow perch are commonly harvested from Copco and Iron Gate Reservoirs for consumption.

Table 2.18: Detection of microcystin in fish tissue and liver samples from the Klamath River and reservoirs

Location Fish Collected	Year	# of fish tissue samples where Microcystin Detected	# of fish tissue samples with Microcystin total >250 µg/kg	# of fish liver samples where Microcystin Detected	# of fish liver samples with Microcystin total >250 µg/kg
Klamath River	2005	0 of 2*	0	2 of 4*	0
Iron Gate Hatchery	2005	0 of 2*	0	0 of 2*	0
	2007	0 of 1*	0	1 of 1*	1
Iron Gate Reservoir	2007	15 of 19**	0	2 of 3*	0
Copco Reservoir	2007	18 of 19**	4	3 of 3*	1

*salmonid
** yellow perch

2.6.4.2 Ocean Sport Fishing Impairment

During the period from 1960 through 1965 there was no closed season for ocean salmon sport fishing north of Tomales Point (CDFG 1967). The catch limit during this period remained constant at 3 salmon per day. In 1960 and 1961 the minimum size limit for salmon was 22 inches, and in 1962 one fish of any size was allowed with the remainder to be over 22 inches. From 1963 through 1965 the minimum size limit was one salmon over 20 inches and two over 22 inches.

In contrast, the currently depressed state of the fall Chinook run in the Klamath Management Zone (KMZ), and the listing of coho as threatened on both the federal (1997 listing) and California (2005 listing) Endangered Species lists, has resulted in increased restrictions on the ocean sport fishery. The 2007 ocean sport fishing season in the Klamath Management Zone (KMZ), extending from Humbug Mountain, OR to Point Arena, CA, was open from May 5 to September 4 (Pacific Fishery Management Council [PFMC] 2007). However, the Klamath Control Zone, extending 6 miles north and south of the Klamath River and 12 miles off-shore, was closed in August. The catching of coho was prohibited and the Chinook catch was limited to two fish per day (PFMC 2007). Chinook were required to be a minimum of 24 inches in total length to be legal to keep (PFMC 2007). These greater restrictions have contributed to the impairment of the sport fishery in the Klamath River basin.

2.6.4.3 In-River Commercial Fishery Impairment

Between 1912 and 1934 approximately 957,000 pounds of Chinook salmon, representing close to 55,000 fish, were harvested and preserved during a single fishing season in the Klamath River (Snyder 1931, p. 7, 8, 88, and 89). Daily salmonid catches by the Tribal commercial fishery commonly ranged from 7,000 to 10,000 fish per day, with a one-day high that was reportedly approximately17,000 fish. Catch totals were mostly Chinook, but coho salmon, steelhead trout, lamprey, and green sturgeon were also caught and preserved (Snyder 1931, p. 7, 8, 88, and 89). Due to precipitous declines in salmonid populations attributed to over harvesting by the in-river commercial salmon fishery, the fishery was declared illegal and closed by court order in 1934. It was subsequently reopened by another court order in 1977; however, the Bureau of Indian Affairs closed the Tribal in-river commercial fishery the following year under a "conservation moratorium." It remained closed until 1987, when it was again reopened (Pierce 1998; Yurok Perspectives 2001, p. 7.1-7.13).

In 1993 the Department of Interior modified catch limits for the Klamath River basin Tribes, allotting 50% of the available Klamath River basin salmon harvest to the Hoopa and Yurok Tribes, or an amount sufficient to support a moderate standard of living, which ever is less. Given the depressed condition of the Klamath River basin salmon stocks in 1993, the Department of Interior concluded that 50% of the salmon harvest during that year would be allocated to the Tribes because there weren't enough fish to allow them to catch enough to support a moderate standard of living (50 CFR Part 661, NOAA 1993). Of the 50% allocated to the Tribes, 80% and 20% of that allocation, referred to as Tribal shares, are allotted to the Yurok and Hoopa Tribes, respectively. Currently, the Yurok and Hoopa Tribes are the only Tribes with Federally-recognized commercial fishing rights in the Klamath River (Pierce 1998; Yurok Perspectives 2001, p. 7.1-7.13)

From 1990 through 1998 the in-river Tribal fishery was closed to commercial gillnetting due to depressed salmon runs. In recent years, harvest rates for the Tribal gillnet fishery have varied and are currently so low that it is hard to support an in-river commercial fishery. For the 2006 salmon season the Pacific Fishery Management Council (PFMC), working with the Klamath Fisheries Management Council, determined that the allowable Tribal share of the Klamath-Trinity River basin salmon harvest is 10,000 fish (PFMC 2006a). This would allocate 8,000 salmon to the Yurok Tribe and 2,000 salmon to the Hoopa Tribe from the in-river salmon fishery.

2.6.4.4 Ocean Commercial Fishery Impairment

Salmon sold to fish buyers and processors within the Klamath Management Zone (KMZ) have dwindled significantly since 1976 through 1980 when an average of 143,900 Chinook and 72,100 coho salmon were delivered per season to the port of Crescent City alone (PFMC 2003, 2006b). From 1993 through the present, concerns about the plummeting coho salmon populations have led to the closure of the entire California ocean commercial troll for coho. In order to more rigorously protect all salmonid stocks within the KMZ, regulations on the ocean commercial fishery (consisting mostly of Chinook salmon) has been progressively more restrictive.

The economic impacts to the fishermen and on-shore industries that support the ocean commercial salmon industry have been, and continue to be significant. The maximum dollar values for the ex-vessel price (the price received by fishermen for fish landed at the dock) adjusted to 2005 dollar values are presented in Table 2.19 for the four major ports in the KMZ. The seasons when regulatory closures prohibited commercial ocean salmon fishing are not shown in the table, and correspond to no income for fishermen.

Table 2.19: Estimates of maximum dollars for the ex-vessel price of the commercial ocean salmon fishery for the four major ports within the KMZ from 1976-1990 and 1991-2001.

Port	Year(s)[1] / Maximum Dollars	Year(s)[1] / Maximum Dollars
Brookings, OR	1976-1980 / 7,355,000	1991-1995 / 126,000
Crescent City, CA	1976-1980 / 5,931,000	1991-1995 / 9,000
Eureka, CA	1976-1980 / 8,884,650	1991 / 43,640
Fort Bragg, CA	1986-1990 / 14,902,000	2001 / 663,000

Source: PFMC 2006b
[1]Multiple year's values represent the average income per year

The 2006 ocean commercial troll non-Tribal salmon fishery was severely curtailed along much of the west coast by the PFMC. The potential offspring of the 2002 Chinook stocks, the four year age class, is that cohort of fish that were predicted to have subsequently returned to the Klamath River as spawners in 2006. The loss of over 33,000 salmonids in 2002, mostly fall Chinook (USFWS 2003b p.ii), was a contributing factor to the low return and resulting fishery restrictions in 2006. In particular, within the KMZ, extending from Humbug Mountain north of Brookings, OR to Horse Mountain just south of Shelter Cove, CA, the 2006 season was closed (NOAA 2006). South of Horse Mountain to Point Arena the season was open only from September 1 through September 15, or when a Chinook salmon quota of 4,000 fish was reached. The extreme seasonal and take restrictions were deemed necessary by the PFMC to assure an adequate numbers of spawners returned to the Klamath River.

During 2007 the PFMC (2008) considered Chinook salmon stocks within the KMZ somewhat healthier than 2006 but only opened the ocean commercial Chinook season from September 10 - September 30, imposing a fleet quota of 6,000 fish. Chinook stocks south of the KMZ to Point Arena were deemed depressed to the point that the PFMC only allowed fishing during the periods from April 9-April 27 (fleet quota of 2,000 fish) and August 29-September 30 (no quota set). The ocean coho salmon fishery remained closed along the California coast for the entire fishing season.

2.7 Problem Statement Synthesis

Based on the analysis presented in this chapter, there is little doubt that the Klamath River is an impaired waterbody. The Klamath River TMDL problem statement has identified numerous water quality related factors that must be addressed in the TMDL allocations and the implementation plan. The following is a summary of the water quality conditions and impacts that are addressed in the TMDL.

- Temperature conditions that exceed natural levels exist throughout the Klamath River basin and contribute to: chronic stress and sometimes acute lethal conditions for cold water fish, migration barriers, proliferation of fish diseases such as Columnaris, lower reproductive success, increased juvenile and adult mortality, and lower overall fish populations.
- Nutrient concentrations in much of the Klamath River watershed are well above natural background levels and contribute to excess periphyton and suspended algae growth, which in turn contributes to poor DO and pH conditions, and also

contributes to increased abundance and exposure of fish to parasites (e.g., *C. shasta*).

- High levels of nutrients and the presence of impoundments have contributed to the development of nuisance levels of blue-green algae that have created potential health hazards for people exposed to reservoir and downstream river waters. This health hazard has negatively impacted both recreational and ceremonial use of the reservoirs and the river.
- Conditions of low DO and high pH are persistent in much of the Klamath River and contribute to multiple impacts on cold water fish including: migration barriers, decreased growth and fecundity, decreased reproductive success, increased juvenile fish mortality, increased adult mortality, and lower overall fish populations.
- Excess sediment delivery to the Klamath River and tributary streams has contributed to habitat impairment, increased levels of nutrients, and to the development of water column temperatures that exceed Basin Plan water quality objectives.
- Reduced flows contribute to increased water column temperatures, the accumulation of organic matter, and low DO conditions which have contributed to impacts on aquatic life.
- Water quality objectives for temperature, DO, pH, biostimulatory substances, and toxicity are regularly exceeded in the Klamath River basin in California.
- Seventeen of the twenty-three designated beneficial uses for the Klamath River are not supported due to existing water quality impairments and related factors.

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CHAPTER 2. REFERENCES

Anderson, C.W. and K.D. Carpenter. 1998. Water Quality and algal Conditions in the North Umpqua River Basin, Oregon, 1992-1995, and Implications for Resource Management. U.S. Department of the Interior, U.S. Geological Survey. Water Investigations Report 98-4125. Portland, OR. 78pp.

Asarian, E, J. Kann, and W. Walker, 2009. Multi-year Nutrient Budget Dynamics for Iron Gate and Copco Reservoirs, California. Final Technical Report to the Karuk Tribe Department of Natural Resources, Orleans, CA. 55pp + appendices.

Bartholow, J.M. 1995. Review and Analysis of Klamath River Basin Water Temperatures as a Factor in the Decline of Anadromous Salmonids with Recommendations for Mitigation. Midcontinent Ecological Science Center, River Systems Management Section. Fort Collins, CO. May 11, 1995. 53pp.

Bartholow, J.M, S.G. Campbell, and M. Flug. 2005. Predicting the Thermal Effects of Dam Removal on the Klamath River. Environmental Management. 34(6): 856-874.

Bartholomew, J. 2008. Personal communication between Dr. Bartholomew of Oregon State University and Clayton Creager (Regional Water Board Staff) regarding a conceptual model image used during her presentation at the Klamath Fish Health Workshop in Fortuna, CA (March 2008) regarding factors contributing to increased incidence of salmon parasite infections. E-mails and telephone discussions permission granted for use of PowerPoint figure and text.

Bartholomew, J. and S.J. Bjork. 2007. Establishing Baseline Information for Assessment of Flow Management Alternatives for Mitigating Effects of Myxozoan Pathogens in the Klamath River. California Energy Commission, PIER Energy Related Environmental Research. CEC-500-2007-089. Commission Contract No. 500-01-044. Corvallis, OR.

Bartholomew, J., S.D. Atkinson, S.L. Hallett, C.M. Zielinski, and J.S. Foott. 2007. Distribution and abundance of the Salmonid parasite *Parvicapsula minibicornis* (Myxozoa) in the Klamath River basin (Oregon-California, USA). Diseases of Aquatic Organisms. 78:137-146.

Belchik, M.R. and A.S. Larson. 1998. A preliminary Status Review of Eulachon and Pacific Lamprey in the Klamath River Basin. Yurok Tribal Fisheries Program. Klamath, CA. April 1998. 24 pp.

Bernot, M.J. and W.K. Dodds. 2005. Nitrogen Retention, Removal, and Saturation in Lotic Ecosystems: Mini-Review. Ecosystems. 8: 442–453.

Beschta, R.L., R.E. Bilby, G.W. Brown, L.B. Holtby, and T.D. Hofstra. 1987. Stream temperature and aquatic habitat: fisheries and forestry interactions. *IN:* E.O. Salo and T.W. Cundy Eds. Streamside management: Forestry and fishery interactions. Contrib. 57: University of Washington, College of Forest Resources, Seattle, pp.191–232.

Biggs, B. J. 2000. Eutrophication of streams and rivers: Dissolved nutrient-chlorophyll relationships for benthic algae. J. N. Am. Benthol. Soc. 19:17-31.

Bigham, D. L., Hoyer, M. V. and Canfield Jr., D. E. 2009. Survey of toxic algal (microcystin) distribution in Florida lakes. Lake and Reservoir Management. 25(3)264-275.

Bjornn, T. and D. Reiser. 1991. Habitat requirements of salmonids in streams. In Meehan, W. Ed., Influences of Forest and Rangeland Management on Salmonids Fishes and Their Habitat. American Fisheries Society Special Publication 19. pp. 83-138.

Bowman, C. 2006. Personal communication with Crystal Bowman, Quartz Valley Indian Reservation EPA Director via e-mail to David Leland (Regional Water Board Staff) on July 18, 2006. Attachment to e-mail regarding preliminary information from the Quartz Valley Tribe about cultural use of the Klamath River and its tributaries for use in the Klamath River Basin TMDL. 1pp.

Brown, L.R. and P.B. Moyle. 1991. Status of Coho Salmon in California: Report to the National Marine Fisheries Service. Department of Wildlife and Fisheries Biology, University of California, Davis. 98pp.

Brown, L.R., P.B. Moyle, and R.M. Yoshiyama. 1994. Historical Decline and Current Status of Coho Salmon in California. North American Journal of Fisheries Management. 14(2):237-261.

California Department of Fish and Game (CDFG). 1965. California Fish and Wildlife Plan. Volume III, Supporting Data. Part B-Inventory Salmon-Steelhead & Marine Resources. 356pp.

California Department of Fish and Game (CDFG). 1967. Fish Bulletin 135. The California Marine Fish Catch for 1965 and California Salmon Landings 1952 through 1965. Marine Resources Branch.

California Department of Fish and Game (CDFG). 2000. Report on "Documentation of the Klamath River Fish Kill, June 2000." October 25, 2000. Northern California-North Coast Region. 10pp. + attachment.

California Department of Fish and Game (CDFG). 2002. Status Review of California Coho Salmon North of San Francisco. Report to the California Fish and Game Commission. The Resources Agency. Sacramento, CA. 232pp +appendices.

California Department of Fish and Game (CDFG). 2004. September 2002 Klamath River Fish-Kill: Final Analysis of Contributing Factors and Impacts. Northern California-North Coast Region. 173pp.

California Department of Fish and Game (CDFG). 2006. Klamath River Basin Spring Chinook Salmon Spawner Escapement, River Harvest and Run-size Estimates. Megatable 1980-2006. 9pp.

California Department of Fish and Game (CDFG). 2008. Klamath River Basin Fall Chinook Salmon Spawner Escapement, In-river Harvest and Run-size Estimates. Megatable 1978-2007. 10pp.

California Fish and Game Commission (CFGC). 2006. Title 14. Fish and Game Commission Notice of Proposed Changes in Regulations. February 7, 2006. 5pp. Accessed November 16, 2007. Available at: <http://www.fgc.ca.gov/regulations/new/2006/7_50b91_1ntc1.pdf>.

Carmichael, W.W., C. Drapeau, and D.M. Anderson. 2000. Harvesting of *Aphanizomenon flos-aquae* Ralphs ex Born. & Flah. Var. *flos-aquae* (Cyanobacteria) from Klamath Lake for human dietary use. Journal of Applied Physiology. 12:585-595.

Corum, S. 2007. Personal communication with Susan Corum, Water Resource Coordinator, Department of Natural Resources, for the Karuk Tribe via e-mail to Katharine Carter (Regional Water Board staff) on December 10, 2007.

Coutant, C.C. 1987. Poor Reproductive Success of Stripped Bass from a Reservoir with Reduced Summer Habitat. Transactions of the American Fisheries Society. 116:154-160.

de Figueiredo, D.R., U.M. Azeiteiro, S.M. Esteves, F.J.M. Gonalves, and M.J. Pereira. 2004. Rapid Communication: Microcystin-producing blooms—a serious global public health issue. Ecotoxicology and Environmental Safety 59:151–163

De la Fuente, J. and D. Elder. 1998. The flood of 1997, Klamath National Forest, Phase I Final Report. November 24, 1998. Klamath National Forest. Yreka, CA. 76 p. + appendices.

Deas, M. 2000. Brief Synopsis of Available Hydrologic, Meterologic, and Water Temperature Data, June 15-July 7, 2000. July 14, 2000. 7pp.

Downing, J.A., S.B. Watson, and E. McCauley. 2001. Predicting Cyanobacteria Dominance in Lakes. Canadian Journal of Fish and Aquatic Science. 58:1905-1908.

Dunsmoor, L.K., and C.W. Huntington. 2006. Suitability of Environmental Conditions within Upper Klamath Lake and the Migratory Corridor Downstream for Use by Anadromous Salmonids. Technical Memorandum to the Klamath Tribes. Revised October 2006. 80 pp. + appendices.

Eilers, J.M., J. Kann, J. Cornett, K. Moser, and A. St. Amand. 2004. Paleolimnological evidence of change in a shallow, hypereutrophic lake: Upper Klamath Lake, Oregon, USA. Hydrobiologia. 520:7-18.

Elder, D., B. Olson, A. Olson, and J. Villeponteaux. 2002. Salmon River Sub-basin Restoration Strategy. Steps to Recovery and Conservation of Aquatic Resources. Report for The Klamath River Basin Fisheries Restoration Task Force, Interagency Agreement 14-16-0001-90532. USDA-Forest Service, Klamath National Forest. Yreka, Klamath National Forest and Salmon River Restoration Council. Sawyers Bar, CA. June 14, 2002. 52 pp.

Engbring, J. 2004. Klamath Fish Conference Call, June 17, 004. Notes. 2pp.

Federal Energy Regulatory Commission (FERC). 2007. Final Environmental Impact Statement for the Klamath Hydroelectric Project. Docket No. 2082-027. Federal Energy Regulatory Commission Office of Energy Projects Division of Hydropower Licensing. November 2007.

Fetcho, K. 2006. Klamath River Blue-Green Algae Bloom Report, Water Year 2005. Yurok Tribe Environmental Program. January 2006.

Fetscher, A.E., L. Busse, and P. R. Ode. 2009. Standard Operating Procedures for Collecting Stream Algae Samples and Associated Physical Habitat and Chemical Data for Ambient Bioassessments in California. California State Water Resources Control Board Surface Water Ambient Monitoring Program (SWAMP) Bioassessment SOP 002.

Foott, J.S. 2000. Klamath River Fish Kill Update. Memorandum. July 18, 2000. United States Fish and Wildlife Service. California-Nevada Fish Health Center. Anderson, CA. 2pp.

Foott, J.S. 2005. Fish Health Issues in the Lower Klamath River Basin. Presentation given at the 2005 Klamath River Fish Health Workshop. November 2005. U.S. Fish and Wildlife Service, California-Nevada Fish Health Center.

Foott, J.S. 2006. Excerpt of a personal communication with Scott Foott of the United States Fish and Wildlife Service, California/Nevada Fish Health Center via e-mail to Katharine Carter (Regional Water Board Staff) on October 13, 2006.

Foott, J.S., T. Martinez, R. Harmon, K. True, B. McCasland, C. Glace, and R. Engle. 2002. FY2001 Investigational Report: Juvenile Chinook Health Monitoring in the Trinity River, Klamath River, and Estuary. June-August 2001. U.S. Fish and Wildlife Service, California-Nevada Fish Health Center. Anderson, CA. 32pp.

Gearheart, R. A., J.K. Anderson, M.G. Forbes, M. Osburn, and D. Oros. 1995. Watershed strategies for improving water quality in Upper Klamath Lake, Oregon - Volumes I, II and III. Humboldt State University, August 1995.

Graham, J.L., K. A. Loftin, and N. Kamman. 2009. Monitoring Recreational Freshwaters. LakeLine 29:16-22

Grove, S. 2002. Mainstem Klamath River fall Chinook spawning survey – Fiscal year 2002. U.S. Fish and Wildlife Service, Arcata Fish and Wildlife Office. Arcata, CA. 35 pp. Accessed from **http://www.krisweb.com/biblio/klamath_usfws_grove_2002_ksspawn.pdf**, on December 27, 2005.

Hallock, R.J., R.F. Elwell, and D.H. Fry, Jr. 1970. Migrations of adult king salmon *Oncorhynchus tshawytsca* in the San Joaquin Delta as demonstrated by the use of sonic tags. California Department of Fish and Game, Fish Bulletin 151. 92pp.

Hampton, M. 2004. Shasta River Fish Counting Facility, Chinook and Coho Salmon Observations in 2003, Siskiyou County, CA. California Department of Fish and Game. Yreka, CA. 19 pp.

Hampton, M. 2005a. Shasta River Fish Counting Facility, Chinook and Coho Salmon Observations in 2004, Siskiyou County, CA. California Department of Fish and Game. Yreka, CA. 19 pp.

Hampton, M. 2005b. Chinook and coho salmon update for Shasta River and Bogus Creek. E-mail and attachments from Mark Hampton of the California Department of Fish and Game on December 9, 2005, 12:29PM. Forwarded to Matt St. John of Regional Water Board Staff by David Webb January 9, 2006, 2:41PM.

Hannum, J.R. 1997. Fish Mortality in Klamath River August 4-14, 1997. Interoffice Memorandum. April 15, 1997. North Coast Regional Water Quality Control Board. Santa Rosa, CA. 3pp.

Hardy, T.B., R.C. Addley, and E. Saraeva. 2006. Evaluation of Interim Instream Flow Needs in the Klamath River, Phase II, Final Report. Report prepared for USDI.

Institute for Natural Systems Engineering. Utah Water Research Laboratory. Utah State University. Logan UT. July 31, 2006. 304pp.

Hendrickson, G.L. 1997. Fish mortalities on Klamath River. Letter dated August 21, 1997. Humboldt State University, Department of Fisheries. Arcata, CA. 2pp.

Herrmann, R.B., C.E. Warren, and P. Doudoroff. 1962. Influence of oxygen concentration on the growth of juvenile coho salmon. Transactions of the American Fisheries Society. 91:155-167.

Hines, D. and J. Ambrose. Undated. Evaluation of Stream Temperatures Based on Observations of Juvenile Coho Salmon in Northern California Streams. 30pp.

Hopelain, J.S. 1998. Age, Growth, and Life History of Klamath River Basin Steelhead Trout (*Oncorhynchus mykiss irideus*) as Determined from Scale Analysis. California Department of Fish and Game. Inland Fisheries Division Administrative Report No. 98-3. 23pp.

Hoopa Valley Tribe Environmental Protection Agency (HVTEPA). 2008. Water Quality Control Plan Hoopa Valley Indian Reservation. Approved September 11, 2002, Amendments Approved February 14, 2008. Hoopa Tribal EPA. Hoopa, CA. 285 pp.

Hudnell, H.K. 2009 The state of U.S. freshwater harmful algal blooms assessments, policy and legislation, Toxicon (2009), doi:10.1016/j.toxicon.2009.07.021

Independent Multidisciplinary Science Team (IMST). 2000. Influences of human activity on stream temperatures and existence of cold water fish in streams with elevated temperature. Report of a workshop. Technical report 2000-2 to the Oregon Plan for Salmon and Watersheds. Oregon Watershed Enhancement Board. Salem, Oregon. 35 p. + appendices.

Johnson, S. L. 2004. Factors influencing stream temperatures in small streams: substrate effects and a shading experiment. Canadian Journal of Fisheries and Aquatic Sciences. 61:913-923.

Jordahl and Benson. 1987. Effect of Low pH on Survival of Brook Trout Embryos and Yolk-Sac Larvae in West Virginia Streams. Transactions of the American Fisheries Society. 116:807-816.

Kann, J. 2006. Technical Memorandum: *Microcystis aeruginosa* Occurrence in the Klamath River System of Southern Oregon and Northern California. Aquatic Ecosystem Sciences LLC. Prepared for the Yurok Tribe Environmental and Fisheries Programs. Klamath, CA. February 3, 2006.

Kann, J. and E. Asarian. 2005. 2002 Nutrient and Hydrological Loading to Iron Gate and Copco Reservoirs, California. Kier Associates Final Technical Report to the Karuk Tribe Department of Natural Resources, Orleans, California. 59p. +appendices.

Kann, J., and S. Corum. 2009. Toxigenic Microcystis aeruginosa bloom dynamics and cell density/chlorophyll a relationships with microcystin toxin in the Klamath River, 2005-2008. Technical Memorandum Prepared for the Karuk Tribe of California Department of Natural Resources. May 2009.

Kann, J. and V.H. Smith. 1999. Estimating the probability of exceeding elevated pH values critical to fish populations in a hypereutrophic lake. Canadian Journal of Fishery Aquatic Sciences. 56:2262-2270.

Karuk Tribe of California. 2002. Water Quality Control Plan. Karuk Tribe Department of Natural Resources. Orleans, CA. 36 p.

Kier Associates. 1999. Mid-term Evaluation of the Klamath River Basin Fisheries Restoration Program. Prepared for the Klamath River Basin Fisheries Task Force. April 1999.

Klamath Fish Health Assessment Team (KFHAT). 2005. End of Year Report, 2004. March 16, 2005. 29pp.

Klamath National Forest (KNF). 1999. Thompson/Seiad/Grider Watershed Analysis. Happy Camp Ranger District.

Klamath National Forest (KNF). 2002. Horse Creek Ecosystem Analysis. Scott River Ranger District.

Klamath Resource Information System (KRIS). 2006. KRIS Klamath Chart Table Page, Shasta Racks data 1930-2002. Accessed January 18, 2006.Available at: <http://www.krisweb.com/>.

Klamath River Basin Fisheries Task Force (KRBFTF). 1991. Long Range Plan for The Klamath River Basin Conservation Area Fishery Restoration Program. Assistance from William M. Kier Associates. 403pp.

Klamt, R. and K. Carter. 2004. June 21, 2004 Klamath River water quality snapshot-summary. North Coast Regional Water Quality Control Board. Santa Rosa, CA. 5pp.

Lehman, P. W., G. Boyer, C. Hall, S. Waller and K. Gehrts. 2005. Distribution and toxicity of a new colonial *Microcystis aeruginosa* bloom in the San Francisco Bay Estuary, California. Hydrobiologia 541:87-99.

Li, R., W.W. Carmichael, Y. Liu, and M.M. Watanabe. 2000. Taxonomic re-evaluation of *Aphanizomenon flos-aquae* NH-5 based on morphology and 16S rRNA gene sequences. Hydrobiologia. 438:99–105.

Ligon, F., A. Rich, G. Rynearson, D. Thornburgh, and W. Trush. 1999. Report of the Scientific Review Panel on California Forest Practice Rules and Salmonid Habitat: Prepared for the Resource Agency of California and the National Marine Fisheries Service Sacramento, CA. 92pp. + appendices.

Lindon, Matt and Heiskary, Steven. 2009. Blue-green algal toxin (microcystin) levels in Minnesota lakes. Lake and Reservoir Management, 25(3):240-252.

Lisle, T.E. 1982. Effects of aggradation and degradation on riffle-pool morphology in natural gravel channels, northwestern California. Water Resources Research. 18(6):1643-1651.

Loheide, S.P., Gorelick, S.M. 2006. Quantifying Stream-Aquifer Interactions through the Analysis of Remotely Sensed Thermographic Profiles and In Situ Temperature Histories. Environmental Science and Technology 40(10):3336-3341.

MacDonald, L.H., A.W. Smart, and R.C. Wissmar. 1991. Monitoring Guidelines to Evaluate Effects of forestry Activities on Streams in the Pacific Northwest and Alaska. EPA/910/9-91-001. Prepared for U.S. Environmental Protection Agency, Region 10 – Water Division. Seattle, WA. 166 pp.

Mangelsdorf, A. 2009. Proposed Site-Specific Dissolved Oxygen Objective for the Klamath River in California. June 2009. 15pp.

Marine, K.R. and J.J. Cech. 2004. Effects of High Water Temperature on Growth, Smoltification, and Predator Avoidance in Juvenile Sacramento River Chinook Salmon. North American Journal of Fisheries Management 24:198-210.

Marshall, L.E. 2005. Annual Report: Trinity River Salmon and Steelhead Hatchery, 2004-2005. Department of Fish and Game. Fisheries Programs Branch. Northern California, North Coast Region. 10pp.

McKernan, K. 2006. Yurok Tribe Response to CUL beneficial uses request. Letter from Kevin McKernan, Director of the Yurok Tribe Environmental Program, to David Leland (Regional Water Board Staff) on July 7, 2006.

Moyle P.B., R.M. Yoshiyama, J.E. Williams, and E.D. Wikramanayake. 1995. Fish Species of Special Concern In California. Department of Wildlife and Fisheries Biology, U.C. Davis. Davis, CA. 272pp.

Moyle, P.B. 2002. Inland Fishes of California, 2nd Ed. Berkeley and Los Angeles, CA. University of California Press.

Murray and Ziebell. 1984. Acclimation of Rainbow Trout to High pH to Prevent Stocking Mortality in Summer. The Progressive Fish-Culturist. 46(3):176-179.

National Oceanic and Atmospheric Administration (NOAA). 1993. Ocean Salmon Fisheries off the Coasts of Washington, Oregon, and California. 58 Federal Register 68063. December 23, 1993. Title 50, Volume 9, Chapter 6, Part 661.

National Oceanic Atmospheric Administration (NOAA). 2006. Southern OR/Northern CA Coasts Coho ESU Threatened. Northwest Regional Office, National Marine Fisheries Service, NOAA. Accessed July 13, 2006. Available at: <http://www.nwr.noaa.gov/ESA-Salmon-Listings/Salmon-Populations/Coho/COSNC.cfm>.

National Research Council of the National Academies (NRC). 2004. Endangered and Threatened Fishes in the Klamath River Basin. Washington, D.C. National Academies Press.

Nielsen, J.L., T.E. Lisle, and V. Ozaki. 1994. Thermally stratified pools and their use by steelhead in northern California streams. Transactions of the American Fisheries Society. 123:613-626.

Norgaard, K.M. 2005. The Effects of Altered Diet on the Heath of the Karuk People. Submitted to the Federal Energy Regulatory Commission Docket #P-2082 on Behalf of the Karuk Tribe of California. November 2005.

Norgaard, K.M. 2006. Personal communication with Dr. Kari Marie Norgaard, Assistant Professor of Sociology and Environmental Studies at Whitman College via e-mail to David Leland (Regional Water Board Staff) on July 7, 2006. Attachment to e-mail regarding preliminary information from the Karuk Tribe about CUL and FISH beneficial use impairment for use in the Klamath River Basin TMDL. 7pp.

North Coast Regional Water Quality Control Board (Regional Water Board). 2009. Staff Report for the 2008 Integrated Report for the Clean Water Act Section 305(b) Surface Water Quality Assessment and the 303(d) List of Impaired Waters. May 18, 2009. Santa Rosa, CA.

Office of Environmental Health and Hazard Assessment - CA Department of Public Health (OEHHA). 2008. Dr. George V. Alexeeff - Deputy Director of Scientific Affairs OEHHA letter providing information related to the occurrence of microsystin in the tissues of Klamath River biota to Mr. Randy Landolt - Managing director, PacifiCorp August 6, 2008.

Oregon Department of Environmental Quality (ODEQ). 1995. Dissolved Oxygen: 1992-1994 Water quality standards review. Final Issue Paper. 166pp. Accessed August 20, 2004.Available at: <http://www.fishlib.org/Bibliographies/waterquality.html>.

Oregon Department of Environmental Quality (ODEQ). 2002. Upper Klamath Lake Drainage Total Maximum Daily Load (TMDL) and Water Quality Management Plan (WQMP). Portland, OR. Accessed November 2, 2009. Available at: <http://www.deq.state.or.us/wq/TMDLs/docs/klamathbasin/ukldrainage/tmdlwqmp.pdf>.

Pacific Fishery Management Council (PFMC). 2003. Review of 2002 Ocean Salmon Fisheries, Ch. IV; Appendices A, C, and D. February 2003. Accessed June 1, 2006. Available at: <http://www.pcouncil.org/salmon/salsafe02/salsafe02.html>.

Pacific Fishery Management Council (PFMC). 2006a. Preseason Report III, Analysis of Council Adopted Management Measure for 2006 Ocean Salmon Fisheries. Prepared by the Salmon Technical Team. April, 2005. Accessed March 15, 2006. Available at: <http://www.pcouncil.org/salmon/salpre06.html >.

Pacific Fishery Management Council (PFMC). 2006b. Review of 2005 Ocean Salmon Fisheries. (Document prepared for the Council and its advisory entities.) Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 200, Portland, Oregon 97220-1384. Accessed March 15, 2006. Available at: <http://www.pcouncil.org/salmon/salsafe05/salsafe05.html>.

Pacific Fishery Management Council (PFMC). 2007. Preseason Report III. Analysis of Council Adopted Management Measures for 2007 Ocean Salmon Fisheries. April 2007. Accessed December 18, 2007. Available at: <http://www.pcouncil.org/salmon/salpreIII07/salpreIII07.html>.

Pacific Fishery Management Council (PFMC). 2008. Preseason Report III. Analysis of Council Adopted Management Measures for 2008 Ocean Salmon Fisheries. Portland, Oregon. April 16, 2008. Accessed June 11, 2008. Available at: <http://www.pcouncil.org/salmon/alpreIII07/salpreIII07.html>.

PacifiCorp. 2004a. Application for New License for Major Project, Klamath Hydroelectric Project (FERC) Project No. 2082, Exhibit E. Portland, Oregon. February 2004.

PacifiCorp. 2004b. Final Technical Report: Fish Resources. Klamath Hydroelectric Project (FERC Project No. 2082). Fish Resources. PacifiCorp, Portland, OR. February 2004. 265 pp.

PacifiCorp. 2004c. FTR: Klamath Hydroelectric Project.(FERC Project No. 2082). Water Resources – Section 6: Analysis of Project Effects on Sediment Transport and River Geomorphology. Portland, Oregon. February 2004.

PacifiCorp. 2006. Appendix B Causes and Effects of Nutrient Conditions in the Upper Klamath River. PacifiCorp, Portland, Oregon.

PacifiCorp. 2008. Water Quality Conditions During 2007 in the Vicinity of the Klamath Hydroelectric Project. Prepared by: Richard Raymond, E&S Environmental Chemistry, Inc., Corvallis, Oregon. Prepared for: CH2M Hill, 2020 SW 4th Avenue, 3rd Floor, Portland, OR 97201; and PacifiCorp Energy, 825 N.E. Multnomah, Suite 1500, Portland, OR 97232. October 14, 2008.

PacifiCorp. 2009. Water Quality Conditions During 2008 in the Vicinity of the Klamath Hydroelectric Project. Prepared by: Richard Raymond, Ph.D. Prepared for: CH2M Hill, 2020 SW 4th Avenue, 3rd Floor, Portland, OR 97201 and PacifiCorp Energy, 825 N.E. Multnomah, Suite 1500 Portland, OR 97232.

Paerl, H.W., 2008. Nutrient and other environmental controls of harmful cyanobacterial blooms along the freshwater-marine continuum. In: Hudnell, H.K. (Ed.), Cyanobacterial Harmful Algal Blooms: State of the Science and Research Needs, Adv. Exp. Med. Biol., 619, Chapter 10. Springer Press, New York, pp. 218–237. Accessed November 12, 2009. <http://www.epa.gov/cyano_habs_symposium/monograph/Ch10.pdf>.

Pierce, R.M. 1998. Klamath Salmon: Understanding Allocation. Klamath River Basin Fisheries Task Force, United States Fish and Wildlife Service, Cooperative Agreement #14-48-113333-98-G00Z. February 1998. 35 pp.

Pierce, R.M. 2002. Dividing the Harvest. *IN*: Proceedings of the 2001 Klamath Basin Fish and Water Management Symposium. Klamath River Inter-Tribal Fish and Water Commission and Humboldt State University Colleges of Natural Resources and Sciences and Arts, Humanities, and Social Sciences. February, 2002.

Poole, G. C., and C.H. Berman. 2001. An Ecological Perspective on In-Stream Temperature: Natural Heat Dynamics and Mechanisms of Human-Caused Thermal Degradation. Environmental Management 27(6):787-802.

Raymond, Richard. 2009. Phytoplankton Species and Abundance During 2008 in the Vicinity of the Klamath Hydroelectric Project. Prepared for: CH2MHill and PacifiCorp Energy. Portland, Oregon.

Reed, R. 2005. Impacts on the Tribe with Decline in the Fishery: Impacts on Way of Life. *IN*: On Salmon and Tribes: The Deterioration of the Salmon Fishery and Health of a Northern California Tribe in the Klamath River Watershed. University of California Davis. June 2, 2005.

Reed, R. 2006. Verbal Comments Received at the Klamath River TMDL CEQA Scoping Meeting. Cultural Biologist, Karuk Tribe of California. July 18, 2006.

Reed, R. 2007a. Personal communication with Ron Reed, Cultural Biologist for the Karuk Tribe via e-mail to Beth Jines (State Water Resources Control Board Staff) on March 13, 2007. E-mail was forwarded by Beth Jines to Matt St. John (Regional Water Board Staff).

Reed, R. 2007b. Personal communication with Ron Reed, Cultural Biologist for the Karuk Tribe via e-mail to Matt St. John (Regional Water Board Staff) on December 18, 2007.

Resighini Rancheria Environmental Department. 2006. Draft Revisions of the Resighini Rancheria Tribal Water Quality Ordinance (Number 02-2006). Draft Revised Tribal Water Quality Ordinance of the Resighini Rancheria. Prepared by Kier Associates. Arcata, CA. Resighini Rancheria. Klamath, CA.

Rushton, K.W. 2005. Annual Report: Iron Gate Hatchery, 2004-2005. Department of Fish and Game. Inland Fisheries. Northern California, North Coast Region. 19pp.

Sinokrot, B.A. and H.G. Stefan. 1993. Stream temperature dynamics: Measurements and modeling. Water Resources Research. 29(7):2299-2312.

Siskiyou County Public Health Department. 2006. News Release Number ALG 06-01. Accessed September 12, 2006. Available at: <http://www. Co.siskiyou.ca.us/phs>.

Sloan, K. 2003. Ethnographic Riverscape: Klamath River Yurok Tribe Ethnographic Inventory (Draft). Prepared by the Yurok Tribe Culture Department for PacifiCorp. FERC Project No. 2082. November 2003.

Sloan, K. 2007a. Personal communication with Kathleen Sloan, Tribal Archeologist and Assistant Director of the Yurok Cultural Resources Division, via e-mail to Katharine Carter (Regional Water Board Staff) on September 19, 2007.

Sloan, K. 2007b. Personal communication with Kathleen Sloan, Tribal Archeologist and Assistant Director of the Yurok Cultural Resources Division, via e-mail to Katharine Carter (Regional Water Board Staff) on October 17, 2007.

Snyder, J.O. 1931. Salmon of the Klamath River, California. Calif. Dept. of Fish and Game, Vol. 10, No. 4. 121 pp.

Spina, A.P. 2007. Thermal ecology of juvenile steelhead in a warm-water environment. Environ. Biol. Fish 80:23-34.

State Water Resources Control Board (State Water Board). 2005. Federal, Tribal and State Authorities Advise Caution on Dangerous Klamath River Algae. State Water Board 05-019. September 30, 2005.

State Water Resources Control Board (State Water Board). 2006. More Blue-Green Algae on Klamath River Than Last Year Say Local, Tribal, State and Federal Authorities. State Water Board 05-018. August 14, 2006.

State Water Resources Control Board (State Water Board). 2008. Blue Green Algae Work Group of the State Water Board, Department of Public Health (DPH), and Office of Environmental Health and Hazard Assessment (OEHHA). Cyanobacteria in California Recreational Water Bodies: Providing Voluntary Guidance about Harmful Algal Blooms, Their Monitoring, and Public Notification – September 2008.

Stocking, R. W. 2006. Distribution of *Ceratomyxa shasta* (Myxozoa) and Habitat Preference of the Polychaete Host, *Manayunkia speciosa* in the Klamath River. Masters Thesis. Oregon State University. February 23, 2006.

Stocking, R. W. and J. L. Bartholomew. 2004. Assessing links between water quality, river health, and Ceratomyxosis of salmonids in the Klamath River system. Oregon State University, Department of Microbiology. 5pp.

Stocking, R.W. and J.L. Bartholomew. 2007. Distribution and Habitat Characteristics of *Manayunkia Speciosa* and Infection Prevalence with the Parasite *Ceratomyxa Shasta* in the Klamath River, Oregon–California. The Journal of Parasitology. 93(1):78-88.

Stocking, R. 2009. Personal communication with Richard Stocking, Oregon Department of Fish and Wildlife – Fish Health Services, via e-mail and phone with Clayton Creager (Regional Water Board staff) on November 19, 20, and 21, 2009.

Strange, J. 2007. Adult Chinook Salmon Migration in the Klamath River Basin: 2005 Sonic Telemetry Study Final Report. Yurok Tribal Fisheries Program, and School of Aquatic and Fishery Sciences- University of Washington in collaboration with Hoopa Valley Tribal fisheries. January 2007. 96pp.

Suter, G.W. 1993. Ecological Risk Assessment. Boca Raton, FL. Lewis Publishers.

Suter, G.W. 1999. Developing conceptual models for complex ecological risk assessments. Human and Ecological Risk Assessment. 5(2): 375-396.

Tetra Tech. 2006. Technical approach to Develop Nutrient Numeric Endpoints for California. Prepared for U.S. Environmental Protection Agency (Contract No. 68-C-02-108-TO-111), and CA State Water Resources Control Board – Planning and Standards Implementation Unit. Lafayette, CA. 120 pp.

Tobler, H. 2007. Toxic lake warning in Calif. Ashland Daily Tidings, Letter to the Editor. Opinion and Editorial section. August 29, 2007.

Tompkins, M. 2006. Floodplain and river corridor complexity : implications for river restoration and planning for floodplain management. PhD dissertation, University of California, Berkeley. Available at: <http://www.lib.berkeley.edu/WRCA/restoration/theses.html>.

United States Environmental Protection Agency (USEPA). 1986. Ambient Water Quality Criteria for Dissolved Oxygen. EPA 440/5-86-003. Office of Water Regulations and Standards Criteria and Standards Division. Washington, DC. 35pp.

United States Environmental Protection Agency (USEPA). 1995. Watershed Protection: A Project Focus. EPA 841-R-95-004. Office of Water, U.S. Environmental Protection Agency, Washington, D.C.

United States Environmental Protection Agency (USEPA). 1998. Guidelines for Ecological Risk Assessment. EPA/630/R-95/002F. Risk Assessment Forum, USEPA, Washington, DC 124 p. + appendices.

United States Environmental Protection Agency (USEPA). 1999a. Protocol for Developing Sediment TMDLs. EPA 841-B-99-004. Office of Water, U.S. Environmental Protection Agency, Washington, D.C.

United States Environmental Protection Agency (USEPA). 1999b. Update of Ambient Water Quality Criteria for Ammonia. EPA 822-R-99-014. Office of Water, U.S. Environmental Protection Agency, Washington, D.C.

United States Environmental Protection Agency (USEPA). 2001. Issue Paper 5: Summary of technical literature examining the effects of temperature on salmonids. Region 10, Seattle, WA. EPA 910-D-01-005. 113pp. Accessed July 2, 2004. Available at: <http://yosemite.epa.gov/R10/ water.nsf>.

United States Environmental Protection Agency (USEPA). 2003. EPA Region 10 Guidance for Pacific Northwest State and Tribal Water Quality Standards. Region 10, Seattle, WA. EPA 910-B-03-002. 49pp. Accessed June 23, 2004. Available at: <http://www.epa.gov/r10earth/temperature.htm>.

United States Environmental Protection Agency (USEPA). 2007. News Release: U.S. EPA, State, Tribes, warn against Klamath River blue-green algae: Contact with blue-green algae can cause eye irritation, skin rash. Released July 5, 2007.

United States Fish and Wildlife Service (USFWS). 1997. Letter dated September 23, 1997 to Bruce Gwynn (Regional Water Board staff) from Bruce G. Halstead (USFWS staff) pertaining to TMDL on the Klamath River. Arcata, CA. 12pp.

United States Fish and Wildlife Service (USFWS). 2003a. Klamath River Fish Die-off, September 2002, Causative Factors of Mortality. Arcata Fish and Wildlife office. Arcata, CA. Report Number AFWO-F-02-03. 115pp.

United States Fish and Wildlife Service (USFWS). 2003b. Klamath River Fish Die-off, September 2002, Report on Estimate of Mortality. Arcata Fish and Wildlife office. Arcata, CA. Report Number AFWO- 01-03. 28pp.

United States Fish and Wildlife Service (USFWS). 2006. Comments on disease presence in the Klamath River in California by Scott Foott of the USFWS California/Nevada Fish Health Center during a panel discussion. Panel Discussion for the Klamath Basin Watershed Conference 2006: Sustainable Watersheds Bring Sustainable Communities. November 8, 2006.

Van Buynder, P.G., T. Oughtred, B. Kirkby, S. Phillips, G. Eaglesham, K. Thomas, and M. Burch. 2001. Nodularin Uptake by Seafood During a Cyanobacterial Bloom. Environmental Toxicology. 16(6): 468-471.

Vaux, W.G. 1968. Intergravel flow and interchange of water in a streambed. Bureau of Commercial Fisheries Biological Laboratory. Auke Bay, Alaska. Fishery Bulletin. 66(3): 479-489.

Wagner, E.J., T. Bosakowski, and S. Intelmann. 1997. Combined Effects of Temperature and High pH on Mortality and the Stress Response of Rainbow Trout after Stocking. Transactions of the American Fisheries Society. 126:985-998.

Walker, W.W. 1985. Statistical bases for mean chlorophyll-a criteria. *Lake and Reservoir Management.* 1:57-62. [alternate volume title: Lake and Reservoir Management – Practical Applications; North American Lake Management Society].

Ward G.H. and Armstrong, N.E. 2006. Q/A Review of Klamath sonde data holdings. Prepared for Paul Zedonis U.S. Fish and Wildlife Service Arcata CA Fish and Wildlife Office. Dataset accessed February 2008.

Ward, G.H., N.E. Armstrong. 2009. (In press) Assessment of Community Metabolism and Associated Kinetic Parameters in the Klamath River. Prepared for: U.S. Fish and Wildlife Service, Arcata Fish and Wildlife Office, 1655 Heindon Road, Arcata, CA 95521. Project Officer – Paul Zedonis.

Washington State Department of Ecology (WDOE). 2002a. Evaluating Criteria for the Protection of Freshwater Aquatic Life in Washington's Surface Water Quality Standards: Dissolved Oxygen. Draft Discussion Paper and Literature Summary. Publication Number 00-10-071. 90pp.

Washington State Department of Ecology (WDOE). 2002b. Evaluating Standards for Protecting Aquatic Life in Washington's Surface Water Quality Standards: Temperature Criteria. Draft Discussion Paper and Literature Summary. Publication Number 00-10-070. 189pp.

Water Right Information Management System (WRIMS). 2006. Water Rights Information for the Klamath River basin in California. State Water Resources Control Board, Division of Water Rights. Data downloaded October 3, 2006.

Welch, E.B. and J. M. Jacoby. 2004. Pollutant Effects in Freshwater: applied Limnology, Third edition. Spon Press. London, UK. 504 pp.

Welsh, H. H., G.R. Hodgson, B.C. Harvey, and M.E. Roche. 2001. Distribution of Juvenile Coho Salmon in Relation to Water Temperatures in Tributaries of the Mattole River, California. Northern American Journal of Fisheries Management. 21:464-470.

Wetzel. 2001. Limnology: Lake and River Ecosystems. Third Edition. Academic Press. London, UK. 985 pp.

Williamson, J.D. and J.S. Foott. 1998. FY98 Investigational Report: Diagnostic Evaluation of Moribund Juvenile Salmonids in the Trinity and Klamath Rivers (June-September 1998). United States Fish and Wildlife Service. California-Nevada Fish Health Center. Anderson, CA. 13pp + appendices.

Wondzell, S.M. and F.J. Swanson. 1999. Floods, channel change, and the hyporheic zone. Water Resources Research. 35(2): 555-567.

World Health Organization (WHO). 1999. Toxic Cyanobacteria in Water: A Guide to Their Public Health Consequences, Monitoring and Management. London, England. 400 pp.

World Health Organization (WHO). 2003. Guidelines for Safe Recreational Water Environments, Volume 1, Coastal and Fresh Waters. Geneva, Switzerland. 253 pp.

Xie, L.Q., P. Xie, L.G. Guo, L. Li, and Y. Miyabara. 2005. Organ distribution and bioaccumulation of microcystins in freshwater fish at different trophic levels from the eutrophic Lake Chaohu, China. Environmental Toxicology 20:293-300.

Yurok Perspectives. 2001. Yurok Perspective of Trinity River Fisheries Resources. Accessed March 15, 2006. Available at: <www.humboldt.edu/~extended/klamath/proceedings2001/KLAMSYM7.PDF>.

Yurok Tribe Environmental Program (YTEP). 2004. Water Quality Control Plan For the Yurok Indian Reservation. Yurok Tribe Environmental Program. Klamath, CA. 37 pp.

Yurok Tribe Environmental Program (YTEP). 2006. Klamath River Blue-Green Algae Bloom Report. Water Year 2005. Prepared by Ken Fetcho. 17pp.

Yurok Tribe Environmental Program (YTEP). 2007. 2006 Klamath River Blue-Green Algae Summary Report. Prepared by Ken Fetcho. 34pp.

Yurok Tribe Environmental Program (YTEP). 2008. FINAL 2007 Klamath River Blue-Green Algae Summary Report. Prepared by Ken Fetcho. 27pp.

CHAPTER 3. ANALYTIC APPROACH

3.1 Introduction

This chapter describes the analytic approach for developing the Klamath River TMDLs for California and the development of the proposed recalculated SSO for DO in the mainstem Klamath River. The analysis incorporated empirical data analysis of the best quality assured water quality data available, review of available reports, and application of water quality models. The water quality models applied were the primary analytic tools used to establish the relationships between pollutant loadings and instream water quality response. In turn, the models were used to quantify the loading capacity of the Klamath River, establish appropriate numeric targets, and calculate load and waste load allocations necessary to achieve the loading capacity and meet water quality standards. Section 3.2 describes these water quality models applied to the Klamath River, and describes the model testing process. Appendix 6 *Model Configuration and Results – Klamath River Model for TMDL Development*, presents the model configuration and testing results in detail. Section 3.3 describes the application of these models for Klamath River TMDL development. Appendix 7 *Modeling Scenarios – Klamath River Model for TMDL Development* (details how each of these scenarios was configured, associated assumptions, and presents the results. Results of these scenarios are also summarized in Chapters 4 and 5.

3.2 Modeling Approach

3.2.1 Hydrologic Models Applied

To support TMDL development for the Klamath River system, the need for an integrated receiving water hydrodynamic and water quality modeling system was identified. A model for the Klamath River had already been developed by PacifiCorp to support studies for the Federal Energy Regulatory Commission hydropower relicensing process (Watercourse Engineering, Inc. 2004) when this project commenced. The version of the model available in 2004 is hereafter referred to as the PacifiCorp Model. Regional Water Board, ODEQ, and EPA determined that this existing PacifiCorp Model would provide the optimal basis, after making some enhancements, for TMDL model development. The PacifiCorp Model uses hydrodynamic and water quality models with a proven track record in the environmental arena and has already been reviewed by most stakeholders in the watershed. Additionally, model results can be directly compared to ODEQ, Regional Water Board and Tribal water quality criteria.

The original PacifiCorp Model consisted of several model components used in series, including the Resource Management Associates (RMA) RMA-2 and RMA-11 models and the U.S. Army Corps of Engineers' CE-QUAL-W2 model. The RMA-2 and RMA-11 models were applied for Link River (which is the stretch of the Klamath River from Upper Klamath Lake to Lake Ewauna), Keno Dam to J.C. Boyle Reservoir, Bypass/ Peaking Reach, and Iron Gate Dam to Turwar. RMA-2 simulates hydrodynamics while

RMA-11 represents water quality processes. The CE-QUAL-W2 model was applied for Lake Ewauna-Keno Dam, J.C. Boyle Reservoir, Copco Reservoir, and Iron Gate Reservoir. CE-QUAL-W2 is a two-dimensional, longitudinal/vertical (laterally averaged), hydrodynamic and water quality model (Cole and Wells 2003).

Since the estuarine portion of the Klamath River (Turwar to the Pacific Ocean) was not included in the original PacifiCorp Model, one of the first updates made was to include an estuarine model. From a review of available data for the estuary, it was apparent that hydrodynamics and water quality within the estuary are highly variable spatially and throughout the year and are greatly influenced by time of year, river flow, tidal cycle, and location of the estuary mouth (which changes due to sand bar movement). Additionally, transect temperature and salinity data in the lower estuary showed significant lateral variability, as did DO to a lesser extent. Therefore, EPA's Environmental Fluid Dynamics Code (EFDC), which is a full 3-D hydrodynamic and water quality model, was selected to model the complex estuarine environment.

EFDC is capable of predicting hydrodynamics, nutrient cycles, DO, temperature, and other parameters and processes pertinent to the TMDL development effort for the estuarine section. It is capable of representing the highly variable flow and water quality conditions within years and between years for the estuary. As with RMA-2, RMA-11, and CE-QUAL-W2, EFDC has a proven record in the environmental arena and model results can be directly compared to ODEQ, Regional Water Board and Tribal water quality criteria. EFDC is EPA-endorsed and supported and available freely in the public domain.

The combination of the PacifiCorp Model (RMA and CE-QUAL-W2), with enhancements discussed below, and the EFDC model for the estuary resulted in the Klamath River model used for TMDL development. Table 3.1 identifies the modeling elements applied to each river segment. These segments are depicted graphically in Figures 3.1 and 3.2. Linkages between the different modeling segments were made by transferring time-variable flow and water quality results from one model to the next (e.g., output from the Link River model became input for the Lake Ewauna-Keno Dam model).

Table 3.1: Models applied to each Klamath River and estuary segment

Modeling Segment #	Modeling Segment	Segment Type	Model(s)	Dimensions
1	Link River	River	RMA-2/RMA-11	1-D
2	Lake Ewauna-Keno Dam	Reservoir	CE-QUAL-W2	2-D
3	Keno Dam to J.C. Boyle Reservoir	River	RMA-2/RMA-11	1-D
4	J.C. Boyle Reservoir	Reservoir	CE-QUAL-W2	2-D
5	Bypass/Full Flow Reach	River	RMA-2/RMA-11	1-D
6	Copco Reservoir	Reservoir	CE-QUAL-W2	2-D
7	Iron Gate Reservoir	Reservoir	CE-QUAL-W2	2-D
8	Iron Gate Dam to Turwar	River	RMA-2/RMA-11	1-D
9	Turwar to Pacific Ocean	Estuary	EFDC	3-D

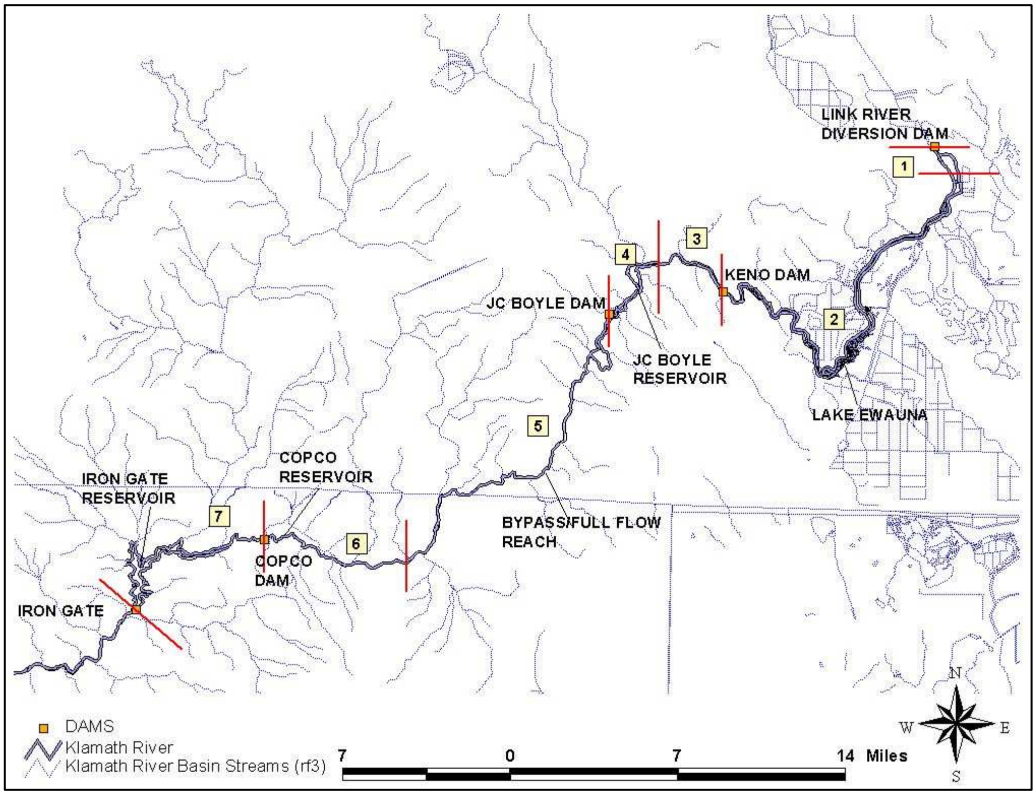

Figure 3.1: Model segments in Oregon and Northern California

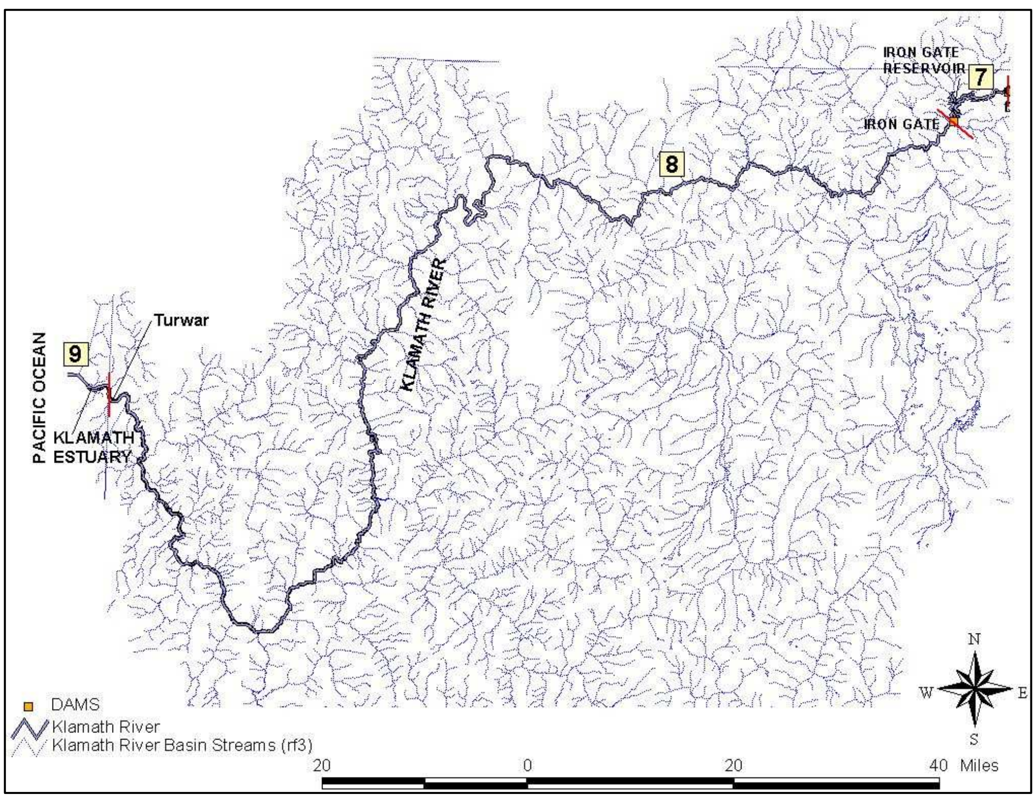

Figure 3.2: Model segments in California

Although the original PacifiCorp Model is capable of addressing the identified water quality issues, a number of adaptations to the model were identified to expedite and strengthen the model for the rigors of TMDL development for the Klamath River. Enhancements were made in the following areas: BOD/organic matter (OM) unification, algae representation in Lake Ewauna, Monod-type continuous SOD and OM decay, pH simulation in RMA, OM-dependent light extinction simulation in RMA, reaeration formulations, and dynamic OM partitioning, and are detailed in Appendix 6. In combination, the RMA/CE-QUAL-W2 and EFDC models as applied for Klamath River TMDL development, are referred to as the Klamath River TMDL models.

The Klamath River TMDL models were also used to develop the proposed recalculated SSO for DO in the mainstem Klamath River (included in this report as Appendix 1), which is a separate Basin Plan amendment that has been closely coordinated with the Klamath River TMDL. The Klamath River SSO for DO will be submitted for Board approval independent of the Klamath River TMDL. The Klamath River SSO for DO is derived from natural background conditions as estimated using percent DO saturation and natural receiving water temperatures. DO concentrations derived from the applicable DO percent saturation criteria are calculated using natural receiving water temperatures. The Klamath River TMDL model was used to create the necessary natural background conditions scenarios.

3.2.1.1 Model Configuration and Testing

The Klamath River TMDL model was configured by designating a set of variables used in the model to define the "state" of a dynamic system (i.e. state variables), preparing the computational grid, and preparing boundary conditions. Once configuration was complete, the model was tested through a rigorous calibration and corroboration process. A summary of these steps is described below, however, a more detailed discussion is included in Appendix 6.

State variables were designated to most accurately predict TMDL impairments, with particular attention paid to temperature, DO, pH, and ammonia toxicity, as well as related physical, chemical, and biological processes. State variables varied for each model type in the Klamath River model (RMA, CE-QUAL-W2, and EFDC). The following state variables were configured for the riverine segments of the Klamath River model (for the RMA portions of the model):

1) Arbitrary Constituent (configured as a tracer to evaluate the mass balance)
2) DO
3) Organic matter (OM)
4) Orthophosphorus (PO_4)
5) Ammonium (NH_4)
6) Nitrite (NO_2)
7) Nitrate (NO_3)
8) Suspended algae

9) Temperature
10) Periphyton
11) Total inorganic carbon (TIC)
12) Alkalinity (Alk)

The reservoir segments of the Klamath River, where the CE-QUAL-W2 model was applied, were configured using the following active state variables:

1) Labile dissolved organic matter (LDOM)
2) Refractory dissolved organic matter (RDOM)
3) Labile particulate organic matter (LPOM)
4) Refractory particulate organic matter (RPOM)
5) Inorganic Suspended Solids (ISS)
6) PO_4
7) NH_4
8) NO_2/NO_3
9) DO
10) Suspended algae
11) Alk
12) TIC
13) Temperature
14) Tracer
15) TDS
16) Age (to track detention time at different locations)
17) Coliform bacteria

The estuarine portion of the Klamath River, which was modeled using EFDC, was configured with the following constituents as state variables:

1) Phytoplankton
2) Periphyton
3) Labile particulate organic carbon (LPOC)
4) Labile dissolved organic carbon (LDOC)
5) Labile particulate organic phosphorous (LPOP)
6) Labile dissolved organic phosphorous (LDOP)
7) PO_4
8) Labile particulate organic nitrogen (LPON)
9) Labile dissolved organic nitrogen (LDON)
10) NH_4
11) NO_2/NO_3
12) DO
13) Temperature
14) Salinity

Note that pH is not included as a state variable in the lists above. It is computed from alkalinity and total inorganic carbon for the riverine and reservoir segments. Alkalinity and total inorganic carbon are transported by the model and are thus included as state variables.

Preparation of the computational grid consisted of segmenting the entire Klamath River into smaller computational segments for application of the various models. In general, bathymetry is the most critical component in developing the grid for the system. Within each of the model segments described above (excluding the Klamath Estuary), the primary waterbody (either a Klamath River section or a reservoir) was subdivided into higher resolution elements for greater detail in modeling. The TMDL modeling framework components were segmented similarly to the PacifiCorp Model. Only the main-stem Klamath River and its reservoirs were simulated with the Klamath River TMDL model. All tributaries to the river were represented as boundary conditions (i.e., they were not explicitly modeled). For the tidal portion of the Klamath River from Turwar to the Pacific Ocean, which was not included in the PacifiCorp Model, a boundary-fit curvilinear grid was developed to accurately represent the shape of the estuary. In the modeling domain, each cell is represented by up to 4 vertical layers.

To run the model, external forcing factors known as boundary conditions were specified for each model segment in the system. These forcing factors are a critical component in the modeling process and have direct implications on the quality of the model's predictions. External forcing factors include a wide range of dynamic information:

- Upstream Inflow Conditions: flows, temperature, and constituent values;
- Tributary (or Lateral) Inflow Conditions: Tributary inflows, temperature, and constituent boundary conditions;
- Withdrawal Boundary Conditions;
- Surface Conditions: Atmospheric conditions (including wind, air temperature, and solar radiation).

Once the Klamath River TMDL model was configured, the model was tested through a calibration and corroboration process at multiple locations. Calibration refers to the adjustment or fine-tuning of modeling parameters to produce the best fit of the simulated output to the field observations. The sequence of calibration for the Klamath River TMDL model involved calibrating flow and water surface elevation first and then calibrating water quality using available monitoring data. Since the original PacifiCorp Model was already calibrated for hydrodynamics, the focus of efforts was on hydrodynamic calibration of the EFDC portion of the model (estuary) and the water quality calibration of the entire model. The corroboration process involved testing calibrated model parameters versus field observations for a separate time period to ensure their appropriateness (qualitative and/or quantitative evaluation of a model's accuracy and predictive capabilities).

The Klamath River TMDL model above the estuary (Model Segments 1 through 8 Link Dam to Turwar) was calibrated using data from the year 2000. This year was selected for calibration because relatively good boundary condition data and in-stream data were available in the upper portion of the system. Data were available, but not to the same extent, for the lower portion of the system (particularly downstream of Iron Gate Dam). Selection of this year was deemed appropriate because water quality conditions in the upper portion of the system drive the response downstream. Although this was an average hydrologic year in terms of flow, simulating the entire year inherently tests the model's ability to represent a range of hydrologic regimes and associated water quality impacts. The model was also corroborated using data from the year 2002, which was a relatively low hydrologic year in terms of flow, for Model Segments 1 through 5, Link Dam to slightly downstream of Stateline. Again, considerably more data were available for the upper portion of the system in 2002 than for other years. The model was not run downstream (Segments 6 through 9) for 2002 primarily due to limited boundary data, but also due to cost considerations. In general, boundary condition data are limited in terms of representing the full range of temporal, spatial, and parameter variability. Thus, it is very likely that evaluation of additional calibration would be more tied to data limitations/ uncertainty than model performance. The estuarine portion (Model Segment 9) was calibrated using data from the year 2004, using bathymetric data and data for key water quality parameters collected as part of an intensive monitoring effort in 2004. Insufficient data were available to calibrate for the year 2000 or 2002 in the estuarine portion of the Klamath River. Calibration and corroboration results are presented in Appendix 6.

3.2.1.2 Assumptions, Limitations, and Uncertainty

Like any dynamic water quality model, the Klamath River TMDL models have inherent limitations and uncertainty. Development and application of the Klamath River TMDL model has focused on key best practices identified in EPA's March 2009 "Guidance on the Development, Evaluation, and Application of Environmental Models," including peer review of models; QA project planning, including data quality assessment; and model corroboration. In addition to the key practices noted above, model sensitivity and uncertainty analysis have also been considered. Appendix 6 details model assumptions, limitations, and uncertainty. The Klamath TMDL development team (US EPA Regions 9 and 10, ODEQ, Regional Water Board, and Tetra Tech) finds that the Klamath River TMDL models are suitable tools for establishing Klamath River TMDL allocations and targets.

3.2.2 Nutrient Numeric Endpoint Analysis

An additional line of evidence for establishing TMDLs in the Klamath River system was provided by an application of the California Nutrient Numeric Endpoint (CA NNE) approach (Tetra Tech 2006) to the Klamath River ([*Nutrient Numeric Endpoint Analysis for the Klamath River, CA* included as Appendix 2 of this report]). The CA NNE approach (Tetra Tech 2006) is a risk-based approach in which algae and nutrient targets can be evaluated based on multiple lines of evidence. The CA NNE approach (Tetra

Tech 2006) also includes a set of relatively simple, but effective, spreadsheet scoping tools for application in lake/reservoir or riverine systems to assist in evaluating the translation between response indicators (e.g. algal biomass) and nutrient concentrations or loads. These response indicators can be incorporated as targets, which can then be translated into site-specific nutrient targets. Nutrient targets established in this way are supplemental to those established to meet specific numeric criteria, such as water quality criteria for dissolved oxygen.

The CA NNE approach recognizes that there is no clear scientific consensus on precise levels of nutrient concentrations or response variables that result in impairment of a designated use. To address this problem, waterbodies are classified in three categories, termed Beneficial Use Risk Categories (BURCs). BURC I waterbodies are not expected to exhibit impairment due to nutrients, while BURC III waterbodies have a high probability of impairment due to nutrients. BURC II waterbodies are in an intermediate range, where additional information and analysis may be needed to determine if a use is supported, threatened, or impaired. Tetra Tech (2006) lists consensus targets for response indicators defining the boundaries between BURC I/II and BURC II/III. The BURC II/III boundary provides an initial scoping point to establish minimum requirements for a TMDL.

As part of the Klamath River CA NNE analysis, multiple lines of evidence including the use of the scoping tools were used to develop numeric targets for maximum reach-averaged density of benthic chlorophyll-a in the Klamath River below Iron Gate Dam, and planktonic chlorophyll-a and blue-green algae (e.g. *Microcystis aeruginosa* and microcystin) numeric targets for Copco and Iron Gate Reservoirs (Appendix 2 of this report). Application of the CA NNE spreadsheet scoping tool for reservoirs successfully predicts observed average concentrations of TN, TP, and chlorophyll-a in Copco and Iron Gate reservoirs, as well as the observed blue-green algal dominance.

Another important tenet of the CA NNE approach (Tetra Tech 2006) is that targets should not be set lower than the value expected under natural conditions. The hydrodynamic model natural conditions baselines scenario (T1BS) predicts TN concentrations in the Klamath River below Iron Gate that are somewhat above the targets estimated by the CA NNE benthic biomass scoping tool; however, the model results are tempered by the fact that the frequency of scouring events that limit periphyton biomass development would also increase in a dams-out scenario. The CA NNE benthic biomass scoping tool suggests that maximum periphyton chlorophyll-a densities in the river under natural conditions would likely be very close to the 150 mg/m^2 target (see section 2.3.2.1).

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3.3 Model Application for TMDL Determination

After the Klamath River TMDL Model was fully tested, it was applied to evaluate a series of scenarios to support TMDL development. The scenarios simulated include:

- Natural condition baseline scenario (T1BSR)
- Oregon allocation scenario (TOD2RN)
- California allocation scenario (TCD2RN)
- With-dam TMDL scenario (T4BSRN)

The natural conditions baseline scenario (T1BSR) was run in order to estimate water quality conditions under natural conditions, because some water quality standards for both Oregon Department of Environmental Quality (ODEQ) and California North Coast Regional Water Quality Control Board (RWQCB) are based on natural conditions. The natural conditions baseline scenario (T1BSR) was also used to assess DO percent saturation potential under natural conditions, which became the basis for the proposed DO SSO. The Oregon and California allocation scenarios TOD2RN and TCD2RN, respectively represent compliance with water quality criteria in Oregon and California, respectively. The Oregon and California with-dam TMDL scenario was run in order to quantify the impacts of the dams on water quality and determining appropriate allocations.

Appendix 7 details how each of these scenarios was configured, associated assumptions, and presents the results. Results of these scenarios are also summarized in Chapters 4 and 5.

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CHAPTER 3. REFERENCES

Cole, T.M. and S.A. Wells. 2003. CE-QUAL-W2: A two-dimensional, laterally averaged, Hydrodynamic and Water Quality Model. Version 3.1. Instruction Report EL-03-1. US Army Engineering and Research Development Center. Vicksburg, MS.

Tetra Tech. 2006. Technical Approach to Develop Nutrient Numeric Endpoints for California. Prepared for U.S. EPA Region 9 and California State Water Resource Control Board. Tetra Tech, Inc. Lafayette, CA.

Watercourse Engineering, Inc. 2003. Klamath River Modeling Framework to Support the PacifiCorp Federal Energy Regulatory Commission Hydropower Relicensing Application. Prepared for PacifiCorp. November 14, 2003.

CHAPTER 4. POLLUTANT SOURCE ANALYSIS

4.1 Introduction

The purpose of a TMDL pollutant source analysis is to inventory and describe all sources of pollutants that are impacting the water quality standards of the impaired waterbody. In addition, this chapter describes the processes for delivery of the pollutants and quantifies the pollutant sources within the watershed. The water quality parameters (or pollutants) considered in this Klamath River TMDL source analysis include:

- Temperature;
- Dissolved Oxygen (DO);
- Organic matter – measured as Carbonaceous Biochemical Oxygen Demand (CBOD)[1];
- Total Phosphorus (TP);
- Total Nitrogen (TN); and
- Microcystin.

This analysis draws upon several sources of information and analytic tools to evaluate the various pollutant sources contributing to impairments within the Klamath River. It also draws upon the most current quality assured data available from ongoing monitoring programs conducted by various entities throughout the Klamath Basin. Application of the Klamath River TMDL models (described in Chapter 3) serves as the primary analytic tool for analyzing the water quality impacts of pollutant source loads. In addition, the source analysis incorporates information from published reports, including the approved TMDLs for the Klamath River tributaries listed below:

- Upper Klamath Lake Drainage TMDL and Water Quality Management Plan – Upper Klamath Lakes and Agency Lakes. Oregon Department of Environmental Quality – May 2002;
- Lost River, California Total Maximum Daily Loads: Nitrogen and Biochemical Oxygen Demand to address Dissolved Oxygen and pH Impairments. United States Environmental Protection Agency Region 9. December 2008;
- Staff Report for the Action Plan for the Shasta River Watershed Temperature and Dissolved Oxygen Total Maximum Daily Loads. State of California North Coast Regional Water Quality Control Board. June 2006;
- Staff Report for the Action Plan for the Scott River Watershed Sediment and Temperature Total Maximum Daily Loads. State of California North Coast Regional Water Quality Control Board. December 2005;
- Salmon River, Siskiyou County, California: Total Maximum Daily Load for Temperature and Implementation Plan. State of California North Coast Regional Water Quality Control Board. June 2005; and

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[1] In this TMDL CBOD refers to CBOD- ultimate. The water quality models represent CBOD as organic matter; it is converted to CBOD-ultimate for TMDL calculations.

- Trinity River Total Maximum Daily Load for Sediment. U.S. Environmental Protection Agency Region IX. December 2001.

Pollutant loads for the year 2000 (the model calibration year) are quantified from fourteen geographic areas or entities (called 'source areas') within the California portion of the Klamath River basin. Each source area has a different combination of source categories / processes at work which contribute to the load from that area. The geographic source areas can be more generally grouped as follows:

- Stateline – waters entering California from Oregon at stateline, which includes the Williamson and Sprague River watersheds, Upper Klamath Lake, the Lost River watershed that drains the Klamath Project area and includes one municipal point source in California, municipal and industrial point sources to the Klamath River in Oregon, and Klamath River waters passing through Keno and JC Boyle Reservoirs. ODEQ's Klamath River TMDL source analysis evaluates the contributions from these discrete sources on the water quality of the Klamath River in Oregon;
- PacifiCorp hydroelectric facilities in California: Copco 1 and 2 and Iron Gate Reservoirs – Copco 1 and 2 Reservoirs are treated as a single source for the purposes of this TMDL;
- Iron Gate Hatchery; and
- Tributaries – Four individual rivers (Shasta, Scott, Salmon, and Trinity Rivers) are included as discrete source areas, while groups of smaller creeks are combined into six additional source areas (stateline to Iron Gate reach tributaries, Iron Gate to Shasta, Shasta to Scott, Scott to Salmon, Salmon to Trinity, and Trinity to Turwar) for this analysis.

The Klamath River is unusual in that it has its origins in a naturally shallow, eutrophic lake, Upper Klamath Lake, which delivers warm water with high levels of nutrients and organic matter to the Klamath River. Due to an increasing stream gradient and inputs from tributaries with water that is both cooler and generally lower in nutrient concentrations, the Klamath River is generally less eutrophic as the river approaches the Pacific Ocean, creating conditions that historically made it one of the most productive cold-water fisheries on the Pacific coast. Because of this unique attribute, traditional (i.e., Tribal) sources have referred to the Klamath River as a "river of renewal." However, despite this unique attribute, current source loads have overwhelmed the historic renewal capabilities of the Klamath River, leading to its impaired status. The intent of the source analysis is to identify and quantify current pollutant source loads, in order to determine the source loads necessary to allow the river once again to be restored through its own unique renewal capabilities.

4.1.1 Pollutant Source Categories

Both point and nonpoint sources of pollution contribute to the water quality impairments in the Klamath River. Land use pollutant source categories impacting Klamath River water quality are identified in Table 4.1. Though difficult to quantify exactly, and sometimes not reflected specifically by watershed models, these land use related nonpoint source categories contribute to water quality impairments in most of the Klamath River source areas. In a basin as large as the Klamath River, where nonpoint sources dominate pollutant loading, it is difficult to precisely quantify loading within source areas from each individual source category. Precise quantification of individual source categories within source areas is not critical because the primary mitigation for nonpoint source loads is not a specific permit limit; rather mitigation is generally based on the use of best management practices that have demonstrated effectiveness to reduce pollutant loads through their application. Therefore the quantitative estimates for the source analysis rely on source area contribution estimates. The source category assessment is a qualitative analysis intended to provide general direction for the implementation strategy. The TMDL load and waste load allocations and targets (Chapter 5) are set for source areas at the levels necessary to meet water quality standards in California. The implementation plan (Chapter 6) presents the regulatory mechanisms necessary to control the major source categories within the source areas and addresses the other source contributions, including the PacifiCorp hydroelectric facilities in California, Iron Gate Hatchery, and suction dredging.

Often, loading from one source category contributes to multiple impairments, as shown in Table 4.1. For example, sediment delivered to the Klamath River from timber harvest related activities and roads can contribute to temperature impairments, but also may contain nutrients that can contribute to DO impairment through biostimulatory effects. Another example of a combined effect is the alteration of riparian functions, such as the degradation of vegetation that provides shade to a waterbody. Not only can this lead to an increase in the temperature load to the water column, it also increases light levels that can increase biostimulatory activity, and reduces the capacity of the riparian zone to filter sediment and nutrients.

Table 4.1: Klamath River anthropogenic pollutant source categories impacting water quality parameters of concern.

Land Use Source Categories Affecting	Temperature	DO	Nutrients	Organic Matter
Wetland conversion		X	X	X
Grazing	X	X	X	X
Irrigated agriculture	X	X	X	X
Timber harvest and sediment	X	X	X	X
Roads	X	X	X	

4.1.2 Natural Conditions Baseline - Background Loads

The starting point for the Klamath River pollutant source analysis involved quantifying natural conditions baseline water quality conditions of the river. The amount of temperature, nutrient, and organic matter loading from natural background sources varies dramatically from one geographic region to another. The TMDL source analysis and allocations recognize and account for the naturally higher background levels of nutrients and organic matter within the upper Klamath River basin in comparison to other ecoregions in California. This higher natural background loading translates into a smaller loading capacity of the river, and less available assimilative capacity to avoid excess heat load, oxygen-consuming substances, and biostimulatory conditions.

As outlined in Chapter 3 and detailed in Appendix 7, the Klamath River TMDL models were applied to characterize natural conditions baseline water quality of the Klamath River. In estimating the natural conditions baseline water quality of the Klamath River, the following characteristics about the Klamath River watershed were incorporated.

The underlying geology in much of the Upper Klamath basin is of volcanic origin. Soils derived from this rock type are naturally high in phosphorus (Walker 2001). Through natural erosion and leaching processes, these soils contribute a high background phosphorous load to Upper Klamath basin waters. In a nutrient loading study conducted by Rykbost and Charlton (2001), monitoring of several natural artesian springs in the upper Klamath basin was characterized by high levels of nitrogen and phosphorus, demonstrating the high natural background loading of nutrients. Upper Klamath Lake has long been noted for its eutrophic condition and demonstrated presence of high levels of organic matter (algae), including nitrogen fixing blue-green algae (Kann and Walker 2001). This nutrient and organic-matter rich Upper Klamath Lake (UKL) water is the headwaters source of the Klamath River.

As described in Section 2.3, Eilers et al. (2004) have identified a clear shift in UKL productivity and species composition in the past 100 years, consistent with large scale land disturbance activities, which can be strongly implicated as the cause of the lake's current hypereutrophic character. These changes also include increased export of nutrients and organic matter from UKL to the downstream waters of Klamath River, contributing to the pollutant loading and water quality conditions that are present today. In addition, this issue has been previously addressed in the technical report for the Upper Klamath Lake Drainage TMDL (ODEQ 2002). This report includes a basin nutrient mass balance model that represents both existing conditions and an approximation of pre-disturbance natural conditions baseline. Pre-disturbance conditions account for the full nutrient retention / loss capabilities of the former extent of wetlands in the upper basin, and landscape export of nutrients prior to increased delivery of nutrients to UKL from silvicultural and agricultural operations. The Upper Klamath Lake Drainage TMDL was based on a number of model years and scenario assumptions providing a range of TMDL compliant conditions. The Klamath River TMDL natural conditions baseline model scenario uses the median of this range of compliance conditions as the boundary condition for source loading to Link River from UKL. A more detailed description of the modeling and assumptions that went into developing these natural condition baseline boundary conditions is available in the Upper Klamath Lake Drainage TMDL (ODEQ 2002), in ODEQ's Klamath River TMDL technical report, and in Appendix 7.

Within the Klamath Mountains Province of the mid- and lower-Klamath River (Figure 1.4), the underlying geology is not volcanic, and therefore does not tend to have the high levels of nitrogen and phosphorus characteristic of the Upper Klamath basin. Consequently, the tributaries that drain to the Klamath River within this province have considerably lower nutrient concentrations. As a result, the eutrophic condition of the Klamath River generally improves as it flows from the Upper Klamath basin to the Pacific Ocean.

Alkalinity is a measure of the ability of water to neutralize acids. In the natural environment, alkalinity comes primarily from the dissolution of carbonate rocks. Carbonate rock sources are rare in much of the Klamath basin due to its volcanic origin. As a result, the Klamath River has a relatively low alkalinity (<100 mg/L). The low alkalinity provides for a weak buffering capacity of Klamath River water. Photosynthetic activity removes carbon dioxide in the water (in the form of carbonic acid) which increases the water pH (see Section 2.4.2.1 for a discussion of impacts). Natural alkalinity serves as a buffer to minimize the photosynthetically induced increase in pH. In low alkalinity waters such as the Klamath River, this buffering capacity is frequently exceeded and high pH values are observed during daytime hours when photosynthesis is occurring. The large daily variation of pH observed in the Klamath River is caused by photosynthetic activity in the low alkalinity water.

Further exacerbating the effect of the naturally productive and weakly buffered system is the presence of regionally high ambient summer air temperatures, and the resulting high heat load to the shallow and predominantly un-shaded Upper Klamath Lake. These naturally warm waters are the source of the Klamath River. In addition, the east-west aspect of much of the Klamath River also makes it prone to heating, even within the steep gorges of some reaches of the river.

In summary, the solar exposure and seasonally high ambient air temperatures, coupled with the high levels of biological productivity and respiration that are enhanced by the high levels of biostimulatory nutrients, yield large volumes of organic matter, seasonally high water temperatures, daily low dissolved oxygen, and high pH levels. All of these water quality conditions can be extremely stressful to many forms of aquatic life. These natural background heat, nutrient, and organic matter loads to the Klamath River underscore the very limited capacity of the river to assimilate anthropogenic pollutant sources, and the necessity for establishing load allocations that will result in attainment of water quality standards.

4.1.3 Pollutant Source Loads - Overview

The Klamath River TMDL models were used to calculate loads for the year 2000, and for purposes of the Klamath TMDL, year 2000 loads represent current loading conditions. The cumulative pollutant loads to the Klamath River for the year 2000 are identified in the schematic diagrams below (Figures 4.1, 4.2, and 4.3). These figures provide an illustration or graphical representation of the current cumulative loading to the Klamath

River for total phosphorus, total nitrogen, and organic matter (CBOD[2]) from the source areas included in the Klamath River TMDL analysis (including source loads from the upper basin above stateline). Cumulative loads used in this analysis include the total annual mass generated from upstream sources that pass through the assessment location (assessment locations along the Klamath River were chosen to be just upstream of major tributary input locations). The loads identified at the assessment locations do not necessarily represent the load contribution from any one source area. Rather the load identified at the assessment location is the cumulative load passing through that location and represents both sources and sinks upstream.

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[2] CBOD is a quantitative measure of the amount of dissolved oxygen required for the biochemical oxidation of carbon-containing compounds.

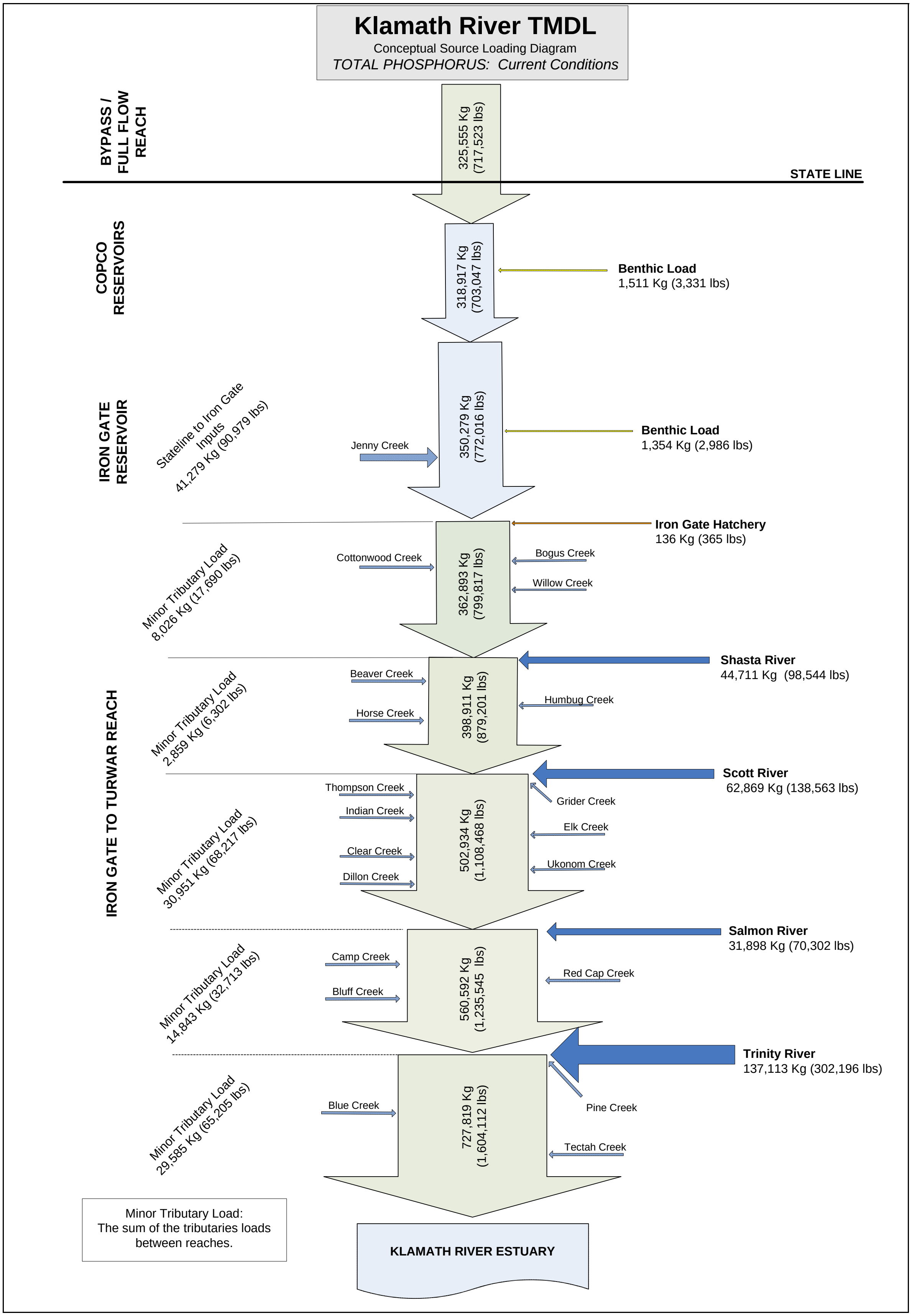

Figure 4.1: Current total phosphorus annual loading diagram

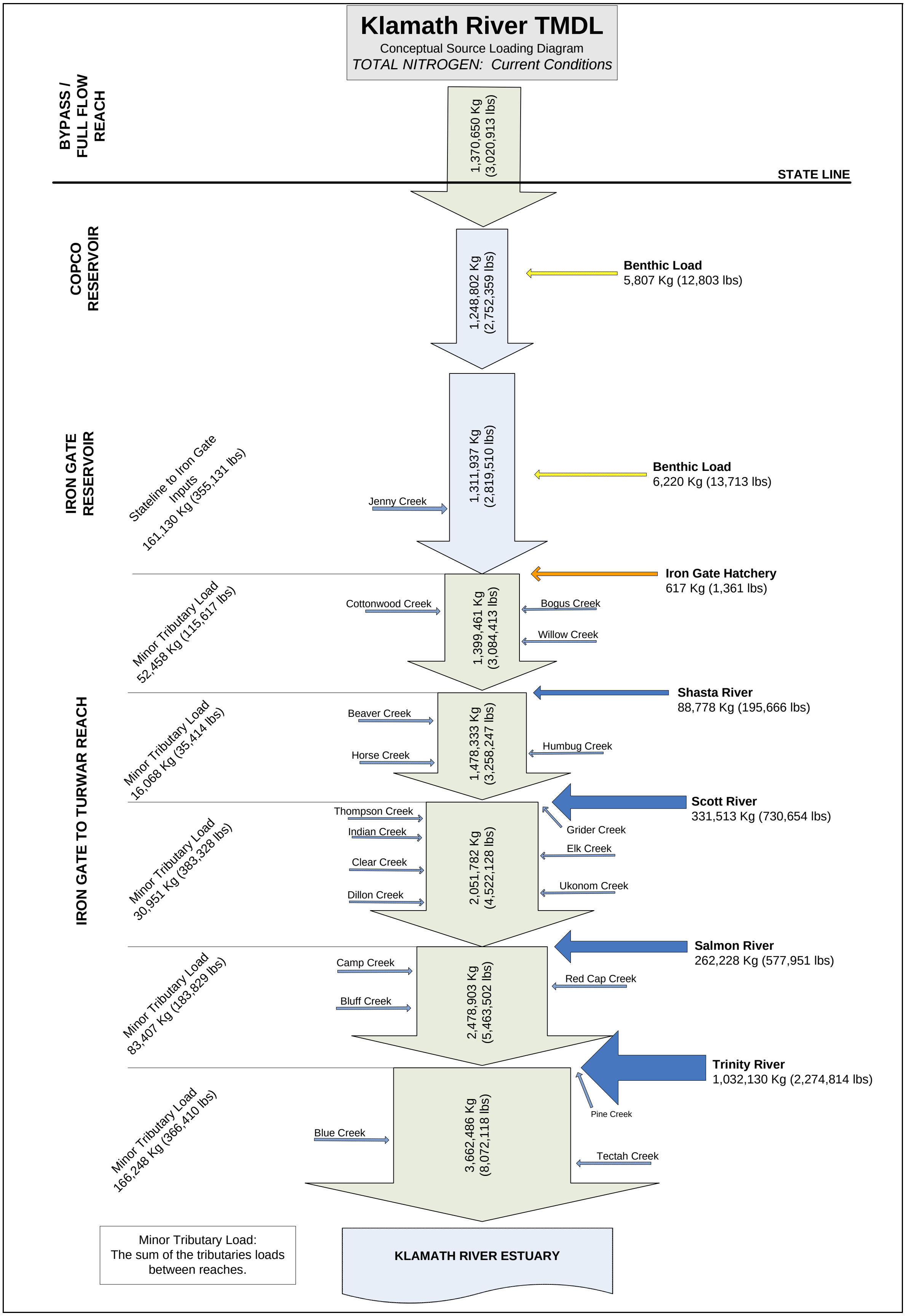

Figure 4.2: Current total nitrogen annual loading diagram

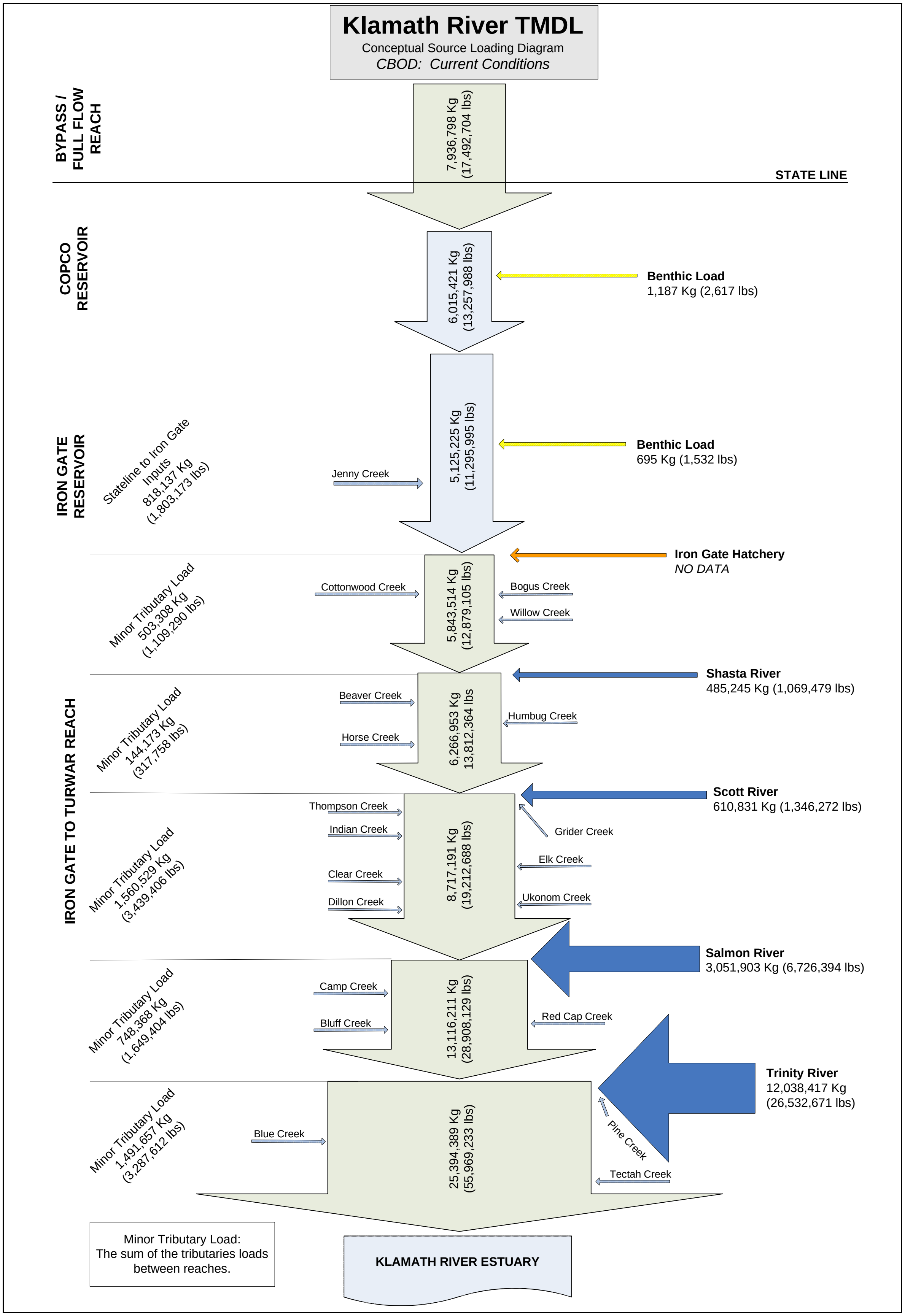

Figure 4.3: Current organic matter (as CBOD) annual loading diagram

The analysis presents load inputs from major and minor tributaries, along with loads along the Klamath River system in California on an annual basis. The loads along the Klamath River system include within-stream and within-reservoir dynamics (e.g., losses, retention, and fluxes). The width of a segment arrow is only approximately proportional to the magnitude of the load for that reach. These figures demonstrate that the Klamath River transports relatively large pollutant loads (~40% of the total load at the mouth of the river) from the upper part of the basin across stateline. The upper basin is relatively low in water yield and high in concentration compared to the relatively high water yield and low concentration contributions of the lower basin tributaries.

The source area loads are also summarized in Table 4.2. Figures 4.1, 4.2, and 4.3 and Table 4.2 provide a comprehensive overview of current loading conditions. For comparison, Table 4.2 also presents estimated annual natural conditions baseline loadings, the current and natural source loading estimates for the critical six month period (May – October) when water quality impairments are generally worst, and the percentage of annual loading associated with each parameter for each source area. The estimates of natural conditions baseline loadings are based on the natural conditions baseline model scenario. The information presented in Table 4.2 is not directly comparable to the information presented in Figures 4.1, 4.2, and 4.3. The vector diagram figures present cumulative loadings along the Klamath River system, incorporating loss and retention within the reservoirs and river reaches, whereas the table only presents the loads to the river from the source areas.

Given the different units typically used to characterize heat load, vector diagrams and a summary table are not presented to summarize the temperature loads to the Klamath River. The temperature effects from different source areas and source categories are presented in Section 4.2.

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Table 4.2: Current and natural conditions baseline nutrient and organic matter loadings to the Klamath River in California

Klamath River TMDL Source Analysis Summary											
		Annual Source Loads (lbs.)			Critical Period Source Loads (lbs.) May - October (six months)			Current Percent Total Annual Loading		
Source Area		**TP**	**TN**	**CBOD**	**TP**	**TN**	**CBOD**	**TP**	**TN**	**CBOD**
Klamath River - Stateline	Current	717,523	3,020,913	17,492,704	316,898	1,343,967	5,949,442	45%	37%	27%
	Natural Baseline	86,737	866,423	6,498,082	29,281	250,408	1,632,541			
Copco Reservoir Outlet	Current	703,047	2,752,359	13,257,988	315,260	1,109,887	3,539,298			
	Natural Baseline	85,776	859,407	6,449,343	28,024	239,122	1,617,123			
Copco Reservoirs – sediment flux	Current	3,331	12,803	2,617	3,204	13,623	1,432	0%	0%	0%
	Natural Baseline	0	0	0	0	0	0			
Stateline to Iron Gate inputs	Current	90,979	355,131	1,803,173	32,638	116,354	358,945	6%	4%	3%
	Natural Baseline	10,157	94,355	690,994	4,212	34,365	235,163			
Iron Gate Reservoir Outlet	Current	772,016	2,891,510	11,295,995	341,109	1,003,978	2,449,221			
	Natural Baseline	95,493	950,527	7,077,933	31,998	271,542	1,867,382			
Iron Gate Reservoir – sediment flux	Current	365	13,713	1,532	1,646	7,240	1,827	0%	0%	0%
	Natural Baseline	0	0	0	0	0	0			
Iron Gate Fish Hatchery	Current	365	1,361	no data	182	680	no data	0.0%	0.0%	no data
	Natural Baseline	0	0	0	0	0	0			
Iron Gate to Shasta Tributaries ▪ Bogus Creek ▪ Willow Creek ▪ Cottonwood Creek	Current	17,690	115,617	1,109,290	4,697	30,701	294,558	1%	1%	2%
	Natural Baseline	17,690	115,617	1,109,290	4,697	30,701	294,558			
Shasta River	Current	98,544	195,666	1,069,479	33,104	64,093	592,149	6%	2%	2%
	Natural Baseline	52,351	154,406	1,691,081	19,651	57,960	634,790			

Table 4.2 (cont.): Current and natural conditions baseline nutrient and organic matter loadings to the Klamath River in California

Klamath River TMDL Source Analysis Summary										
		Annual Source Loads (lbs.)			Critical Period Source Loads (lbs.) May - October (six months)			Current Percent Total Annual Loading		
Source Area		**TP**	**TN**	**CBOD**	**TP**	**TN**	**CBOD**	**TP**	**TN**	**CBOD**
Shasta to Scott Tributaries ▪ Humbug Creek ▪ Beaver Creek ▪ Horse Creek	Current	6,302	35,414	317,758	1,673	9,401	84,348	0%	0%	0%
	Natural Baseline	6,302	35,414	317,758	1,673	9,401	84,348			
Scott River	Current	138,563	730,654	1,346,272	52,957	208,948	1,056,452	9%	9%	2%
	Natural Baseline	138,563	730,654	1,346,272	52,957	208,948	1,056,452			
Scott to Salmon Tributaries ▪ Grider Creek ▪ Thompson Creek ▪ Happy Camp Creek / Indian ▪ Elk Creek ▪ Clear Creek ▪ Ukonom Creek ▪ Dillon Creek	Current	68,217	383,328	3,439,406	12,978	72,930	654,360	4%	5%	5%
	Natural Baseline	68,217	383,328	3,439,406	12,978	72,930	654,360			
Salmon River	Current	70,302	577,951	6,726,394	15,358	192,412	1,946,043	4%	7%	10%
	Natural Baseline	70,302	577,951	6,726,394	15,358	192,412	1,946,043			
Salmon to Trinity Tributaries ▪ Camp Creek ▪ Red Cap Creek ▪ Bluff Creek	Current	32,713	183,829	1,649,404	6,002	33,726	302,610	2%	2%	3%
	Natural Baseline	32,713	183,829	1,649,404	6,002	33,726	302,610			
Trinity River	Current	302,196	2,274,814	26,532,671	56,891	460,714	4,780,372	19%	28%	41%
	Natural Baseline	360,625	2,719,956	31,627,566	75,449	610,999	6,339,738			
Trinity River to Turwar Tributaries ▪ Pine Creek ▪ Tectah Creek ▪ Blue Creek	Current	65,205	366,410	3,287,612	11,972	67,277	603,640	4%	4%	5%
	Natural Baseline	65,205	366,410	3,287,612	11,972	67,277	603,640			
Total of CA source areas	Current	1,612,295	8,267,604	64,778,312				100%	100%	100%

4.2 Pollutant Source Area Loads

This section discusses the pollutant loads from the key source areas.

4.2.1 Stateline – Upper Klamath Basin

4.2.1.1 Temperature

The combined water temperature effects of sources of increased thermal loads in Oregon were evaluated by comparing the results of the current condition model scenario (i.e. the calibrated model for 2000) with the natural conditions baseline scenario at stateline. The results, summarized in Figure 4.4, indicate that the overall temperature effect of all sources upstream of California leads to significant temperature increases, possibly as much as 6 ^{o}F (3.3 ^{o}C), from approximately April to December. Positive values represent an increase above the natural conditions baseline. The sources represented in the current conditions scenario include alterations due to discharge of irrigation return flows (Klamath Straits Drain, Lost River Diversion Channel) and changes in hydrodynamics resulting from reservoir operations (Keno, JC Boyle).

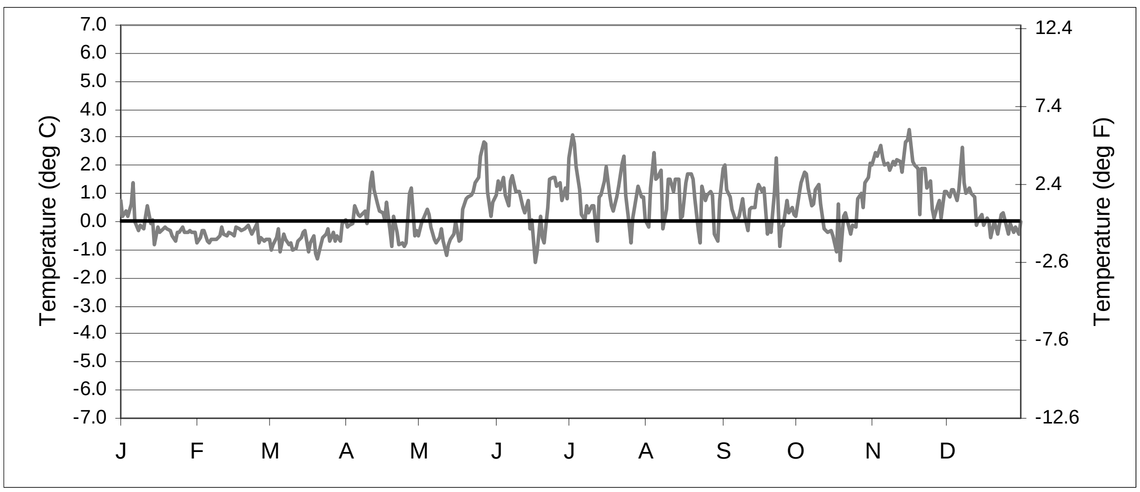

Figure 4.4: Estimated changes of daily maximum temperatures at Stateline due to anthropogenic sources upstream. Positive values represent an increase above the natural conditions baseline.

The diversion of water directly from the Klamath River and its tributaries, including Upper Klamath Lake, greatly alters the flow of the Klamath River, particularly in the spring. Reductions in flow can lead to increased diurnal temperature fluctuations, as well as increased daily average temperatures. These concepts are detailed in Section 2.4.3.3.

As described in Appendix 7, the natural conditions baseline scenario was developed using current flows from Upper Klamath Lake and the Klamath Project area, and therefore does not reflect thermal impacts caused by reduced flows. Thus, Figure 4.4 also does not reflect those thermal effects. To assess the effects of altered flows due to diversions on water temperatures, model scenarios for current flows and natural flows, with all other factors assigned as natural conditions, were compared. The natural flow estimates from the US Bureau of Reclamation's natural flow study (USBR 2005) were used to characterize natural flows. Figure 4.5 presents the difference in daily maximum temperature predicted to occur at stateline solely from differences in flow due to diversion of water (i.e. no dam effects and no irrigation return flow effects are represented in Figure 4.5). Positive values represent an increase in temperatures due to altered flow. The temperature difference between the two scenarios is generally slight, but indicates as much as 2.7 ^{o}F (1.5 ^{o}C) increase in daily maximum temperature in early spring, a 3.6 ^{o}F (2.0 ^{o}C) decrease in May, and a 1.8 ^{o}F (1.0 ^{o}C) increase in November. The results illustrate the effects of the altered annual hydrograph presented in Figure 1.11, in which the unimpaired flows are higher in the Spring and lower in the Fall. This relatively small difference in stream temperatures at stateline during the summer months is likely due to the fact that the source of the Klamath River, Upper Klamath Lake, is a relatively warm waterbody, reaching equilibrium temperatures irrespective of alteration in flow conditions during the summer season.

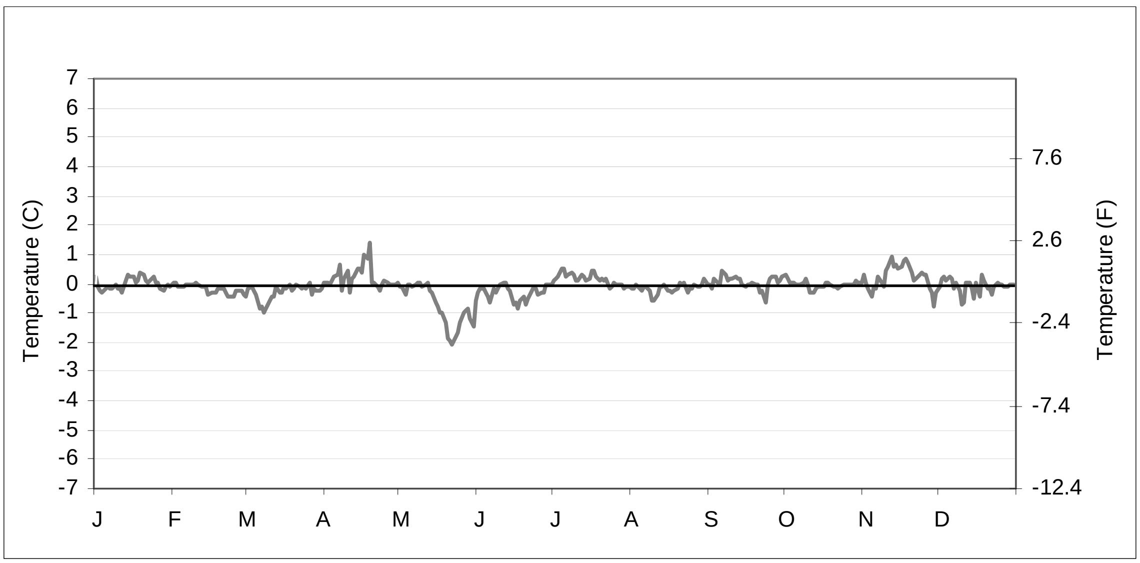

Figure 4.5: Estimated change in daily maximum temperature at Stateline resulting from altered flows, 2000 simulation year. Positive values represent an increase in temperatures due to altered flow.

4.2.1.2 Nutrients and Organic Matter

The largest single source area for nutrient and organic matter loads to the Klamath River originates in the Upper Klamath basin above stateline. Current TP and TN loads at stateline comprise approximately 44% and 37% of the TP and TN loading, respectively, to the Klamath River in California (Table 4.2). The above-Stateline fraction of the total organic matter (CBOD) loading to the California portion of the Klamath River for CBOD is somewhat less at 27%. Figure 4.6 compares the current annual TP, TN, and CBOD loads at stateline to those estimated loads under the natural conditions baseline, reflecting 727%, 248%, and 169% increases in annual loads from natural conditions baseline for TP, TN, and CBOD, respectively.

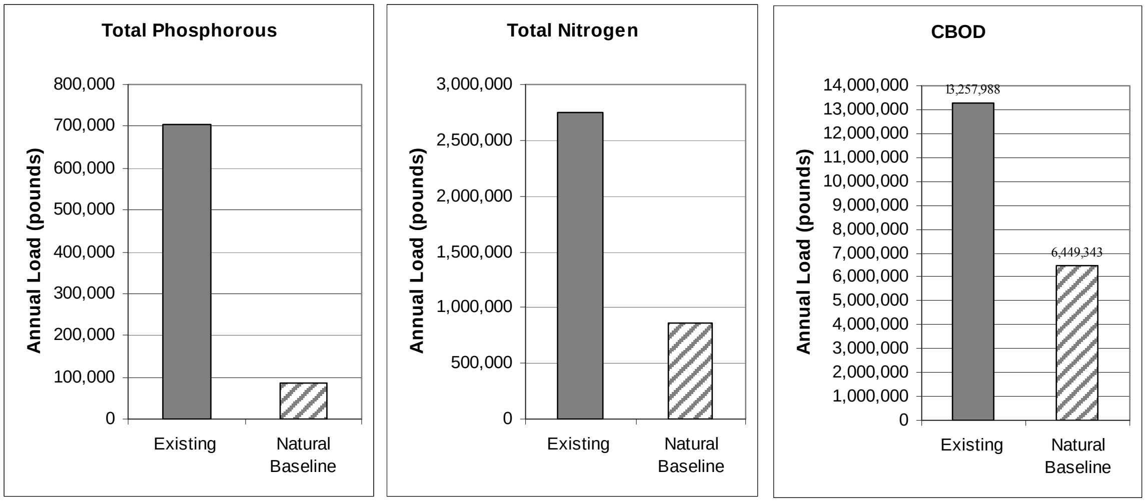

Figure 4.6: Comparison of current annual TP, TN, and CBOD loads at Stateline to natural conditions baseline loads

All of the land use source categories identified in Section 4.1.1 contribute to the increased loads at stateline. The Upper Klamath Lake Drainage TMDL (ODEQ 2002) analyzes the sources contributing loads to Upper Klamath Lake. In addition to irrigated agriculture, upland sources (e.g., gravel road surface erosion, timber harvest operations), nutrient flux from reclaimed wetlands, and internal nutrient loading from Upper Klamath Lake bottom sediments contribute to loading to Upper Klamath Lake. The movement of water from Upper Klamath Lake is regulated and at times much of the flow is diverted to support irrigated agriculture. Some portion of these flows is eventually transferred back to the Klamath River. Working in collaboration with ODEQ, Regional Water Board staff has developed the following source analysis of how the flows diverted to the Lost River basin impact water quality upon their return discharge into the Klamath River.

The Lost River Diversion Channel (LRDC) and Klamath Straits Drain (KSD) are part of United States Bureau of Reclamation’s (USBR’s) Klamath Project and discharge into the Klamath River in the impounded reach upstream of Keno Dam. These facilities, along with water withdrawal canals, hydrologically connect the Klamath River to the Lost River system (for this document the “Lost River system” refers to the hydrologically connected natural and constructed portions of the Lost River, Tule Lake, Lower Klamath Lake, Klamath Straits Drain and other associated canals and drains). ODEQ is also developing a TMDL to address water quality impairments within the Lost River system in Oregon and EPA has promulgated a TMDL for the lower Lost River drainage in California (USEPA 2008). _ODEQ’s Klamath River TMDL investigates the impact of discharge from LRDC and KSD to the Klamath River while the Lost River system TMDL investigates water quality impacts on the Lost River drainage.

USBR’s Klamath Project supplies water to approximately 240,000 acres of cropland (38% of it in California and 62% of it in Oregon) (USBR 2009). Prior to the development of the Klamath Project, there was no surface water connection between the Klamath River and the Lost River system except during extreme flows (NRC 2004).

With the advent of the Klamath Project, water is supplied from Upper Klamath Lake and Klamath River along with reservoirs and tributaries within the Lost River system. Included in the project are reclaimed lands of Tule Lake and Lower Klamath Lakes and facilities related to flood control. In terms of its relationship with the Klamath River, the Klamath Project withdrawals water from Upper Klamath Lake via A-canal and the impounded reach of the Klamath River behind Keno Dam via Ady Canal and North Canal. The LRDC can transfer water to or from the Klamath River. Pump stations at the western end of KSD transfer water to the Klamath River.

A number of studies have concluded that the USBR's Klamath Project is an annual net sink of nutrients in relation to the Klamath River (Rybost and Charlton 2001, Danosky and Kaffka 2002 and Hicks 2009). ODEQ extended the Hicks 2009 analysis to include an entire year, 2002, using DEQ data to supplement the USBR dataset. Daily flow estimates were obtained from USBR's website. When concentration data were not available for a specific canal, a nearby river concentration was used as a surrogate. For this analysis, sources of nutrients to the Klamath River are Klamath Straits Drain and Lost River Diversion Channel and extractions from the Klamath River are A-canal, Lost River Diversion Channel, North Canal and Ady Canal.

Even when examining an entire year of 2002, the Klamath Project appears to be a sink of nutrients in relation to the Klamath River (Figure 4.7). Despite the higher phosphorus concentrations returning to the Klamath River than leaving it, the loading is strongly influenced by the flow and only 30% of the flow that enters the Lost River system from the Klamath is returned to the Klamath River. In 2002, total phosphorus removed from the Klamath River was 2.8×10^5 pounds (130 metric tons) while 1.4×10^5 pounds (64 metric tons) was returned, equivalent to a 50% decrease in estimated total annual load. Total nitrogen removed from the Klamath River was 2.8×10^6 pounds (1300 metric tons) while 9.6×10^5 pounds (440 metric tons), equivalent to a 66% decrease in estimated total annual load.

Even though USBR's Klamath Project appears to be a net sink of nutrients, it also appears to have detrimental impacts to the water quality of Klamath River. Based on mean August 2002 flows, approximately 1255 cfs was diverted out of the Upper Klamath Lake and the Klamath River, leaving approximately 182 cfs in Keno Reservoir just upstream of Klamath Straits Drain (Figure 4.8). Klamath Straits Drain discharge then accounts for approximately half the flow of the Klamath River at Keno Dam. Therefore, its higher concentration of nutrients relative to the Klamath River increases the nutrient concentration which in turn contributes to water quality degradation in the Keno impoundment (Figure 4.9).

The following information is also provided regarding the potential for agricultural operations within the Lost River drainage to affect nutrient dynamics and thus impact water quality within the Klamath basin.

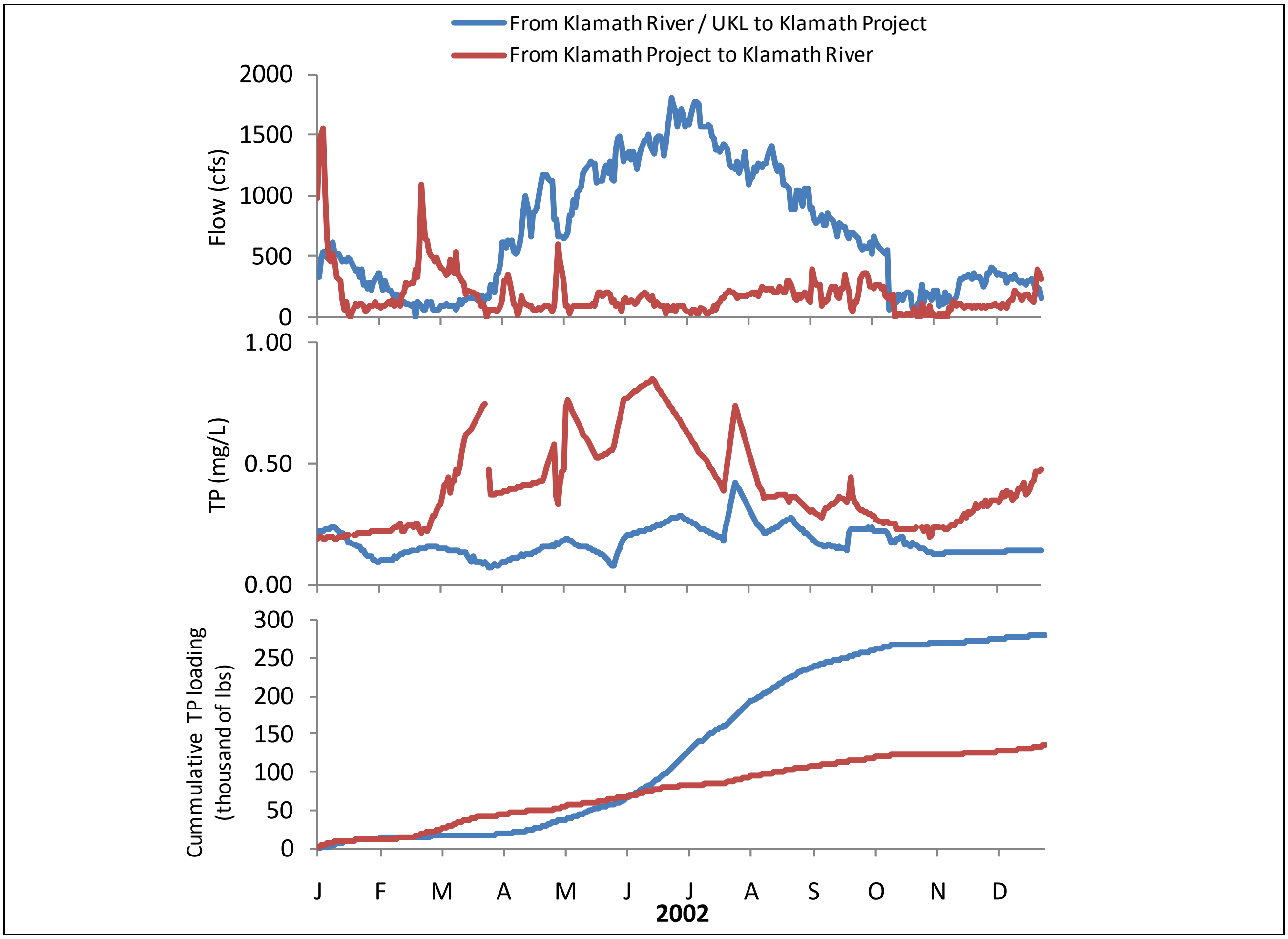

Figure 4.7: Flow, concentration and cumulative loading analysis of USBR's Klamath Project. Total phosphorus (TP) concentrations weighted based on relative flow rates.

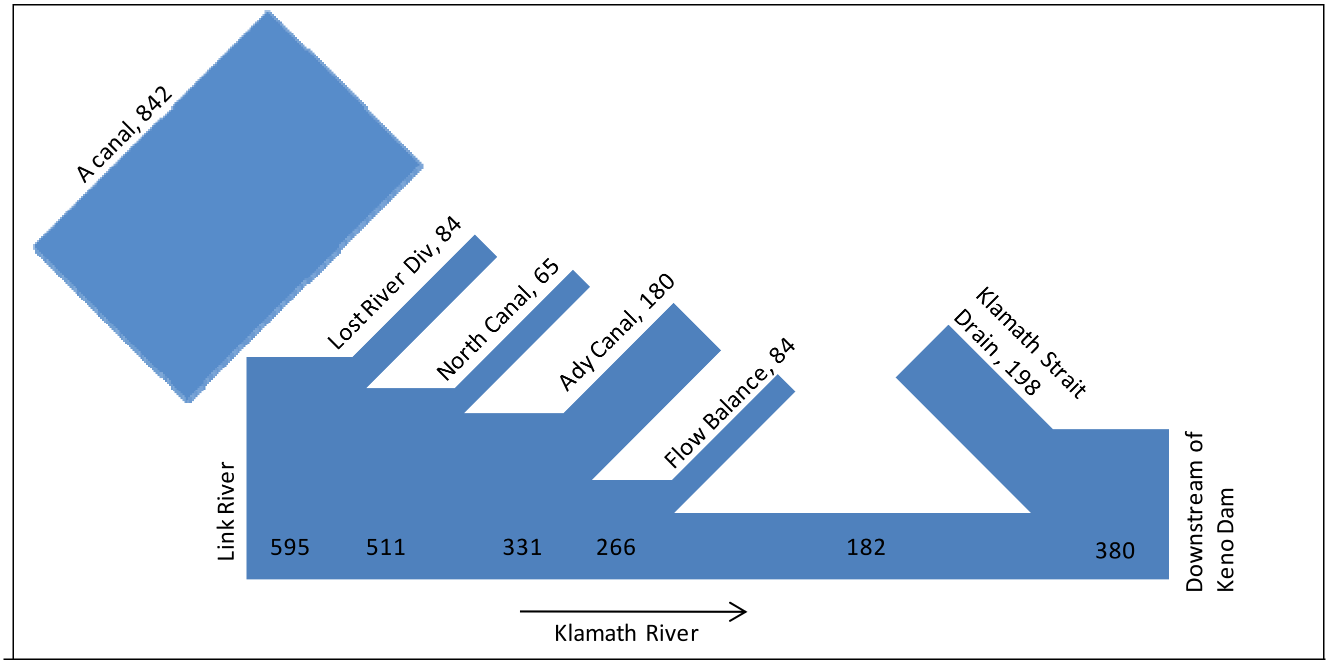

Figure 4.8: Schematic of an example flow balance in cubic feet per second for Keno Reservoir in August 2002. Flows are represented by the thickness of each box. The flow balance portion was derived by subtracting the outflow from the other measured flows.

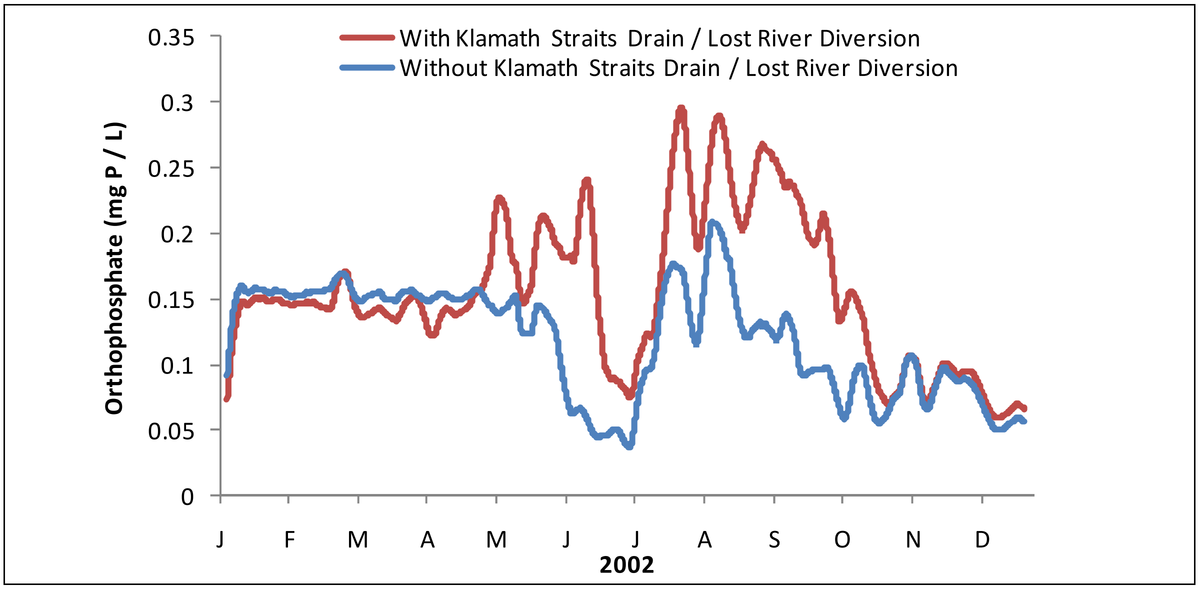

Figure 4.9: Klamath River (Keno Reservoir) model results from just downstream of Klamath Straits Drain discharge. The "With Klamath Straits Drain / Lost River Diversion" results are from the 2002 calibration model. The "Without …" results are from a scenario exactly like the 2002 calibration except the constituent concentrations of parameters for Lost River Diversion and Klamath Straits Drain were set to the same constituent concentrations as Link River.

A water quality study in the Tule Lake irrigation district by the University of California Davis concluded: "The differences in water quality between tiles and drainage ditches suggest that the ditches and water management infrastructure itself has a role in regulating nutrient transfers and can contribute nutrients (especially TP) to the system: from internal hydrologic cycles present in the ditches and canals, from agitation of sediments, from the death and decay of aquatic plants, from N fixation by blue green algae, and from N fixation of sediments due to pumping and transfer of water" (Danosky and Kaffka 2002).

These results are consistent with a water quality investigation by USGS in the Yakima basin (McCarthy and Johnson, 2009). The water quality investigation indicated that combining irrigation and artificial-drainage networks may exacerbate the ecological effects of agricultural runoff by increasing direct connectivity between fields and streams and minimizing potentially mitigating effects of longer subsurface pathways such as denitrification and dilution. Similar findings relative to Upper Klamath Lake are reported by Rykbost and Charlton (2001):

> "Nutrient loading in Klamath Lake is unquestionably enhanced by the drainage of irrigation water from agricultural properties adjacent to the lake. Prior to reclamation, all of these properties were either permanent or seasonal wetlands. Following construction of dikes and drainage systems, the properties were managed for pastures and/or crop production. Soils are high in organic matter content and native fertility; therefore pastures and hay crops on these lands are generally not fertilized. Natural processes associated with mineralization of these soils release nutrients subject to transport in drainage water."

There are also municipal and industrial point sources discharge to the Klamath River within Oregon. There are two municipal wastewater point sources that discharge to the Klamath River in Oregon: South Suburban Sanitation District and Spring Street Sanitation plant run by the City of Klamath Falls. There are two industrial wastewater point sources that discharge to the Klamath River in Oregon: Columbia Forest Products, and Collins Forest Products. There is one municipal wastewater point source that discharges to the Lost River system, the City of Tulelake wastewater treatment plant.

All of these pollutant sources and loads have been considered in the Stateline pollutant source analysis (Figure 4.6).

4.2.2 Copco 1 and 2 and Iron Gate Reservoirs

4.2.2.1 Temperature

An analysis of model results was prepared that isolates the effects of each reservoir (Copco 1 and 2 and Iron Gate), in order to evaluate the impacts of the reservoirs on Klamath River temperature. The effects of the reservoirs were isolated by calculating the change in river temperature between the upstream and downstream limits of each reservoir for both current and natural conditions baseline. The temperature impact of each reservoir was calculated by subtracting the change in temperature that would result from free-flowing conditions (i.e. in the absence of the reservoirs) in the reservoir reaches from the change in temperature that currently occurs in the reservoir reaches. The resulting calculation estimates the change in temperature due to the presence of the reservoirs, by subtracting the amount of heating expected to occur in a natural (free-flowing) state.

The results of the modeling analysis demonstrate that the presence of Copco 1 and 2 significantly influences the temperature of the Klamath River in that reach. Figure 4.10 presents the change in daily maximum temperature associated with the presence of the reservoir for the 2000 calendar year. Positive values represent an increase in temperatures due to the presence of Copco 1 and 2. These results indicate that the presence of Copco Reservoir can increase Klamath River water temperatures by as much as 6.8 ^{o}F (3.8 ^{o}C) during the late summer and fall months, and can decrease daily maximum temperatures by up to 13.3 ^{o}F (7.4 ^{o}C).

The results of the Iron Gate modeling analysis are very similar to the Copco analysis results. The results also demonstrate that the presence of Iron Gate Reservoir significantly influences the temperature of the Klamath River in that reach. Figure 4.11 presents the change in daily maximum temperature associated with the presence of the reservoir for the 2000 calendar year. Positive values represent an increase in temperatures due to the presence of Iron Gate Reservoir. These results indicate that the presence of Iron Gate Reservoir increases Klamath River daily maximum water temperatures by up to 5.8 ^{o}F (3.2 ^{o}C) during the fall months. The timing of this increase coincides with the time when Chinook salmon currently spawn in the Klamath River mainstem directly downstream of the reservoir. The results also indicate that Klamath River daily maximum water temperatures decrease by a similar magnitude (up to 6.8 ^{o}F [3.8 ^{o}C]) for short periods throughout the year, and that the presence of Iron Gate reservoir generally results in reduced daily maximum temperatures by approximately 1.8 ^oF (1.0 ^oC) from February to August.

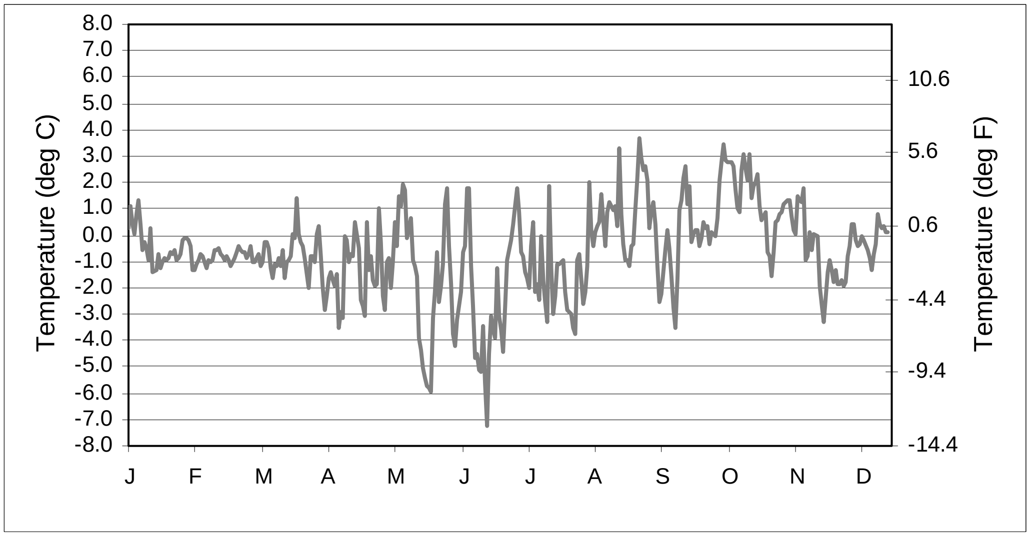

Figure 4.10: Calculated change in daily maximum Klamath River temperatures resulting from the presence of Copco Reservoir for the 2000 calendar year. Positive values represent an increase in temperatures due to the presence of Copco 1 and 2.

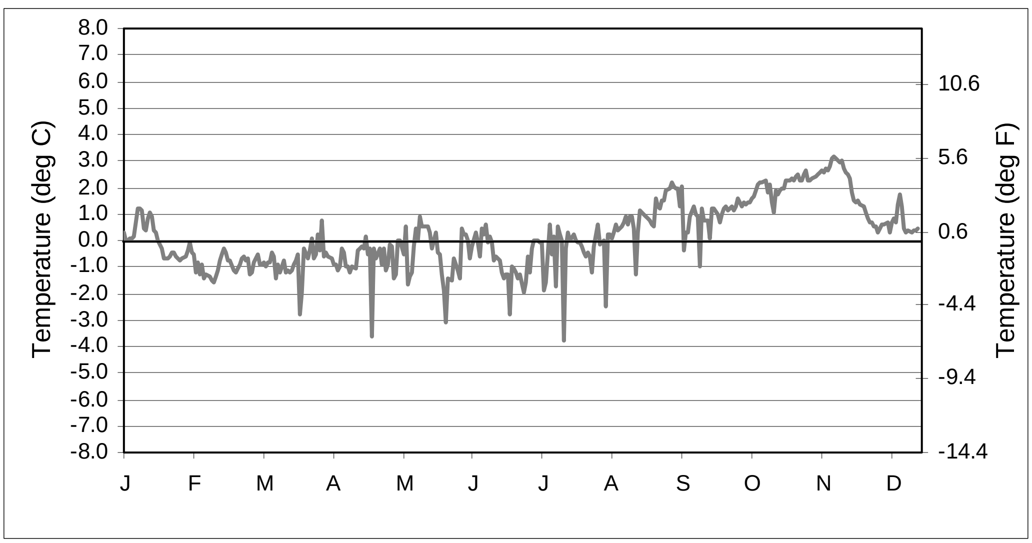

Figure 4.11: Calculated change in daily maximum Klamath River temperatures resulting from the presence of Iron Gate Reservoir for the 2000 calendar year. Positive values represent an increase in temperatures due to the presence of Iron Gate Reservoir.

The analyses of the effects of Iron Gate and Copco 1 and 2 Reservoirs indicate that each of these reservoirs can increase Klamath River water temperatures in these reaches by more than as 5.0 ^oF (2.8 ^oC). Such an increase is explicitly prohibited by the intrastate water quality objective for temperature, which limits temperature increases at any time or place to 5.0 ^oF (2.8 ^oC).

4.2.2.2 Dissolved Oxygen, Nutrients, Organic Matter, Chlorophyll-a, *Microcystis aeruginosa* and Microcystin

The purpose of this section is to describe the complex manner in which increased residence time and heat gain (found in the reservoirs) affect the dynamics of the Klamath River and ultimately impact dissolved oxygen, nutrients, organic matter, chlorophyll-a, *Microcystis aeruginosa* and microcystin. The reservoir related impacts require that reservoirs be considered as a contributing source area and assigned allocations and numeric targets as part of this TMDL.

Dissolved Oxygen

As discussed in Chapter 2 and illustrated in Figure 2.15, within Copco 1 and 2 and Iron Gate Reservoirs DO conditions exist that do not meet water quality standards. The proposed DO objective for the river reaches from Stateline to Iron Gate Dam would require 90% saturation under natural temperatures for October 1 through March 31; and 85% from April 1 through September 30. This objective corresponds to a daily minimum DO concentration ranging from 6.3 mg/L in June to 10.6 mg/L in December from Stateline to Iron Gate Dam. The DO proposed objective is based on the natural conditions baseline TMDL model scenario, which is without dams (i.e., free flowing river). A comparison can be made to Figure 2.15 (Dissolved oxygen and temperature depth profiles in Iron Gate Reservoir – average for July and August 2000 – 2005) where for the period, dissolved oxygen concentrations are well below the proposed objective in the water column, temperatures are below 18.7 ^{0} C. Iron Gate and Copco Reservoirs become stratified during the summer months with warm, DO-rich water near the surface and colder, DO-poor water near the bottom. For much of the summer season, there is no overlapping layer that has DO and temperature conditions where both are simultaneously supportive of the COLD beneficial use. For this assessment, DO concentrations less than 6 mg/L are used as a screening-level target for assessing suitability of DO for COLD. In Iron Gate Reservoir, the levels of DO are only suitable for resident rainbow trout to a depth of 4 meters, on average (rainbow trout are assumed to be the most sensitive cold water-dependent species currently present in the California reservoirs). However, surface water temperatures in Iron Gate reservoir exceed the natural summer mean (18.7 ^{o} C under free-flowing conditions) and frequently reaches levels that are stressful which results in non-supporting conditions for resident rainbow trout above a depth of approximately 10 meters. Copco Reservoir similarly stratifies, with suitable DO above approximately 7.5 meters depth and suitable temperatures below 17 meters deep. Monitoring data demonstrating these conditions, which persist throughout the stratified portions of the reservoirs for much of the summer period, have been reported on several occasions, including the PacifiCorp Water Quality Conditions reports for 2007 and 2008 (PacifiCorp 2008 – Figures 3-14 and 3-16; and PacifiCorp 2009 – Figures 23 and 24). By contrast, under free-flowing river and natural temperature conditions, there would be co-occurring temperature and DO conditions that meet these targets. (Please also see Tables 2.11 and 2.12, as well as Figures 2.25 and 2.26). For additional information regarding DO conditions with the Copco Reservoirs, including depth profile data, see PacifiCorp (2008) and PacifiCorp (2009).

The occurrence of DO conditions that do not provide supporting conditions within Copco 1 and 2 and Iron Gate Reservoirs during summer months is due to the physical characteristics of these reservoirs and the nutrient and organic matter loads entering the reservoirs, and is exacerbated by internal nutrient and organic matter loading within the reservoirs.

Changed Environment, Internal Nutrient Cycling, and Biostimulatory Conditions
Reservoirs alter the nutrient dynamics of a river system. By design, reservoirs represent areas of a river system in which velocity is decreased and residence time increased. The discussion of residence time for Copco and Iron Gate Reservoirs below comes from estimates developed by Tetra Tech (Appendix 3) as part of an evaluation of nutrient retention by Copco and Iron Gate Reservoirs:

> For the two downstream reservoirs in the Klamath system, Copco and Iron Gate, the relevant parameters are given in Table 4.3. Determination of a residence time is problematic for run-of-river reservoirs that are dominated by winter flow-through. Not only does residence time vary throughout the year, but in addition the reservoirs are not well-mixed in summer, and retention time in the hypolimnion may be much longer than in the epilimnion. For the period of May 2005 through May 2006 reported by Kann and Asarian (2007), the overall residence time in both reservoirs was on the order of 6 days, but the summer residence time of surface waters was around 20-25 days for Copco and 25-35 days for Iron Gate (but can reach as high as 50 days in Iron Gate).

Table 4.3 Hydraulic parameters for Klamath reservoirs (May 2005– May 2006)

Impoundments	**Residence Time (*T*, yrs)**	**Mead Depth (*z*, m)**
Copco	0.0384	11.7
Iron Gate	0.0484	16.6

The relatively quiescent waters in Copco and Iron Gate Reservoirs promote the settling of particulate material, including nutrient-bearing organic material and algae, and nutrients (i.e. PO_4 and NH_4) sorbed to inorganic sediment. In addition, the physical characteristics of these reservoirs cause them to stratify during summer months, resulting in the bottom layer of the reservoir (i.e. hypolimnion) becoming devoid of oxygen (i.e. anoxic). Under these conditions, organic debris (including dead algal detritus) that has settled to the bottom of the reservoir is subject to one or more of the following processes that can lead to the transfer of nutrients from the reservoir bottom sediments back into the water column; processes collectively referred to as internal nutrient loading:

- If the sediments are disturbed by wind-driven currents or by other means (organisms or degassing) interstitial nutrients can be transferred to the water column simply by agitation.
- Decrease in the redox potential (increase in the availability of electrons) in the surficial bottom sediments caused by intensive microbial respiration, as would be the case for highly organic sediment, can cause biogeochemical changes that result in accelerated release of mineralized or soluble organic phosphorus and ammonia from the sediments to the overlying water, even if the sediments are immobile.

- High pH at the sediment surface may cause release of adsorbed phosphorus from sediments, with or without agitation of sediments.
- In stratified lakes suspended algae cells may, under calm conditions, sink to deeper waters at or below the thermocline, where phosphorus is more concentrated than in the surface waters where most photosynthesis occurs, and then be re-suspended either by wind or buoyancy control mechanisms after assimilating phosphorus, thus bringing phosphorus from the sediments to the water column. This phenomenon has been documented by Moisander (2008) and illustrated in Figure 4.12.
- Reservoirs having large populations of nitrogen fixing algae and blue-green algae can significantly contribute to nitrogen concentrations in the water column for export downstream.

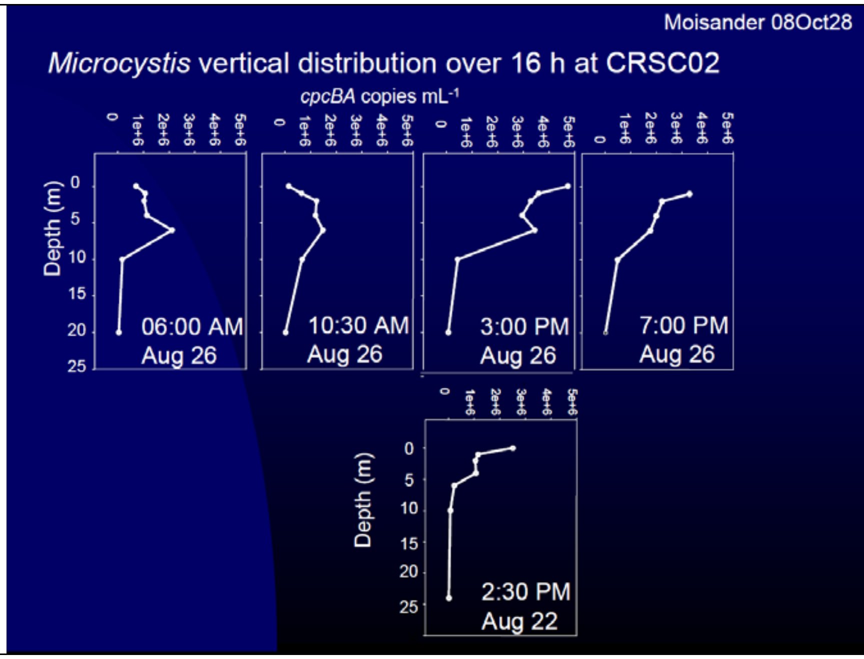

Figure 4.12: Vertical migration of *Microcystis* over a 16 hour period in Copco Reservoir on August 26, 2006.
Source: Moisander 2008

These internal nutrient loading processes can occur simultaneously within a reservoir, and serve as an input (or source) of nutrients into the water column of the reservoir. In addition, phosphate (PO_4) and ammonia (NH_4), the dissolved inorganic nutrients that were once sequestered within the sediments, become available for uptake by planktonic algae within the reservoir.

Role of Copco and Iron Gate Reservoirs in Klamath River Nutrient Dynamics

The purpose of this section is to briefly review the impact of Copco and Iron Gate Reservoirs on Klamath River nutrient dynamics through an evaluation of various estimates of their nutrient retention / export characteristics. Nutrient loads delivered downstream of the reservoirs are influenced by retention and export from the reservoirs. Retention and export can vary annually and seasonally causing the reservoirs to alternate between being either sources or sinks. A recently completed 30-month study of reservoir nutrient budget dynamics (Asarian et al. 2009) provides a strong empirical foundation for this assessment.

For the purposes of this report the term retention is meant as *net* retention, which is the difference between influent (mainstem plus tributaries) and effluent loads. The net retention includes permanent losses (denitrification to atmosphere and deep burial), temporary storage and exchanges (within reservoir water column and active sediment), and gains from the atmosphere due to nitrogen fixation. This definition of net retention is slightly different from that used by Asarian et al. (2009) because that report excluded (subtracted) changes in reservoir storage in calculating retention. However, only the net effect of these processes can be resolved and validated from observed water column concentration data. Ultimately, it is the net retention – the difference in loads and the resulting differences in concentration – that controls eutrophication response in the reservoirs and export of nutrients downstream. Table 4.4 presents the current annual and critical summer growth period (May – October) TP and TN loadings at stateline, Copco 2 outlet, and Iron Gate outlet based on the calibrated TMDL model results for 2000 (note: increasing loads through the reservoirs for TP are due to tributary inputs, not in-reservoir sources).

Table 4.4 TMDL model estimates of current total phosphorus and total nitrogen loads at Stateline, Copco outlet, and Iron Gate outlet

Current Conditions	**Annual Source Loads (lbs.)**		**Critical Period Source Loads (lbs.) May - October**	
Source Area	**TP**	**TN**	**TP**	**TN**
Klamath River - Stateline	717,523	3,020,913	316,898	1,348,967
Copco Reservoirs – tailrace	703,047	2,752,359	315,260	1,109,887
Iron Gate Reservoir – tailrace	772,016	2,891,510	341,109	1,003,978

Table 4.5 presents a summary of analyses regarding nutrient retention and export for Copco and Iron Gate reservoirs. The analyses include model estimates as well as empirical data analysis. As an example, the TMDL model estimates in the first row of each section (TP or TN) of Table 4.5 shows the percentage of reservoir inflow load (mainstem Klamath River plus tributaries) retained in Copco 1, Iron Gate, and the two reservoirs combined. A positive percentage change represents net retention and a negative percentage change represents net export. Within the critical summer growth period (May – October), the TMDL model estimates a combined reservoir retention of TP of 7.6% annually and 6.0% during the period May to October. For nitrogen the annual retention is 14.9% and 30% during the summer growing period (May to October). The TMDL model estimates are consistent with the estimates developed by Asarian et al. (2009) through statistical analysis of empirical monitoring data for the period of May to September. Asarian et al.(2009) have estimated the combined effect of the reservoirs to be 15% retention of TN and 10% retention for TP on an annual basis and seasonally TP 8% and TN 31%. The other estimates included in Table 4.5 were taken from an analysis of nutrient dynamics in the Klamath River performed by Tetra Tech (Appendix 3) and included as Appendix 3 to this report. Some of these estimates have somewhat greater variance, but overall, the analyses demonstrate that the reservoirs retain total nutrients on

an annual basis, with the exception that some of the analyses indicate that the reservoirs have the potential to export a small amount of TP.

Table 4.5: Estimated nutrient retention and export for Copco and Iron Gate Reservoirs

	Time Period Assessed	Method	Copco	Iron Gate	Combined
Total Phosphorous	2000 - annual	TMDL Models	5.1%	3.3%	7.6%
	2000 - May to October	TMDL Models	4.7%	2.0%	6.0%
	2005 - 2006	Asarian et al.2009 empirical model applied by TetraTech (Appendix 3)	16.4%	17.3%	
	2005 - 2006	Nürnberg (1984) empirical model applied by TetraTech (Appendix 3)	4.6%	3.8%	
	2005 - 2006	Range of 5 literature-based empirical models applied by Kann and Asarian (2007)	1.4% - 29%	-1.9% - 29%	
	2005 - 2007 - entire study period	Asarian et al. 2009			10.0%
	2005 - 2007 - May to September	Asarian et al. 2009			8.0%

Table 4.5 (cont.): Estimated nutrient retention and export for Copco and Iron Gate Reservoirs

	Time Period Assessed	Method	Copco	Iron Gate	Combined
Total Nitrogen	2000 - annual	TMDL Models	10.0%	6.7%	14.9%
	2000 - May to October*	TMDL Models	18.6%	16.0%	30.1%
	2002 – March to November	PacifiCorp (2006) , based on Kann and Asarian (2005)			21%
	2005 - 2006	Bachman (1980), empirical model applied by TetraTech (2008)	13.8%	14.5%	
	2005 - 2006	Range of 2 literature-based empirical models applied by Kann and Asarian (2007)	8.7% - 10.3%	9.4% - 10.0%	
	2005 - 2007 - entire study period	Asarian et al. 2009			15.0%
	2005 - 2007 - May to September	Asarian et al. 2009			31.0%

Notes: ▪ TMDL model estimates include river reach from stateline through reservoir tailraces. ▪ Asarian et al. (2009) values based on flow-weighted concentrations in Tables 8 & 9 of that document▪ Positive number is net retention; negative number is net export

Net retention is an important factor in assessing the affect of the reservoirs on nutrient dynamics, but there are several other factors that must also be considered to determine the comprehensive effect on water quality. Several of these factors were discussed previously (Section 2.4.2.1) when considering the impoundments as a risk cofactor for nutrient and organic matter related impacts on beneficial uses. A summary of these factors includes:

- The effect of retaining the nutrients within the reservoirs with respect to contributions to the nuisance algal conditions in the reservoirs.
- The net retention of nutrients within the reservoirs can be substantial -rich conditions downstream of Iron Gate Dam.
- It is clear that the reservoirs spread out event-driven spikes of nutrient loads. However, this is not necessarily a good thing in regard to algal response in the lower river. Without the impoundments, some of the nutrient load would move in event-driven pulses, and a good portion of such loads would flush through the system without elevating concentrations for long enough or at an appropriate time of year to promote elevated periphyton growth.
- For phosphorus, it is inappropriate to assess retention only at an annual time step, as the majority of the retention occurs in Winter-Spring, when more of the phosphorus is in particulate form and water quality conditions (i.e., flow, light, temperature) are not subject to biostimulatory conditions.

The reservoir source analysis provides several key findings for the development of the Klamath River TMDLs:

- Conditions within the reservoirs cause depletion of dissolved oxygen below levels needed for support of the fishery and will require dissolved oxygen allocations to address this deficit and to ensure support of beneficial uses.
- The slow-moving waters of the reservoirs lead to enhanced algal growth. Biostimulatory conditions within the reservoirs are a result of excessive nutrient loads from upstream and the environment created by the presence of the dams. Chlorophyll-a and blue-green algal related targets are achieved above the reservoirs but not within the reservoirs, thus the slower and warmer waters in the reservoir reaches are the cause of these impairments. These conditions are demonstrated previously in Section 2.4 of this document.
- The nutrient retention and export lines of evidence in Table 4.5 suggest that the reservoirs provide some retention of nutrients. The retention during the May to September period is larger for total nitrogen (30.1%) than for total phosphorous (8%). The percent retention for the reservoirs does not account for the retention that would occur under free-flowing conditions. While the reservoir retention rates are higher if the loss of the retention under free-flowing conditions is accounted for, the net retention would be somewhat less than the rate reported above. However, total phosphorous concentrations at Iron Gate can be higher than total phosphorous concentrations above the reservoirs in September (i.e., 2005 and 2007, see Figure 14 in Asarian et al. 2009) when benthic algae standing crop is still very high and can still be increasing (data are limited regarding exact time of fall sloughing).
- Given the recent developments regarding dam removal (see Klamath Hydroelectric Settlement Agreement) it is unclear whether it will be necessary for the Regional Water Board to balance any potential benefits of the nutrient retention provided by the reservoirs versus the negative water quality impacts created by the reservoirs. It is necessary in the development of allocations for these facilities to provide a mechanism to track the progress of upstream nutrient reductions to achieve TMDL targets with the status of dam removal, and track

downstream impacts of nutrient reductions (to address in-reservoir impacts) should the dams remain in-place.

The primary impact of the reservoirs as a source area (aside from temperature impacts already described) is their role in creating biostimulatory conditions leading to high levels of chlorophyll-a and blue-green algae (including microcystin), and the oxygen deficits found in the hypolimnion during the summer months.

4.2.3 Iron Gate Hatchery

The California Department of Fish and Game (CDFG) operates Iron Gate Hatchery, a salmonid fish hatchery and rearing facility immediately downstream from Iron Gate Dam. This facility is operated in accordance with an NPDES permit. Iron Gate Dam was constructed without volitional fish passage capabilities. Thus, the hatchery was constructed concurrently with Iron Gate Dam in 1962 to mitigate for migrating salmonid stocks that would no longer have access to spawning and rearing habitat upstream from Iron Gate Dam. Since the hatchery is part of the mitigation required of PacifiCorp due to the blockage by the dam of salmonid habitat upstream of the dam, PacifiCorp is a co-permittee with CDFG for the facility.

Water for hatchery operations is supplied from Iron Gate Reservoir. There are two intakes from the reservoir which deliver water to the fish hatchery: one at a depth of approximately 18 feet and the other at a depth of approximately 74 feet below normal pool elevation (actual depths vary depending on the water level in the reservoir). During the cooler months, water is withdrawn from 18 feet; as water temperatures in the reservoir warm, the intake point is moved to the lower depth (74 feet). In the existing NPDES permit, average flows through the hatchery system are estimated to be 16.1 million gallons per day (mgd) (24.9 cubic feet per second [cfs]), while maximum flows are 31.9 mgd (49.4 cfs). Upon renewal, the Hatchery NPDES permit will be updated to reflect an average discharge of 12 mgd, equal to 18.6 cfs. The hatchery consists of an aeration tower, adult holding ponds, a fish ladder, an adult trap, spawning facilities, a production pond system (where juvenile fish are reared), and two settling ponds. During daily operations, flows ranging from 7.75 to 15.5 mgd (12.0 to 24.0 cfs) pass through the production and settling ponds and discharge directly into the Klamath River. These flows carry waste generated during the feeding and care of the fish including suspended solids, settleable solids, and chemicals used in disease control. When the fish production ponds are cleaned, flows ranging from 1.9 mgd to 5.5 mgd (2.9 cfs to 8.5 cfs), comprised of metabolic wastes, unconsumed food, algae, silt, and detritus, are released to settling ponds, and then into the Klamath River.

Due to the relatively small discharge flows from Iron Gate Hatchery, and the minimal water quality data characterizing the quality of the discharge, the Klamath River TMDL model does not represent hatchery inputs. Therefore, the analysis of loads from the hatchery is based solely on empirical data.

4.2.3.1 <u>Temperature</u>

Iron Gate Hatchery effluent temperatures were not measured prior to 2008. Effluent temperatures are currently measured as quarterly grab samples. Thus, adequate temperature data are not available to evaluate the effects of the hatchery effluent on the Klamath River. Regardless, because the discharge of elevated temperature waste is not allowed per the interstate water quality objective for temperature, any effluent discharged to the river at a higher temperature than the river exceeds the interstate objective.

4.2.3.2 Nutrients and Organic Matter

Regional Water Board staff conducted a study from September to November 2004 to evaluate the hatchery discharge. Water to support hatchery operations is taken from the Iron Gate Reservoir from the deeper water layer. This water is aerated during transport to the hatchery. As reflected in the existing NPDES permit, flow through the hatchery remains relatively constant at 16.1 million gallons per day. This figure will be updated to reflect an average discharge of 12 mgd in the revised NPDES permit. The hatchery discharges water at two locations: (1) the rearing pens and (2) the settling ponds. Nutrient concentrations measured from these two discharges were statistically compared.

The *Mann-Whitney U Test* was used to assess whether there is a significant difference between the distributions of concentrations for the two hatchery discharges. The test found there was no significant difference between the distributions of discharge concentration for both total phosphorus concentrations ($p = 0.689$) and total nitrogen concentration ($p = 0.479$). Based on these results, the two discharges were combined and treated as a single discharge for the hatchery nutrient loading estimates.

There are two potential sources of loading associated with the hatchery operations. Nutrient loads may be added to the downstream Klamath River due to within-hatchery processes such as stock feeding. Nutrient loads may also be added to the downstream Klamath River due to the withdrawal of water from the deeper, nutrient-enriched water layer in Iron Gate Reservoir for hatchery operations.

To estimate the total nutrient loading for the hatchery, concentrations measured upstream of Iron Gate Reservoir were used as background to compare to the combined discharge concentrations for the rearing and settling pond discharges. Daily loads were determined for each date of the 2004 study. These daily loads were extrapolated to the next date that samples were collected. The total load for the study period (69 days) was determined and normalized to a daily load. Annual loads for total phosphorus and total nitrogen were calculated from these daily load estimates.

The median annual load to the Klamath River due to hatchery operations through the raceways and settling ponds was estimated to be 2109 lbs of total nitrogen and 567 lbs of total phosphorous. These results suggest that the hatchery is a relatively minor source of nutrients to the Klamath River. Organic matter loading of hatchery operations was not estimated since measurements of CBOD were not collected during the 2004 study.

4.2.4 Tributaries

4.2.4.1 Temperature

Regional Water Board staff evaluated whether the major Klamath River tributaries (Shasta, Scott, Salmon, and Trinity Rivers) are contributing to the temperature impairment of the Klamath River by analyzing the influence those tributaries have on the temperature of the Klamath River itself, as well as the potential for those tributaries to provide thermal refugia for salmonids and other cold water species. The approach to analyzing these issues required the estimation of natural tributary flows and temperatures.

Two Klamath River model scenarios were developed to evaluate the effects of the major Klamath River tributaries on the temperatures of the Klamath River, the natural conditions baseline scenario and the California allocation scenario, as described in Appendix 7. Additional analyses were conducted to further understand how water management in the Shasta and Scott basins affects Klamath River temperature conditions, also described in Appendix 7. No additional analysis was conducted to evaluate effects of the Salmon River on the Klamath River, because the Salmon River TMDL found that current temperatures at the mouth of the Salmon River are consistent with the natural conditions baseline.

The natural conditions baseline scenario represents estimated natural flows and temperatures in the Shasta, Scott, and Trinity Rivers, as well as estimated natural temperatures in the Klamath River upstream of the major tributaries. A range of natural Scott River flow estimates was evaluated. The development of these scenarios is described in Appendix 7.

The California allocation scenario represents temperature conditions expected from full compliance with: 1) the Scott and Shasta TMDLs, 2) the Trinity Record of Decision (ROD), and 3) attainment of water quality standards in the Klamath River upstream (i.e. at stateline, Iron Gate, and Copco). The Shasta, Scott, and Trinity River temperature estimates used in this analysis are meant to depict the temperatures resulting from compliance with the Scott and Shasta TMDLs, and Trinity River Record of Decision.

<u>Shasta River</u>

Under the California allocation scenario the Shasta River would have a negligible temperature effect on the Klamath River. Figure 4.13 presents the difference in maximum daily Klamath River temperatures downstream and upstream of the Shasta River for both the current condition and California allocation scenarios. Figure 4.13 shows that the Shasta River could have a slight warming effect on the Klamath River in the fall months under California compliant conditions, but there is only a small temperature difference (generally less than 0.5 ^{o}C (0.9 ^{o}F)) between the two simulation results otherwise.

Figure 4.14 presents the difference in maximum daily Klamath River temperatures downstream and upstream of the Shasta River for both current and natural conditions. The results of the natural conditions baseline scenario modeling analysis indicate that given natural temperature and flow conditions in the Klamath and Shasta Rivers, the Shasta River could cool the daily maximum temperature of the Klamath River by as much as 1.5 ^{o}C (2.7 ^{o}F) during the summer season, with typical reductions of 0.5 – 1.0 ^{o}C (0.9 – 1.8 ^{o}F) occurring from June through September. The Shasta River would be expected to reduce Klamath River temperatures 0.5 ^{o}C (0.9 ^{o}F) or less from October through mid-November, as it currently does. The magnitude of change in Klamath River temperatures downstream of the Shasta River is reflective of the great difference in Shasta River flows and temperatures between current and natural conditions. For instance, irrigation diversions reduce Shasta River flows by approximately 80% at the mouth during late summer (Deas et al. 2004; Deas and Null 2007).

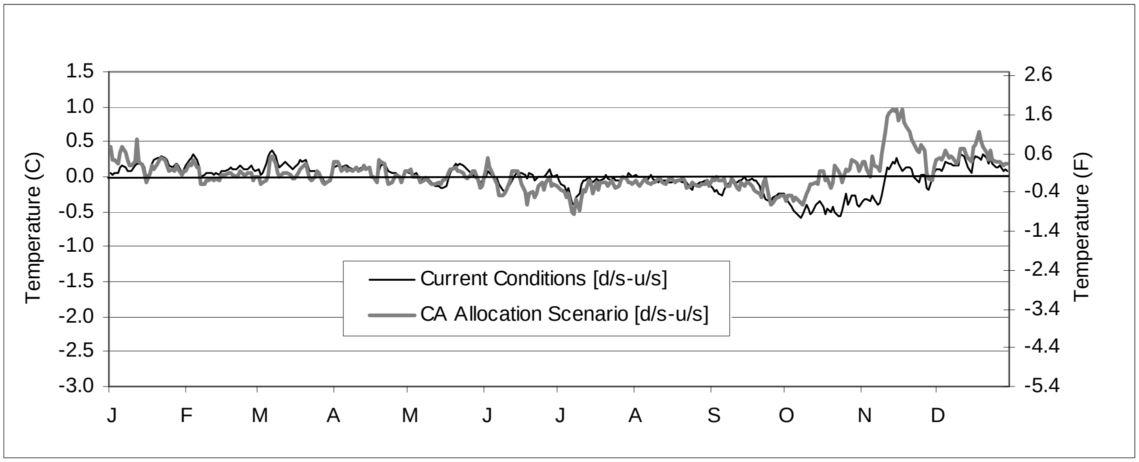

Figure 4.13: Change in Klamath River daily maximum temperatures resulting from current and Shasta TMDL compliant Shasta River conditions. Negative values indicate that the Shasta River is cooling the Klamath River.

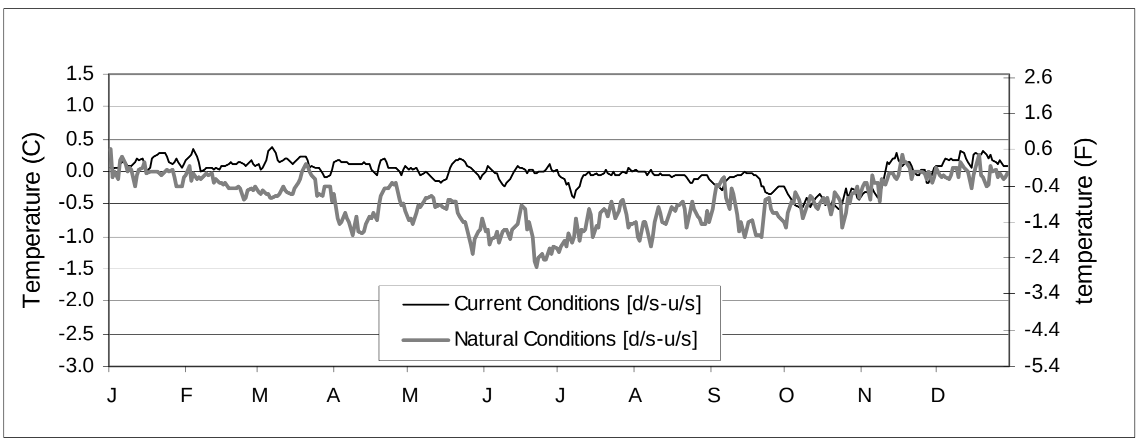

Figure 4.14: Change in Klamath River daily maximum temperatures resulting from current and estimated natural Shasta River conditions. Negative values indicate that the Shasta River is cooling the Klamath River.

Temperatures are too high to support adult salmonids when the 7-day average of the daily maximum temperatures exceeds 20 ^{o}C (68 ^{o}F), and too high to support juvenile salmonids when the 7-day average of the daily maximum temperatures exceeds 18 ^{o}C (64.4 ^{o}F) (see section 2.5.2). Currently, Klamath River temperatures regularly exceed 20 ^{o}C (68 ^{o}F) from July to September (see Figure 2.12, Dunsmoor and Huntington 2006). Shasta River temperatures are also currently too warm in the summer months to provide a thermal refuge for Klamath River salmonids. The California allocation scenario assumes a 1.6 ^{o}C (2.9 ^{o}F) daily average temperature reduction relative to current conditions at the mouth of the Shasta River, based on the Shasta TMDL temperature analysis (Regional Water

Board 2006). The 1.6 °C (2.9 °F) Shasta River temperature reduction depicted in the California allocation scenario improves conditions, but daily average temperatures are 20 °C (68 °F) or greater from mid-June to early September, as seen in Figure 4.15. These temperatures are unsuitable for juvenile salmonids. The Shasta River temperature conditions depicted in the natural conditions baseline scenario, however, only exceed 20 °C (68 °F) for a few days during the year. Daily average temperatures greater than 20 °C (68 °F) are significant because temperatures above 20 °C (68 °F) do not adequately support adult Chinook migration and holding (see section 2.5.2 and Appendix 4, Section 1.3.2). Thus, the results of this analysis indicate that the Shasta River would provide a thermal refuge for Klamath River salmonids under natural conditions, but would only provide adult salmonids a thermal refuge for a short time in the spring and fall under Shasta TMDL compliant conditions.

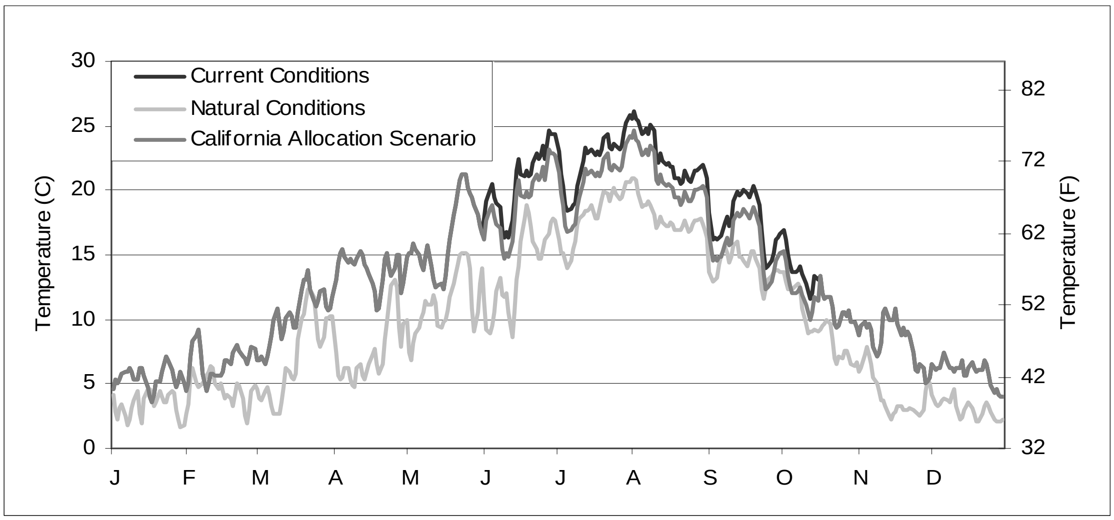

Figure 4.15: Estimated daily average Shasta River temperatures at the mouth of the Shasta River for the three management scenarios evaluated.

<u>Scott River</u>

The Scott River Temperature TMDL does not include a flow recommendation. The Scott River TMDL Action Plan requested Siskiyou County to conduct a groundwater study to further evaluate groundwater-surface water interactions in the Scott Valley. This work is in progress. The Klamath River TMDL California allocation scenario represents flows and temperatures consistent with the Scott River TMDL, and includes current flows. The results of the California allocation scenario compared to current conditions are similar with respect to Klamath River temperatures downstream of the Scott River (Figure 4.16). An exception occurs during the height of the spring snow melt, in late May, when the Scott River cools the Klamath River an additional 1.0 °C (1.8 °F) in the California allocation scenario. Another exception occurs in the fall when the Scott River currently reduces the Klamath River temperature slightly, whereas it increases the Klamath River temperature slightly in the California allocation scenario. The difference is a result of the fact that in the California allocation scenario the Klamath River is much cooler during those months, compared to the current conditions scenario. The Scott River has nearly the same effect on the Klamath River in the two scenarios during the remainder of the year.

The results of the natural conditions baseline scenario indicate the Scott River could potentially have a more significant temperature influence on the Klamath River under natural conditions, reducing temperatures by 2.0 ^{o}C (3.6 ^{o}F) in June, which amounts to as much as an additional 1.0 ^{o}C (1.8 ^{o}F) reduction below the current conditions scenario. The additional Klamath River temperature reduction gradually decreases to 0 by September (Figure 4.17).

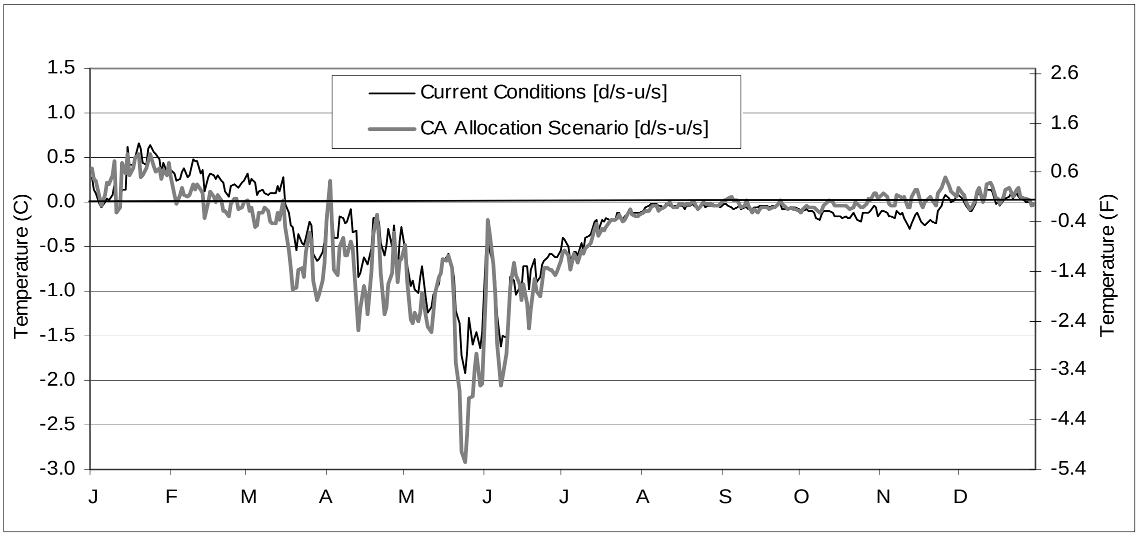

Figure 4.16: Change in Klamath River daily maximum temperatures resulting from current and Scott TMDL compliant Scott River conditions. Negative values indicate that the Scott River is cooling the Klamath River.

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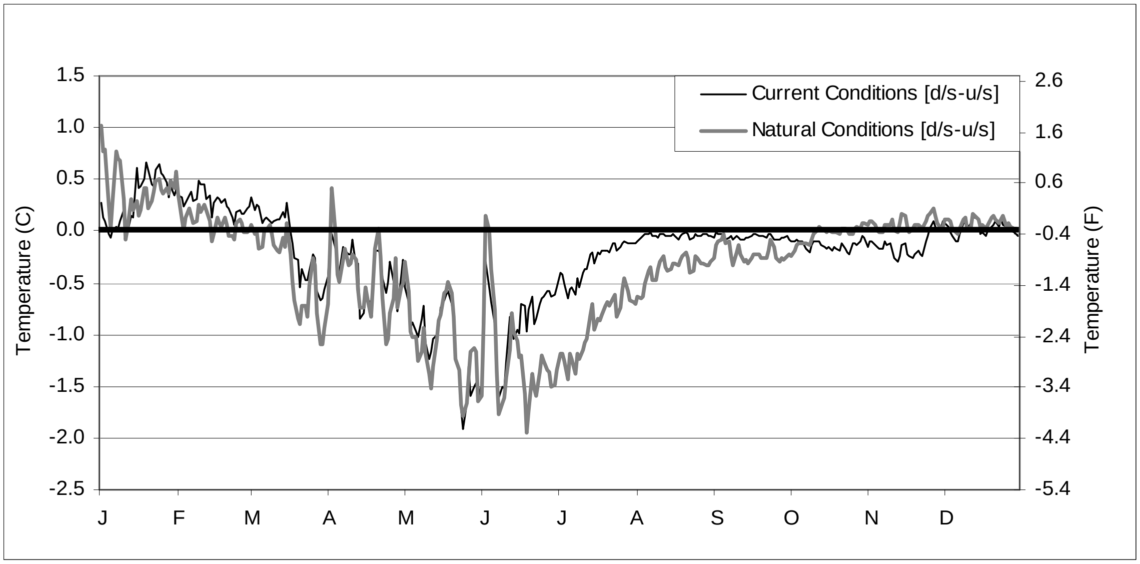

Figure 4.17: Change in Klamath River daily maximum temperatures resulting from current and estimated natural Scott River conditions. Negative values indicate that the Scott River is cooling the Klamath River.

Current Scott River temperatures from June to October are too hot to offer salmonids a thermal refuge from the high temperatures of the Klamath River. The results of the natural conditions baselines scenario indicate the Scott River would provide a thermal refuge during early and late summer under those conditions (Figure 4.18). Such conditions would provide migrating adult salmonids a thermal refuge during their upstream migration prior to spawning, but would not support juvenile rearing throughout the summer.

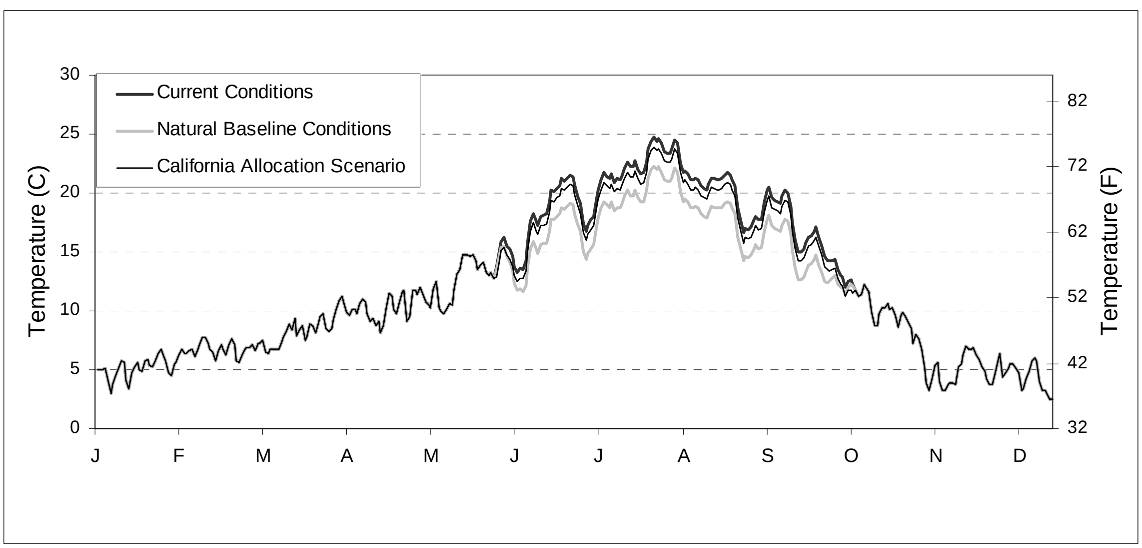

Figure 4.18: Estimated daily average Scott River temperatures at the mouth of the Scott River for three scenarios.

Trinity River
The California allocation scenario modeling analysis indicates that natural Trinity River flows, as well as those prescribed by the ROD, have a moderate cooling effect on the Klamath River downstream of the Trinity River. Figure 4.19 presents the difference in daily maximum Klamath River temperatures downstream and upstream of the Trinity River for both current and Trinity ROD flow (i.e., California allocation scenario) conditions. Similarly, Figure 4.20 presents the difference in daily maximum Klamath River temperatures downstream and upstream of the Trinity River for both the year 2000 (current condition scenario) and natural conditions. .

It is important to note that the upstream temperatures in the natural conditions baseline and California allocation scenarios reflect the absence of upstream reservoirs, as well as the effects of the estimated natural Shasta and Scott River inputs. These results are most apparent when comparing the difference between the estimated natural and Trinity ROD flow (i.e. California allocation) conditions. As discussed in Section 3.3.3.2, the estimated natural Trinity River flows and the Trinity ROD flows are equal during the summer months. However, under the California allocation scenario, the Trinity ROD flow has a bigger effect downstream from June to October because the Klamath River temperatures upstream are warmer in comparison to the natural conditions scenario.

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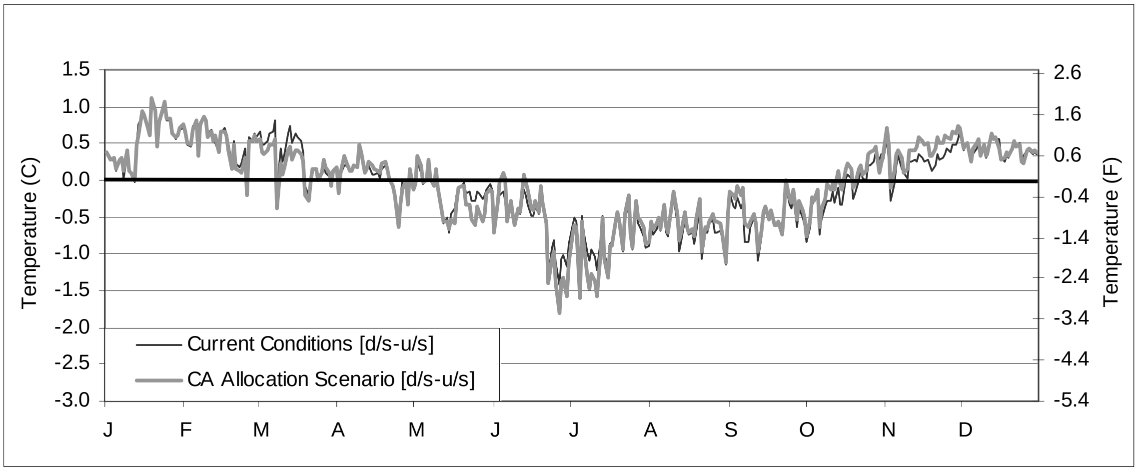


Figure 4.19: Change in Klamath River daily maximum temperatures resulting from current and Trinity ROD compliant Trinity River conditions. Negative values indicate that the Trinity is cooling the Klamath River.

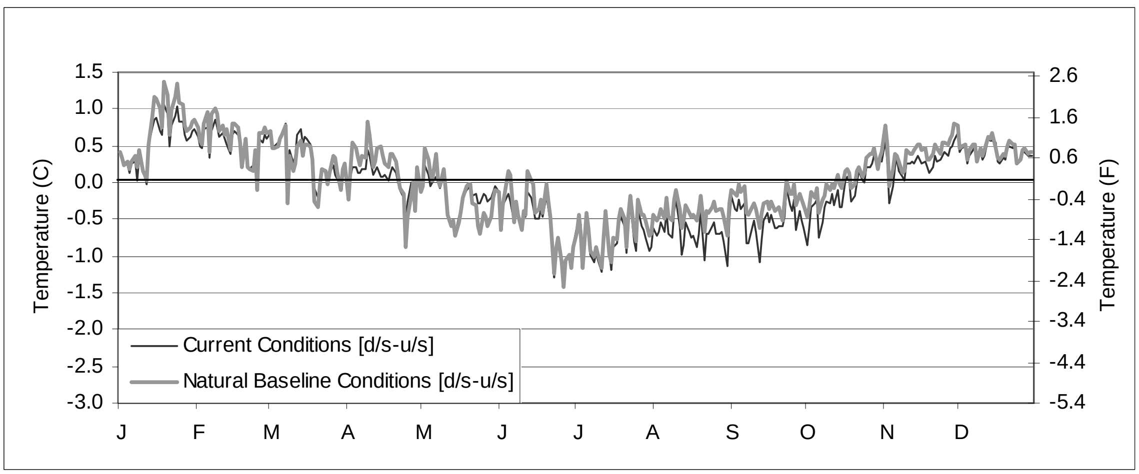


Figure 4.20: Change in Klamath River daily maximum temperatures resulting from current and estimated natural Trinity River conditions. Negative values indicate that the Trinity River is cooling the Klamath River.

<u>Effects of Shade on Klamath River Tributaries</u>

Temperature TMDLs have been established for twelve watersheds in the north coast region of California. These watersheds include three of the major Klamath River tributaries: the Salmon, Scott, and Shasta River watersheds. All twelve temperature TMDLs have evaluated the effects of shade on stream temperatures and each of these analyses have consistently reached the same conclusion regarding stream shade: the temperature of a stream is significantly influenced by the amount of solar radiation the stream receives. A second conclusion of these analyses is that changes in streamside vegetation affect shade (and thus, temperature) to a greater degree in smaller streams than in large streams. This is largely due to the fact that the height of trees is greater in relation to stream width in smaller streams, whereas trees are less effective at casting shade on larger streams. These conclusions are consistent with published literature and temperature analyses conducted in the Pacific Northwest (Independent Multidisciplinary Science Team, 2000; Johnson, 2004; Miner and Godwin, 2003; ODEQ, 2002).

Regional Water Board staff evaluated the sensitivity of Klamath River tributaries to the effects of solar radiation using the USGS stream reach temperature model SSTEMP. That analysis of six moderate-sized tributaries (Indian, Elk, Clear, Dillon, Red Cap, and Bluff Creeks) confirms the importance that solar radiation loads have in determining stream temperatures (Wilder, 2007).

Given the similarity of Klamath River tributaries to other north coast watersheds, and the universal nature of the laws of thermodynamics, Regional Water Board staff have determined that the conclusions of shade-related analyses from previous temperature TMDLs stated above apply region-wide, and especially to Klamath tributaries not already assigned TMDL shade allocations. Riparian shade controls are needed in many Klamath River tributaries not subject to an existing TMDL Action Plan.

Effects of Minor Tributaries on Klamath River Temperatures

The effects of minor Klamath River tributary (i.e., all tributaries except the Shasta, Scott, Salmon, and Trinity Rivers) temperatures on Klamath River temperatures were evaluated early in the modeling process. The segment of the model downstream of Iron Gate reservoir was simulated with and without the tributary temperatures reduced by 2 °C from their current temperature estimates. The comparison showed that the change in minor tributary temperatures had an indistinguishable effect on Klamath River water temperatures. Thus, Regional Water Board staff concluded that at the scale that the model predicts water temperature the Klamath River is not sensitive to the temperature of the minor tributaries. Despite the insensitivity of the Klamath River to minor tributary temperatures, these tributaries are vital where they provide thermal refugia.

Effects of Sediment Loads on Klamath River Tributaries

Historic increases in sediment loads have resulted in the widening of stream channels, reduction of riparian shade, and consequent elevation of stream temperatures. The primary causes of increased sediment loads are both natural and human-caused mass wasting. The US Forest Service has estimated that 446 of the 2260 (20%) total stream miles evaluated within Klamath National Forest lands were significantly altered during the flood of 1997 (De la Fuente and Elder, 1998). Much of the damage done to stream channels happened when debris slides that had initiated in the headwater areas resulted in debris torrents that traveled long distances (up to many miles), and in the process severely disrupted stream channels and removed riparian vegetation. Temperature data from one of the affected streams, Elk Creek, showed that in the summer after the flood, the peak temperature was the highest of seven years of record, and was 2.1 ^{o}C (3.8 ^{o}F) higher than the average from 1990-1995. Likewise, the diurnal variation increased to 6.9 ^{o}C (12.5^{o}F), 2.7 ^{o}C (4.9 ^{o}F) higher than the 1990-1995 average.

Regional Water Board staff (Wilder, 2007) evaluated the sensitivity of Klamath River tributaries to the effects of channel widening, using the USGS stream reach temperature model SSTEMP. The results of that analysis show that daily average stream temperatures can increase in the range of 1 ^{o}C to 2 ^{o}C when the wetted channel width doubles. However, these results are conservative given that the analysis only evaluated the effects of a change in wetted width and did not consider the loss of riparian vegetation (and consequent decrease in shade) that occurs when the active channel increases in width following a debris torrent or aggradation event. Furthermore, because the downstream endpoints of the modeled reaches are near the mouths of the streams where streams are already near equilibrium, it is likely that even larger temperature increases would occur in some reaches upstream where the difference between the current temperature and the equilibrium temperature is greater. Regional Water Board staff have also identified an apparent correlation of decreases in temperature with decreases in channel width in thermal infrared survey data collected in 2004 by Watershed Sciences, LLC (Watershed Sciences LLC, 2004).

Increased sediment loads in tributary streams also create temperature impacts associated with loss of thermal refugia in the Klamath mainstem. Because the daily maximum temperatures of the Klamath mainstem are at lethal levels through most of the summer, the opportunity for salmonids to rear in the mainstem during those times depends on access to thermal refugia. The majority of thermal refugia in the Klamath mainstem are located at the mouths of cold tributaries where they mix with the Klamath River (Belchik 1997). The volume of thermal refugia at tributary mouths can be greatly affected by the sediment loads of the tributaries. Higher sediment loads can cause tributaries to infiltrate into gravels before reaching the river, create barriers that restrict fish from entering tributaries, and fill in pools where cold water exists. Four of the five largest (>1000 ft^2) thermal refuge areas between Iron Gate Dam and Seiad Valley are created by tributaries that were significantly impacted by sediment loads during the 1997 flood event (Belchik 1997; Kier Associates 1999).

4.2.4.2 Literature Review on Effects of Suction Dredging on Geomorphology and Aquatic Resources

This section provides a brief overview of the findings in the literature Regional Water Board staff relied upon to develop the Thermal Refugia Protection Policy. The proper functioning of thermal refugia areas in the Klamath River Basin is necessary to meet the Basin Plan water temperature objective since these areas of cold water in the mainstem Klamath River are representative of natural water temperatures. The literature review specifically addresses the relevant documented impacts of suction dredging and provides the support for the recommendation in the policy to exclude suction dredging from designated buffer areas surrounding known thermal refugia in the Klamath basin. While there has been no direct study of the effects of suction dredging on thermal refugia, per se, studies are available in the literature on the impacts of suction dredging on geomorphology and aquatic resources. The conclusions of the studies are consistent in documenting certain impacts, with the extent and nature of some impacts more dependent on conditions at the study site. In general, studies cite short-term localized effects, while longer term and more widespread impacts are usually less than significant. The literature review that follows focuses on the relevant short-term effects, because of their potential to impact the function of refugia during the summertime period. It is during this time period when mainstem Klamath River temperatures are elevated close to lethal levels and anadromous salmonid rely on thermal refugia for survival.

The fact that sensitive anadromous fish are dependent on cold water and essentially captive in a thermal refuge supports a cautious and a conservative approach to regulating suction dredging in order to maintain and protect these fragile areas. Two prominent fisheries biologists, Moyle and Harvey, have voiced support for such an approach. "Given current levels of uncertainty about the effects of dredging, where threatened or endangered aquatic species inhabit dredged areas, fisheries managers would be prudent to suspect that dredging is harmful to aquatic resources" (Harvey and Lisle1998). In the North American Journal of Fisheries Management, Virginia Thomas similarly advised that "managers should concentrate their control efforts on very sensitive areas and areas of intensive dredge activity" (Thomas 1985). In expert testimony given as part of a 2005 Karuk lawsuit against the California Department of Fish and Game, Dr. Peter Moyle stated that "suction dredging through a combination of disturbance of resident fish, alteration of substrates, and indirect effects of heavy human use of small areas, especially thermal refugia, will further contribute to the decline of the fishes" (Moyle 2006). Brief discussions of the effects of suction dredging relevant to the function of thermal refugia are presented below.

Stream Channel Alteration

The potential impact on the channel and consequent effects on a refugial area provides the greatest support for protecting the area around thermal refugia. Impacts tend to be localized and are dependent on the channel structure and form, the stream flow dynamics, and the intensity and duration of a suction dredging operation. "The majority of suction dredge operators in Canyon Creek did not work long periods or disturb large areas of the streambed. Dredging impacts upon the channel geomorphology were confined to the area dredged and the area immediately down stream." (Hassler et al 1986)

Dredging has a higher potential to result in long-term impacts in smaller streams with lower winter flows that cannot readjust the channel every year. Excavation by dredging causes direct and significant local changes in channel topography and substrate conditions, particularly in small streams (Harvey 1998). Thirty-four percent of the suction dredgers observed were undercutting stream banks. While direct effects observed from suction dredging are generally localized, changes in the local form and structure of the channel may affect larger areas:

- "While deposition of bedload is most notable close to dredging sites, disruption of the continuity of bedload transport can have unpredictable consequences downstream, including both erosion and deposition" (Womack and Schumm 1977, Harvey 1998).
- "Miners commonly pile rocks too large to pass through their dredges. These piles can persist during high flows and, as imposed topographic high points, may destabilize channels during high flows" (Harvey 1998).
- Stream channel morphology and substrate composition can be altered as rocks, gravel, and silt are scoured away and then deposited in a different location within a stream; often in previously undisturbed areas (US District Court, 2004).

- Harvey (1986) reported that a 50-foot reach of a tributary to Butte Creek was completely channelized and riffles were transformed into exposed gravel bars by a 10-day operation by one dredge.

The potential to impact the rather local phenomenon of thermal refugia documented in the Klamath River system is of considerable concern to the sustainability of the anadromous fishery. The fact that thermal refugia enhancement efforts in the summertime are done with hand tools also points to their relative sensitivity to even minor channel alterations. Even though most studies show less than significant long-term effects on channel structure, and some effects may not be well documented, the potential for significant short-term effects in a localized area warrants the enhanced protections proposed in the Thermal Refugia Protection Policy.

Impacts to Streambanks
Dredging the stream banks is particularly problematic. While this is prohibited by DFG regulations, enforcement is not always possible. Stream bank disturbance and destruction of riparian habitat has been documented in the Siskiyou National Forest in Oregon (Nawa 2002). The California Department of Fish and Game also cites observations by McCleneghan and Johnson (1983) and Hassler (1986) of dredgers using prohibited practices and causing streambank erosion (CDFG 2009). Stern (1988) reported that undercutting of stream banks was the most common adverse impact on Canyon Creek.

Pool Filling
Fine sediment mobilized by dredging can fill pools in a low flow condition, (Thomas 1985, Harvey 1986) thereby reducing the amount of space for fish in a refugial area. Harvey (1986) reports that the number of rainbow trout in a small pool in Butte Creek, California declined by 50% after dredging upstream of the pool filled 25% of the pool volume. The potential for suction dredging discharges to fill pools downstream is the basis for the recommendation to exclude suction dredging upstream of thermal refugia.

While it has been postulated that the pools created by suction dredging may in themselves provide a thermal refuge for fish, the potential negative effects on channel structure and stability outweigh this potential benefit. Furthermore, in the Klamath basin, the thermal refugia areas already exist along the river, they simply need to be protected and enhanced.

Impacts to Food Supply
The potential to impact the food supply for fish within a refugial area is also of considerable concern. Macroinvertebrates are entrained in the dredge suction, causing direct mortality (Griffith and Andrews, 1981) and physically removing macroinvertebrates from the refugial area and discharging them below the refugia, which effectively removes a portion of the food supply from the refugial area.

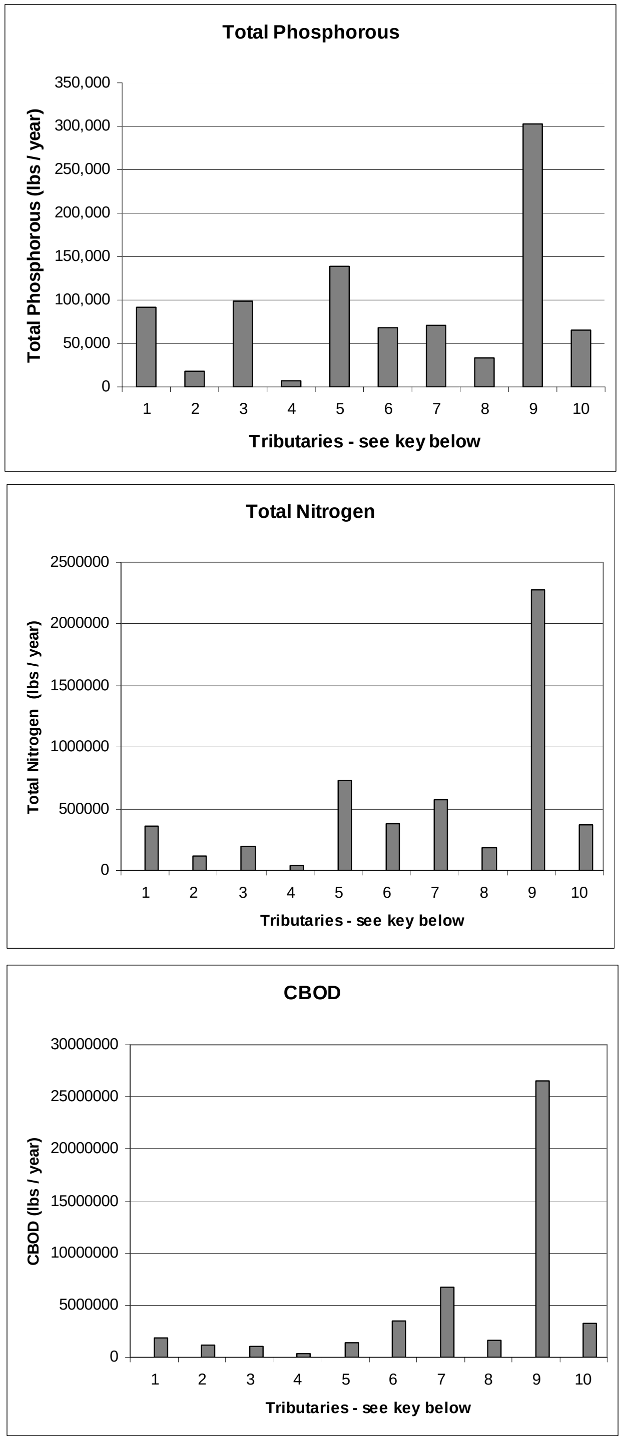
Depending on the type of substrate that the suction dredge is "working," finer material may be displaced from the active dredge area downstream, depositing on the stream bed and causing impacts to aquatic life. The effects of fine sediment deposition on macroinvertebrates are well studied and documented (Bjornn et al 1974 and 1977, Chutter 1969, Sandine 1974). Deposition of fine sediment that buries macroinvertebrates has a negative impact on those food organisms, resulting in changes in overall abundance and the aquatic community structure. Dredging also changes the substrate composition and affects macroinvertebrate populations (Harvey 1986, Somer and Hassler 1992, Thomas 1985), and can have negative consequences for growth and survival of salmonids (Suttle et al 2004). Prussian, et al. (1999) report reduction in benthic macroinvertebrate abundance of 97% and number of taxa by 88% relative to an upstream site. The abundance and diversity of macroinvertebrates returned to values comparable to the reference site by 80 to 160 m downstream of the dredge. Studies of the recovery of impacted macroinvertebrate populations report a return to pre-dredging abundance within 30-45 days (Harvey 1986, Thomas 1985).

These studies point out that the level of impact on macroinvertebrates, an important component of the food supply for fish, is directly related to the extent and duration of the disturbance: the level of impact increases with increases in the duration of and/or spatial extent of disturbance. The extent to which these impacts translate to impacts to fish in a refugial area is a function of how much deposition occurs in the refugial area.

Behavioral Responses
Divers, equipment, and activity in a thermal refugial area may result in "hazing" or scaring juvenile fish from refugia out into the warmer waters of a stream. Roelofs (1983) expressed concern that dredging could frighten adult summer-run steelhead, based on their response to divers, and Campbell and Moyle (1992) indicated that recreational activity increased salmon movement in pools and may increase adult stress" (CDFG 2009). On the other hand, Thomas (1985) documented juvenile fish feeding on entrained organisms at dredge outfalls. Were the plume from the dredge discharge outside of the refugial area, fish, while temporarily having an immediate feeding opportunity, could be "lured" into warmer water by this behavior.

Displacement of Cool Water
Another potential effect for which we have not seen documentation is a suction dredge operating in a thermal refugia displacing cold water from the refugial area to warmer water. This could potentially increase the effective size of the cold water refugia by extending the cold water plume. Alternatively, it also may result in cold water being taken from the refugial area, shrinking the effective size of the refugia, and discharging that cold water into a larger body of warm water, where it could be quickly warmed up.

4.2.4.3 Nutrients and Organic Matter
Current annual nutrient and CBOD loads from the California tributaries to the Klamath River are presented in Figure 4.21. Loads are presented for the Shasta, Scott, Salmon, and Trinity Rivers, and for groups of tributaries located between each of the major tributaries. These loads were calculated based on the best available quality assured concentration data from 2000 through 2007 and flows from the 2000 calendar year. A description of the sources of the data and the methodologies used to calculate the tributary loads is provided in Appendix 6. Cumulatively the California tributary loading comprises the following percentage of the total annual loads estimated for the Klamath River: 55% TP; 62% TN; and 72% CBOD. California tributaries below Iron Gate also



Stations List:

1-	Stateline to Iron Gate Tributaries	2-	Iron Gate to Shasta Tributaries
3-	Shasta River	4-	Shasta to Scott Tributaries
5-	Scott River	6-	Scott to Salmon Tributaries
7-	Salmon River	8-	Salmon to Trinity Tributaries
9-	Trinity River	10-	Trinity River to Turwar Tributaries

Figure 4.21: Current total annual loading (pounds/year) of total phosphorus, total nitrogen, and CBOD to the Klamath River from California tributaries

contribute the largest amount of flow volume to the river, generally at lower nutrient concentrations compared with the lower flows, but higher concentrations from the upper basin. Most tributaries have nutrient and CBOD concentrations that are regarded to be at or below concentrations considered to be reference conditions for the region (US EPA 2000). There are exceptions, such as Shasta River and Bogus Creek.

The Shasta River Temperature and Dissolved Oxygen TMDLs include load allocations and implementation actions, which when achieved will result in reduced nutrient and organic matter loads delivered to the Klamath River. For the Klamath River TMDL's California allocation scenario, the nutrient and CBOD loads from the Shasta River were calculated based on Shasta River TMDL compliant conditions, as described in Appendix 7. These TMDL compliant Shasta River loads reflect the expected annual loads to the Klamath River when the Shasta River TMDL is fully implemented and nutrient/ biostimulatory substances and DO water quality objectives within the Shasta River are achieved. Figure 4.22 compares current and California allocation scenario TP, TN, and CBOD loads from the Shasta River. The California allocation scenario conditions represent 72%, 59%, and 18% reductions, respectively, from current TP, TN, and CBOD loads delivered from the Shasta River to the Klamath River.

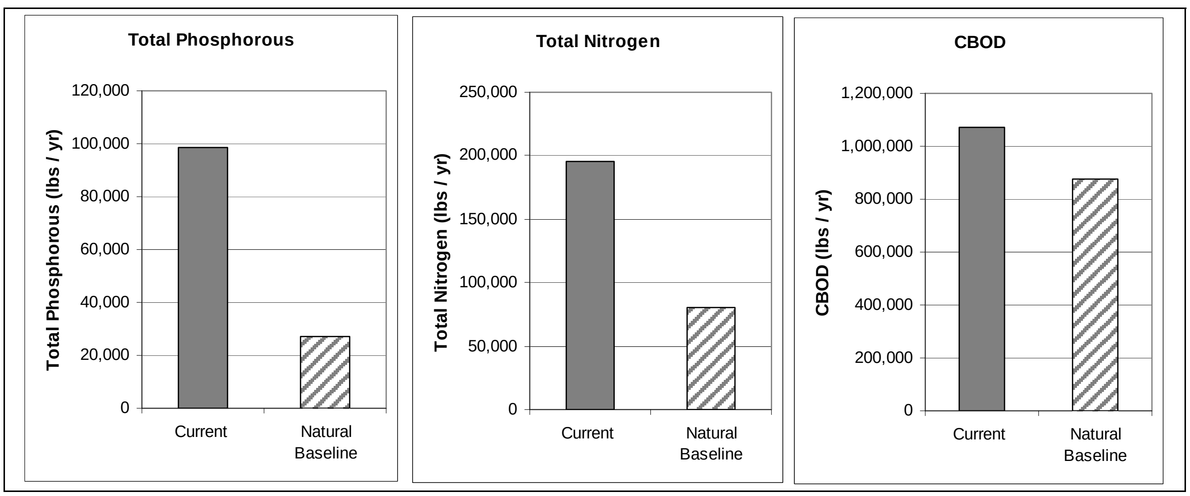


Figure 4.22: Shasta River comparison of current loads (pounds/year) of TP, TN, and CBOD with natural conditions baseline loads.

For the California allocation scenario, the nutrient and CBOD loads at the mouths of the other California tributaries (except Bogus Creek) were represented as the average of the available quality assured concentration data from 2000 through 2007 and flows from the 2000 calendar year. This representation of average tributary nutrient and CBOD loads is sufficient to meet dissolved oxygen and biostimulatory substances objectives in the Klamath River.

CHAPTER 4. REFERENCES

Asarian, E, J. Kann, and W. Walker, 2009. Multi-year Nutrient Budget Dynamics for Iron Gate and Copco Reservoirs, California. Final Technical Report to the Karuk Tribe Department of Natural Resources, Orleans, CA. 55pp + appendices.

Bachman, R.W. 1980. Prediction of total nitrogen in lakes and reservoirs. Pp. 320-324 in Restoration of Lakes and Inland Waters: Proceedings of an International Symposium on Inland Waters and Lake Restoration, Portland, ME. EPA-440/5-81-010. Office of Water, U.S. Environmental Protection Agency, Washington, DC.

Belchik, M. 1997. Summer Locations and Salmonid Use of Cool Water Areas in the Klamath River. Iron Gate Dam to Seiad Creek, 1996. Yurok Tribal Fisheries Program. Klamath, CA. 13pp.

Bjornn, T.C., Brusven, M.A., M. Molnau, F.J. Watts, and R.L Wallace. 1974. Sediment in streams and its effects on aquatic life. Univ. of Idaho, Water Resources Research Inst., Project No. B-025-IDA

Bjornn, T. C., M. A. Brusven, M. P. Molnau, J. H. Mulligan, R. A.[R.] Klamt, E. Chacho, and C. Schaye. 1977. Transport of granitic sediments in streams and its effect on invertebrates and fish. Bulletin 17. University of Idaho, College of Forestry, Wildlife and Range Sciences, Moscow, Idaho.

California Department of Fish and Game. 2009. Suction Dredge Permitting Program: Literature Review. September 2009.

Chutter, F.M. 1969. The Effects of Silt and Sand on the Invertebrate Fauna of Streams and Rivers. Hydrobiologia, 34: 57-76.

Danosky and Kaffka, 2002. Farming Practices and Water Quality in the Upper Klamath Basin, Final Report to the California State Water Resources Board.

Deas, M. and P.B. Moyle, J. Mount, J.R. Lund, C.L> Lowney, S. Tanaka. 2004. Priority actions for restoration of the Shasta River – Technical Report. Prepared for The Nature Conservancy. June 11, 2004, 2004. 57pp.

Deas, M. and Null, S. 2007. Technical Memorandum: Year 2000 Unimpaired Shasta River Model Simulation for Flow and Water Temperature – Draft. Watercourse Engineering, Inc.

Dunsmoor, L.K., and C.W. Huntington. 2006. Suitability of Environmental Conditions within Upper Klamath Lake and the Migratory Corridor Downstream for Use by Anadromous Salmonids. Technical Memorandum to the Klamath Tribes. Revised October 2006. 80 pp. + appendices.

De la Fuente, J. and D. Elder. 1998. The flood of 1997, Klamath National Forest, Phase I Final Report. November 24, 1998. Klamath National Forest. Yreka, CA. 76 p. plus appendices.

Griffith, J.S. and D.A. Andrews. 1981. Effects of a Small Suction Dredge on Fishes and Aquatic Invertebrates in Idaho Streams. North American Journal of Fisheries Management. 1(1): 21-28. January.

Harvey, B. C. 1986. Effects of suction gold dredging on fish and invertebrates in two California streams. N. Am. J. Fish. Manage. 6:401-409.

Harvey, B. C. and T. E. Lisle. 1998. Effects of suction dredging on streams: a review and an evaluation strategy. *Fisheries* 23:8–17.

Hassler, T J., W. L. Somer, and G. R. Stern. 1986. Impacts of suction dredge mining on anadromous fish, invertebrates, and habitat in Canyon Creek, California. California Cooperative Fishery Research Unit, Humboldt State University, Arcata, CA.

Hicks, 2009, Comments to North Coast Regional Water Quality Control Board on Public Review Draft of Klamath River TMDL and Action Plan. United State Department of the Interior, Bureau of Reclamation, Klamath Basin Area Office, Klamath Falls, Oregon.

Independent Multidisciplinary Science Team (IMST). 2000. Influences of human activity on stream temperatures and existence of cold water fish in streams with elevated temperature: report of a workshop. Technical report 2000-2 to the Oregon Plan for Salmon and Watersheds: Oregon Watershed Enhancement Board. Salem, Oregon. 35 p. plus appendices.

Johnson, S. L. 2004. Factors influencing stream temperatures in small streams: substrate effects and a shading experiment. Canadian Journal of Fisheries and Aquatic Sciences. (61): 913-923.

Kann, J., and E. Asarian. 2005. 2002 Nutrient and Hydrologic Loading to Iron Gate and Copco Reservoirs, California. Kier Associates Final Technical Report to the Karuk Tribe Department of Natural Resources, Orleans, California. 59pp + appendices.

Kann, J. and E. Asarian. 2007. Nutrient Budgets and Phytoplankton Trends in Iron Gate and Copco Reservoirs, California, May 2005 - May 2006. Submitted to the State Water Resources Control Board, Sacramento, CA by the Karuk Tribe of California, Department of Natural Resources, Orleans, CA.

Kann, J. and W. Walker. 1999. Nutrient and hydrological loading to Upper Klamath Lake, Oregon, 1991–1998. Prepared for the Klamath Tribes Natural Resources

Department and the Bureau of Reclamation. Klamath Falls, Oregon. 48 p. plus appendices.

Karuk Tribe. 2009. Water Quality Assessment Report 2008. Karuk Tribe Department of Natural Resources, Orleans, CA. 75 p. Available online at: http://www.klamathwaterquality.com/documents/2009/2008WQReportKaruk.pdf.

McCarthy, K and Johnson, H.M, 2009. U.S. Geological Survey Scientific Investigations Report 2009–5030, Effect of Agricultural Practices on Hydrology and Water Chemistry in a Small Irrigated Catchment, Yakima River Basin, Washington

Miner, J.R. and D. Godwin. 2003. Documenting progress toward achieving stream temperature compliance in Oregon TMDL plans. Oregon State University Extension. Salem, Oregon. 10 pp.

Moisander, P. 2008. Presentation to the Klamath Blue-Green Algae Work Group (Sacramento) - Diversity and nutrient limitation of *Microcystis* in Klamath River reservoirs. University of California Santa Cruz, Ocean Sciences Department.

Moisander, P.H., et al. 2009. Nutrient limitation of Microcystis aeruginosa in northern California Klamath River reservoirs. Harmful Algae (2009), accessed at: http://dx.doi:10.1016/j.hal.2009.04.005

Most, Stephen. 2006. River of Renewal: Myth & History in the Klamath Basin. Oregon Historical Society Press. Portland, OR.

Moyle, Peter B. 2006. Declaration of Peter B. Moyle, Ph.D., in Support of Entry into Stipulated Judgment. Superior Court of California. C/A No. RG 05 211597. January 2006. 10 pp.

National Research Council of the National Academies (NRC). 2004. Endangered and Threatened Fishes in the Klamath River Basin. Washington, D.C. National Academies Press.

Nawa, Richard K. 2002. Observations of Mining Activities in Siskiyou National Forest Riparian Reserves and Probable Impacts to Aquatic Organisms. Siskiyou Project.

Nürnberg, G. K, 1984. The prediction of internal phosphorus loading in lakes with anoxic hypolimnia. *Limnol. Oceanogr.*, 29: 111-124.

Oregon Department of Environmental Quality (ODEQ). 2002. Upper Klamath Lake Drainage Total Maximum Daily Load (TMDL) and Water Quality Management Plan (WQMP).

PacifiCorp. 2006. Causes and Effects of Nutrient Conditions in the Upper Klamath River. Klamath Hydroelectric Project (FERC Project No. 2082). PacifiCorp, Portland, Oregon. November 2006. 77 pp.

PacifiCorp. 2008. Water Quality Conditions During 2007 in the Vicinity of the Klamath Hydroelectric Project. Prepared by: Richard Raymond, E&S Environmental Chemistry, Inc., Corvallis, Oregon. Prepared for: CH2M Hill, 2020 SW 4th Avenue, 3rd Floor, Portland, OR 97201; and PacifiCorp Energy, 825 N.E. Multnomah, Suite 1500, Portland, OR 97232. October 14, 2008.

PacifiCorp. 2009. Water Quality Conditions During 2008 in the Vicinity of the Klamath Hydroelectric Project. Prepared by: Richard Raymond, Ph.D. Prepared for: CH2M Hill, 2020 SW 4th Avenue, 3rd Floor, Portland, OR 97201 and PacifiCorp Energy, 825 N.E. Multnomah, Suite 1500 Portland, OR 97232.

Prussian A. M., T V. Royer, and G. Minshall. 1999. Impact of suction dredging on water quality, benthic habitat, and biota in the Fortymile River, Resurrection Creek, and Chatanika River, Alaska. EPA Seattle, Washington.

Reckhow, K.H. and S.C. Chapra. 1983. Engineering Approaches For Lake Management – Volume 1: Data Analysis and Empirical Modeling. Butterworth Publishers – Ann Arbor Science Book. pp:105.

Rykbost, K.A and Charlton, B.A, 2001, Nutrient Loading of Surface Waters in the Upper Klamath Basin: Agriculture and Natural Sciences, Special Report 1023, Agricultural Experiment Station, Oregon State University, March 2001. Can be accessed at <http://ir.library.oregonstate.edu/jspui/handle/1957/6244>.

Sandine, M.F. 1974. Natural and Simulated Insect-Substrate relationships in Idaho Batholith Streams. M.S. Thesis, University of Idaho, Moscow, Idaho

Somer, W.L. and T.J. Hassler. 1992. Effects of Suction-Dredge Gold Mining on Benthic Invertebrates in a Northern California Stream. N. Am. J. of Fisheries Mgt, 12: 244-252.

Stern, G. R. 1988. Effects of suction dredge mining on anadromous salmonid habitat in Canyon Creek, Trinity County, California. M.S. Thesis, Humboldt State University, Arcata, California, 80 pp.

Suttle, K.B., M.E. Power, J.M. Levine, and C. McNeely. 2004. How Fine Sediment in Riverbeds Impairs Growth and Survival of Juvenile Salmonids. Ecological Society of America. Ecological Applications, 14(4): 969–974

Thomas, V. G. 1985. Experimentally determined impacts of a small, suction gold dredge on a Montana stream. N. Am. J. Fish. Manage. 5:480-488.

United States Bureau of Reclamation (USBR). 2005. Natural Flow of the Upper Klamath River – Phase I. 115pp. Accessed January 8, 2007. Available at: <http://www.usbr.gov/mp/kbao/docs/undepleted_klam_fnl_rpt.pdf>.

United States Bureau of Reclamation (USBR).2009. Klamath Project Description. Website accessed 09/17/2009: http://www.usbr.gov/projects/Project.jsp?proj_Name=Klamath%20Project

US District court for the Northern District of California (US District Court), 2004, Karuk Tribe of California, Plaintiff, vs. United States Forest Service; Jeff Walter, Forest Supervisor, Six Rivers National Forest; Margaret Boland, Forest Supervisor, Klamath National Forest, Defendants. First Amended Complaint for Declaratory and Injunctive Relief. 38 pp.

US Environmental Protection Agency (USEPA). 2008. Lost River, California Total Maximum Daily Loads - Nitrogen and Biochemical Oxygen Demand to Address Dissolved Oxygen and pH impairments.

US Environmental Protection Agency (USEPA). 2000. Ambient Water Quality Criteria Recommendations: Information Supporting the Development of State and Tribal Nutrient Criteria – Rivers and Streams in Nutrient Ecoregion II. Office of Water, Washington DC. EPA 822-B-00-015.

Watershed Sciences, LLC. 2004. Aerial Surveys in the Klamath River Basin: Thermal Infrared and Color Videography.

Watershed Sciences, LLC. 2004b. Aerial Surveys using Thermal Infrared and Color Videography: Scott River and Shasta River Sub-Basins. Prepared for the North Coast Regional Water Quality Control Board and University of California Davis. February 26, 2004. 39 pp. + appendix.

Wetzel. 2001. Limnology: Lake and River Ecosystems. Third Edition. Academic Press. London, UK. 985 pp.

Wilder, C. 2007. Stream Temperature Analysis for Select Tributaries of the Middle and Lower Klamath River. North Coast Regional Water Quality Control Board.

Womack, W. R., and S. A. Schumm. 1977. Terraces of Douglas Creek, northwestern Colorado: an example of episodic erosion. Geology 5:72-76.

CHAPTER 5. KLAMATH RIVER TMDLs – ALLOCATIONS and NUMERIC TARGETS

5.1 Introduction

This chapter presents the numeric targets, loading capacity, and load and waste load allocations for the Klamath River in California. This chapter consists of three sections. Section 5.1 describes the numeric targets, loading capacity, load and waste load allocations, and margin of safety associated with the temperature, dissolved oxygen, and nutrient-related water quality impairments of the Klamath River in California. Section 5.2 presents the specific temperature-related numeric targets, and load and waste load allocations for the Klamath River by river reach and associated source areas. Section 5.3 presents the specific dissolved oxygen and nutrient-related numeric targets, and load and waste load allocations for the Klamath River by river reach and associated source areas. Table 5.1 summarizes the temperature, dissolved oxygen, and nutrient-related numeric targets and allocations.

Table 5.1: Summary of Klamath River TMDLs numeric targets and allocations

Location	Parameter	Target	Allocation
Watershed-wide[1]	Temperature	Riparian Shade: site-potential effective shade. Effective shade is a measure of the percentage of total daily direct beam solar radiation that is blocked by vegetation or topography before reaching the ground or stream surface, and takes into account the differences in solar intensity that occur throughout a day (Approximated in Figures 5.4, 5.5, and 5.6) Instream Target: 0 miles of substantial human-caused sediment-related channel alteration <1% of all road-stream crossings divert or fail as a result of a 100-year or smaller flood Decreasing trend of road-related landslides	Riparian Shade: the shade provided by topography and full potential vegetation conditions at a site, with an allowance for natural disturbances such as floods, wind throw, disease, landslides, and fire Human-caused discharges of sediment: zero temperature increase caused by substantial human-caused sediment-related channel alteration
Stateline	Temperature	Estimated natural temperature, expressed as monthly average temperature (See Table 5.3)	Zero increase above natural temperature
	Dissolved Oxygen	Dissolved oxygen concentrations at 85% saturation under natural temperature conditions expressed as monthly average and monthly minimum concentrations April 1 through September 30 and 90% saturation under natural temperature conditions from October 1 through March 31. (See Table 5.7)	N/A
	Nutrients/ Organic Matter	N/A	Allocations to TN, TP, and CBOD[2] expressed as monthly average concentrations (See Table 5.8)

1 Watershed-wide allocations and targets are assigned to the Klamath River Middle and Lower Hydrologic Areas. Major tributaries are not assigned temperature allocations because the Scott, Shasta and Salmon River watershed already have assigned allocations, and the Lost and Trinity are not listed as impaired for temperature.

2 Section 7.5.2 describes the recommended compliance assessment approach for CBOD targets and allocations that fall below the Method Detection Limit (MDL).

Table 5.1 (cont.): Summary of Klamath River TMDLs numeric targets and allocations

Location	Parameter	Target	Allocation
PacifiCorp Facilities	Temperature /Dissolved Oxygen	N/A	Temperature and dissolved oxygen "Compliance Lens" Or Alternative in-reservoir temperature and dissolved oxygen conditions that provide equal or better protection of COLD and MIGR beneficial uses.
	Nutrients/ Organic Matter	TP, TN, and CBOD concentrations expressed as monthly means reservoir tailraces (Table 5.10) Chlorophyll-a – growing season average of 10 µg/L *Microcystis aeruginosa* cell density ≤ 20,000 cells/L Microcystin toxin < 4 µg/L	Annual nutrient loading reduction necessary to attain chlorophyll-a, *Microcystis aeruginosa*, and microcystin numeric targets: TP = 22,367 lbs.; and TN = 120,577 lbs Or, alternative pollutant load reductions and/or management measures or offsets that achieve the in-reservoir targets.
	Temperature	Estimated natural temperature at reservoir tailrace –expressed as monthly average temperature (See Table 5.4)	Temperature increase expected to naturally occur in the river reach occupied by the reservoirs (See Table 5.5)
	Dissolved Oxygen	DO concentrations ≥ 85% saturation based on natural temperatures at reservoir tailraces expressed as monthly mean and minimum from April 1 through September 31 and 90% saturation based on natural temperatures from October 1 through March 31. (See Table 5.9)	N/A
Iron Gate Hatchery	Temperature	Expressed as monthly average temperatures at Iron Gate Hatchery discharge (See Table 5.6)	Zero increase above natural temperature
	Dissolved Oxygen	Expressed as monthly mean and minimum dissolved oxygen concentrations at Iron Gate Hatchery discharge (See Table 5.11)	N/A
	Nutrients/ Organic Matter	TP, TN, and CBOD concentrations expressed as monthly mean concentrations at Iron Gate Hatchery discharge (See Table 5.12)	Zero net increase of nutrient and organic matter loads above California allocation scenario conditions.
Tributaries	Dissolved Oxygen	Expressed as monthly mean and minimum concentrations greater than or equal to 85% saturation below Salmon River (See Table 5.13)	N/A
	Nutrients/ Organic Matter	Expressed as monthly mean concentrations of TP, TN, and CBOD below the Salmon River (Table 5.14) Reach-averaged maximum density of 150 mg of chlorophyll-a /m^2 below the Salmon River	TN, TP, and CBOD concentrations expressed as monthly mean concentrations (See Table 5.15 and 5.16)

The Klamath River TMDL nutrient, dissolved oxygen, and organic matter (CBOD) allocations and related targets are designed to reduce the impacts of advanced eutrophication driven by land disturbance activities, the presence of reservoirs, flow alterations, and direct inputs of pollutants. The targets and allocations, as discussed in Chapter 2, are consistent with trophic classifications that are ecologically appropriate and supportive of Klamath basin beneficial uses. The allocation strategy addresses all of the stressors that are driving biostimulatory and toxicity related impairments including total phosphorous (TP), total nitrogen (TN), and organic matter (measured as CBOD). While nutrient ratios in the Klamath River can indicate nitrogen limitation in the short-term, a long-term strategy for controlling eutrophication of the Klamath River needs to reduce phosphorus loading. Comprehensive nutrient management strategies that address phosphorous have consistently demonstrated to be essential for successful long-term ecosystem restoration (Welch 2009). Because the vast majority of the nutrient (TP and TN) and organic matter (CBOD) pollutant loads are related to nonpoint sources, pollutant reduction measures are designed to address reductions with all three pollutants. The allocation strategy addresses all identified sources, but the largest reductions are related to loads from the upper basin source area (above Stateline) which exports the largest pollutant loads in comparison historical or undisturbed conditions. Allocations are also assigned to the Klamath Hydroelectric Project (KHP) facilities to address water quality issues within the reservoirs that are controllable water quality conditions within the facilities, and to ensure that water quality standards are met.

5.1.1 Numeric Targets

Numeric targets are the numeric water quality conditions that represent attainment of the water quality standards. Numeric targets serve as the goal post from which TMDLs and associated load and waste load allocations are developed. Numeric targets refer to the desired water quality conditions, and serve as good indicators of progress towards TMDL compliance and beneficial use support. In some cases numeric targets can equal a numeric water quality objective. In other cases, numeric targets are a numeric interpretation of the conditions that meet a narrative water quality objective. Numeric targets are typically instream water quality measures, but in some cases are measures of landscape conditions that affect instream water quality conditions. Targets are set at levels associated with well-functioning stream systems. In all cases, numeric targets are used in the calculation of a TMDL.

5.1.1.1 Temperature Numeric Targets

The primary temperature numeric targets for the Klamath River temperature TMDL are monthly average temperatures calculated from the estimated natural temperature regime of the Klamath River, and are presented in Section 5.2. In addition, secondary targets are established for riparian shade and sediment related channel alteration, diversion potential at stream crossings, and road-related landslides. These secondary targets are also presented in Section 5.2. The riparian shade targets are expressed as effective shade, which is a measure of the percentage of total daily direct beam solar radiation that is blocked by vegetation or topography before reaching the ground or stream surface, and takes into account the differences in solar intensity that occur throughout a day. Instream and watershed targets are established to address sediment-related temperature factors and human-caused mechanisms of sediment delivery associated with sediment-related temperature factors.

5.1.1.2 Dissolved Oxygen and Nutrient-Related Numeric Targets

The numeric DO targets are monthly average and monthly minimum DO concentrations calculated at 85% DO saturation under natural temperatures for most of the mainstem Klamath River except 90% DO saturation upstream of Hoopa from October 1 through April 31 and 80% during the month of August in the upper and middle estuary. These targets are, consistent with the proposed site-specific DO objective for the Klamath River in California (see Appendix 1), and are presented in Section 5.3. Numeric targets are also established for nutrients (TN and TP) and organic matter (CBOD) for the reservoirs, Iron Gate Hatchery, and tributaries, and are expressed as monthly average concentrations in Section 5.3. Additional numeric targets are established to reflect compliance with the narrative biostimulatory substances and toxicity objectives. These additional numeric targets, detailed in Section 2.3.2.2, are:

- Suspended algae chlorophyll-a: summer mean = 10 µg/L;
- *Microcystis aeruginosa* cell density: 20,000 cells/mL;
- Microcystin: 4 µg/L; and
- Benthic algae biomass: 150 mg chlorophyll-a / m^2.

5.1.2 Loading Capacity, Allocations, and Margin of Safety

The *loading capacity* refers to total amount of pollutant loads that a waterbody can receive and meet water quality standards. In order to achieve the loading capacity (i.e. the Total Maximum Daily Load [TMDL]), allocations are attributed to the natural background, non-point sources, and point sources of the applicable pollutants. *Waste load allocations* are contributions of a pollutant from permitted point sources, while *load allocations* are contributions from non-point sources. Contributions from natural background are incorporated into nonpoint source load allocations.

The starting point for the load allocation analysis is the equation that describes the Total Maximum Daily Load or loading capacity:

$$\text{TMDL} = \text{Loading Capacity} = \Sigma\text{WLAs} + \Sigma\text{LAs} + \text{Natural Background} + \text{MOS}$$

where Σ = the sum, WLAs = waste load allocations, LAs = load allocations, and MOS = margin of safety.

A margin of safety in a TMDL is required in the Clean Water Act to account for uncertainty and to assure that the TMDL will achieve water quality standards. The Clean Water Act directs states to develop a margin of safety "which takes into account any lack of knowledge concerning the relationship between effluent limitations and water quality." TMDLs can be developed with explicit and/or implicit margins of safety. An explicit margin of safety is established by withholding an explicit fraction of the loading capacity available for allocation. An implicit margin of safety is established by incorporating conservative assumptions in the calculation of the loading capacity.

5.1.2.1 Temperature Loading Capacity, Allocations, and Margin of Safety

For the temperature TMDL, two separate water quality objectives apply, as described in Section 2.2.1.2. The temperature objective for *interstate* waters prohibits the discharge of elevated temperature waste, whereas the *intrastate* temperature objective states that temperatures must be maintained as natural, unless a proposed increase is less than 5 ^{o}F and doesn't adversely impact beneficial uses. Because water temperatures in Klamath basin streams already adversely affect the beneficial uses during critical time periods, the natural receiving water condition becomes the temperature objective.

The loading capacity provides a reference for calculating the amount of pollutant load reduction required to bring a water body into compliance with standards. Because the applicable objectives do not allow for the discharge of elevated temperature waste, or increases in water temperature, the temperature loading capacity equals the natural receiving water condition, and in turn no increase is permissible and all sources are allocated a temperature load of zero.

The Klamath River watershed temperature TMDL addresses the heat loads that arise from seven sources:

1. Conditions of Klamath River water crossing the Oregon-California border (stateline);
2. Thermal discharges from Copco 2 and Iron Gate dams;
3. The impoundment of water in the reservoirs;
4. Temperature effects of Iron Gate Hatchery;
5. Temperature effects of major tributaries on Klamath River temperatures;
6. Effects of excess solar radiation; and
7. Effects of excess sediment loads.

The TMDL equation for temperature is:

Temperature TMDL = Loading Capacity = ΣWLAs + ΣLAs + Natural Background + MOS

The Klamath River temperature TMDL for California relies on an implicit *margin of safety*. As stated in Section 2.2.1.2, the intrastate Water Quality Objective for Temperature allows for temperature increases of up to 2.8 ^{o}C (5 ^{o}F) if beneficial uses of water are not adversely affected. For most of the year the Klamath River is too hot to accommodate more heat without beneficial uses of water being adversely affected. There are periods in the winter and spring months, however, when temperatures increases of 2.8 ^{o}C (5 ^{o}F) or less may occur without beneficial uses of water being adversely affected. The timing of those periods changes from year to year and is difficult to predict. Therefore, this TMDL takes a conservative approach, allocating no temperature increases year-round. This conservative approach constitutes an implicit *margin of safety*. Substitution of the allocations results in the following temperature TMDL for the Klamath River watershed in California:

Temperature TMDL = Loading Capacity
= 0 increase above natural background
= 0 anthropogenic heat load at stateline
+ 0 heat load discharged from Copco 2 and Iron Gate Reservoirs
+ 0 heat load discharge from Iron Gate Hatchery
+ 0 heat load discharge from tributaries
+ 0 heat load from excess solar radiation
+ 0 heat load from anthropogenic sediment loads
+ natural background.
= natural background

Section 5.2 details the load and waste load allocations for these sources.

5.1.2.2 Dissolved Oxygen, Nutrient and Organic Matter Loading Capacity, Allocations, and Margin of Safety

The TMDLs addressing dissolved oxygen and nutrient-related water quality impairments, including microcystin, are closely interrelated because of the strong relationship between biostimulatory conditions, decomposition of organic matter, and resulting dissolved oxygen conditions. A site-specific DO objective for the Klamath River in California is proposed in conjunction with the Klamath River TMDLs (Appendix 1). The Klamath River TMDLs for California are calculated to attain and maintain this proposed site-specific DO objective in the river reaches of the Klamath River in California. The proposed site-specific DO objective and associated DO targets are the primary driver in establishing the nutrient and organic matter loading capacity for the river reaches of the Klamath River in California. Stateline and tributary allocations for nutrients (TN and TP) and organic matter (CBOD)[3] were set to ensure that the proposed site-specific DO objectives are met in the river reaches in California.

Achievement of the stateline and tributary nutrient and organic matter allocations, however, will not result in compliance with the DO, temperature, chlorophyll-a, *Microcystis aeruginosa* cell density, and microcystin targets within Copco 1 and 2 and Iron Gate Reservoirs during summer months. Therefore, additional temperature and dissolved oxygen load allocations are assigned to the reservoirs for the period of May through October in order to meet temperature and dissolved oxygen standards in the reservoirs, as described in Section 5.3. In addition, TP, TN, and CBOD allocations are assigned to PacifiCorp at the upstream end of Copco 1 Reservoir in order to meet the chlorophyll-a, *Microcystis aeruginosa* cell density, and microcystin targets within the reservoirs, as described in Section 5.3. Alternative pollutant load reductions and/or alternative management measures or offsets may also result in achievement of the in-reservoir chlorophyll-a, *Microcystis aeruginosa*, and microcystin targets.

The loading capacity and associated load and waste load allocations for total phosphorus (TP), total nitrogen (TN), and organic matter (CBOD) for the Klamath River in California, including Copco 1 and 2 and Iron Gate Reservoirs, are presented in Figures 5.1, 5.2, and 5.3, respectively. These figures provide an illustration or graphical representation of the cumulative loading under TMDL compliance conditions to the Klamath River for total phosphorous, total nitrogen, and organic matter (CBOD). Cumulative loads used in this analysis include the total annual mass generated from upstream sources that pass through the assessment location (assessment locations along the Klamath River system were chosen to be just upstream of major tributary input locations). The analysis presents load inputs from major and minor tributaries, along with loads along the Klamath River system, and includes within-river and within-reservoir dynamics (e.g., losses, retention, and fluxes). The width of a segment arrow is only approximately proportional to the magnitude of the load within that reach. These figures present the loading capacities divided into various reaches of the Klamath River in California, and also present the load and waste load allocations assigned the different sources necessary to achieve the loading capacity. For most Klamath River compliance locations, allocations have been set as monthly mean concentrations for nutrients (TP and TN) and organic matter (CBOD). In order to summarize the Total Maximum Daily Load for these parameters, the allocations are also expressed as daily loads (concentration x flow = mass). The contribution of natural background nutrient and organic matter loads is incorporated into the compliance load for each source area.

[3] The allocations for organic matter are expressed as CBOD, and refer to CBOD- ultimate. The water quality models represent CBOD as organic matter; it is converted to CBOD-ultimate for TMDL allocation calculations.

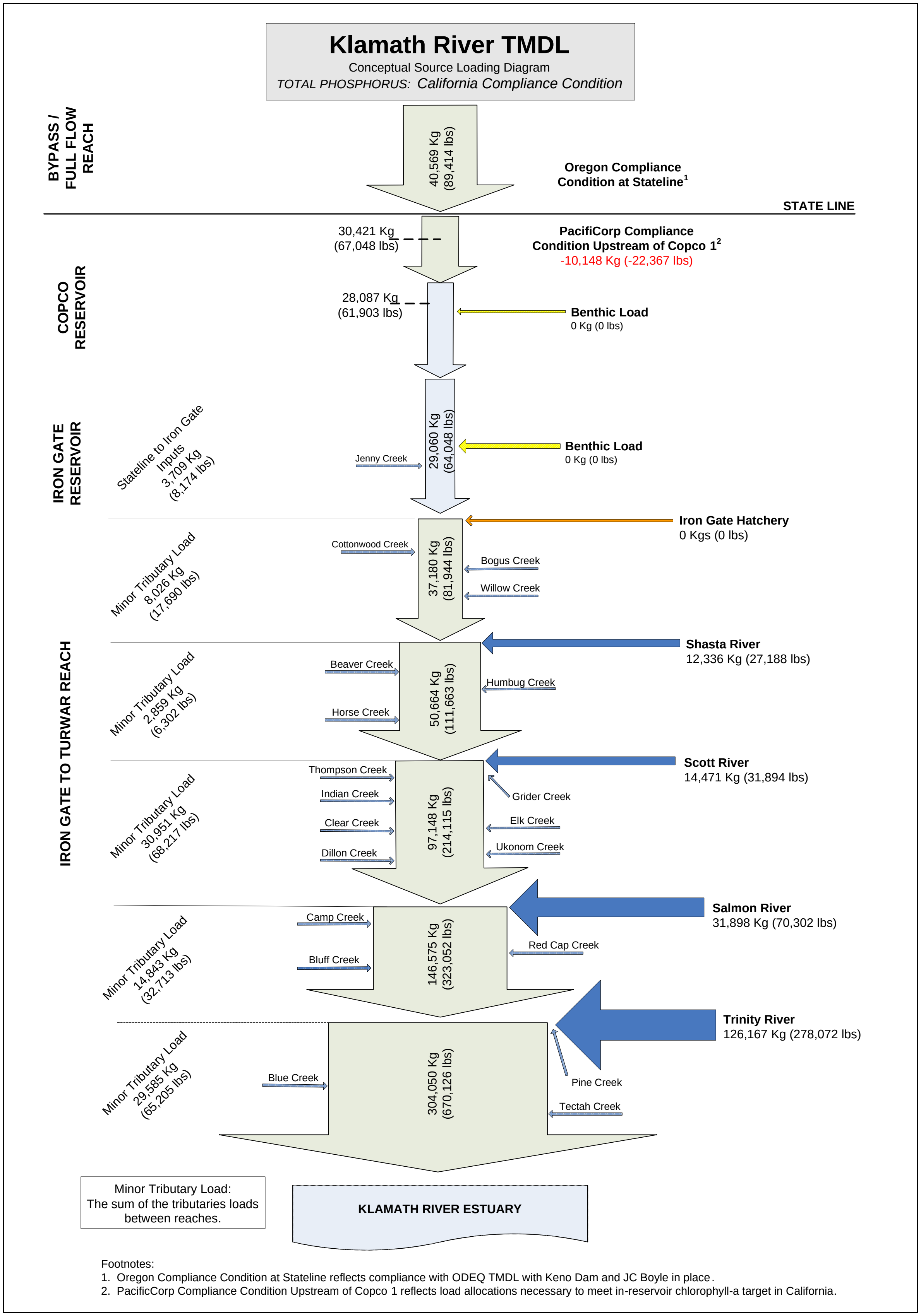


Figure 5.1: Annual total phosphorous loading capacity and allocations for the Klamath River in California

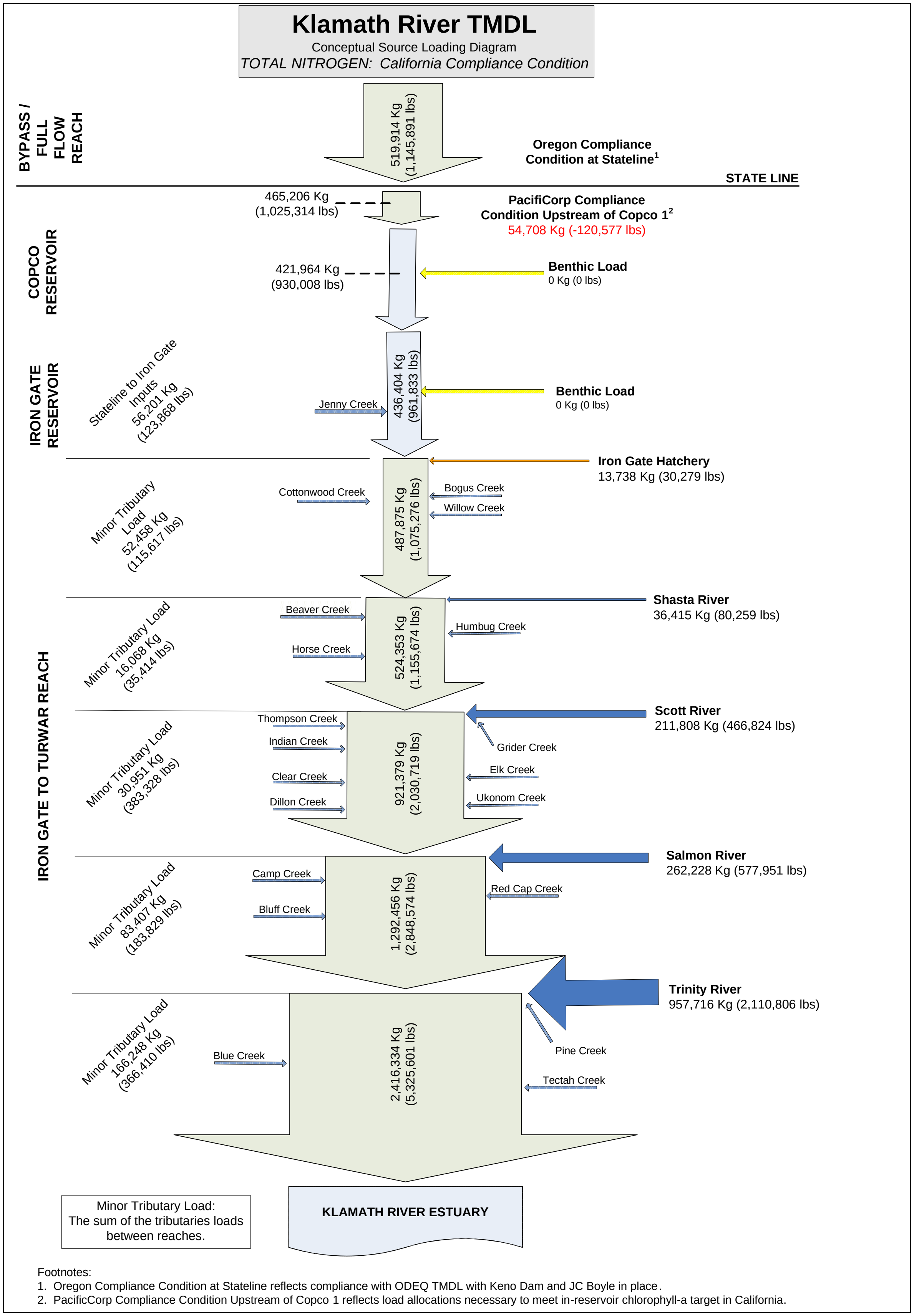
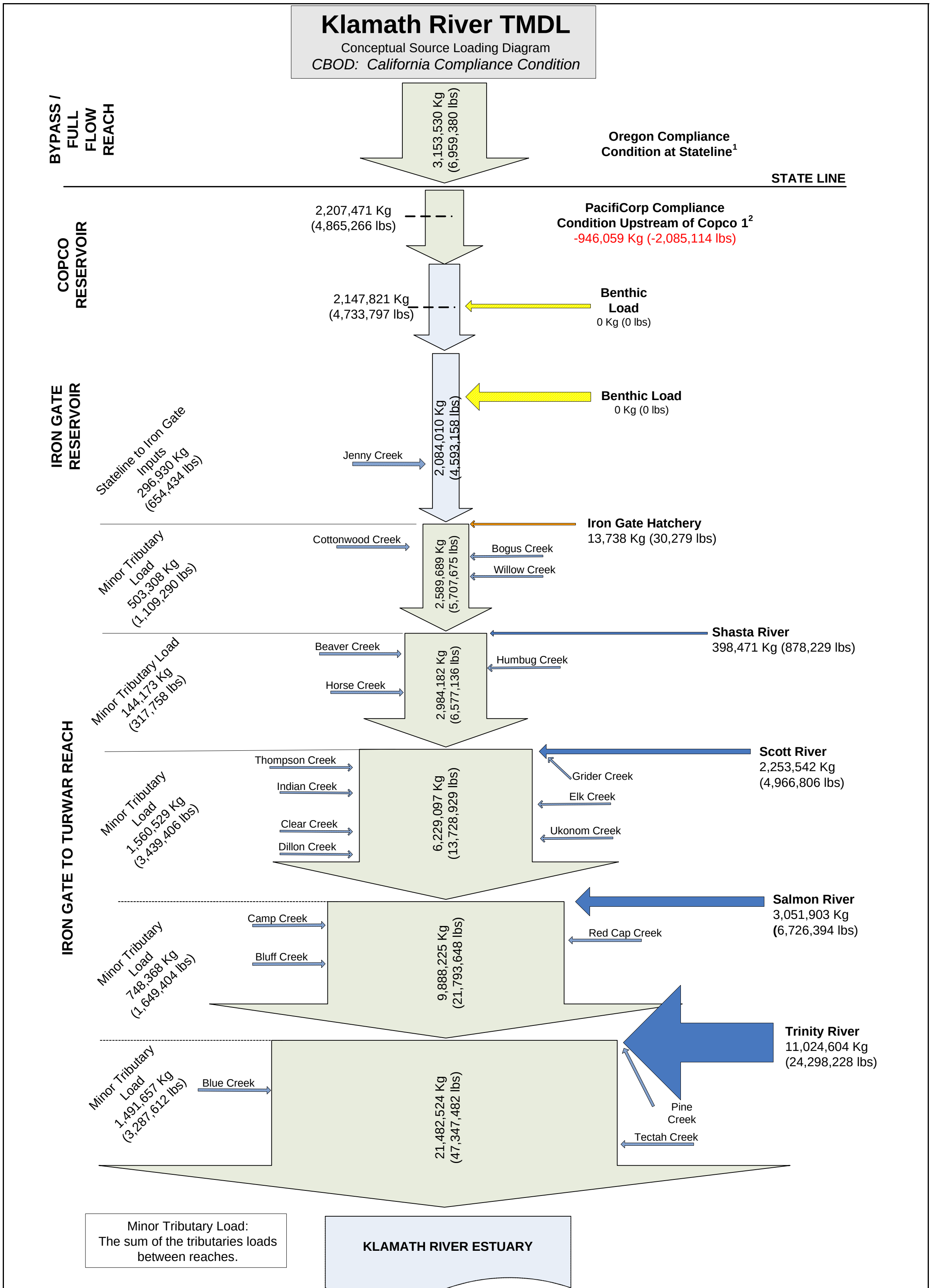


Figure 5.2: Annual total nitrogen loading capacity and allocations for the Klamath River in California.



Footnotes:
1. Oregon Compliance Condition at Stateline reflects compliance with ODEQ TMDL with Keno Dam and JC Boyle in place.
2. PacifiCorp Compliance Condition Upstream of Copco 1 reflects load allocations necessary to meet in-reservoir chlorophyll-a target in California.

Figure 5.3: Annual organic matter (CBOD) loading capacity and allocations for the Klamath River in California.

The Klamath River TMDLs addressing, DO, nutrient, and microcystin impairments in California rely on an implicit *margin of safety*. An implicit margin of safety was deemed appropriate because uncertainty was reduced in the analysis by applying a comprehensive, dynamic numerical model to incorporate conservative assumptions into loading estimates and allocations. Incorporation of the conservative assumptions allows for those assumptions to be expressed in the predicted dissolved oxygen and chlorophyll-a levels. The model takes advantage of available data collected over multiple years, and deterministically represents the cause-effect relationship between discrete sources and water quality conditions throughout the Klamath's riverine, reservoir, and estuarine portions. By representing conditions in great spatial and temporal detail, the model effectively considers a spectrum of conditions that may be overlooked by a simpler analysis. It was determined that the largest source of uncertainty in this system is the highly variable and dominant loading from Upper Klamath Lake rather than the numeric water quality model. Conservative assumptions that make up the implicit margin of safety include:

- The numeric model used to predict the impact of allocations assumes that sediment oxygen demand (SOD) does not improve in the riverine sections following upstream load reductions. The magnitude of SOD will likely decrease with the decrease of organic loading allocated by the TMDL, and result in increased DO concentrations over time.
- Predicted conditions in the Klamath River are strongly influenced by the predicted variable conditions of the Upper Klamath Lake TMDL. Conservative allocations were set by using a combination of the predicted conditions. The timing of the allocations within Oregon is based on the scenario which represents the greatest loading from Upper Klamath Lake (i.e. results in the longest period of water quality not meeting numeric criterion). The magnitudes of the allocations are based on median loading conditions from Upper Klamath Lake. This is conservative because allocations are based on the difference from a baseline condition. The closer the concentration or temperature is to the numeric criteria, the less loading is necessary to cause a measurable degradation.
- An empirical analysis suggests that the TMDL model may underestimate nutrient loss and retention within the Klamath River. The underestimate does not appear to be large. However, this potential underestimate results in more conservative allocations upstream.
- The year chosen for developing the water quality models and establishing the TMDL was selected because it included periods of critical low flow and poor water quality conditions, which results in more stringent load allocations.
- Allocations to nonpoint source are for all nutrients (TN, TP, and CBOD), not just the predicted limiting nutrient.
- Year 2000 flows are less than more recent flow requirements (i.e. USBR Klamath Project Operations and PacifiCorp Klamath Hydro Project Biological Opinion flows).

The TMDLs for TP, TN, and CBOD for the Klamath River in California, to address DO, nutrient, and microcystin impairments, are the sum of waste load allocations, load allocations, and natural background for each parameter. The only waste load allocations assigned for these TMDLs is to the Iron Gate Hatchery. The contribution of natural background TP, TN, and CBOD loads is incorporated into the load allocations for each source area.

Daily load and waste load allocations for total phosphorus, total nitrogen, and organic matter (CBOD) for the Klamath River in California are presented in Table 5.2. These daily loads are those that result in compliance with all TMDL targets.

Table 5.2: TMDLs for TP, TN, and CBOD (lbs.)

Source Area	Daily TP Load Allocations (lbs.)	Daily TN Load Allocations (lbs.)	Daily CBOD Load Allocations (lbs.)
Stateline	245+	3,139.4+	19,042+
Upstream of Copco 1 Reservoir	(61.3)+	(330.3)+	(5,713)+
Stateline to Iron Gate Dam inputs	22.4+	339.4+	1,793+
Δ Iron Gate Hatchery	0+	0+	0+
Tributaries between Iron Gate Dam and the Shasta River	48.5+	317+	3,039+
Shasta River	74.8+	220+	2,406+
Tributaries between Shasta River and Scott River	17.3+	97+	871+
Scott River	87.4+	1,279+	13,608+
Tributaries between Scott River and Salmon River	186.9+	1,050+	9,423+
Salmon River	192.6+	1,583.4+	18,428+
Tributaries between Salmon River and Trinity River	89.6+	504+	4,519+
Trinity River	761.8+	5,783+	66,571+
Tributaries between Trinity River and Turwar Creek	178.6+	1,004+	9,007+
Total	**1844**	**14,986**	**143,019**

5.2 Temperature-Related Numeric Targets and Allocations

This section presents the temperature-related numeric targets, and load and waste load allocations for the Klamath River by river reach and associated source areas.

5.2.1. Watershed-Wide Temperature-Related Targets and Load Allocations in California

There are two temperature-related load allocations that apply to the Klamath River mainstem and all minor tributary watersheds in California. These allocations are for excess solar radiation and human-caused discharges of sediment. For clarity of presentation the numeric targets are presented after presentation of these allocations.

5.2.1.1 Riparian Shade

Regional Water Board staff have concluded that the load allocation for excess solar radiation assigned in previous TMDLs (e.g. Navarro, Mattole, Scott, Shasta, and Eel River Temperature TMDLs), is also an appropriate allocation for excess solar radiation in the Klamath River watershed in California. The load allocation for solar radiation is expressed as its inverse: shade. Accordingly, the **temperature load allocations for shade** are equal to:

> the shade provided by topography and full potential vegetation conditions at a site, with an allowance for natural disturbances such as floods, wind throw, disease, landslides, and fire.

The targets for riparian shade are expressed as effective shade. Effective shade is a measure of the percentage of total daily direct beam solar radiation that is blocked by vegetation or topography before reaching the ground or stream surface, and takes into account the differences in solar intensity that occur throughout a day.

The effective shade curves in Figures 5.4-5.9 graphically present the levels of effective shade that are expected to naturally occur for a given type of vegetation, aspect, and stream width. The effective shade conditions expressed in these curves are those expected to meet the load allocation for excess solar radiation. These curves constitute the numeric targets for riparian shade within the Klamath River basin in California. Other natural factors, such as geologic or soil conditions, may reduce the site-potential effective shade at a location. Where natural factors affect site-potential effective shade, the site-potential effective shade meets the load allocation for excess solar radiation.

The curves in Figures 5.4-5.9 were developed using the Shade-a-lator riparian shade model (Boyd and Kasper 2003), which calculates the effective shade resulting from vegetation and/or topography, given the date, site geometry, and vegetation conditions. The analysis was developed for July 21, the beginning of the period of peak water and air temperatures (NCDC 2009; data collected by Regional Water Board staff). The analysis assumed no topographic shade and no vegetation overhang. The wetted channel width was assumed to be one-third the bankfull width. Wetted depth was assumed to be 0.25 meters (0.82 feet). All other assumptions are expressed in the figure titles. The height and density of the various vegetation types depicted are based on measurements by Regional Water Board staff, literature values, and professional judgment. The level of effective shade is most sensitive to the height of vegetation.

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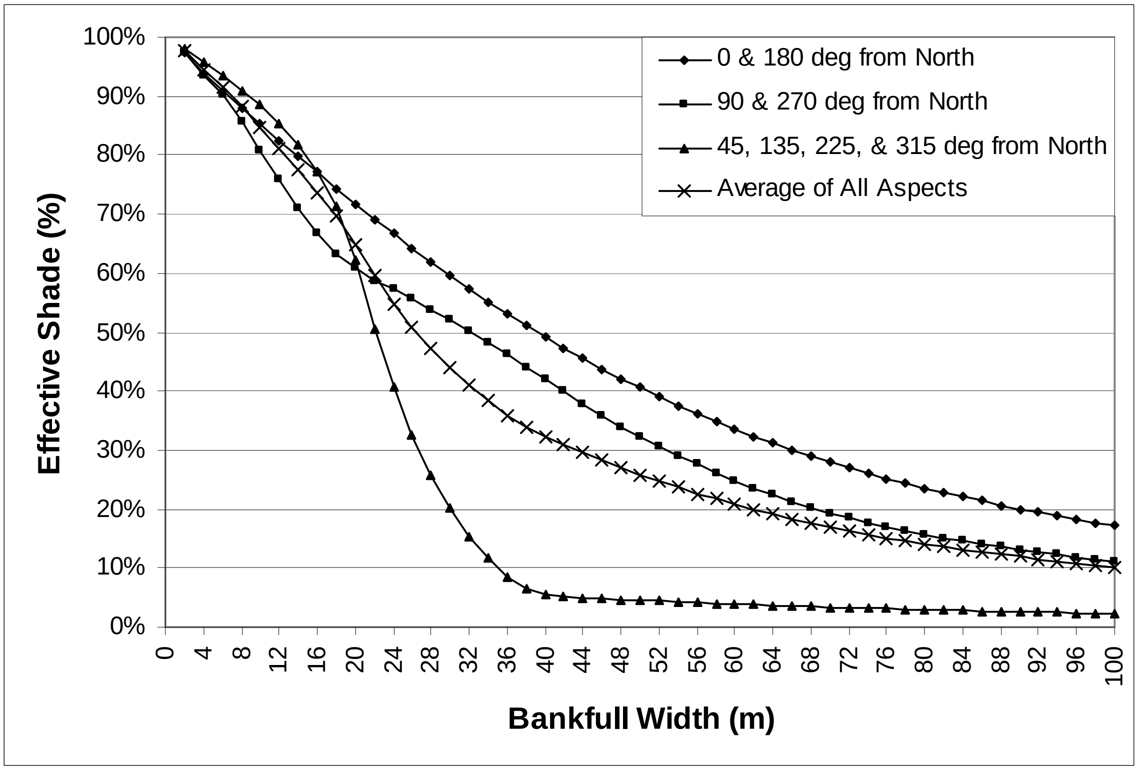

Figure 5.4: Douglas fir / mixed hardwood & conifer potential shade curves, height=40 m, density = 80%, buffer width = 30 m

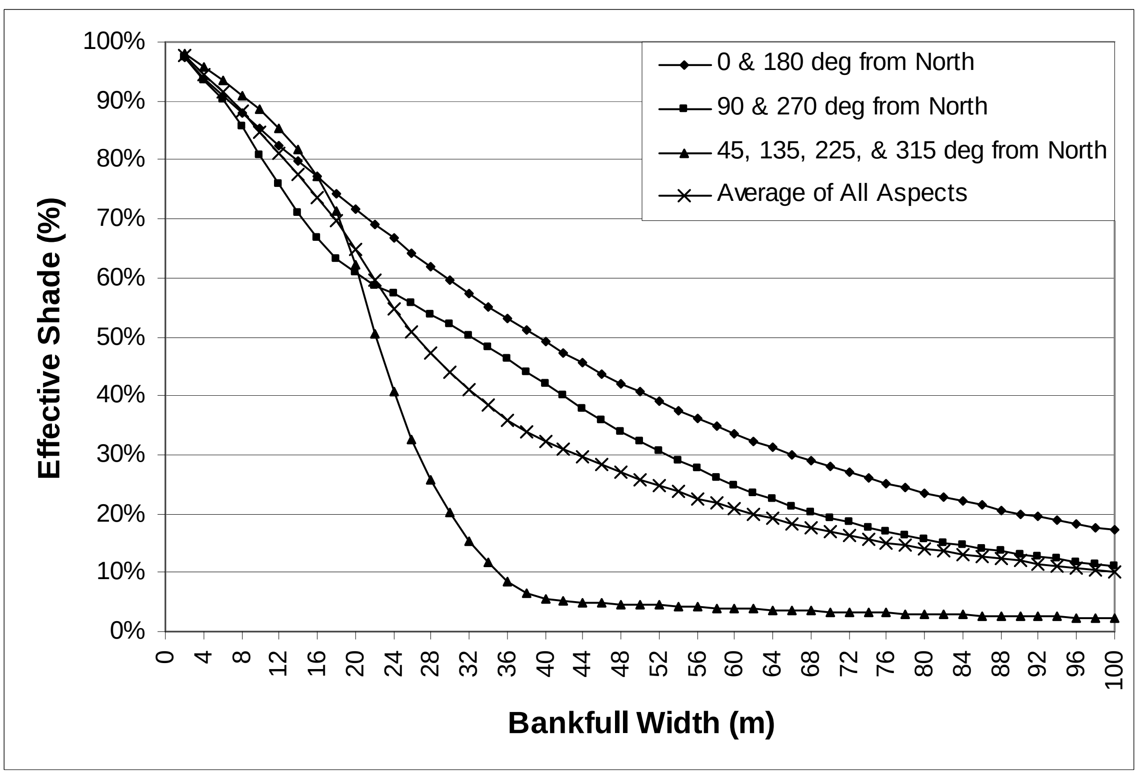

Figure 5.5: Klamath mixed conifer, height =35 m, density = 80%, buffer width = 30 m

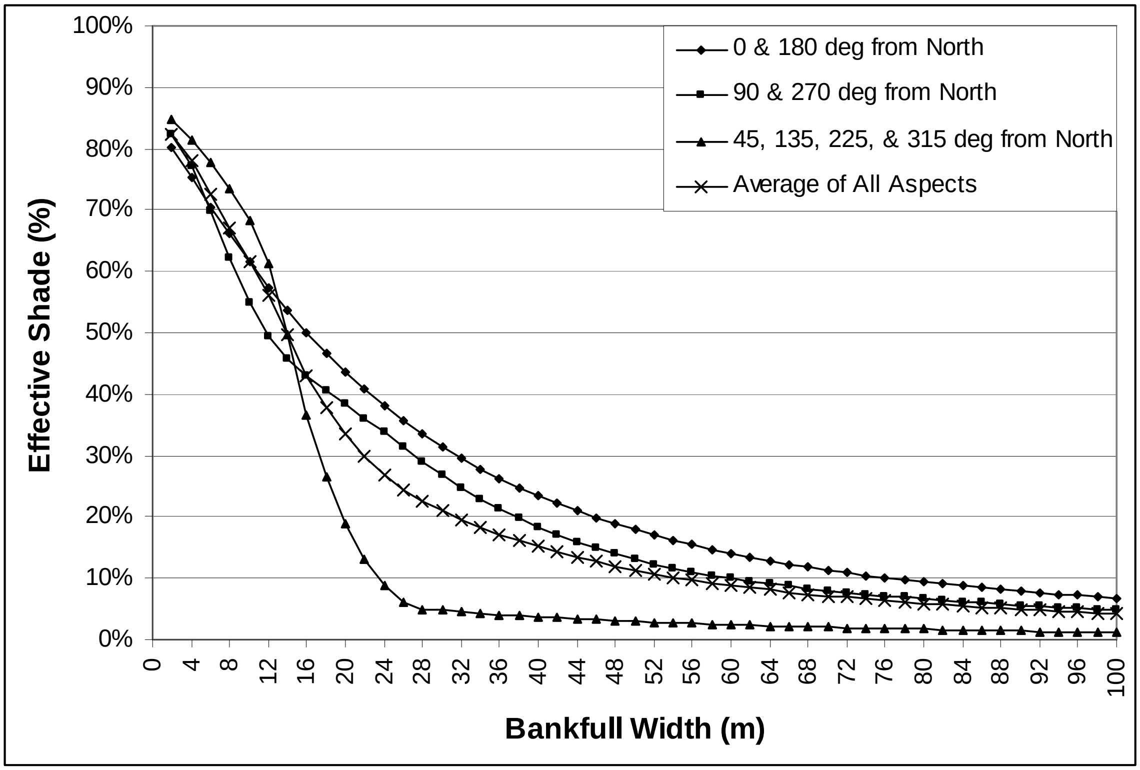

Figure 5.6: Black cottonwood: height = 24 m, density = 50 %, buffer width = 15 m

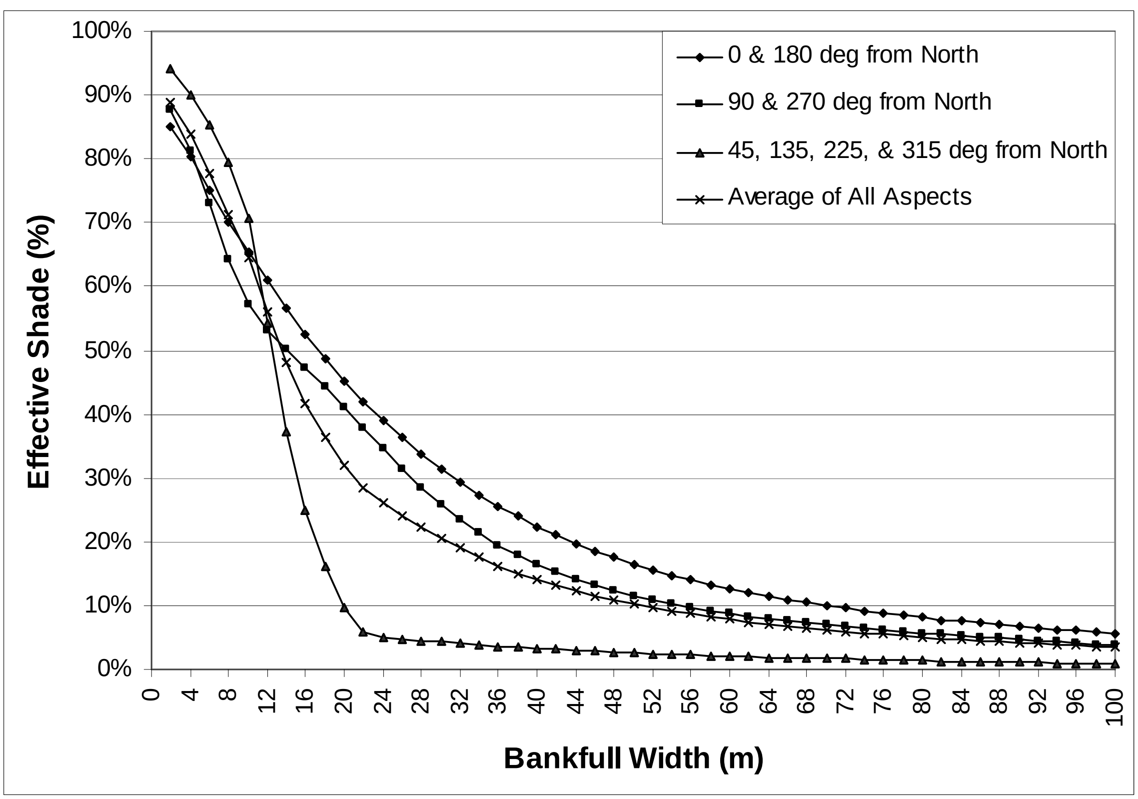

Figure 5.7: Oak woodland: height = 20 m, density = 50%, buffer width = 30 m

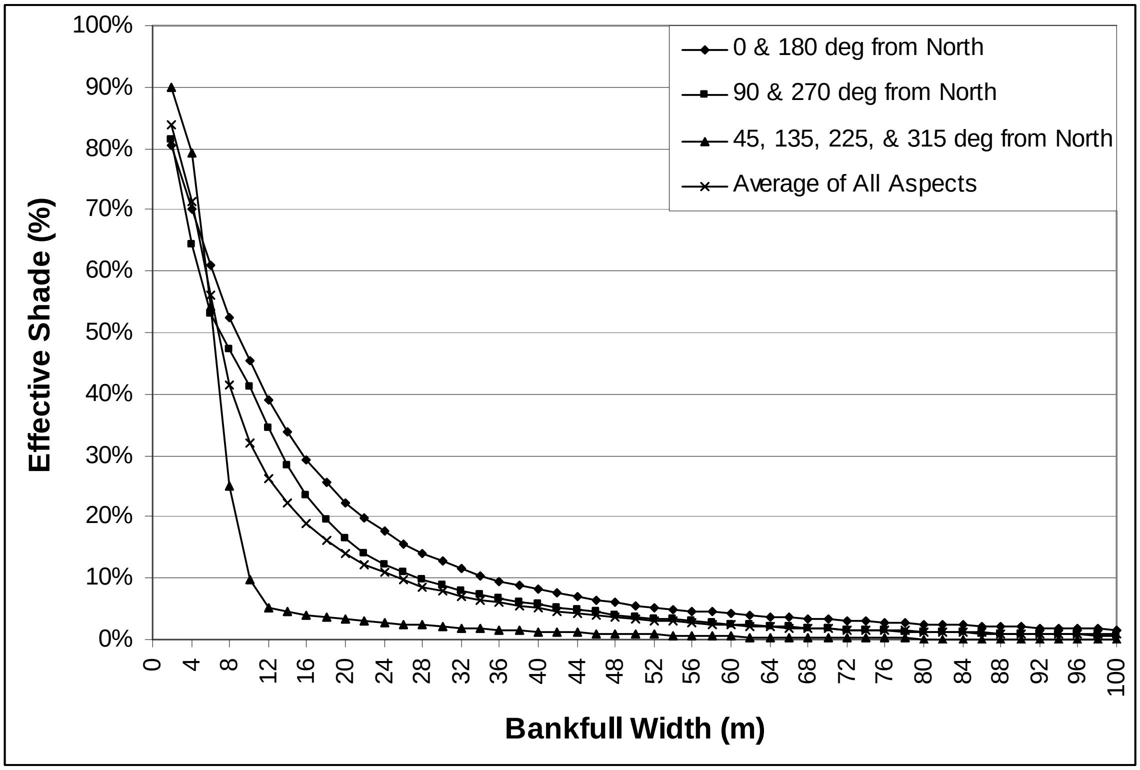

Figure 5.8: Willow: height = 10 m, density = 50%, buffer width = 15 m

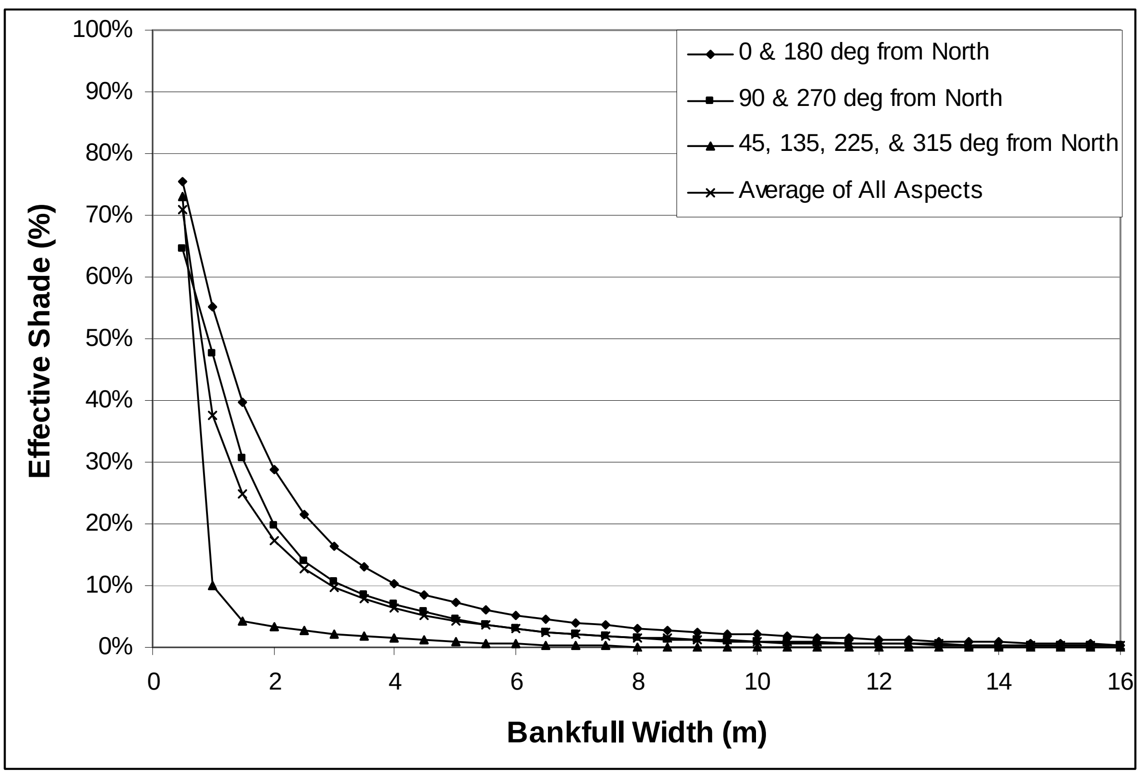

Figure 5.9: Grass/sedge: height = 1 m, density = 75%, buffer width = 15 m. Note the scale of the x-axis is not the same as figures 5.4-5.8.

5.2.1.2 Excess Sediment

Regional Water Board staff have concluded that stream temperature increases in the Klamath River watershed cannot be accommodated without adverse effects to beneficial uses. Therefore, stream temperature increases that result from human-caused discharges of sediment constitute an exceedence of the water quality objective for temperature. Accordingly, the **temperature-related load allocation for human-caused discharges of sediment** equals:

> zero temperature increase caused by substantial human-caused sediment-related channel alteration.

For this purpose, the following definition is used to define *substantial human-caused sediment-related channel alteration*:

> Substantial human-caused sediment-related channel alteration: "A human-caused alteration of stream channel dimensions that increases channel width, decreases depth, or removes riparian vegetation to a degree that alters stream temperature dynamics and is caused by increased sediment loading".

Two types of targets are designated for this category, an instream target and watershed targets.

The instream target associated with *Substantial Human-Caused Sediment-Related Channel Alteration* is:

> 0 miles of substantial human-caused sediment-related channel alteration.

The watershed target for *Stream Crossings with Diversion Potential or Significant Failure Potential* is:

> <1% of all stream crossings divert or fail as a result of a 100-year or smaller flood.

Most roads, including skid trails, cross ephemeral or perennial streams. Crossings are built to capture the stream flow and safely convey it through, under, or around the roadbed. However, stream crossings can fail, adding sediment from the crossing structure (i.e., fill), or from the roadbed, directly into the stream. Stream crossing failures are generally related to culverts that are undersized, poorly placed, plugged, or partially plugged. When a crossing fails, the total sediment volume delivered to the stream usually includes both the volume of road fill associated with the crossing and sediment from collateral failures such as debris torrents that scour the channel and stream banks.

Diversion potential is the potential for a road to divert water from its intended drainage system across or through the road fill, thereby delivering road-related sediment to a watercourse. Generally, less than one percent of stream crossings have conditions where modification is inappropriate because it would endanger travelers or where modification is impractical because of physical constraints (D. Hagans, pers. comm., 1998, in USEPA 1998).

The watershed target associated with *Road-Related Landslides* is:

Decreasing number of potential road-related landslide source areas.

Since road failures usually occur many years after roads are constructed and are often unpredictable, it is expected that the rate of road-related landslides is not likely to decrease until roads in problem areas are treated or decommissioned. Appropriate location, design, construction, and maintenance of roads is expected to result in a reduction of the rate of road failures.

5.2.2 Temperature Numeric Targets and Load Allocations at Stateline

The ODEQ has identified the Klamath River in Oregon on its CWA section 303(d) list as failing to meet Oregon temperature criteria. Accordingly, in 2010, ODEQ intends to issue and implement TMDLs for temperature for the Klamath River in the state of Oregon. These Oregon-issued TMDLs will be based on Oregon's water quality standards. The Oregon temperature standard contains a human use allowance of 0.3 ^{o}C (0.54 ^{o}F) temperature increase when natural temperature conditions are above the numeric temperature criteria, which is 20 ^{o}C (68 ^{o}F) in this situation. The human use allowance is distributed among the point and non-point sources of Klamath River temperature increases in Oregon. Because of the small magnitude and locations of thermal sources in Oregon, the Klamath River temperatures at Stateline that result from implementation of Oregon's temperature standard are consistent with California's water quality objective for temperature (i.e. the small magnitude of the allocated temperature increases and their distance from California results in temperatures that cannot be distinguished from natural temperatures by the time the water reaches Stateline).

Because these TMDLs (and their anticipated load allocations and wasteload allocations) are being developed by Oregon as part of a comprehensive multistate analysis of pollutant loadings to the Klamath River, they are also being designed to meet California water quality standards at the Oregon/California border. It is appropriate for the Regional Water Board to account for these anticipated upstream load reductions in Oregon when developing the TMDLs for the segments of the Klamath River that are downstream in California. For ease of reference, these anticipated reductions in Oregon-source loads are identified in this TMDL in California as load allocations that reflect anticipated water quality at the Oregon/California border once the Oregon TMDLs are fully implemented. Thus, the temperature allocations and targets (Table 5.3) at Stateline reflect an understanding and acknowledgement that meeting water quality standards in Oregon is critical for meeting water quality objectives in California.

The temperature targets at Stateline presented in Table 5.3 are expressed as monthly average temperatures and reflect temperatures at Stateline that are consistent with ODEQ's temperature TMDL.

Table 5.3: Temperature Numeric Targets (°C) at Stateline, expressed as monthly averages, based on the California allocation scenario results. The California allocation scenario is consistent with the Oregon allocation scenario at Stateline.

May	June	July	August	September	October
14.4 °C 58 °F	18.2 °C 64.8 °F	19.1 °C 66.5 °F	18.9 °C 66 °F	15.1 °C 59.2 °F	10.4 °C 50.7 °F
November	**December**	**January**	**February**	**March**	**April**
3.6 °C 38.4 °F	2.3 °C 36.1 °F	3 °C 37.4 °F	6 °C 42.8 °F	9.4 °C 48.9 °F	12 °C 53.5 °F

The allocation for temperature at Stateline is zero increase above natural, in accordance with water quality objectives.

5.2.3 Temperature Numeric Targets and Load Allocations to Copco 2 and Iron Gate

The numeric temperature targets assigned to Iron Gate and Copco 2 tailraces are calculated from the California allocation scenario, and are expressed as monthly average temperatures in Table 5.4. The California allocation scenario is based on achievement of water quality standards, which are set to protect all beneficial uses of water. Regional Water Board staff have determined that achievement of water quality standards is necessary to support a balanced indigenous population of fish and shellfish (see section 2.3.1).

Table 5.4: Temperature numeric targets for Iron Gate and Copco Reservoir tailrace waters

	May	June	July	August	September	October
Copco 1&2	14.8 °C 58.7 °F	18.5 °C 65.3 °F	19.7 °C 67.5 °F	19.3 °C 66.8 °F	15.4 °C 59.7 °F	10.5 °C 50.9 °F
Iron Gate	15.1 °C 59.1 °F	18.7 °C 65.6 °F	19.9 °C 67.9 °F	19.5 °C 67.1 °F	15.5 °C 60 °F	10.6 °C 51 °F
	November	**December**	**January**	**February**	**March**	**April**
Copco 1&2	3.5 °C 38.3 °F	2.2 °C 35.9 °F	2.9 °C 37.3 °F	5.9 °C 42.7 °F	9.4 °C 48.9 °F	11.7 °C 53 °F
Iron Gate	3.4 °C 38.2 °F	2.1 °C 35.8 °F	2.9 °C 37.2 °F	5.9 °C 42.6 °F	9.4 °C 48.9 °F	11.5 °C 52.7 °F

Iron Gate and Copco Reservoirs discharge elevated temperature waste, as defined by the *Water Quality Control Plan for Control of Temperature in the Coastal and Interstate Waters and Enclosed Bays and Estuaries of California* (Thermal Plan). The discharge of elevated temperature waste to the Klamath River is prohibited by the Thermal Plan. Furthermore, temperature alterations caused by the reservoirs adversely affect beneficial uses. Thus, there is no allowable temperature increase that can be allocated to waters from Iron Gate and Copco 1 and 2 Reservoirs. Accordingly, the temperature load allocation for these reservoirs equals zero temperature increase above natural temperatures.

The determination of compliance with water quality objectives for temperature is complicated by the fact that under current conditions the temperature of water entering Copco 1 Reservoir (the most upstream California reservoir) carries an anthropogenic heat load from upstream sources. The upstream heat sources are also allocated temperature loads through the State of Oregon's Klamath River TMDL, although these allocations are expected to be achieved gradually over time. Because the upstream heat loads are outside of the control of the dam operators (PacifiCorp), the allocations apply to the condition of the water as it enters the reservoirs.

Another complicating factor is that even without the presence of the reservoirs the Klamath River would be expected to naturally change temperature through the reaches currently occupied by the reservoirs. Thus, to account for natural processes, the temperature load allocation for the reservoirs includes an allowance for natural temperature increases. The allowable temperature increase was developed from model analysis for the year 2000 that predicts the natural temperature increases that would occur through the free flowing river reaches that would exist in absence of the reservoirs.

The temperature increase that would be expected to occur in the reach of the Klamath River occupied by the Copco 1 and 2 Reservoirs is presented in Figure 5.10. These results indicate that the daily average temperature would naturally increase by approximately 0.5 ^{o}C (0.9 ^{o}F) through the Copco reach. Similarly, the results indicate that the daily maximum temperatures occasionally increase by approximately 0.5 ^{o}C (0.9 ^{o}F); however, from approximately June through December the daily maximum temperature would actually decrease through the Copco reach. The increase in daily average temperatures, coupled with a decrease in daily maximum temperatures indicates a reduced daily range of temperatures. The reduced daily range may be due to more topographic shading in this reach in comparison to upstream reaches.

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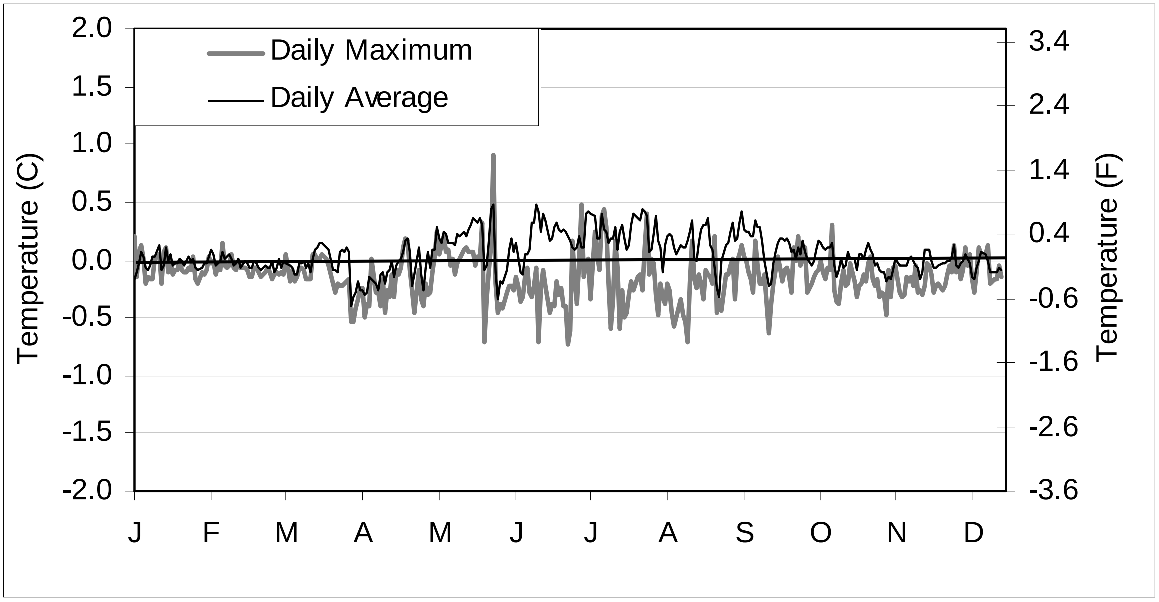

Figure 5.10: Natural temperature change through the Copco Reservoir reaches. Calculated as difference of downstream and upstream[4] daily maximum and daily average temperatures; a positive value indicates warming through the reach.

The temperature increase that would be expected to occur in the reach of the Klamath River occupied by Iron Gate Reservoir is presented in Figure 5.11. These results indicate that the daily average temperature would naturally increase by approximately 0.1 ^{o}C (0.2 ^{o}F) through the Iron Gate reach. Similarly, the results indicate that the daily maximum temperatures would naturally increase by approximately 0.1 ^{o}C (0.2 ^{o}F) in the same reach.

Given that the water quality objectives for temperature do not allow for temperature increases above natural, the water released from Iron Gate and Copco 2 Reservoirs to the Klamath River is allocated temperature increases that correspond to natural temperature increases, as presented in Table 5.5. The temperature allocation is intended to be added to the in-flowing temperature of the river immediately upstream of each reservoir.

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[4] Downstream is at the Copco 2 tailrace location, and upstream is at the inlet to Copco 1.

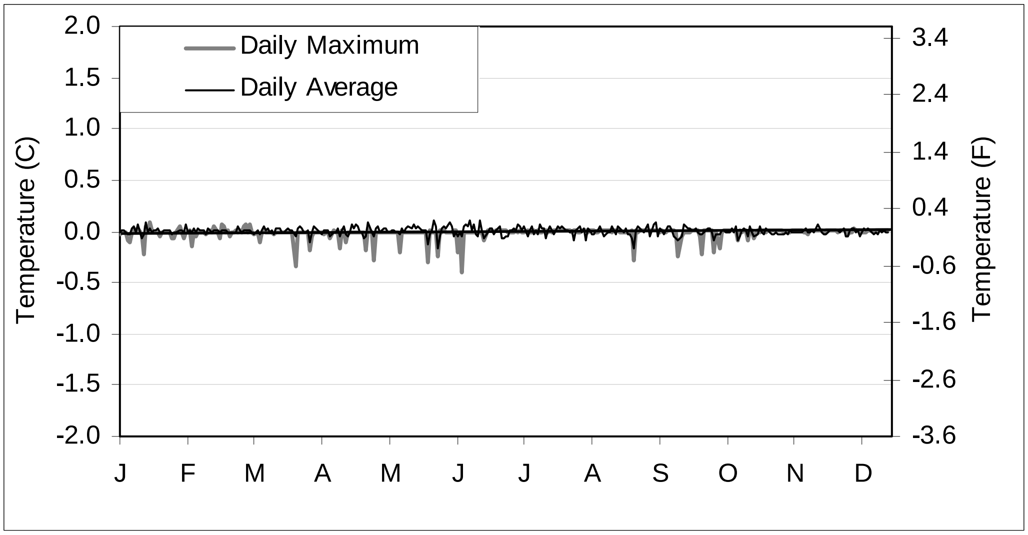

Figure 5.11: Natural temperature change through the Iron Gate Reservoir reach. Calculated as difference of downstream and upstream daily maximum and daily average temperatures; a positive value indicates warming through the reach.

Table 5.5: Temperature load allocations for reservoir tailrace waters, expressed as increase in temperature relative to inflow temperature

Facility	Daily Average	Daily Maximum
Iron Gate	0.1 °C (0.18 °F)	0.1 °C (0.18 °F)
Copco 1 & 2	0.5 °C (0.9 °F)	0.5 °C (0.9 °F)

5.2.4 Temperature Numeric Targets and Waste Load Allocations to Iron Gate Hatchery

The numeric temperature targets assigned to the Iron Gate Hatchery (Table 5.6) are expressed as monthly average temperatures, equal to the temperatures associated with the Klamath River downstream of Iron Gate Dam, and are calculated from the California allocation scenario.

Table 5.6: Temperature numeric targets for Iron Gate hatchery, expressed as monthly averages, based on California allocation scenario results

May	June	July	August	September	October
15.1 °C 59.1 °F	18.7 °C 65.6 °F	20.0 °C 68.0 °F	19.5 °C 67.1 °F	15.6 °C 60.0 °F	10.6 °C 51.0 °F
November	**December**	**January**	**February**	**March**	**April**
3.5 °C 38.2 °F	2.2 °C 35.9 °F	2.9 °C 37.3 °F	5.9 °C 42.7 °F	9.4 °C 48.9 °F	11.5 °C 52.7 °F

The discharge of elevated temperature waste to the Klamath River is prohibited by the state Thermal Plan. Thus, there is no allowable temperature increase that can be allocated to Iron Gate Hatchery. Accordingly, the temperature load allocation for the Hatchery equals zero temperature increase above natural temperatures (see Table 5.6).

5.3 Dissolved Oxygen and Nutrient-Related Numeric Targets and Allocations

This section presents the dissolved oxygen and nutrient-related numeric targets, and load and waste load allocations for the Klamath River by river reach and associated source areas.

5.3.1 Dissolved Oxygen and Nutrient-Related Numeric Targets and Load Allocations at Stateline

The ODEQ has identified the Klamath River in Oregon on its CWA section 303(d) list as failing to meet certain Oregon water quality standards. Accordingly in 2010, ODEQ intends to issue and implement TMDLs addressing chlorophyll-a, dissolved oxygen, and pH impairments for the Klamath River in the state of Oregon. These Oregon-issued TMDLs will be based on the Oregon allocation scenario (see Appendix 7), which is designed to meet Oregon's water quality standards. Because these TMDLs (and their anticipated load allocations and waste load allocations) are being developed by Oregon as part of a comprehensive multistate analysis of pollutant loadings to the Klamath River, they are also being designed to meet California water quality standards at the Oregon/California border. It is appropriate for the Regional Water Board to account for these anticipated upstream load reductions in Oregon when developing the TMDLs for the segments of the Klamath River that are downstream in California. For ease of reference, these anticipated reductions in Oregon-source loads are identified in this TMDL as load allocations at Stateline that reflect anticipated water quality at the Oregon /California border once the Oregon TMDLs are fully implemented. Thus, the load allocations and numeric targets at Stateline reflect an understanding and acknowledgement that improvements in water quality upstream are critical in meeting water quality objectives in California.

Allocation values are based on model output and significant digits have been set based on consideration of analytical method detection limits and criteria / objective reporting requirements. The following convention has been used for each of the following parameters: dissolved oxygen (DO) – tenths of mg/L; nutrients (total nitrogen and total phosphorous) – thousandths of mg/L; and whole units for carbonaceous oxygen demand (CBOD).

The dissolved oxygen targets at stateline are expressed as monthly average and monthly minimum DO concentrations (Table 5.7). These dissolved oxygen targets are consistent with the DO concentrations at Stateline under the Oregon and California allocation scenarios and achieve 85% saturation or better under natural temperature conditions from April 1 through September 30 and 90% saturation or better from October 1 through March 31.

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Table 5.7: Dissolved oxygen numeric targets (mg/L) at Stateline.

	May	June	July	August	September	October
Mean	8.8	8.2	8.2	8.2	8.8	9.6
Minimum	8.1	7.2	7.0	7.1	7.91	8.3
	November	**December**	**January**	**February**	**March**	**April**
Mean	11.5	11.8	11.5	10.5	9.7	9.1
Minimum	10.3	11.3	10.9	10.1	9.2	8.7

Nutrient and organic matter allocations at Stateline are based on the Oregon allocation scenario and are set to control biostimulatory and oxygen consuming effects on DO and to achieve the DO objective/targets at Stateline. These allocations are expressed as monthly mean concentrations (mg/L) for total phosphorous (TP), total nitrogen (TN), and organic matter (CBOD) as shown in Table 5.8.

Table 5.8: Nutrient and organic matter monthly mean concentration (mg/l) allocations at Stateline.

	May	June	July	August	September	October
TP	0.029	0.026	0.027	0.026	0.024	0.023
TN	0.372	0.279	0.261	0.252	0.257	0.285
CBOD	2	1	1	1	1	1
	November	**December**	**January**	**February**	**March**	**April**
TP	0.026	0.029	0.024	0.028	0.029	0.030
TN	0.322	0.362	0.304	0.376	0.384	0.395
CBOD[5]	1	1	2	3	3	3

5.3.2 Dissolved Oxygen and Nutrient-Related Numeric Targets and Load Allocations to Klamath Hydroelectric Project Facilities in California

Dissolved oxygen and nutrient-related numeric targets and load allocations are set for the Copco 2 and Iron Gate tailraces as well as for the reservoirs themselves.

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[5] The Method Detection Limit (MDL) and Reporting Limit (RL) for CBOD are equal at 3 mg/L. These levels are operationally defined and do not vary between laboratories. Option 1) Analytical results of CBOD will be assessed using a 3-month running average for compliance evaluation against concentration targets. Analytical results reported as below the MDL will be assessed at one-half the MDL (i.e., 1.5 mg/L). Option 2) Analytical results reported below the MDL for CBOD will be assumed to represent one-half the MDL (i.e., 1.5 mg/L). This assumption is commonly used in water quality assessment (Helsel and Hirsch, 1992). Alternatively, assessment of compliance with CBOD targets can be conducted using the concentration of Total Organic Carbon (TOC). The target concentrations were derived using a conversion factor applied to particulate and dissolved organic matter. Analytical results of TOC can be converted to an equivalent concentration of CBOD using these conversions.

5.3.2.1 Copco 2 and Iron Gate Reservoir Targets

Copco 2 and Iron Gate tailrace targets for dissolved oxygen are calculated from the California allocation scenario, and are expressed as monthly mean and monthly minimum DO concentrations (Table 5.9).

Table 5.9: Dissolved oxygen numeric targets (mg/l) for Copco 2 and Iron Gate tailraces

Copco 2 Tailrace						
	May	**June**	**July**	**August**	**September**	**October**
Mean	8.8	8.2	8.2	8.2	8.8	9.7
Minimum	8.0	7.3	7.0	7.0	7.9	8.4
	November	**December**	**January**	**February**	**March**	**April**
Mean	11.6	12.0	11.6	10.6	9.8	9.3
Minimum	10.4	11.6	11.1	10.2	9.2	8.7
Iron Gate Tailrace						
	May	**June**	**July**	**August**	**September**	**October**
Mean	8.8	8.2	8.1	8.1	8.8	9.7
Minimum	7.9	7.2	7.0	6.9	7.8	8.4
	November	**December**	**January**	**February**	**March**	**April**
Mean	11.7	12.1	11.7	10.7	9.8	9.3
Minimum	10.5	11.6	11.2	10.3	9.2	8.6

Numeric targets for nutrients (TP and TN) and organic matter (CBOD) are established for the tailraces of Copco 2 and Iron Gate (Table 5.10). These nutrient and organic matter targets are based on the with-dam TMDL scenario and are established at the monthly mean concentrations that coincide with meeting the in-reservoir chlorophyll-a summer mean target of 10 µg/L, *Microcystis aeruginosa* cell density target of 20,000 cells/mL, and microcystin target of 4 µg/L. See Section 2.3.2.2 for detailed background information regarding the selection of these numeric targets.

In addition, Table 7.9 in Section 7.8 (Chapter 7 – Reassessment and Monitoring Program) includes monthly mean nutrient (TP and TN) and organic matter (CBOD) “trigger” concentrations at the tailrace of Iron Gate. These nutrient and organic matter “trigger” concentrations are based on the California allocation scenario, which represents conditions that comply with water quality standards without dams. As discussed in Section 7.8, nutrient and organic matter conditions, as well as other measures of riverine productivity, should be assessed over time at Iron Gate tailrace and locations downstream, and compared relative to the trigger concentrations at Iron Gate tailrace.

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Table 5.10: Nutrient and organic matter monthly mean concentration targets (mg/L) for Copco 2 and Iron Gate tailraces

Copco 2 Tailrace						
	May	**June**	**July**	**August**	**September**	**October**
TP	0.017	0.015	0.016	0.016	0.015	0.015
TN	0.259	0.201	0.174	0.178	0.168	0.211
CBOD[5]	2	1	1	1	1	1
	November	**December**	**January**	**February**	**March**	**April**
TP	0.017	0.023	0.016	0.019	0.019	0.018
TN	0.264	0.341	0.241	0.315	0.303	0.278
CBOD[5]	1	1	1	2	2	2
Iron Gate Tailrace						
	May	**June**	**July**	**August**	**September**	**October**
TP	0.255	0.202	0.157	0.149	0.140	0.161
TN	0.016	0.014	0.013	0.013	0.013	0.013
CBOD[5]	1	1	1	1	1	1
	November	**December**	**January**	**February**	**March**	**April**
TP	0.203	0.276	0.195	0.298	0.299	0.267
TN	0.015	0.017	0.013	0.018	0.019	0.017
CBOD[5]	1	1	1	2	2	2

5.3.2.2 Klamath Hydroelectric Project Nutrient Load Allocations

Allocations for nutrients (TP and TN) are assigned to the Klamath Hydroelectric Project facilities in California in order to achieve the in-reservoir chlorophyll-a, *Microcystis aeruginosa* and microcystin numeric targets. These allocations are based on the with-dams TMDL scenario, and are to be achieved at a location upstream of Copco 1. These annual allocations (see Figure 5.1) equal:

- 67,048 pounds TP/year;
- 1,025,314 pounds TN/year;

and equate to the following annual reductions below the nutrient allocations at Stateline:

- 22,367 pounds TP/year;
- 120,577 pounds TN/year.

These allocations or alternative pollutant load reductions and/or alternative management measures or offsets are necessary to: 1) meet the Basin Plan narrative toxicity objective (and the associated chlorophyll-a, *Microcystis aeruginosa*, and microcystin numeric targets), 2) meet the narrative biostimulatory substances objective (and the associated TP and TN targets), and 3) support the REC-1; REC-2, and CUL beneficial uses of the river system with Copco 1, Copco 2, and Iron Gate Reservoirs in place.

Figures 5.12, 5.13, and 5.14 present annual TP, TN, and organic matter (CBOD) loads downstream of Iron Gate Reservoir based on the following model scenarios: current conditions; California allocations scenario conditions; with-dam TMDL scenario condition; and natural conditions baseline. These figures demonstrate that larger nutrient reductions are needed in order to achieve water quality standards with the Klamath

Hydroelectric Project facilities in California in place. Alternative pollutant load reductions and/or alternative management measures or offsets that result in achieving the in-reservoir chlorophyll-a, *Microcystis aeruginosa*, and microcystin numeric targets may be proposed to the Regional Water Board for approval.

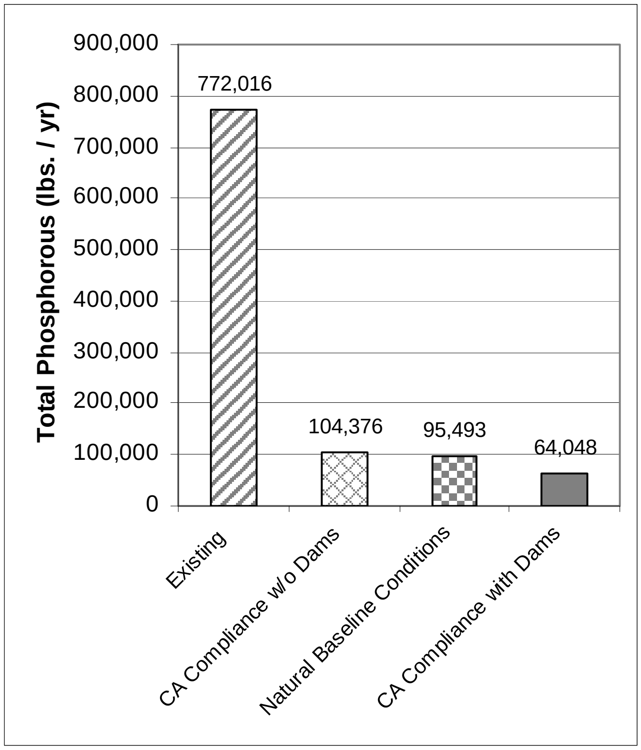

Figure 5.12 Loading condition comparison below Iron Gate Dam for total phosphorus

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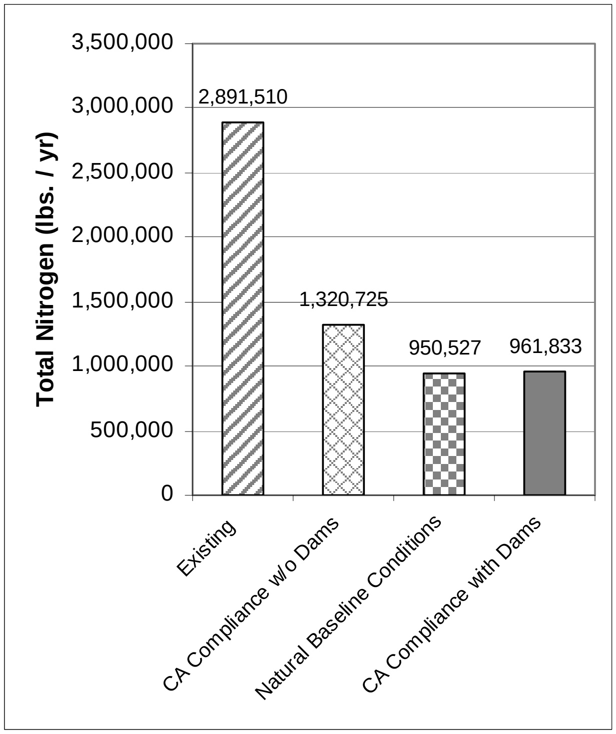

Figure 5.13 Loading condition comparison below Iron Gate Dam for total nitrogen

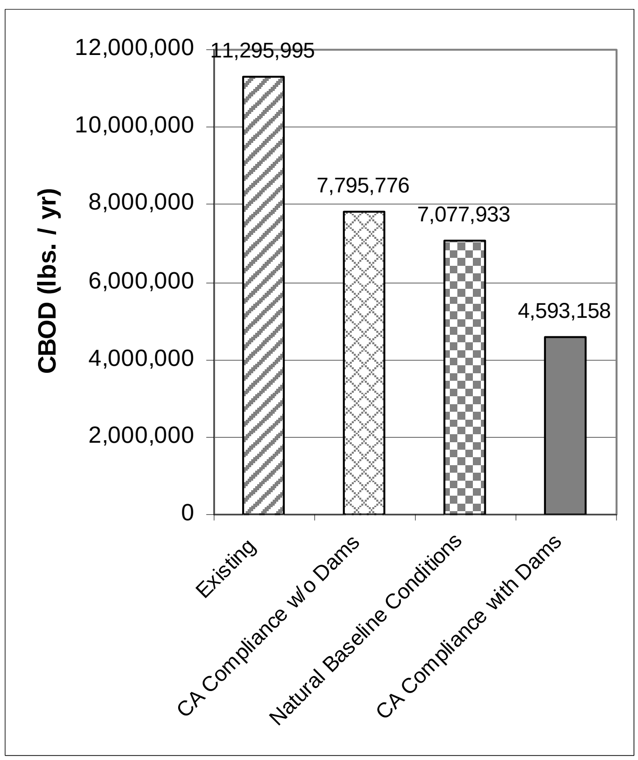

Figure 5.14 Loading condition comparison below Iron Gate Dam for CBOD

Achievement of the nutrient and organic matter allocations at Stateline and the Klamath Hydroelectric Project nutrient allocations will not result in compliance with the DO and temperature targets within Copco 1 and 2 and Iron Gate Reservoirs during periods of thermal stratification. Therefore, additional temperature and dissolved oxygen load allocations are assigned to the reservoirs for the period of May through October to ensure compliance with the DO and temperature targets within the reservoirs, and ensure support of COLD. The temperature and DO allocations for waters within Copco 1 and 2 and Iron Gate Reservoirs are dual allocations, wherein achievement of the water quality objective for temperature must co-occur with dissolved oxygen conditions. Allocations for dissolved oxygen and temperature are intended to create a "compliance lens" where both DO and temperature conditions meet Basin Plan objectives for water temperature and DO and are therefore protective of COLD and MIGR. The concept of the compliance lens where both DO and temperature objectives are met is illustrated in Figure 5.15.

The allocation is for the critical period of May through October and requires that DO concentrations consistent with 85% saturation or better through September and 90% or better in October (based on natural receiving water temperatures) co-occur with temperatures consistent with natural water temperatures (natural baseline summer mean is ~18.7^{o} C) from the point of entry to the reservoirs within a lens and throughout the reservoir.

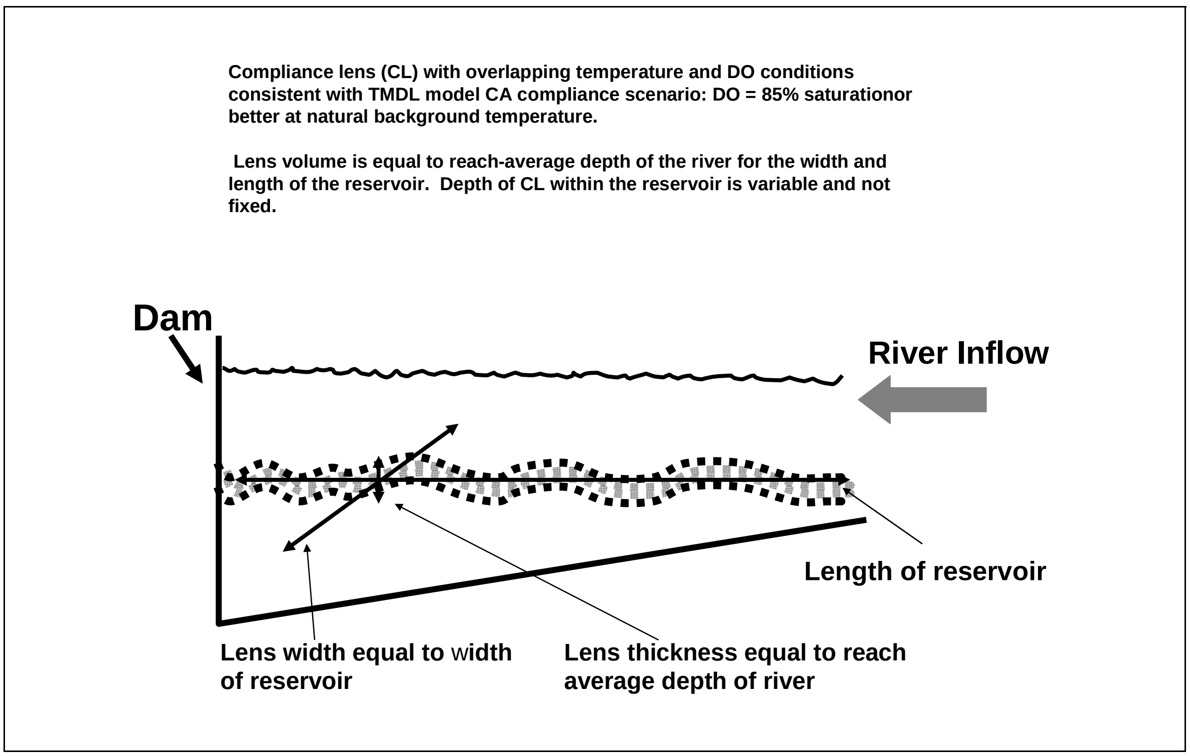

Figure 5.15: Illustrated conceptual model of reservoir compliance lens for temperature and dissolved oxygen

The volume of each reservoir compliance lens is equal to the average hydraulic depth of the river in a free-flowing state for the width and length of the reservoir. The depth at which the compliance lens occurs within the reservoirs will vary, as will an instantaneous mass of DO required to meet the allocation.

Alternative in-reservoir temperature and DO conditions that provide equal or better protection of COLD and MIGR within Copco 1, Copco 2, and Iron Gate Reservoirs may be proposed for Regional Water Board approval.

5.3.3 Dissolved Oxygen and Nutrient-Related Numeric Targets and Waste Load Allocations to Iron Gate Hatchery

The DO targets for Iron Gate Hatchery discharge are monthly mean and monthly minimum DO concentrations (Table 5.11). The targets apply to the Iron Gate Hatchery discharge location just above the mouth of Bogus Creek. The target concentrations were calculated from the California allocation scenario, and reflect compliance DO conditions immediately downstream of Iron Gate Dam.

Table 5.11: Dissolved oxygen numeric targets (mg/L) for Iron Gate hatchery discharge

	May	**June**	**July**	**August**	**September**	**October**
Mean	8.8	8.2	8.2	8.2	8.8	9.7
Minimum	7.9	7.2	6.9	6.8	7.8	8.4
	November	**December**	**January**	**February**	**March**	**April**
Mean	11.6	12.0	11.7	10.7	9.8	9.3
Minimum	10.5	11.6	11.2	10.3	9.2	8.6

The waste load allocation to the Iron Gate Hatchery is zero net increase of nutrient and organic matter loads in the river above California dissolved oxygen compliance conditions (i.e. with no dams). Table 5.12 presents the Iron Gate Hatchery nutrient and organic matter targets, expressed as monthly mean concentrations. These concentration targets reflect California allocation scenario conditions above the confluence with Bogus Creek.

Table 5.12 Nutrient and organic matter monthly mean concentration targets (mg/L) for Iron Gate hatchery based on California allocation scenario conditions

	May	**June**	**July**	**August**	**September**	**October**
TP	0.027	0.024	0.025	0.024	0.022	0.021
TN	0.282	0.198	0.167	0.160	0.149	0.166
CBOD[5]	2	1	1	1	1	1
	November	**December**	**January**	**February**	**March**	**April**
TP	0.024	0.026	0.021	0.025	0.026	0.028
TN	0.186	0.214	0.220	0.289	0.299	0.295
CBOD[5]	1	1	2	2	2.	2

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5.3.4 Dissolved Oxygen and Nutrient-Related Numeric Targets and Load Allocations to California Tributaries

The primary targets associated with California tributary nutrient and organic matter loadings are dissolved oxygen concentrations within the Klamath River mainstem. The monthly mean and monthly minimum DO targets are calculated from the California allocation scenario. The primary DO target compliance location is located downstream of the Salmon River immediately upstream of the boundary of the Hoopa Valley Indian Reservation; these targets are presented in Table 5.13.

Table 5.13: Dissolved oxygen numeric targets (mg/l) for the Klamath River mainstem below the Salmon River

	May	June	July	August	September	October
Mean	9.7	8.9	8.3	8.2	8.8	9.7
Minimum	8.9	8.0	7.5	7.4	8.0	9.0
	November	**December**	**January**	**February**	**March**	**April**
Mean	11.7	12.2	12.2	11.6	11.2	11.7
Minimum	10.7	11.7	11.8	11.2	10.5	10.7

Nutrient and organic matter numeric targets are also set for the Klamath River mainstem downstream of the Salmon River. The TP, TN, and CBOD numeric targets are expressed as monthly mean concentrations (mg/L); consistent with the California allocation scenario (Table 5.14).

Table 5.14: Nutrient and organic matter monthly mean targets (mg/L) for Klamath River below the Salmon River

	May	June	July	August	September	October
TP	0.023	0.022	0.022	0.022	0.024	0.026
TN	0.229	0.207	0.182	0.184	0.212	0.242
CBOD^5	2	2	2	2	2	1
	November	**December**	**January**	**February**	**March**	**April**
TP	0.027	0.026	0.021	0.022	0.023	0.023
TN	0.241	0.233	0.173	0.198	0.218	0.221
CBOD^5	1	1	1	2	2	2

A reach-averaged maximum density periphyton biomass numeric target of 150 mg of chlorophyll-a / m^2 is established for the Klamath River mainstem downstream of the Salmon River. This value was developed through the California NNE analysis for the Klamath River[6] (Appendix 2).

Nutrient (TP and TN) and organic matter (CBOD) allocations for the minor California tributaries to the Klamath River are set as monthly mean concentrations that apply year-round. The Shasta, Scott, Salmon, and Trinity River nutrient and organic matter allocations are monthly mean concentrations, but are different for wet (November

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[6] Compliance with this target shall be assessed by calculating the average periphyton chlorophyll-a from not less than ten samples collected within the Klamath River downstream of the Salmon River and upstream of the Trinity River.

through April) and dry (May through October) seasons. These allocations are calculated from the California allocation scenario, and are summarized in Tables 5.15 and 5.16. The Shasta River TN, TP, and CBOD allocations are consistent with the existing approved Shasta River TMDL. No additional load reductions are required from the Shasta River.

Table 5.15: Nutrient and organic matter seasonal monthly mean concentration allocations (mg/l) for tributaries to the Klamath River

Tributary	Season	TP	TN	CBOD[1]
Shasta River	Dry: May – October	0.071	0.21	2
	Wet: November – April	0.071	0.21	2
Scott River	Dry: May – October	0.028	0.310	4
	Wet: November – April	0.019	0.325	3
Salmon River	Dry: May – October	0.018	0.229	2
	Wet: November – April	0.028	0.194	2
Trinity River	Dry: May – October	0.029	0.233	2
	Wet: November – April	0.033	0.245	3

Table 5.16: Nutrient and organic matter annual monthly mean concentration allocations (mg/l) for tributaries to the Klamath River

Tributary	TP	TN	CBOD[1]
Bogus Creek	0.014	0.077	1
Willow Creek	0.014	0.077	1
Cottonwood Creek	0.014	0.077	1
Humbug	0.014	0.077	1
Beaver Creek	0.014	0.077	1
Horse Creek	0.014	0.077	1
Grider Creek	0.014	0.077	1
Thompson Creek	0.014	0.077	1
India Creek	0.014	0.077	1
Elk Creek	0.014	0.077	1
Clear Creek	0.014	0.077	1
Ukonom Creek	0.014	0.077	1
Dillon Creek	0.014	0.077	1
Camp Creek	0.014	0.077	1
Red Cap Creek	0.014	0.077	1
Bluff Creek	0.014	0.077	1
Pine Creek	0.014	0.077	1
Tectah Creek	0.014	0.077	1
Blue Creek	0.014	0.077	1

CHAPTER 5. REFERENCES

Boyd, M. and B. Kasper. 2003. Analytical methods for dynamic open channel heat and mass transfer: Methodology for heat source model. Version 7.0.

National Climate Data Center (NCDC). 2009. Daily Station Normals (1971-2000): Happy Camp Ranger Stn, California (043761). Accessed December 7, 2009. Available at: <http://cdo.ncdc.noaa.gov/cgi-bin/climatenormalsclimatenormals.pl.>

State Water Resources Control Board (State Water Board). 2008. Blue Green Algae Work Group of the State Water Board, Department of Public Health (DPH), and Office of Environmental Health and Hazard Assessment (OEHHA). Cyanobacteria in California Recreational Water Bodies: Providing Voluntary Guidance about Harmful Algal Blooms, Their Monitoring, and Public Notification – September 2008.

U. S. Environmental Protection Agency. 1998. South Fork Trinity River and Hayfork Creek Total Maximum Daily Load for Sediment. Available at: <http://www.epa.gov/region9/water/tmdl/trinityso/fsftmdl.pdf>.

Welch, Eugene, B. 2009. Should nitrogen be reduced to manage eutrophication if it is growth limiting? Evidence from Moses Lake. *Lake and Reservoir Management*, 25:401–409, 2009

World Health Organization (WHO). 2003. Guidelines for Safe Recreational Water Environments, Volume 1, Coastal and Fresh Waters. Geneva, Switzerland. 253 pp.

CHAPTER 6. IMPLEMENTATION PLAN

6.1 Introduction

The Klamath TMDL establishes the allowable loadings or other quantifiable parameters for a waterbody that is the total permissible pollutant load that will achieve water quality standards. This “loading capacity” provides a reference for calculating the amount of pollutant reduction needed to bring a waterbody into compliance with water quality standards or designated uses. The TMDL identifies and assigns allocations to all sources of pollution, including waste load allocations to point sources and load allocations to nonpoint sources (40 CFR § 130 .2(i)). The rationale for the allocations and targets is provided in detail in Chapters 2 through 5 of the TMDL Staff Report.

The TMDL Program is the primary program responsible for achieving clean water where traditional controls on point sources have proven inadequate to do so. The program is charged with developing implementation plans that consider all sources and causes of impairment, and allocating responsibility for corrective measures that will attain water quality standards. This chapter of the staff report describes the Klamath TMDL implementation plan that implements the TMDL load allocations in the Klamath River basin in California pursuant to Water Code section 13242. This implementation plan includes measures in the Lost River basin and constitutes the implementation plan for the Lost River TMDL promulgated by the USEPA in 2008. It also implements site-specific water quality objectives for dissolved oxygen that were developed in conjunction with the Klamath TMDL (Appendix 1).

In developing the implementation plan, the Regional Water Board staff considered the nature of the discharges in the Klamath River basin as well as existing efforts to protect and restore water quality in the basin. The implementation plan proposes discrete and identifiable implementation measures that will bring the waterbody into compliance and it identifies the parties responsible for implementing those measures. It also describes the Regional Water Board’s current regulatory strategy for controlling pollutant sources, recommends improvements to existing regulatory controls, and describes the recommended approach to controlling pollutant sources where traditional implementation controls may not apply or where the Regional Water Board lacks implementing jurisdiction. The plan sets time schedules by which the responsible parties will implement their compliance measures and also includes a monitoring plan to track progress towards compliance. The progress of the implementation plan will be tracked through basinwide monitoring of water quality trends as well as through discharger reporting of compliance measures. The Regional Water Board will make any necessary revisions to the implementation plan as needed to achieve water quality standards within a reasonable timeframe. Reassessment and monitoring of the TMDL is discussed in Chapter 7.

Restoration of water quality of the Klamath River requires coordinated basinwide implementation of TMDLs. The implementation plan includes the following measures to achieve this goal:

- A Memorandum of Agreement to coordinate implementation with the Oregon Department of Environmental Quality
- Development of an Memorandum of Agency Agreement with the US Bureau of Reclamation, US Fish and Wildlife Service, and Tulelake Irrigation District
- Measures to address the water quality impacts from the Klamath Hydroelectric Project
- Incorporation of Klamath TMDL requirements into point and nonpoint source permits as appropriate, including timber harvest permits and region-wide permits for Caltrans and the USFS
- Certification of the Five County Salmonid Protection Program to address sediment discharges from county roads
- Development of a conditional waiver by 2012 for discharges associated with agricultural activities, including grazing and irrigated agriculture.
- Adoption of a 'Thermal Refugia Protection Policy'
- Prohibition against unauthorized discharge of waste that violate water quality standards

6.1.1. Geographic Scope

Load allocations and targets are assigned to source categories on the mainstem Klamath, minor tributaries, and the mouths of major tributaries. The technical analysis does not include the Butte Valley Hydrologic Area. Major tributaries are not assigned temperature allocations because the Scott, Shasta and Salmon River watershed already have assigned allocations, and the Lost and Trinity are not listed as impaired for temperature. In contrast, the geographic scope of the implementation plan includes the entire Klamath Basin, and the plan also includes the implementation plan for the Lost River. The Regional Water Board may apply any existing authorities available in a basin plan amendment, and is not necessarily constrained by the scope of the technical TMDL process. Applying the scope of implementation to the entire Klamath basin allows for better coordination with existing programs and permits that may be working to improve water quality basinwide. Load allocations must be enforced through permitting mechanisms and incorporating TMDL implementation into a more broad based nonpoint source approach increases efficiency and consistency in regulation. Often the same types of management measures are needed to address water quality under the core regulatory nonpoint source program with or without the presence of the TMDL allocations. Where possible, it is sensible to combine water quality requirements under one permitting structure.

Staff received comments regarding implementation measures for agriculture, including the development of a basinwide conditional waiver as proposed in the previous drafts. While the recommendation to develop an agricultural waiver remains in this draft, the interim requirements on agriculture were removed, including the interim requirement to develop water quality and ranch management plans. Stakeholders requested the opportunity to develop regulatory measures for agriculture through a local stakeholder process. In response, Regional Water Board staff agree to focus staff resources on development of a locally supported program to address agriculture basinwide. The development of the waiver will proceed through a public stakeholder process and be considered for adoption by 2012. In the meantime, the implementation plan includes interim recommendations for landowners to take in anticipation of the future agricultural water quality program. The Regional Water Board will consider whether to extend existing TMDL waivers in the Scott and Shasta with or without revisions or whether to or incorporate them into the proposed agricultural waiver as part of the Scott and Shasta waiver renewal process.

6.1.2 Coordination with Oregon

Achieving compliance with the Klamath River TMDLs in California and Oregon will require a coordinated approach that involves state and federal agencies as well as responsible parties in both states. To this end, the Regional Water Board, Oregon Department of Environmental Quality (ODEQ), and USEPA Regions 9 and 10 have signed a Memorandum of Agreement (MOA) for implementing the Klamath River basin TMDLs.

Coordinating implementation will focus restoration and regulatory programs on both short-term and long-term goals for the basin. The regulatory process will accommodate short-term measures working in concert with longer-term programs to achieve full compliance over a longer time frame. Short-term measures are needed to immediately lessen the threat to cold water fishery and tribal cultural beneficial uses, among others. Regional Water Board staff encourage implementation of large scale, centralized projects designed to reduce nutrient loads to the Klamath River in Oregon and California. Fundamental for the control of nutrient loads to the Klamath River is coordinating with the U.S. Bureau of Reclamation (USBR) to address discharges from the Klamath Project. To this end, Regional Water Board staff propose development of a Memorandum of Agency Agreement with USBR to control discharges to the Klamath River. In addition, Regional Water Board staff are working with ODEQ and USEPA Regions 9 and 10 in cooperation with PacifiCorp to develop a Klamath basin water quality improvement tracking and accounting program. As planned, this program will provide a mechanism that would allow for collaboration among basin stakeholders on common projects while earning credit towards their regulatory requirements related to TMDLs (See Section 6.7).

6.1.3 Klamath Hydroelectric Project, Klamath Basin Restoration Agreement, and Dam Removal Agreement

The Klamath River TMDLs assign load allocations and targets at levels necessary to achieve water quality standards, including the recalculated SSO for DO as presented in Appendix 1, within the Klamath Hydroelectric Project (KHP) area. Regulation and enforcement of the TMDL allocations is traditionally through the State Water Board water quality certification process that accompanies renewal of a license issued by the Federal Energy Regulatory Commission (FERC). As described in more detail below, certain parties have been engaged in settlement negotiations that contemplate the voluntary removal of the KHP. Because the regulatory process and outcome of the settlement negotiations is largely outside of the Regional Water Board's control, the Klamath River TMDL implementation plan accommodates various alternatives by allowing the use of offsets focused on offsite nutrient reduction for an interim period while options for infrastructure improvements and dam removal are studied.

The Klamath Basin Restoration Agreement (KBRA) is a negotiated settlement agreement among as many as 26 different parties and is designed to settle long-standing disputes in the Klamath River basin. It focuses on water allocations in the upper basin, provides for fisheries restoration, and is structured around the central assumption that an agreement to remove the lower four Klamath River dams will be reached. On November 13, 2008, an Agreement in Principle (AIP) to remove four Klamath River dams was announced after negotiations among representatives of the federal government, the state of California[1], the state of Oregon, and PacifiCorp. The Regional Water Board was not a party to the KBRA nor AIP negotiations. A draft of the final Klamath Hydroelectric Settlement Agreement (KHSA) was released on September 30, 2009. Settlement Parties contemplate federal legislation that would indefinitely delay the relicensing process before the FERC and accompanying Clean Water Act section 401 permitting process before the SWRCB. (See section 6.5 of the draft Agreement [Abeyance of Relicensing Proceeding].) The Regional Water Board staff provided input to the KHSA parties on appropriate interim water quality measures and regulatory pathways for TMDL compliance.

6.1.4 Nonpoint Source Land Use Activities and Controls

Implementation actions taken to achieve load allocations must be consistent with the *Policy for Implementation and Enforcement of the Nonpoint Source Pollution Control Program* (State NPS Policy). This policy requires that "all current and proposed nonpoint source discharges must be regulated under waste discharge requirements (WDRs), waivers of WDRs, a Basin Plan prohibition, or some combination of these tools (Regional Water Board 2007, p.4-33.00)." For some pollutant sources, the method of compliance with this policy is already in place, and if it is determined to be sufficient, no further action by the Regional Water Board is necessary. However, if the source is currently unregulated, or the current permits, waivers and/or prohibitions are not sufficient to attain the TMDL, a means to comply with the State NPS Policy must be proposed as part of the implementation plan. The Regional Water Board may also certify existing pollution control programs as sufficient to implement the Klamath TMDL if it can make the following findings:

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[1] State of California is defined as the State of California Resources Agency and its constituent departments and excludes all other state agencies, departments, boards and commissions. The Regional Water Board is not a constituent department under the Resources Agency.

1. the implementing program is consistent with the assumptions and requirements of the TMDL;
2. sufficient mechanisms exist to provide reasonable assurances that the program will address the impairment in a reasonable period of time; and
3. sufficient mechanisms exist to ensure that the program will be enforced, or that the Regional Water Board has sufficient confidence that the program will be implemented such that further regulatory action would be unnecessary and redundant.

The threats to water quality from nonpoint source activities in the Klamath River basin are mainly associated with timber harvest, roads, grazing, and irrigated agriculture on private and federal lands. The implementation plan focuses on reducing nutrient loading in the upper basin, controlling sediment discharges, and protecting riparian vegetation in the tributaries downstream of Iron Gate Dam in accordance with the technical TMDL allocations. In response to numerous comments received, staff have removed interim requirements on individual landowners and operators discharging waste associated with agriculture, grazing and roads not already covered by a permit or waiver in lieu of incorporating TMDL implementation into basin and/or region wide nonpoint source programs for efficiency and consistency.

To protect against serious and significant individual threats to water quality, staff propose the adoption of a prohibition against discharges of waste that violate water quality standards. This prohibition is a restatement of existing law and is not intended to provide a nonpoint source program that implements measures to control the cumulative impact of individual nonpoint source discharges of waste. Individuals who believe they may need permit coverage for their discharges should contact the Regional Water Board and inquire about obtaining an individual permit. Also in response to numerous comments from individual landowners, staff has removed the conditional sediment prohibition that included requirements to control sediment discharges. The implementation plan now provides Guidance on the Control of Excess Sediment that will help address sediment sources in the Klamath River basin. The implementation plan also proposes a Thermal Refugia Protection Policy that provides enhanced protection of thermal refugia in specific locations on the Klamath mainstem.

With the exception of existing waste discharge requirements (WDRs) and waivers for timber harvest and TMDL waivers adopted as part of the Scott and Shasta River TMDLs, the Regional Water Board has not adopted a regulatory program for discharges of nonpoint source pollution as required by the State Nonpoint Source Policy. To address this and other gaps in regulation, the implementation plan recommends development of nonpoint source programs for controlling discharges from land use activities that discharge waste and contribute to the water quality impairments. It is the Regional Board staff recommendation to enforce TMDL requirements through basinwide and regionwide programs where possible, rather than piecemeal various requirements in each TMDL action plan. Table 6.1 provides an overview of Regional Water Board staff recommendations of regulatory mechanisms to implement the TMDL allocations in the Klamath River basin in California.

Table 6.1: Existing and proposed permitting

Nonpoint Source Regulatory Mechanism	Existing/New (Timeframe)	Responsible Party
Timber Harvest WDRs and waiver on Nonfederal lands	Existing	All parties conducting timber harvest activities on nonfederal lands in the Klamath River basin
Waiver for nonpoint source discharges associated with certain activities on lands managed by the USFS	New (2010)	USFS
Waiver for discharges associated with agriculture including irrigated agriculture and grazing	New (2012)	Parties discharging in association with agricultural activities in the Klamath River basin in California
Waiver Certifying 5C Program for County Roads	New (2010)	Del Norte, Humboldt, Siskiyou, and Trinity Counties
Statewide NPDES Stormwater Permit for Caltrans Activities	Existing	Caltrans

6.1.5 Implementation Plan Development and Consideration of Relevant Factors

On February 19, 2009, the Regional Water Board circulated a draft scoping document for TMDL implementation called the *Water Quality Restoration Plan for the Klamath River Basin in California: Draft Scoping for TMDL Implementation* (Regional Water Board 2009). Regional Water Board staff held five public workshops where an overview of the impairments and potential implementation measures was provided. The document includes an overview of draft load allocations, identifies potential responsible parties, and potential permitting and other applicable implementation mechanisms. The document discusses implementation challenges of controlling sources where traditional controls may not apply or where the Regional Water Board lacks implementing jurisdiction. Readers were encouraged to provide Regional Board staff with any relevant information on implementation, including, but not limited to:

- source inputs not previously identified,
- current efforts to address the TMDL pollutants and any documented success of such efforts,
- other programs that could be incorporated into an implementation plan strategy,
- how to maximize the efficiency of implementation strategies for water quality improvement,
- benefits and burdens of different implementation approaches,
- suggestions for tracking implementation and progress towards meeting water quality standards (i.e. compliance and trend monitoring), and
- potential restoration ideas and other creative solutions for improving water quality in the Klamath Basin.

Regional Water Board staff received numerous submittals that helped inform the development of the proposed implementation plan and received additional input from stakeholders on the June draft Staff Report documents.

This implementation plan reflects the consideration and balancing of various relevant factors including, cost, equity, magnitude of impact, degree of management controls in place, feasibility, and probability of success. For example, the plan acknowledges that the allocation at stateline will require an unprecedented level of cooperation between the states and federal government to achieve pollutant loading reductions necessary to meet water quality objectives and support beneficial uses in both states. Focus on implementation in Oregon is equitable considering its large contribution to the Klamath impairments. This led to the formation of a Management Agency Agreement with Oregon and EPA to help coordinate implementation, including implementation in the Lost River basin. This approach is guided by feasibility, degree of management controls in place, probability of success, political and other considerations.

In addition, the plan proposes structuring a pollutant Tracking and Accounting Program to encourage the implementation of engineered treatment options. The program is intended to provide some flexibility to implementation through the allowance of offsets and time schedules and will consider engineering constraints, costs, feasibility, and other factors. Rather than implement very costly retrofits that may not yield large improvements to overall water quality, contributions toward coordinated restoration efforts are encouraged to maximize water quality improvements through resource consolidation.

The Regional Water Board recognizes that the Klamath Hydroelectric Project will undergo one of two possible processes; either the FERC relicensing and 401 Water Quality Certification process, or the KHSA route. Each are driven by concerns in addition to water quality and will necessarily be decided by a different agency after thorough analyses. The implementation plan allows PacifiCorp to submit a proposed plan that accommodates the possible regulatory processes which reflects staff's consideration of legal feasibility and management controls in effect.

Finally, in this most recent draft, the implementation plan provides a more coordinated and consistent approach to nonpoint source pollution control in response to comments from individual landowners and in order to more effectively address water quality problems. This plan removes additional interim nonpoint source requirements on individual landowners and instead proposes the development of a sensible agricultural waiver, in collaboration with stakeholders. Where possible, staff identifies requirements by other agencies that meet TMDL needs in order to consolidate monitoring and avoid inconsistent terminology. Parties are encouraged to submit any additional and specific information for the Regional Water Board's consideration in this third opportunity for public review of the Klamath TMDL.

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6.1.6 Implementation Plan Organization

This implementation chapter is organized according to the source areas identified in the technical TMDL. Each section provides a summary of the load allocations and targets for that source area, identifies the parties responsible for meeting those allocations, and discusses the Regional Water Board staff's approach to implementation and recommended implementation actions for the responsible parties.

The source areas receiving allocations and targets are:

1. Stateline (section 6.2)
2. Klamath Hydroelectric Project (KHP) and Iron Gate Hatchery (section 6.3)
3. Klamath River tributaries (section 6.4)
4. Watershed-Wide Nonpoint Source Land Use Activities (sections 6.5 and 6.6)

The presentation of the watershed-wide implementation actions in section 6.5 begins with a description of actions to address watershed-wide temperature allocations, proposed Prohibition on discharges of waste that violate water quality standards, and the Thermal Refugia Protection Policy, followed by discussion of the following land use activities:

- Road construction and maintenance;
- Agriculture including grazing and irrigation agriculture; and
- Timber harvest.

Implementation actions associated with all land use activities on federally managed lands are presented in section 6.6. The Klamath River water quality improvement Tracking and Accounting Program is described in section 6.7.

6.2 Stateline

The Oregon-California stateline (Stateline) is the point at which the Klamath River crosses the Oregon-California border, and is designated as a compliance point in the Klamath TMDL. The pollutant loads in the Klamath River entering California are the result of loadings in Oregon, including the Lost River basin, which is partially in California. Nutrient loads in the Klamath River at stateline originate mainly from Upper Klamath Lake, as well as from the Lost River basin through the Klamath Straits Drain and Lost River Diversion Channel, and to a lesser extent from point sources in Oregon. Nutrients coming from these sources contribute to DO and pH swings downstream, as well as to aquatic plant growth within the river and blue-green algae blooms within the Copco and Iron Gate reservoirs in California.

6.2.1 Allocations and Targets

The ODEQ has identified the Klamath River in Oregon on its CWA section 303(d) list as failing to meet Oregon water quality criteria. Accordingly, in 2010, ODEQ intends to issue and implement TMDLs addressing temperature, dissolved oxygen, pH, ammonia, and chlorophyll-a impairments for the Klamath River in the state of Oregon. These Oregon-issued TMDLs will be based on Oregon's water quality standards. Because these TMDLs (and their anticipated load and wasteload allocations) are being developed by Oregon as part of a comprehensive multistate analysis of pollutant loadings to the Klamath River, they are also being designed to meet California water quality standards at stateline. It is appropriate for the Regional Water Board to account for these anticipated upstream load reductions in Oregon when developing the TMDLs for the segments of the Klamath River that are downstream in California. The Regional Water Board's Klamath River TMDLs for California assign nutrient, organic matter, and temperature allocations, as well as temperature and dissolved oxygen targets at stateline. These allocations and targets at stateline are presented in sections 5.2.2 and 5.3.1 and reflect anticipated water quality at stateline once the Oregon TMDLs are fully implemented. Improvements in water quality in Oregon represent a critical part of the solution in meeting water quality objectives in California.

6.2.2 Responsible Parties

Point and Nonpoint Sources in Oregon and Lost River basin in California
Regional Water Board
Oregon Department of Environmental Quality
Oregon Department of Agriculture
USEPA Regions 9 and 10

6.2.3 Implementation

6.2.3.1 Oregon

Consistent with Oregon Administrative Rules (OARs), ODEQ is responsible for developing an implementation plan, called a Water Quality Management Plan (WQMP), to meet the Klamath and Lost River TMDLs in Oregon. The OARs establish the required elements of WQMPs, which include the following:

- Identification of management measures to meet load allocations;
- A timeline for implementation with measureable milestones;
- A timeline for attainment of water quality standards;
- A monitoring plan; and
- General discussion of costs and funding for implementation.

The OARs also require the WQMP to identify persons and agencies responsible for implementation; as well as provide reasonable assurance that implementation will occur through either regulatory or voluntary means. A main difference between TMDL implementation planning in Oregon and California is that ODEQ does not specify the nature of the actions responsible parties are expected to take and is not charged with enforcing the TMDL load allocations and targets directly. Instead, ODEQ implementation plan designates management agencies (DMAs) that must develop 'sector or source specific' implementation plans (also called WQMPs) that meet the TMDL load allocations. DMAs designated in ODEQ's TMDL will likely include USBR, Oregon

Department of Agriculture, and the Irrigation Districts. The WQMPs are subject to approval by ODEQ, but the DMAs maintain the primary authority to enforce the measures in those plans.

Oregon Department of Agricultural (ODA) fulfills its requirement to develop a WQMP pursuant to an existing program established by Oregon Senate Bill 1010. SB 1010 requires ODA to develop administrative rules specific to hydrologic 'subareas' in Oregon. The administrative rules describe water quality requirements for landowners and consist of a description of the subarea, a list of unacceptable water quality conditions, and a process for complaints and investigations. The unacceptable conditions include excessive sheet and rill erosion and downward trending riparian conditions as defined by US Bureau of Land Management (BLM) technical guidelines. Landowners are also prohibited from degrading stream shading consistent with site capability – similar to the California riparian shade allocation.

Landowners are directed by Oregon Senate Bill 1010 to develop Agricultural Water Quality Management Plans that implement the administrative rules and control water pollution resulting from agricultural activities. A Local Advisory Committee typically represents the landowners in development of both the area administrative rules and the management area plans with oversight by ODA. The area management plans include provisions for ODEQ to work with ODA to monitor progress towards plan implementation including the effectiveness of the plan in meeting applicable TMDL load allocations. The rules are enforceable, while the plans are not. The plan in the Lost River basin in Oregon is called the Lost River Subarea Agricultural WQMP and is implemented by the Klamath Soil and Water Conservation District.

ODA maintains primary authority to regulate agriculture to protect water quality. Since ODEQ authority is secondary, it is important for ODA to effectively use its authority in order to achieve the Klamath and Lost River TMDL load allocations and targets in Oregon with oversight by ODEQ. The strength of Oregon's agricultural water quality management program is its focus on landowner driven efforts. By working with the KSWCD in the Lost River basin, landowners have already implemented management measures and water quality improvement projects that address the TMDL pollutants. It is important for ODA to continue to use its authority as appropriate to achieve the Klamath and Lost River TMDL load allocations and targets in Oregon. Regional Water Board staff support the following measures to coordinate the Oregon SB 1010 water quality program with TMDL implementation:

- Update the Oregon Administrative Rules for the Lost River subbasin Area to address nutrients and organic matter in irrigation tailwater;
- Incorporate TMDL implementation measures and timelines into the Lost River Agricultural Water Quality Management Plan;
- Conduct water quality monitoring to track the progress of TMDL implementation towards meeting allocations and targets; and

- Periodic review by ODA and ODEQ to ensure the TMDL requirements are being met.

6.2.3.2 Regional Water Board's Role

The Regional Water Board intends to work closely with ODEQ and ODA in implementing the Klamath and Lost River TMDLs. One of the purposes of coordination with Oregon is to align each state's approach to controlling nonpoint sources of pollution. Currently, the major difference between the states is the regulatory framework and the enforcement authorities of the water quality control agencies in each state. In California, the Regional Water Board is required by the State NPS Policy to regulate all sources of waste, including agricultural activities, directly through permits, waivers and/or prohibitions, as discussed in section 6.1.4. The Regional Water Board has broad enforcement capabilities to ensure compliance with the terms and conditions of permits and prohibitions. While the Regional Water Board's regulatory authority is broader than ODEQ's, the implementation measures required to achieve the TMDL are similar in both states. For the USBR and USFWS, the implementation plan measures include an evaluation and implementation of methods to reduce the water quality impacts of the operation of the U.S. Bureau of Reclamation's Klamath Project and the Klamath River basin Wildlife Refuges and implementation of an effective pollutant reduction strategy. Implementation measures for USBR and USFWS are discussed in section 6.4.3.

6.2.3.3 Memorandum of Agreement to Coordinate State and Federal Agency TMDL Implementation Actions in the Klamath River Basin

Klamath TMDL implementation will be coordinated with the ODEQ and the USEPA. The Regional Water Board, ODEQ, and EPA Regions 9 and 10 have developed a Memorandum of Agreement (MOA) that establishes a framework for joint implementation of the Klamath River and Lost River TMDLs. The MOA includes commitments such as:

- Work to develop and implement a joint adaptive management program, including joint time frames for reviewing progress and considering adjustments to TMDLs;
- Work with the Klamath Basin Monitoring Program (KBMP) and other appropriate entities to develop and implement basinwide monitoring programs designed to track progress, fill in data gaps, and provide a feedback loop for management actions on both sides of the common state border;
- Work jointly with common implementation parties (e.g., USBR, U.S. Forest Service, USFWS, BLM, PacifiCorp, and the Klamath Water Users Association (KWUA) to develop effective implementation plans and achieve water quality standards;
- Explore engineered treatment options such as treatment wetlands, algae harvesting, and package wastewater treatment systems to reduce nutrient loads to the Klamath River and encourage implementation of these options where feasible; and
- Work to develop and implement a basinwide water quality tracking and accounting program that would establish a framework to track water quality

improvements, facilitate planning and coordinated TMDL implementation, and enable appropriate water quality offsets or trades.

<u>Stateline Implementation Measures</u>

Regional Water Board, Oregon (ODEQ) and USEPA 9 and 10:

<u>Measure</u>

- Work together to implement and monitor measures that will achieve compliance with the Klamath and Lost River TMDLs in Oregon and California as specified in the Klamath River/Lost River TMDL Implementation Memorandum of Agreement.

<u>Timeline</u>

- Ongoing

6.3 Klamath Hydroelectric Project and Iron Gate Hatchery

6.3.1 Klamath Hydroelectric Project

The KHP is a federally licensed project owned and operated by PacifiCorp and consists of eight facilities in California and Oregon. The implementation plan will address the impacts of the project facilities in California, which includes the following three dam/reservoir pairs: Copco 1, Copco 2, and Iron Gate. Figure 6.1 shows all the dams on the Klamath River. All except Link River Dam are part of the KHP. The Fall Creek Dam is located on Fall Creek, not the Klamath River.

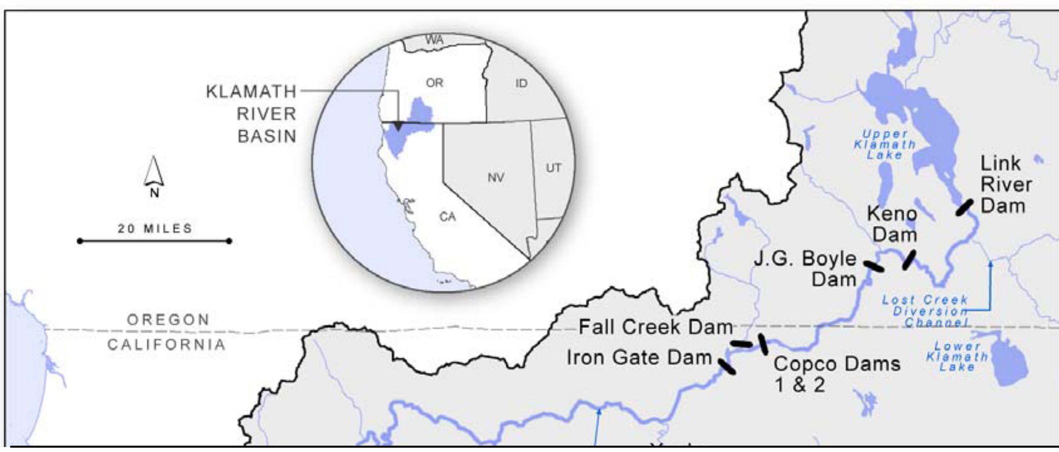

Figure 6.1: Map of Klamath Hydroelectric Project facilities. Link River Dam is not part of the KHP.

The technical TMDL analysis found that the KHP contributes to the impairment of the Klamath River by:

- Altering the nutrient dynamics of the river, and contributing to biostimulatory conditions in the summer/fall growing season;

- Creating physical conditions that promote nuisance blooms of suspended algae, including toxin-forming blue-green algae species;
- Creating low dissolved oxygen and high temperature conditions within the reservoirs and at the tailraces; and
- Altering the temperature regime in the Klamath River downstream.

6.3.1.1 Allocations and Targets

The TMDL includes allocations and targets for the KHP facilities in California. The allocations and targets assigned to meet water quality standards in the reservoirs include a temperature/DO compliance lens, nutrient allocations, as well as nutrient and organic matter targets, and algae-based targets. In addition, temperature allocations and temperature, DO, nutrient and organic matter targets are assigned to the reservoir tailraces. See sections 5.2.3 and 5.3.2 for a complete discussion of these allocations and targets.

6.3.1.2 Responsible Parties

Regional Water Board
State Water Resources Control Board (State Water Board)
PacifiCorp

6.3.1.3 Implementation

To comply with the TMDL, PacifiCorp must implement management measures that result in attainment of the load allocations and targets to the KHP facilities in California. Regulation and enforcement of these TMDL allocations is traditionally through the State Water Board Clean Water Act section 401 water quality certification process, since the Regional Water Board is preempted from issuing a permit to the KHP. The KHP is licensed by FERC with a license that expired on March 1, 2006. The KHP continues to operate under an annual license until renewal. Renewal of the license requires compliance with the California Environmental Quality Act (CEQA) and the issuance of a Clean Water Act section 401 water quality certification by the State Water Board. In issuing water quality certification, the state may impose conditions on the KHP in order to certify that the project protects beneficial uses and meets water quality objectives as specified in the Basin Plan. The Klamath TMDLs, upon adoption, will become part of the Basin Plan and will thus become part of the comprehensive plan that FERC must consider as part of its licensing decision. As authorized by section 401, the State Water Board will apply appropriate state water quality requirements through the FERC licensing proceeding as part of its decision to issue or deny water quality certification.

In 2004, FERC prepared a Final Environmental Impact Statement (FEIS) (PacifiCorp, 2004a) that describes the positive and negative environmental effects of the proposed action to relicense the continued operation of the KHP, and alternative actions, including decommissioning all or part of the project. As part of the 401 certification proceeding, the State Water Board is preparing an Environmental Impact Report (EIR) since the FEIS does not fully comply with CEQA (State Water Board 2008). The FEIS will form the basis of the EIR, and the State Water Board has initiated the process of soliciting information from stakeholders regarding the adequacy of the FEIS and the scope of the EIR. The EIR will evaluate four alternatives for operating the KHP, two of which include removal of two and four of the KHP dams, respectively. Regional Water Board staff will continue to participate in the FERC relicensing and 401 process at the State Water Board to provide information and consultation to ensure that the KHP meets water quality standards and other Basin Plan requirements.

On November 13, 2008, an Agreement in Principle (AIP) to remove four of the Klamath River dams (JC Boyle, Copco 1 and 2, and Iron Gate) was announced after negotiations between the representatives of the federal government, the state of California, the state of Oregon, and PacifiCorp. The Regional Water Board was not a party to the negotiations. A draft of the final Klamath Hydroelectric Settlement Agreement (KHSA) was released on September 30, 2009 and signed on February 18, 2010. Settlement Parties contemplate federal legislation that would indefinitely delay the relicensing process before the FERC and accompanying Clean Water Act section 401 permitting process before the SWRCB. (See section 6.5 of the draft KHSA [Abeyance of Relicensing Proceeding].) In contemplation of the absence of the FERC/401 process, Regional Water Board staff participated in discussions about how the Parties view the regulatory pathways envisioned in the draft KHSA and their relationship to Oregon and California's TMDLs. This is reflected in section 6.3 of the draft KHSA released on September 30, 2009. Section 6.3.2 of the KHSA provides:

> 6.3.2 TMDL Implementation Plans
>
> A. No later than 60 days after ODEQ's and the North Coast Regional Water Quality Control Board (NCRWQCB)'s approval, respectively, of a TMDL for the Klamath River, PacifiCorp shall submit to ODEQ and NCRWQCB, as applicable, proposed TMDL implementation plans for agency approval. The TMDL implementation plans shall be developed in consultation with ODEQ and NCRWQCB.
>
> B. To the extent consistent with this Settlement, PacifiCorp shall prepare the TMDL implementation plans in accordance with Oregon Administrative Rules (OAR) 340-042-0080(3) and California Water Code section 13242, respectively. The plans shall include a timeline for implementing management strategies and shall incorporate water quality-related measures in the Non-ICP Interim Measures set forth in Appendix D. Facilities Removal by the Designated Removal Entity (DRE) shall be the final measure in the timeline. At PacifiCorp's discretion, the proposed plans may further include other planned activities and management strategies developed individually or cooperatively with other sources or designated management agencies. ODEQ and NCRWQCB may authorize PacifiCorp's use of offsite pollutant reduction measures, subject to an iterative evaluation and approval process; provided, any ODEQ authorization of such offsite measures conducted in Oregon solely to

facilitate attainment of load allocations in California waters shall not create an ODEQ obligation to administer or enforce the measures.

Under section 3.3 of the draft KHSA, the Secretary of the Department of the Interior will conduct very detailed studies and assessments to determine, *inter alia*, whether dam removal (i) will advance restoration of the salmonid fisheries of the Klamath Basin, and (ii) is in the public interest. The Secretary is to make a determination by March, 2012, subject to various contingencies, on whether to move forward with the project. As part of this process, a detailed plan for facility removal will be developed that describes the " physical methods to be undertaken to effect Facilities Removal, including but not limited to a timetable for Decommissioning and Facilities Removal, which is removal of all or part of each Facility as necessary to effect a free-flow condition and volitional fish passage." (KHSA, section 3.3.2.)

In its comments on the draft TMDL Action Plan, PacifiCorp objected to the 60 day time frame to submit its proposed implementation plan. Regional Board staff do not object to revisiting the time frame for submittal, and in fact hope to align it with Oregon's TMDL requirements to the extent possible for efficiency. (Note: OR is responsible for water quality certification of J.C. Boyle, one of four hydroelectric facilities in the KHP.) However, the suggestion to allow eighteen months does not seem appropriate here, particularly because the bulk of PacifiCorp's implementation has already been defined in various interim measures agreed to by Settlement Parties.

Since PacifiCorp is a Party to the KHSA and understands its intricacies, it may propose timelines in its implementation plan that best align with the timelines contained in the Settlement. The implementation plan should identify appropriate intervals whereby PacifiCorp will provide the Regional Water Board updates on the status and progress of the plan. At a minimum, the Regional Water Board will want to review the plan in 2012 in light of the Secretary's Determination. Based on the evidence and analyses conducted pursuant to the Secretarial Determination, and the substantive conclusions by the Department of Interior, the Regional Water Board will revisit the content of the KHP implementation plan. In addition, the proposed implementation plan must include a mechanism for Regional Water Board approval of offset projects described in more detail below. Regional Water Board staff are flexible about how this may occur, but the plan must be formulated with the goal of having approved projects ready for implementation in the event of an Affirmative Determination.

Section 6.3.2 of the KHSA describes generally the content of the implementation plan to include a timeline for implementing management strategies, water quality-related measures in Appendix D, and Facilities Removal as the final measure. The proposed plan may further include other planned activities and management strategies developed individually or cooperatively with other sources or designated management agencies. Appendix D contains water-quality measures that could potentially serve to meet TMDL needs if implemented effectively. As described in more detail below, Interim Measures 10 and 11 have significant potential to contribute towards meeting the Klamath River

TMDL load allocations and targets in California. PacifiCorp may propose the use of offsite pollutant reduction measures (i.e. offsets or "trades") to meet the allocations and targets, including those for Iron Gate Hatchery (section 6.3.1.3). Candidate offsite pollutant reduction measures should be informed by Interim Measures 10 and 11 (discussed below) and credits determined through the water quality improvement Tracking and Accounting Program (TAP) (section 6.7).

Interim Measure 10 provides funding for a water quality conference that focuses on the design and implementation of nutrient and organic matter reduction projects. The conference should assess the appropriateness and feasibility of various centralized pollutant removal technologies, including wetland treatment systems, wastewater treatment systems with energy recovery capabilities, aquatic plant harvesting, as well as agricultural best management practices. The conference serves as an opportunity to bring together water quality restoration experts, with the objective of developing recommendations and preliminary conceptual design for projects to achieve large-scale nutrient and organic matter reductions in the basin.

Interim Measure 11 provides funding for interim water quality improvements and is critical for achieving large-scale nutrient reductions in the basin. Under this Interim Measure, PacifiCorp spends $250K/yr until the date of Secretarial Determination to be used for studies or pilot projects. By the date of the Secretarial Determination, a priority list of projects will be developed, informed by the water quality conference and Secretarial Determination studies. In the event of an Affirmative Determination by the Secretary, PacifiCorp provides funding of up to $5.4 million for implementation of projects and $560K/year for operation and maintenance of such projects. As stated in the KHSA, the "purpose of this measure is to improve water quality in the Klamath River during the Interim Period leading up to dam removal. The emphasis of this measure shall be nutrient reduction projects in the watershed to provide water quality improvements in the Mainstem Klamath River, while also addressing water quality, algal and public health issues in Project reservoirs…."

Regional Water Board staff agree that Interim Measure 11 should focus on the development and implementation of nutrient reduction projects, building upon ideas generated from the Interim Measure 10 water quality conference. PacifiCorp should focus on offsets in its proposed implementation plan, and commit to the goal of having viable projects ready for implementation by the date of the Secretarial Determination. Further, a list of priority projects should be completed by PacifiCorp and the Implementation Committee, and select project(s) should be ready for construction by the date of the Secretarial Determination. That means that projects must be presented to the Regional Water Board prior to the Secretarial Determination date with adequate time for review.

The Klamath Hydroelectric Settlement Agreement includes the formation of an Interim Measures Implementation Committee (IMIC - Interim Measure 1) for the purpose of collaborating with PacifiCorp on "ecological and other issues related to the implementation of the Interim Measures set forth in Appendix D" (KHSA, Appendix B). The IMIC will meet, discuss, and seek to reach consensus on implementation of various Interim Measures, including Interim Measure 11. Though not a Party, Section 3.2 of Appendix B states that the North Coast Regional Water Board may be a member of the IMIC, and the Regional Water Board intends to have a staff representative participate on the IMIC with the purpose of providing guidance on a project's potential to meet TMDL requirements. As previously stated, the TMDL implementation plan must provide for separate updates and presentations to the Regional Water Board for approval. The IMIC is not involved in Interim Measure 10: Water Quality Conference. This measure states that PacifiCorp, the North Coast Regional Water Quality Control Board, and the Oregon Department of Environmental Quality, will convene a steering committee to develop the agenda and panels for the water quality conference. The Regional Water Board intends to work closely with ODEQ and PacifiCorp on Interim Measure 10.

Interim Measure 11 also identifies the development of a water quality tracking and accounting framework. Regional Water Board staff support PacifiCorp's involvement in developing a water quality improvement tracking and accounting program for the Klamath River basin. The purpose of the program is to provide a structure that facilitates the efficient application of offset programs by consolidating contributions and distributions. Consistent with the stated purpose of Interim Measure 11 and the goal of TMDL compliance, the majority of PacifiCorp's funding should be focused on the development and implementation of on-the-ground projects that, once implemented, will provide water quality improvements in the mainstem Klamath River.

The Interims contain valuable monitoring provisions and also a Coho Enhancement Fund and turbine venting project that could positively influence water quality. Water quality monitoring performed under Interim Measure 15 will be valuable in tracking baseline water quality conditions and compliance with the TMDLs.

The TMDL accommodates a variety of implementation options to address reservoir-related water quality impairments depending on whether the settlement moves forward or the State Water Board and FERC processes continue. Regardless of the process, PacifiCorp must implement measures designed to move toward compliance with TMDL allocations and protection of beneficial uses. This is true for any process that proposes continued operation of the KHP, as well as for any alternative that considers dam removal. In addition, PacifiCorp must implement adequate water quality control measures to offset on-going reservoir impacts while the reservoirs are modified to meet the load allocations or, alternatively, up to the time they are decommissioned. PacifiCorp may propose the use of offsite pollutant reduction measures in the interim period consistent with the Klamath River water quality improvement tracking and accounting program, subject to an iterative evaluation and approval process. The implementation plan submitted by PacifiCorp should provide certain time periods after which a reassessment process may occur to avoid having to develop an alternative plan in the event that the settlement is discontinued. For now, we think that the acknowledgement that the FERC/401 process resumes if the settlement terminates will suffice. If that occurs, the Regional Water Board will revisit PacifiCorp's implementation plan to discuss possible revisions. The implementation plan must also provide for Regional Water Board review of more site specific environmental assessments of dam removal before approval of that approach as a final TMDL compliance measure.

<u>Implementation Measures for the Klamath Hydroelectric Project</u>

PacifiCorp:

<u>Measure</u>

- Submit a proposed implementation plan that incorporates timelines and contingencies pursuant to the KHSA. In the event that the KHSA does not move forward, the implementation plan should specify that the FERC/water quality certification process shall resume. Section 6.3.2 of the KHSA describes TMDL implementation to include a timeline for implementing management strategies, water quality-related measures in Appendix D, and Facilities Removal as the final measure. PacifiCorp may propose the use of offsite pollutant reduction measures (i.e. offsets or "trades") to meet the allocations and targets in the context of Interim measures 10 and 11. The implementation plan should identify appropriate intervals whereby PacifiCorp will provide the Regional Water Board updates on the status and progress of the plan, and provide adequate time for review so that select project(s) are ready for construction by the date of the Secretarial Determination. The implementation plan must provide for Regional Water Board review of more site specific environmental assessments of dam removal before its approval of that approach as a final TMDL compliance measure.

<u>Timeline</u>

- Within 60 days of when the Basin Plan amendment takes effect.

.

<u>Measure</u>

- Implement measures to meet and/or offset TMDL allocations and targets as prescribed in the approved implementation plan.

<u>Timeline</u>

- As required by the approved implementation plan.

State Water Board:

<u>Measure</u>

- If applicable, process the 401 water quality certification FERC relicensing of the Klamath Hydroelectric Project to meet Basin Plan requirements, including Klamath River

TMDL allocations and targets. This Action Plan is not intended to constrain the discretion of the State Water Board to determine, as appropriate, time periods required for various studies, options for interim requirements, and methods for final compliance.

Timeline

- Pursuant to the FERC licensing process timeline.

6.3.2 Iron Gate Hatchery

Iron Gate Fish Hatchery is owned by PacifiCorp and operated by the California Department of Fish and Game (CDFG). The hatchery is located at the base of Iron Gate Dam and discharges effluent under NPDES Permit No. CA0006688 and WDR No. R1-2000-17.

6.3.2.1 Allocations and Targets

The TMDL assigns temperature, nutrient, and organic matter waste load allocations, as well as temperature, DO, nutrient and organic matter targets to discharges from Iron Gate Hatchery. These allocations and targets are presented in sections 5.2.4 and 5.3.3.

6.3.2.2 Responsible Parties

Regional Water Board
PacifiCorp
California Department of Fish and Game

6.3.2.3 Implementation

The waste load allocations to the Iron Gate Hatchery discharges will be implemented through the federal NPDES permit, which is held jointly by CDFG and PacifiCorp. The current permit passed its expiration date in August 2004, and the hatchery continues to operate under the terms of the existing permit until a new permit is issued. The TMDL wasteload allocations and targets to the hatchery discharge will be translated into effluent limits in the new NPDES permit. The TMDL compliance schedule to accompany the new permit may allow additional time needed for CDFG to make any infrastructure improvements to the hatchery and to implement management measures that meet TMDL allocations. The time schedule will include specific intermediate milestones with the final goal of meeting the Klamath TMDL allocations and targets. Intermediate milestones for pollutant reductions in the hatchery discharges may include:

1. Improving effluent water quality to the level of the intake water to the hatchery; and
2. Meeting current receiving water quality in the Klamath River at the point of discharge.

The hatchery may have the option of achieving some or all of its load reductions through offset mitigation if the potential changes to hatchery operations are limited in their ability to effectively reduce pollutant loads. Any offset mitigation would be coordinated through the Klamath River water quality improvement tracking and accounting program (section 6.7).

Implementation Measures for Iron Gate Hatchery

Regional Water Board:

Measure

- Revise NPDES Permit No. CA0006688 and WDR No. R1-2000-17 to incorporate revised effluent limits to implement the TMDL wasteload allocations, and the recalculated site-specific objectives for dissolved oxygen, and to require that the responsible parties implement measures to improve the water quality of discharges from the Iron Gate Hatchery to meet TMDL allocations and targets on a compliance schedule.

Timeline

Bring revised permit to the Regional Water Board for consideration by December 2011.

PacifiCorp and CDFG:

Measure

- Implement measures to improve the water quality of discharges from the Iron Gate Hatchery to meet and/or offset the Klamath River TMDL wasteload allocations and targets.

Timeline

- As specified in the revised NPDES permit.

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6.4 Implementation in the Klamath Basin Tributaries and Coordination with Existing TMDLs

The tributaries to the Klamath River include five major tributaries and numerous minor tributaries. The major tributaries are the Trinity, Salmon, Scott, Shasta and Lost Rivers. All the major tributaries, except the Lost River, join the Klamath River in California and are also wholly contained within California. The Lost River traverses the Oregon/ California border three times and ultimately joins the Klamath River in Oregon via the Klamath Straits Drain. The major tributaries each have had technical TMDLs completed that are specific to the tributary basin. The Regional Water Board has adopted TMDL implementation plans for the Shasta, Scott, and Salmon River basins. The Trinity, South Fork Trinity, and Lost River basins have had TMDLs promulgated by the USEPA without associated implementation plans. Table 6.2 provides a summary of completed TMDLs and adopted implementation plans in the major tributaries.

Table 6.2: Completed TMDLs for the major tributaries of the Klamath River basin.

Subwatershed	TMDL(s)	Year	Agency
Lower Lost River	Nutrients and Biochemical Oxygen Demand (BOD)	Final Technical TMDL, 2008	USEPA
Shasta River	Temperature, dissolved oxygen	Final Technical TMDL and Implementation Plan, 2007	Regional Water Board
Scott River	Temperature, sediment	Final Technical TMDL and Implementation Plan, 2006	Regional Water Board
Salmon River	Temperature	Final Technical TMDL and Implementation Plan, 2005	Regional Water Board
Trinity River	Sediment	Final Technical TMDL, 2001	USEPA
South Fork Trinity River	Sediment	Final Technical TMDL, 1998	USEPA

This section discusses the approach to implementation specific to each of the major tributaries given existing TMDLs and implementation plans. The intent of the Klamath implementation plan is to make TMDL requirements as consistent as possible throughout the Klamath River basin while considering existing TMDL implementation plans and ongoing water quality improvements efforts.

6.4.1 Allocations and Targets

The Klamath River TMDLs assign nutrient and organic matter load allocations to the mouths of all the major Klamath tributaries in California and 18 specified minor tributaries. The nutrient and organic matter allocations for Klamath River tributaries in California are expressed as monthly mean concentrations, and are presented in section 5.3.4. These allocations are intended primarily to establish boundary conditions and to prevent any increase of nutrients to the Klamath mainstem. The Shasta River is the only tributary in California that has an existing TMDL with nutrient and organic matter-related allocations. The Klamath River TMDL allocations to the mouth of the Shasta River are consistent with the allocations assigned in the Shasta River TMDLs. Since the Lost River discharges to the Klamath River in Oregon, those allocations will be included as part of ODEQ's Klamath River TMDLs. Other major tributaries that do not have nutrient TMDLs were set to current conditions.

There are also two temperature-related load allocations and associated targets that apply watershed-wide, i.e. to the Klamath River mainstem and all minor tributaries in California. These allocations and related targets are for excess solar radiation and human-caused discharges of sediment, and are presented in section 5.2.1. Watershed-wide allocations are not assigned to major tributary basins because of their existing allocations that are consistent with the Klamath TMDL.

6.4.2 Implementation

This implementation plan proposes a basinwide prohibition on unauthorized discharges of waste that violate water quality standards and the Thermal Refugia Protection Policy as described in section 6.5. However, there are no additional management measures proposed for responsible parties in the tributary basins that already have existing TMDLs except for the USFS, Caltrans, and the Klamath basin county roads. For these parties, staff recommend a regionwide approach and permitting that will provide consistency in regulation throughout the Klamath basin. The permits should meet the requirements of any existing TMDL implementation plans and should also consider future TMDLs and 303(d) list impairments in the North Coast Region. The following sections outline the existing tributary TMDL requirements and the necessary coordination in implementing the Klamath River TMDLs basinwide. The Lost River implementation plan is presented in section 6.4.3 below. Lost River implementation in California is important because significant load reductions are needed to meet Klamath River water quality standards, and TMDL implementation in this watershed requires coordination with Oregon and federal agencies to meet the allocations at stateline.

6.4.3 Lost River Implementation Plan

The USEPA completed a technical TMDL for the Lost River basin in California in December 2008 (USEPA 2008) that included load allocations to meet water quality standards in the Lost River Basin. Implementation measures in the Lost River basin in California are needed to meet the Klamath River TMDL nutrient and organic matter allocations assigned to the Lost River basin at its discharge points to the Klamath River. This staff report includes measures to implement the Lost River TMDL allocations in coordination with the Klamath implementation plan and constitutes the implementation plan for the Lost River basin. The responsible parties and the specific implementation measures are identified at the end of this section.

Significant load reductions are needed to meet Klamath River water quality standards as well as standards in the Lost River basin. Lost River TMDL implementation will be coordinated with the Oregon Department of Environmental Quality (ODEQ) and federal agencies, including the US Bureau of Reclamation (USBR), US Fish and Wildlife Service (USFWS), and the USEPA. In addition to the measures cited here, individual landowners conducting activities associated with nonpoint source discharges, specifically irrigated agriculture and grazing, will be included in the coverage of the agricultural waiver to be developed by 2012, and are therefore included in section 6.5.6 that includes recommendations and encourages early participation in that process.

6.4.3.1 Background

Historically, the Lost River was only hydrologically connected to the Klamath River in years with extremely high flow. The Lost River was physically linked to the Klamath River when the Lost River basin was engineered to its current configuration in the early 1900s to accommodate the development of the USBR Klamath Project (Reclamation's Klamath Project). Reclamation's Klamath Project diverts water from the Klamath River at three separate locations just downstream of Upper Klamath Lake, and from one location in Upper Klamath Lake. Reclamation's Klamath Project delivers water to approximately 200,000 acres of farmland as well as four National Wildlife Refuges (Figure 6.2). Of the total acreage of Reclamation's Klamath Project, approximately 70,000 acres are in California. The Lost River originates in California, enters Oregon, flows through Reclamation's Klamath Project in Oregon and then into the Tule Lake National Wildlife Refuge (TLNWR) in California, the historical terminus of the Lost River. Water from the TLNWR is pumped through a tunnel into the Lower Klamath National Wildlife Refuge (LKNWR) to maintain farmland in the TLNWR, stabilize water levels in the Tule Lake sump, remove salt from the Tule Lake basin, and provide water to LKNWR.[2] Drainage from LKNWR flows back across Oregon through the Klamath Straits Drain (KSD), which discharges into the Klamath River in Oregon. Return flows from Reclamation's Klamath Project are also discharged seasonally into the Klamath River through the Lost River Diversion Channel (LRDC) in Oregon. Based on the Klamath TMDL analysis, the current loading from the KSD comprises approximately 13 percent of the total phosphorus loading, 23 percent of the total nitrogen loading, and 40 percent of the organic matter loading in the Klamath River at stateline. While on a seasonal basis, Reclamation's Klamath Project diverts more nutrient and organic matter loads from the Klamath River than it returns to it, Reclamation's Klamath Project discharges contribute to exceeding the Klamath River water quality standards.

The principal sources of water inflows to the Lost River system in California are agricultural drains that collect irrigation return flows from privately owned agricultural lands within Reclamation's Klamath Project. The drains and canals are owned by USBR, but are operated by various irrigation districts that hold water delivery contracts with USBR. The KSD and LRDC are owned and operated by USBR, but receive pollutant inputs from upstream agricultural operators. All of Tule Lake and the open water areas of LKNWR are currently part of the National Wildlife Refuge system and are managed by U.S. Fish and Wildlife Service (USFWS). Some refuge lands are jointly managed by USBR for agricultural use.

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[2] Information concerning the purpose of this pumping was provided in a comment letter submitted by the Klamath Water Users Association. USBR has subsequently commented that "Water is not pumped from TLNWR to LKNWR 'to maintain farmland in the TLNWR' or 'remove salt from the Tule Lake basin'. Water is pumped for water elevation control in the wildlife refuge year round, for flood control in winter and early spring months, and for refuge water supply in the summer and fall months."

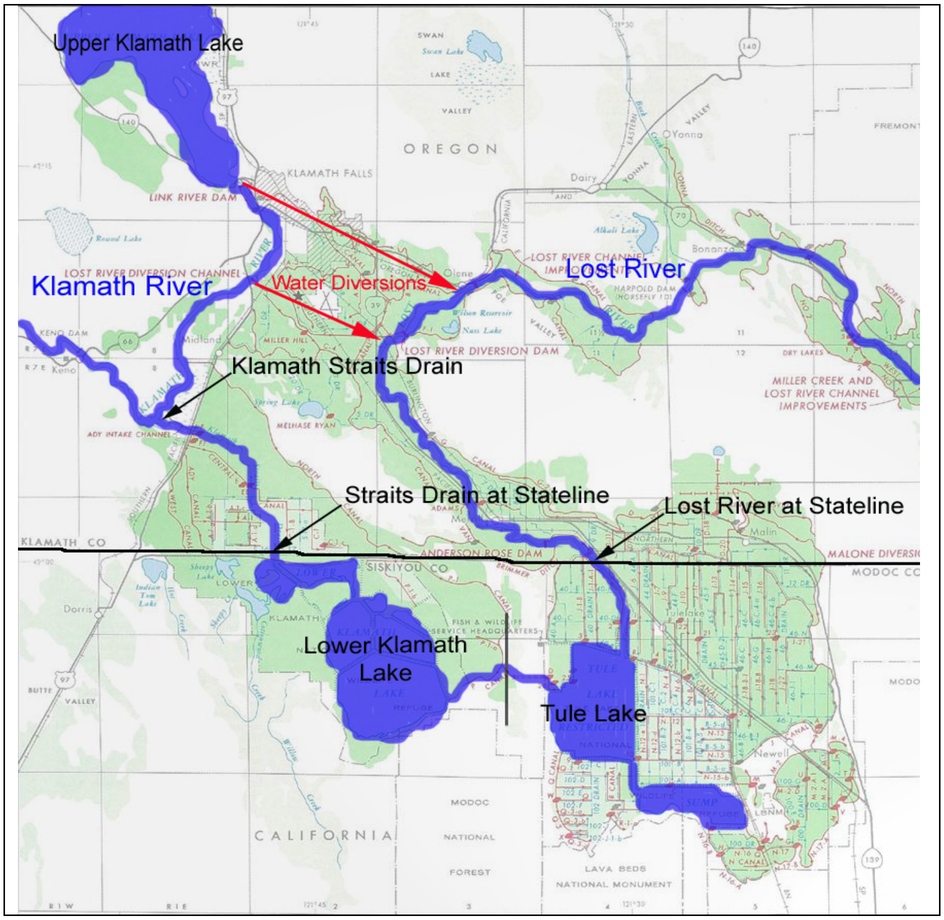

Figure 6.2: The Lost River basin

The load allocations from the USEPA Lost River TMDL in California are shown in Table 6.3.

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Table 6.3: Lost River, California TMDLs and allocations by segment.

Segment	Source	Dissolved inorganic nitrogen (DIN) (metric tons/yr)	Dissolved inorganic nitrogen (DIN) (average kg/day)	Carbonaceous biochemical oxygen demand (CBOD) (metric tons/yr)	Carbonaceous biochemical oxygen demand (CBOD) (average kg/day)
1	Lost River at Stateline Road (OR Border) Load Allocation	27.8	76.0	54.3	148.6
	Load Allocation for irrigation drainage loads to Lost River between Stateline Rd and Tule Lake Refuge	1.2	3.2	17.5	47.8
	Wasteload Allocation-CalTrans	0.1	0.3	0.2	0.5
Total	Lost River (from border to Tule Lake Refuge) TMDLs	29.0	79.5	71.9	197.0
2	Upstream load - from Lost River	29.0	79.5	71.9	197.0
	Load Allocation for irrigation drainage loads to Tule Lake Refuge	36.2	99.0	253.3	694.0
	Wasteload Allocation-CalTrans	0.1	0.3	0.2	0.5
	Wasteload Allocation City of Tulelake WWTP	1.0	2.7	3.5	9.6
Total	Tule Lake Refuge TMDLs	66.3	181.5	328.9	901.1
3	Upstream load - from Tule Lake Refuge[a]	19.4	53.2	245.9	673.7
	Load Allocation for irrigation drainage loads to Lower Klamath Refuge	3.9	10.7	39.4	107.8
	Load Allocation to Ady Canal	4.4	12.1	39.4	107.8
	Wasteload Allocation -CalTrans	0.1	0.3	0.2	0.5
Total	Lower Klamath Refuge TMDLs	27.8	76.2	324.8	889.9
4	Upstream load from Lower Klamath Refuge[b]	20.2	55.2	193.3	529.5
	Load Allocation for irrigation drainage loads to Klamath Straits Drain[c]	1.5	4.1	10.5	28.8
Total	Klamath Straits Drain (Stateline Highway to border) TMDLs	21.7	59.3	203.8	558.2

Source: USEPA 2008

[a]Upstream load from Tule Lake Refuge—only a portion of the waters from Tule Lake Refuge are pumped to Lower Klamath Refuge. Additionally, the model assumes that Tule Lake Refuge is a single mixed segment; to avoid transferring uncertainties associated with the coarse spatial resolution to the next downstream segment, monitoring data collected at the D Pumping Plant intake was used as the basis for upstream inputs for this segment.

[b]Because the model assumes that Lower Klamath Refuge is a single mixed segment, water quality inputs to the next segment were based on monitoring data collected at Klamath Straits Drain at Stateline Highway.

[c]In comments on the draft Lost River TMDLs, USBR stated that the portion of the Klamath Straits Drain that exits the Lower Klamath Lake National Wildlife Refuge, and is within California, does not have any agricultural contributions. The table above is taken directly from the Lost River Basin TMDL, in California (USEPA 2008) and has not been altered.

6.4.3.2 Responsible Parties in the Lost River Basin
The parties responsible for implementing water quality control measures that meet the Lost River and Klamath River TMDL allocations in California include:

- US Bureau of Reclamation
- US Fish and Wildlife Service
- Tulelake Irrigation District
- City of Tulelake
- Any party whose activities have the potential to contribute towards the TMDL impairments through the discharge of nutrients or organic material.

6.4.3.3 Implementation
Significant load reductions are needed in the Lost River basin to meet water quality standards in the Lost River basin and to meet the Lost River TMDL load allocations in California. Agricultural operators in the Lost River basin in California and Oregon have been implementing water quality control measures for a number of years. For example:

- The NRCS has funded approximately $50 million in projects through the Environmental Quality Incentive Program; a program funded by the US Department of Agriculture (USDA). The funds were split evenly between projects in California and projects in Oregon.
- The Conservation Reserve Program (CRP), also funded by the USDA, pays for conservation easements to establish riparian buffers on agricultural land. In Oregon, this program is expanded and called the Conservation Reserve Enhancement Program to include active restoration of riparian areas.
- Water quality improvement projects have been implemented through the Oregon Water Enhancement Board.
- The Lava Beds/Butte Valley Resource Conservation District (RCD) in Tulelake and the Klamath Soil and Water Conservation District in Oregon have obtained funding through the Agricultural Water Enhancement Program.

Regional Water Board staff support and encourage the continuation of these ongoing programs and coordinating current efforts with TMDL implementation. The implementation measures described in this section apply to dischargers in the Lost River basin in California and, combined with the measures listed below, are sufficient to implement the Lost River TMDL in California. The Regional Water Board's proposed basinwide nonpoint source program for agriculture, to be developed separate from this implementation plan (section 6.5.6) will include agricultural dischargers in the Lost River basin. Tulelake Irrigation District is responsible for discharges in California associated with the conveyance and delivery of water within the district's boundaries. They are named as a party to the MAA because their operations are linked with the overall operation of the project. There will be more opportunity for water quality improvements if TID's management practices are coordinated with USBR and USFWS. The load allocations assigned in the Oregon Klamath River TMDL will be implemented by ODEQ through their regulatory authority in Oregon. The Regional Water Board will coordinate with ODEQ on implementation as defined by the implementation Memorandum of Agreement signed in June 2009 (see section 6.2.3.3).

6.4.3.4 Proposed Management Agency Agreement

Regional Water Board staff proposes the development of a Management Agency Agreement (MAA) between USBR, USFWS, the Tulelake Irrigation District, and the Regional Water Board to implement the Lost River and Klamath River TMDLs. The MAA would be a voluntary and cooperative means of implementing the TMDL The MAA should be completed within six months of when the Klamath River TMDL Action Plan takes effect and should include the following actions items:

- Complete a water quality study based on best available science to characterize the seasonal and annual nutrient and organic matter loading through Reclamation's Klamath Project and refuges. The study should be completed and inform the development of a water quality management plan described in the following bullet.
- Based on the results of the water quality study, develop a water quality management plan to meet the Lower Lost River and Klamath River TMDL allocations and targets. The plan should be submitted to the Regional Water Board for approval within 18 months of the time the Klamath River TMDL Action Plan takes effect.
- Include a schedule with interim milestones for meeting the TMDL allocations and targets;
- Coordinate implementation actions with other responsible parties discharging pollutants within Reclamation's Klamath Project and refuges;
- Develop a monitoring and reporting program with the Regional Water Board to evaluate the effectiveness of management measures and track progress towards meeting the Lower Lost River and Klamath River TMDL allocations and targets;
- Coordinate with the Klamath River water quality improvement tracking and accounting program in implementing offset projects; and
- Periodically report to the Regional Water Board on actions taken to implement the TMDL and progress towards meeting the TMDL allocations and targets.

6.4.3.5 Coordination with ODEQ and US EPA

As stipulated in the Klamath River and Lost River TMDL Implementation Memorandum of Agreement (MOA) developed by the Regional Water Board, ODEQ and US EPA Regions 9 and 10, the agencies agree to work jointly with common implementation parties, including USBR, USFWS, and the Klamath Water Users Association (KWUA) to develop effective implementation plans and achieve water quality standards. Regional Water Board staff suggest that USBR and USFWS develop the water quality management plan in conjunction with the development of an implementation plan to meet the Klamath River TMDLs in Oregon.

6.4.3.6 Tulelake Wastewater Treatment Plant

The Tulelake Wastewater Treatment Plant (WWTP) is owned and operated by the City of Tulelake and discharges effluent under NPDES Permit No. CA0023272 and WDR No. R1-2004-0075. The waste load allocations to the Tulelake WWTP discharges will be implemented through the federal NPDES permit, which is held by the City of Tulelake. The current permit was as adopted in October 2004, and the treatment plant will continue to operate under the terms of the existing permit until a new permit is issued. The TMDL waste load allocations and targets to the treatment plant discharge will be translated into effluent limits in the new NPDES permit. The TMDL compliance schedule to accompany the new permit may allow additional time needed for the City of Tulelake to make any infrastructure improvements to the treatment plant and to implement management measures that meet TMDL allocations. The City of Tulelake is assessing the possibility of moving to a land discharge system, in which case, the current NPDES permit would be rescinded, and the discharge would be regulated through WDRs. A land discharge system would meet the TMDL waste load allocations, since there would no longer be a discharge to surface waters from the WWTP.

Implementation Measures in the Lost River Basin

Regional Water Board, USBR, USFWS, and TID:

Measure
- Develop and implement a Management Agency Agreement (MAA) between USBR, USFWS, TID and the Regional Board that addresses the water quality impacts of Reclamation's Klamath Project. The MAA should include the action items identified above in section 6.4.3.4.

Timeline
- Complete MAA within six months of when the Klamath River TMDL Action Plan takes effect.

Regional Water Board:

Measure
- Revise NPDES Permit No. CA0023272 and WDRs No. R1-2004-0075 to include a compliance schedule and ensure that the discharge requirements are consistent with the Basin Plan requirements and the Lower Lost River TMDL wasteload allocations. Timeline
- Bring revised permit to the Regional Water Board for consideration by June 2012

City of Tulelake:

Measure
- Implement measures to improve the water quality of discharges from the Tulelake WWTP to meet the Lower Lost River TMDL wasteload allocations.

Timeline
- As specified in the revised NPDES permit.

6.4.4 Coordination with the Shasta River TMDL

The Klamath River TMDL analysis found that the load reductions called for in the Shasta River TMDL are sufficient to meet water quality standards in the Klamath River. The

Shasta River TMDL Action Plan includes a goal to increase dedicated instream cold water flows by 45 cubic feet per second (cfs), or alternative flow regime that achieves the same temperature reductions from May 15 to October 15. Achieving the Shasta River 45 cfs flow goal, or alternative flow regime that achieves the same temperature reductions from May 15 to October 15, is necessary for attainment of the Klamath River temperature TMDL and associated temperature standards. Water made available through the implementation of conservation measures should be dedicated to beneficial use in order to be effective under this Plan. 'Dedicated' means that the diverter, either individually or as a group, can demonstrate that the measure contains assurances that it will result in water quality benefits. The Regional Water Board staff, with help from the Division of Water Rights, is providing information to assist landowners who want to voluntarily dedicate instream flow. Under Water Code section 1707, any person entitled to use water, whether based on an appropriative, riparian or other water right, may petition the State Water Board to change the purpose of use to the preservation and enhancement of wetlands habitat, fish and wildlife resources, or recreation. The State Water Board may approve the petition if the change does not increase the amount of the original entitlement, does not unreasonably affect any legal user of water, and meets other requirements of the Water Code. These efforts are not a requirement of the Klamath TMDL and are provided here for informational purposes only.

The Shasta River TMDL Action Plan includes a conditional waiver of WDRs for parties discharging to the Shasta River basin as long as they comply with the Action Plan measures. The agricultural conditional waiver of WDRs proposed for development as part of a future stakeholder process (see section 6.5.6) may eventually supersede the Shasta River basin conditional waiver when they are adopted. The Regional Water Board will assess the effectiveness of the Shasta River TMDL waiver when it expires. At that time, the Regional Water Board will decide whether to extend the Shasta TMDL waiver, revise and reissue the Shasta TMDL waiver, or incorporate it into the proposed regionwide conditional waiver developed for nonpoint source discharges from agricultural activities. In the meantime, compliance with the Shasta River waiver is sufficient to meet the requirements of the Klamath River TMDL.

6.4.5 Coordination with the Scott River TMDL

The Scott River TMDL Action Plan includes sediment and temperature control measures, and it is anticipated that these measures are sufficient to meet the Klamath River TMDL watershed-wide temperature allocations and targets. The Scott River TMDL recommended that the County of Siskiyou, in cooperation with other appropriate stakeholders, develop a plan for a study of the connection between groundwater and surface water in the Scott Valley. This study plan has been completed. The Regional Water Board has provided funds to implement the initial phases of the plan. This plan should move forward in order to help assist Scott water users to develop appropriate management practices that can be implemented following the study in order to ensure adequate flow in the Scott River. This is not a requirement of the Klamath TMDL and is provided here for informational purposes only.

The Klamath River TMDL assigns nutrient and organic matter allocations to the Scott River, and the Scott River Action Plan does not include measures to control discharges of these pollutants. The Regional Water Board will assess the effectiveness of the Scott River TMDL waiver when it expires. At that time, the Regional Water Board will decide whether to extend Scott TMDL waiver, revise and reissue the Scott TMDL waiver, or incorporate it into the proposed regionwide conditional waiver for nonpoint source discharges from agricultural activities. The need for nutrient control measures will be addressed as part of that determination.

6.4.6 Coordination with the Salmon River TMDL

The USFS manages 97% of the land in the Salmon River basin, and the Regional Water Board passed a resolution in 2005 to develop an MOU with the USFS that would implement the Salmon River TMDL. The MOU was signed in September 2009. As discussed in section 6.6 (Implementation on Federally Managed Lands) Regional Water Board staff are in the process of developing a conditional waiver of WDRs to address USFS nonpoint source discharges in the Region, including the Salmon River basin. This waiver would incorporate the implementation measures agreed upon in the MOU and would also require compliance with the Klamath TMDL allocations and targets.

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6.4.7 Trinity River Implementation

6.4.7.1 Responsible Parties
The Bureau of Reclamation is identified here as the party responsible for implementing the Trinity River Restoration Project as described below.

6.4.7.2 Implementation
The USEPA completed sediment TMDLs for the South Fork Trinity River in 1998 and for the mainstem Trinity River in 2001. These USEPA promulgated TMDLs do not currently include implementation plans. The Trinity River is also assigned nutrient and organic matter allocations in the Klamath River TMDL that are consistent with current conditions. Watershed-wide allocations do not apply to the Trinity River because allocations were already assigned in previous TMDLs. Riparian shade protection measures will be implemented in the Trinity River basin through existing or future Regional Water Board regulatory programs that address sediment discharges.

The primary adverse impacts associated with excessive sediment in the Trinity River pertain to anadromous salmonid fish habitat, which the Trinity River Restoration Program (TRRP) was designed to correct. The TRRP is a management program, headed by the Department of the Interior, to restore the fish and wildlife populations in the Trinity River basin to levels that existed prior to construction of the Trinity and Lewiston dams. The EPA cites implementation of the TRRP 2000 Record of Decision (ROD), including flow regime, mainstem/watershed restoration, and adaptive management, in its TMDL implementation recommendations. The Regional Water Board is in the process of developing a general permit for the restoration component of the ROD and considers its proposed permitting action on TRRP measures to be early TMDL implementation of the Trinity TMDL.

The Klamath River TMDL analysis used flows for the Trinity River that were specified in the ROD and signed by the US Secretary of the Interior and the Hoopa Valley Tribal Chairman. The TMDL analysis found that these flows are necessary to meet water quality objectives for water temperature in the mainstem Klamath River. Implementation of the TRRP, including the ROD, has been added to the Basin Plan Amendment language.

Implementation Measures in the Trinity River Basin

Regional Water Board:

Measure
- Develop general Waste Discharge Requirements/401 water quality certification for TRRP mechanical restoration.

Timeline
- 2010

USBR: Measure

- Implement Trinity River Restoration Plan Record of Decision

Timeline

- Ongoing

6.5 Nonpoint Source Control and the Watershed-Wide Allocations

This section presents the proposed TMDL implementation measures assigned to responsible parties that are discharging nonpoint sources of waste in the Klamath Basin. The following land uses were identified as the primary nonpoint sources of pollution in the Klamath River basin that contribute to the water quality impairments:

- Road construction and maintenance;
- Agriculture including grazing and irrigated agriculture;
- Timber harvest; and
- Land use activities on land managed by the USFS.

This section summarizes the watershed-wide allocations and targets for temperature, introduces a proposed prohibition on unauthorized discharges that violate water quality standards, provides guidance on control of excess sediment discharges, and introduces the Thermal Refugia Protection Policy. It then presents the implementation measures associated with the above named land use categories. For each of the land use activities, Regional Water Board staff evaluate the effectiveness of current regulatory programs and strategies as well as other regulatory and non-regulatory water quality protection efforts. Staff then make recommendations for implementation measures as needed to ensure the Klamath TMDLs and measures are coordinated within the context of the Regional Water Board’s regionwide nonpoint source planning approach. Ultimately it is the Regional Water Board’s goal to combine as many discharge requirements for various land use activities as comprehensively as possible into one permitting structure.

Changes from the June 2009 draft

The Regional Water Board staff have made the following changes to this section of the draft implementation plan in response to comments received during the public comment period for the previously released June 2009 draft:

1. Prohibition on Unauthorized Discharges of Waste that Cause a Violation of Water Quality Standards. (section 6.5.2)
2. Removal of the proposed sediment prohibition and replace with Guidance for the Control of Excess Sediment. (section 6.5.3)
3. Removal of the proposed prohibition on the discharge of waste in and around thermal refugia in the Klamath Basin and replace with Thermal Refugia Protection Policy for the Klamath Basin to be included in the Action Plan. (Section 6.5.4)

4. Changes to the implementation measures for the USFS to incorporate the current development of a conditional waiver for certain nonpoint source activities on lands managed by the USFS. The waiver is scheduled for Regional Water Board adoption in April 2010. (section 6.6)

These changes are discussed in the sections indicated above. Other smaller changes have also been made, including a discussion on how TMDL requirements for maintenance of riparian shade relate to the Anadromous Salmonid Protection Rules for timber harvest, recently adopted by the California Board of Forestry section 6.5.7.6.

6.5.1 Watershed-wide Allocations and Targets for Water Temperature

The following watershed-wide allocations and targets apply only to the Klamath River mainstem and minor tributaries.

6.5.1.1 Riparian Shade Allocations and Targets

The Klamath River TMDL assigns allocations and targets for riparian shade to limit water temperature increases due to solar radiation (section 5.2.1). Land use activities in the Klamath River basin have the potential to degrade riparian conditions, and all parties are responsible for meeting the same riparian shade allocation. The following discussion is intended to clarify implementation of the riparian shade allocation and provide the basis for the implementation recommendations specific to each land use.

The riparian shade allocation requires the maintenance of the following *shade conditions*:

> the shade provided by topography and full potential vegetation conditions at a site, with an allowance for natural disturbances such as floods, wind throw, disease, landslides, and fire.

The allocation allows for site-specific determination of shade potential, recognizing that potential varies by location. Shade conditions can be equated to the *effective shade* to the waterbody. Effective shade is defined as:

> a measure of the percentage of total daily direct beam solar radiation that is blocked by vegetation or topography before reaching the ground or stream surface, taking into account the differences in solar intensity that occur throughout a day.

The process for assessing compliance with the Klamath River TMDL riparian shade allocation begins by comparing the current effective shade and the site potential effective shade. The site potential effective shade is designated as the riparian shade target in the TMDL. The TMDL provides general targets for effective shade based on the shade percentages that are expected to naturally occur for a given type of vegetation, aspect, and stream width. The effective shade curves in Figures 5.4 – 5.9, found in Chapter 5 of this staff report, represent the numeric targets for riparian shade within the Klamath River basin in California. The targets are intended as a guide for riparian management, and may be modified based on site-specific conditions, as discussed in Section 5.2.1.1.

In simple terms, compliance with the shade allocation is achieved by not removing trees that provide shade to the waterbody. To accomplish this, it is recommended that responsible parties delineate a separate management area for riparian vegetation that has the potential to shade a waterbody, and manage these riparian areas differently than the surrounding land. These areas are referred to variously as a riparian management zone, streamside buffer area, or a watershed and lake protection zone. The riparian management area should be large enough to include any trees that have the potential to provide shade to surface waters once they reach their site potential height. In most cases, the landowner will not be required to actively restore riparian conditions by planting trees in order to comply with the TMDL. However, active restoration of riparian conditions may be appropriate in instances where riparian vegetation has been removed and causes violation of the Basin Plan temperature standards and the Klamath River shade allocations and targets, or where natural vegetation is not readily becoming reestablished on its own. Regional Water Board staff acknowledge that it may be necessary in some cases to remove some riparian vegetation to hasten recovery towards site potential effective shade conditions.

6.5.1.2 Sediment Related Water Temperature Allocation and Targets

The TMDL found that sediment discharges in the Klamath River basin have a potential cumulative impact on water temperatures through the alteration of channel structure, particularly in the tributary basins. To control the impacts of excess sediment on water temperature, the Klamath River TMDL assigns the following temperature-related load allocation for human-caused discharges of sediment (section 5.2.1.2):

> Zero temperature increase caused by substantial human-caused sediment-related channel alteration.

Substantial human-caused sediment-related channel alteration is defined as:

> A human-caused alteration of stream channel dimensions that increases channel width, decreases depth, or removes riparian vegetation to a degree that alters stream temperature dynamics and is caused by increased sediment loading.

The TMDL also identifies three targets related to the impacts of excess sediment:

1. 0 miles of substantial human-caused sediment-related channel alteration.
2. Less than 1% of all stream crossings divert or fail as a result of a 100-year or smaller flood.
3. Decreasing number of potential road-related landslide source areas.

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6.5.2 Prohibition of Discharges in Violation of Water Quality Objectives in the Klamath River Basin

In response to numerous comments received, staff have removed any interim requirements on individual landowners and operators to control discharges associated with irrigated agriculture and grazing activities and sediment discharges in lieu of incorporating TMDL implementation into basin and/or region wide nonpoint source programs for efficiency and consistency. The following prohibition against unauthorized discharges of waste that violate water quality standards is proposed to protect against serious and significant individual threats to water quality. This prohibition is a restatement of existing law and is not intended to provide a nonpoint source program that implements measures to control the cumulative impact of individual nonpoint source discharges of waste from agricultural activities. Individuals who are concerned about any discharges that violate water quality standards should contact the Regional Water Board and inquire about obtaining an individual permit.

<u>Prohibition of Discharges in Violation of Water Quality Objectives in the Klamath River Basin</u>

> Discharges of waste that violate any narrative or numerical water quality objectives that are not authorized by waste discharge requirements or other order or action by the Regional or State Water Board, are prohibited

6.5.3 Guidance to Control Excess Sediment Discharges

To help achieve the watershed-wide TMDL allocations and targets, the implementation plan provides guidance for the control of excess sediment. This guidance is suggestive only and in no way limits the enforcement authority of the Regional Water Board under applicable law.

Parties conducting land use activities that have the potential to discharge excess sediment should implement the following sequential measures:

1. <u>Prevent</u> – Plan, design, and implement the project or activity in such a way that no excess sediment discharge occurs or could occur to waters of the state.
2. <u>Minimize</u> – If the discharge or threatened discharge of excess sediment cannot be fully prevented, then plan, design, and implement the project in such a way that discharges to waters of the state are minimized to the maximum extent possible.

Parties responsible for existing sediment sources (including human-caused legacy sources) should implement the following measures:

1. <u>Inventory</u>: Identify sources of excess sediment discharge or threatened discharge and quantify the discharge or threatened discharge from the sources.

2. Prioritize: Prioritize efforts to control the inventoried sediment sources based on, but not limited to, severity of threat to water quality and beneficial uses, the feasibility of source control, and source site accessibility.
3. Schedule: Develop a schedule to implement the cleanup of excess sediment discharge sites.
4. Implement: Develop and implement feasible sediment control practices to prevent, minimize, and control the discharge.
5. Monitor and Adapt: Use monitoring results to direct adaptive management in order to refine excess sediment control practices and implementation schedules.

6.5.4 Thermal Refugia Protection Policy

The Thermal Refugia Protection Policy proposed by the Klamath implementation plan intends to provide enhanced protection of cold water refugia along the mainstem Klamath River and in the lower Scott River. Thermal refugia are typically identified as areas of cool water created by inflowing tributaries, springs, seeps upwelling hyporheic flow, and/or groundwater in an otherwise warm stream channel offering refuge habitat to cold-water fish and other cold water aquatic species (Watercourse, 2005). The refugia created by some tributaries in the Klamath River basin are typically in the plumes and pools of cold water that form in the mainstem at the tributary confluence. Refugia also exist in some tributary streams themselves. Thermal refugia in the Klamath River basin are essential to the support of the cold water fishery because they moderate the impact of naturally elevated temperatures in the mainstem Klamath River and also can provide a refuge from depressed mainstem dissolved oxygen levels. Their protection has become even more important since the Klamath River has become impaired for temperature. The implementation plan focuses on protecting the critical function of thermal refugia in moderating mainstem Klamath River temperatures in the mid-to later-summer months.

The elements of the Thermal Refugia Protection Policy are:

1. The identification of known thermal refugia locations in the Klamath basin where the policy would apply.
2. The designation of an instream buffer area surrounding thermal refugia where discharges of waste associated with suction dredging are restricted unless otherwise permitted by the Regional Water Board.
3. Recommendations to the State Water Resources Control Board and the California Department of Fish and Game to incorporate the provisions of the Policy into any future permit(s) addressing suction dredging activities.
4. Heightened scrutiny in Regional Board permitting and water quality certification of activities that have the potential to impact the function of thermal refugia.
5. A recommendation to the State Water Board to consider the impact of increased diversions in tributaries that provide thermal refugia when issuing water rights permits to divert surface water or other water rights actions in the Klamath River basin in California.

6. Recommendation to large landowners in the Klamath basin to prioritize restoration and water quality control efforts in tributary watersheds that provide thermal refugia.

6.5.4.1 Identification of Thermal Refugia in the Klamath River Basin in California

The shape and extent of refugia are highly variable and are dependent on stream geomorphology, riparian canopy, sediment dynamics, and flow. Regional Water Board staff recognize that there are a number of factors that can cause seasonal and inter-annual changes in the existence, location, and size of the thermal refugia in the basin. Taken as a whole, these thermal refugia comprise a network of support for populations of cold water fishes in the Klamath River basin.

In order to identify the locations of known thermal refugia in the basin, Regional Water Board staff solicited information from fisheries biologists working in the Klamath River basin through a formal request in April 2009. Based on the information staff received, as well as review of the available reports on the topic, staff compiled a list of the known thermal refugia in the Klamath River basin in California (Table 6.4). References consulted to compile the list of tributaries include the following and will be included in the administrative record of the Klamath TMDL:

1. Grunbaum, Jon B. Memo of Recommended Suction Dredging Guidelines for the Happy Camp Ranger District of Klamath National Forest. 2005.
2. Superior Court of California, County of Alemeda, Hayward Division. Case No.: RG 05 211597. Declaration of Peter B. Moyle, Ph. D., in Support of Entry of Stipulated Judgment. January 26, 2006.
3. Belchik, Michael. Use of Thermal Refugial Areas on the Klamath River by Juvenile Salmonids; Summer 1998. Yurok Tribal Fisheries Program. November, 2003.
4. Belchik, Michael. Summer Locations and Salmonid Use of Cool Water Areas in the Klamath River. Yurok Tribal Fisheries Program. August 1997.

Letters and emails were received from the following persons in response to the April 2009 request:

- Mark Stopher of the California Department of Fish and Game, April 15, 2009.
- Mike Belchick of the Yurok Tribal Fisheries Program, April 24, 2009.
- Earl Crosby of the Karuk Tribe, April 30, 2009.
- Will Harling, Executive Director of the Mid-Klamath Watershed Council, April 28, 2009.
- Jon Grunbaum, Fisheries Biologist for the Klamath National Forest, May 1, 2009.

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Maps showing the locations of these creeks in the Klamath River basin are provide in Appendix 9.

Table 6.4: Tributaries to the Klamath River known to provide thermal refugia in and around their confluence

Tributaries		
Aikens Creek	Halverson Creek	Pine Creek
Aubrey Creek	Hopkins Creek	Portuguese Creek
Barkhouse Creek	Horse Creek	Red Cap Creek
Beaver Creek	Humbug Creek	Reynolds Creek
Blue Creek	Hunter Creek	Roach Creek
Bluff Creek	Ikes Creek	Rock Creek
Bogus Creek	Independence Creek	Rogers Creek
Boise Creek	Indian Creek	Rosaleno Creek
Boulder Creek[1]	Irving Creek	Sandy Bar Creek
Cade Creek	Kelsey Creek[1]	Salt Creek
Camp Creek	King Creek	Seiad Creek
Canyon Creek[1]	Kohl Creek	Slate Creek
Cappell Creek	Kuntz Creek	Stanshaw Creek
Cheenitch Creek	Ladds Creek	Swillup Creek
China Creek	Little Horse Creek	Ten Eyck Creek
Clear Creek	Little Humbug Creek	Thompson Creek
Coon Creek	Little Grider Creek	Thomas Creek
Crawford Creek (Humboldt Co.)	Lumgrey Creek	Ti Creek
Crawford Creek (Siskiyou Co.)	McGarvey Creek	Titus Creek
Dillon Creek	Mill Creek	Tom Martin Creek
Doggett Creek	Miners Creek	Trinity River
Dona Creek	McKinney Creek	Tully Creek
Donahue Flat Creek	Nantucket Creek	Ukonom Creek
Elk Creek	Negro Creek	Ullathorne Creek
Elliot Creek	Oak Flat Creek	Walker Creek
Empire Creek	O'Neil Creek	West Grider Creek
Fort Goff Creek	Pecwan Creek	Whitmore Creek
Grider Creek	Pearch Creek	Wilson Creek

[1] Scott River tributary

6.5.4.2 <u>Designation of the Instream Buffer Areas</u>

Instream buffer areas are located in and around the mouths of the tributaries that create refugia in the mainstem Klamath River. Two buffer areas are recommended within the wetted channel of the Klamath River; one upstream and one downstream of the tributary confluence providing thermal refugia. A third buffer area is recommended in the wetted channel of the tributary stream providing thermal refugia, located upstream of the tributary confluence with the Klamath River. These three buffer areas are assigned different lengths based on the potential impacts of instream activities such as suction dredging within that area. Figure 6.3 shows a generic tributary/river confluence with the different instream buffer areas delineated.

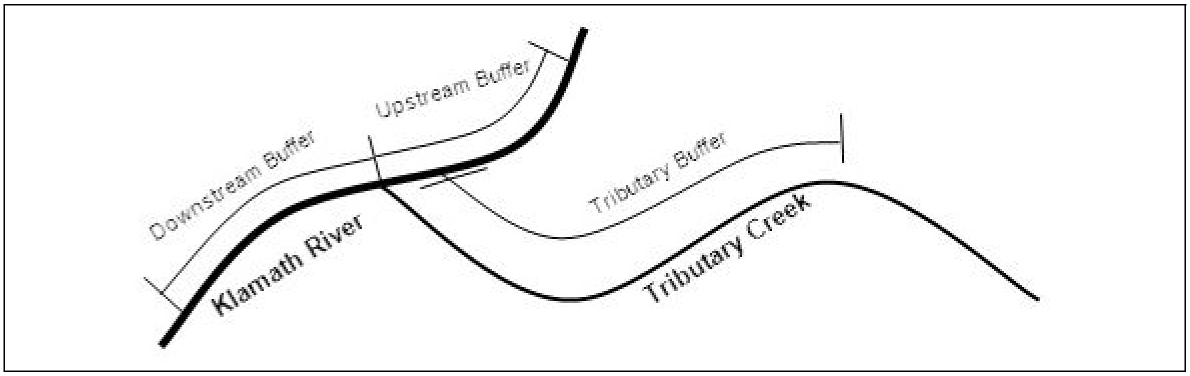

Figure 6.3: Conceptual diagram of proposed buffers in and around the confluence of a tributary providing thermal refugia

Regional Water Board staff recommend a default buffer where no site-specific information is available regarding the spatial extent of the refugia. Where site-specific information is available, an extended buffer may be recommended. Regional Water Board staff referenced a thermal infrared study of the Klamath River basin conducted in August 2003 to identify creeks where a more extensive buffer is appropriate (Watershed Sciences 2004). The study showed the spatial dimensions and water temperatures of cold-water refugia in the mainstem Klamath River. Staff also considered information submitted in response to the April 2009 solicitation.

The buffer length that extends downstream of the tributary confluence is sized to protect cold water plumes that form in the Klamath River where tributaries enter the mainstem river. Most thermal refugia formed by cold water plumes are located within 300 feet of the tributary confluence. Adding a margin of safety to this distance, staff recommend an instream buffer of 500 feet from the tributary confluence in the downstream direction. The responses Regional Water Board staff received from the April 2009 solicitation identified a number of refugia locations where a buffer of 500 feet would not be sufficient to protect the refugia from impacts of instream activities such as suction dredging. For these refugia, staff are recommending a 1500 foot buffer. The tributaries where a 1500 foot buffer is recommended include: Aubrey, Beaver, Clear, Dillon, Elk Creek, Grider, Horse, Indian, Rock, Swillup, Thompson, and Ukonom (See Appendix 9 for a map showing locations).

To protect the refugia from activities upstream of the tributary confluence, the buffer needs to be large enough so that instream activities such as suction dredging have a negligible impact on the function of the refugia downstream. Suction dredging can create plumes of sediment that usually settle out downstream within 300 ft. Adding a margin of safety to this distance, Regional Water Board staff recommend a buffer area of 500 feet in the Klamath River upstream of tributary confluences where known refugia exist.

The portion of the tributary that is just upstream of the tributary mouth can function either as a water supply for the cold water plume in the mainstem, or it can function as a thermal refuge itself. The functions provided by the tributary depend partially on whether fish have physical access to that tributary. If the tributary itself is the refugia, the buffer should extend at least as far as the thermal refuge area within the tributary. To protect the tributaries that provide cold water refugia, staff recommend the buffer be established within the lower 500 feet of the tributary. As with the buffer extent in the downstream direction in the Klamath River, the fisheries biologists that responded to the April 2009 solicitation identified a number of tributaries known to provide refugia for fish. To protect these tributaries from the impacts of instream activities, it is recommended that the buffer be extended to 3000 feet within the tributary upstream of its confluence with the mainstem river. The following is a list of tributary creeks that Regional Water Board staff recommend be provided this added protection: Aubrey, Beaver, Clear, Dillon, Elk Creek, Empire, Fort Goff, Grider, Horse, Indian, King, Little Horse, Little Humbug, Mill, Nantucket, O'Neil, Portuguese, Reynolds, Rock, Sandy Bar, Seiad, Stanshaw, Swillup, Thompson, Ti and Titus (See Appendix 9 for a map showing locations).

6.5.4.3 Changes to List of Thermal Refugia Locations and Designated Buffer Lengths

Staff recommend that the list of identified thermal refugia in the Klamath basin and/or the designated buffer lengths be updated as new information becomes available. This should be done through a public process. Persons proposing modification to the list should submit supporting evidence to the Executive Officer. The Executive Officer may add or remove thermal refugia and/or buffer length designations after public notice and opportunity for public comment. The current list and maps showing the locations of thermal refugia and designated buffer lengths will be maintained on the Regional Water Board website at www.waterboards.ca.gov/northcoast/water_issues/programs/tmdls/klamath_river/.

6.5.4.4 Discharge Restriction In Designated Instream Buffer Areas

The implementation plan recommends restricting discharges associated with suction dredging activities within the designated instream buffer areas described above. These discharges are not currently covered by a permit from the Regional Water Board. The restriction would apply April 15 – September 15. The time period has been changed from the December 2009 public review draft of the Klamath TMDL based on public comments and further review by Regional Water Board staff of the impacts of suction dredging discharges on water quality and fish habitat. The December 2009 draft recommended that the discharges be restricted from June 15 – September 15 based on data that shows this as the critical time period when thermal refugia are needed to support the cold water fishery in the Klamath basin. Staff added two months on the front end to ensure that the impacts of suction dredging during these two months do not compromise the function of the refugia during the critical period. Studies cited in section 4.2.4 of the staff report show that suction dredging can have short term impacts on channel structure and benthic macroinvertebrates populations that are a food source for salmonid using the refugia. The two month period provides time for the channel to readjust and invertebrate populations to recover in time for the June 15-September 15 critical period when the refugia are needed to support the fishery. The discharge restriction during the April 15 – September 15 time period would not apply to other activities where discharges are already regulated by a separate regulatory mechanism such as WDRs, waiver(s) of WDRs, and/or a 401 water quality certification.

6.5.4.5 Status of Suction Dredging as a Point or Nonpoint Source
The status of a discharge from a suction dredge as a point or nonpoint source is currently undefined in California, but other states have designated it a point source and developed NPDES permits to address these discharges. Should suction dredging discharges be found to be point sources in California, they would be prohibited from discharging in the Klamath Basin by an existing general prohibition against all point source discharges in the Basin Plan (Basin Plan at 4-1.00). The State of California would also be obliged to develop an NPDES permit for suction dredging to regulate it as a point source. To accommodate this scenario, the Regional Water Board staff propose that the Basin Plan prohibition on point source discharges only apply to discharges associated with suction dredging activities within the buffer areas designated in the Thermal Refugia Protection Policy. Suction dredging outside of these areas would be permitted by an NPDES permit.

6.5.4.6 SB 670 and the CA Department of Fish and Game Suction Dredging Permit
The California Department of Fish and Game (CDFG) had been administering a permit for suction dredging activities in the Klamath River basin up until May 2009 when the State Senate passed a bill (SB 670) requiring the CDFG to temporarily halt issuance of all suction dredge mining permits. Senate Bill 670 prohibits the use of suction dredge mining equipment in rivers and streams that provide critical habitat to spawning salmon and steelhead until the CDFG updates its suction dredge rules so they comply with CEQA. Pursuant to SB 670, the California Department of Fish and Game is in the process of developing a Fish and Game permit for suction dredging activities in California with input from the State Water Resources Control Board. The Klamath River TMDL implementation plan supports this process as the means to address the impacts of suction dredging activities, and Regional Water Board staff recommend that CDFG be directed in the Basin Plan to incorporate the Thermal Refugia Protection Policy into the revised permit. In the event that the State Water Board issues a state-wide permit for suction dredging, Regional Water Board staff recommend that the Thermal Refugia Protection Policy be incorporated into the revised permit. This directive in no way limits either permitting agency from implementing more stringent requirements.

6.5.4.7 Tributary Flows
Maintaining near natural flows in the Klamath River tributaries in California is an important component of meeting the Basin Plan water temperature objective. In particular, cold water flows are necessary to maintain the function of thermal refugia in the Klamath River basin. Regional Water Board staff will work with other state and federal agencies and tribes to identify and address illegal diversions in the Klamath River basin in California. In addition, Regional Water Board staff recommend that the State Water Board, in administering water rights permits to divert surface water and other actions in the Klamath River basin in California consider the impact of increased diversions on tributaries that provide thermal refugia.

6.5.5 Road Construction and Maintenance on Nonfederal Lands
The road networks in the Klamath River basin contribute to elevated temperatures in tributary watersheds through the discharge of excess sediment. The implementation plan

includes measures for parties responsible for construction and maintenance of roads in the Klamath River basin to meet the road-related TMDL allocations and targets. The road-related TMDL targets (section 6.5.1.2) are measurable and will be used to track the progress of implementation in the basin.

6.5.5.1 Responsible Parties

- All parties responsible for the construction and maintenance of roads
- Modoc, Del Norte, Humboldt, Siskiyou, and Trinity Counties
- California Department of Transportation (Caltrans)

6.5.5.2 Existing Regulatory Structure

The Regional Water Board currently has the following regulatory mechanisms in place:

- Discharges from roads associated with a timber harvest plan (THP) or NTMP are regulated through the Regional Water Board's existing WDRs and waivers of WDRs as described in Section 6.5.7. Existing plans used to meet the TMDL requirements may need to be updated so they meet the applicable watershed-wide allocations and targets.
- Discharges from roads related to logging or construction are subject to discharge prohibitions in the Basin Plan.
- Discharges from state highways managed by Caltrans are regulated through a statewide NPDES permit.
- Any road construction over one acre must enroll in the state-wide construction stormwater permit, which functions similarly to a nonpoint source permit by requiring BMPs and other management measures designed to reduce runoff and erosion. The State Water Board has recently adopted an updated construction permit.
- A water quality certification pursuant to section 401 of the Clean Water Act must be obtained from the Regional Water Board by anyone proposing to conduct a project that requires a federal permit. The most common trigger for a 401 water quality certification is the federal Section 404 US Army Corp of Engineers permit that is required of anyone who proposes an activity that would discharge dredged or fill material into waters of the United States. The 404 permit applies to roads in the Klamath River basin not associated with silviculture or agriculture, which are specifically exempted. All other road construction and/or maintenance projects in and around stream channels in the Klamath River basin are required to apply for this 404 permit. Regional Water Board staff routinely require water quality protection measures in certifying these types of projects.

The construction of roads that involves less than one acre of land disturbance, as well as routine maintenance of existing roads, including county roads, roads associated with grazing and irrigated agriculture, and rural residential roads in the Klamath River basin, are currently not regulated by the Regional Water Board through waivers or WDRs.

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6.5.5.3 Implementation to Address Road-Related Discharges on Private Lands

Most roads located on private lands in the Klamath River basin are associated with timberland ownerships, however roads associated with other land uses, such as agriculture, also exist as do a significant number of rural residential roads. Measures to address road-related discharges will also be incorporated into any land use specific WDRs and waivers proposed as part of this implementation plan such as those proposed for grazing activities and irrigated agriculture. Regional Water Board staff encourage the larger landowners in the Klamath River basin that are responsible for maintaining a significant road network on their land to work with staff to develop ownership-wide WDRs that meet the TMDL requirements on a programmatic level. One of the benefits of ownership-wide WDRs is that they may be developed with input from regulated entities to consider site-specific conditions within the ownership and existing road management plans.

Following are three excellent references on constructing and maintaining forest and ranch roads that can be used to select management practices to comply with the TMDL.

1. National Management Measures to Control Nonpoint Source Pollution from Forestry, US EPA, 2005. (see road sections within) http://www.epa.gov/owow/nps/forestrymgmt

2. Handbook for Forest and Ranch Roads, Weaver and Hagans, 1994. http://www.krisweb.com/biblio/gen_mcrcd_weaveretal_1994_handbook.pdf

3. Environmentally Sensitive Maintenance for Dirt and Gravel Roads, compiled for US EPA, 2005. http://www.epa.gov/owow/nps/sensitive/sensitive.html

If you do not have access to the internet, call the Regional Board at 707-576-6750 to obtain a hardcopy of any of these documents.

6.5.5.4 Existing Management Plans and Programs

Parties managing roads in the Klamath Basin may have already developed property-wide plans that include management measures to control nonpoint source pollution. Roads are often a major component of these plans, since they have significant potential to impact water quality. Implementation of existing plans and programs may be used to fulfill the requirements of the TMDL. For example, industrial timber companies may be implementing a Habitat Conservation Plan (HCP) as part of their Endangered Species Act compliance. Another existing management plan that may be used in part to comply with the TMDL is the Non-Industrial Timber Management Plan (NTMP). NTMPs are developed by individual landowners under 2,500 acres to comply with the Forest Practice Rules and must include water quality protection measures for roads. It is the responsibility of the landowner to ensure existing plans and programs achieve TMDL allocations and that additional measures are implemented as needed for compliance. Regional Board staff are available to work with landowners to implement the Klamath TMDLs and revise existing programs accordingly.

Green Diamond WDRs

The Regional Water Board staff are currently in the process of developing WDRs for Green Diamond Resource Company (Green Diamond) to address potential discharges associated with road-related maintenance and management activities as part of their Aquatic HCP. The WDRs are scheduled for adoption by the Regional Water Board by April 2010. These WDRs will incorporate implementation measures to meet the Klamath River TMDLs. By complying with the WDRs in the Klamath basin, Green Diamond will be in compliance with the Klamath TMDL requirements for road-related discharges.

Green Diamond's HCP establishes a solid framework for TMDL compliance because it contains stringent water quality protections implemented across their landownership. For example, the HCP requires watershed assessments of road-related sediment sources, prioritization of those sources, and implementation of appropriate management practices to upgrade or decommission roads according to the assessment. The monitoring included in the HCP can also comply with the Klamath TMDLs because the HCP and the TMDL both track implementation of management practices that control pollution as well as progress towards meeting instream water quality objectives.

Following are some of the examples of management measures summarized from the Green Diamond HCP (2006) relevant to TMDL implementation for controlling impacts from roads:

Slope Stability

- Establishes a system for identifying slope stability management zones (SMZ) where steep slopes lead to Class I and II waters.
- Road construction is prohibited in the SMZ without approved review and harvest is limited

Road Management

- Conduct assessments in 58 sub-watershed road work units (RWUs) to identify sediment source sites
- Provides $2.5 million a year for 15 years for treating high and moderate priority sites
- Road use is seasonally restricted and prohibited if sediment delivery is identified
- All new culverts must meet 100-year return interval flow design standard and existing culverts must be within 15% of the design flow to not be replaced
- Conduct emergency inspections of all accessible rocked roads if a storm produces 3 or more inches of rain in a 24-hour period, and prioritize repairs

Monitoring

- Monitor road-related delivery of fine sediment and evaluation of the effectiveness of road management measures

Regional Board staff will work with Green Diamond to integrate the HCP with the WDRs and TMDL implementation.

6.5.5.5 Implementation Measures to Address County Roads

Del Norte, Humboldt, Modoc, Siskiyou, and Trinity Counties are responsible for maintaining county roads and meeting water quality standards. The potential for roads to discharge sediment in amounts that can cause alteration to stream channels is documented in the technical TMDL source analysis (Chapter 4). The Regional Water Board does not currently regulate discharges associated with county roads and plans to develop a regulatory approach in compliance with the State NPS Policy. The approach recommended by the Klamath implementation plan is to certify the Five County Roads Program (5C Program) that includes all counties in the Klamath Basin except Modoc County. Discharges from Modoc County will be addressed through the Regional Board's Basin Plan prohibitions.

Pursuant to the Impaired Waters Policy, Regional Water Boards may rely upon the 5C program to implement the TMDL if it can determine the following:

- the implementing program is consistent with the assumptions and requirements of the TMDL;
- sufficient mechanisms exist to provide reasonable assurances that the program will address the impairment in a reasonable period of time; and
- sufficient mechanisms exist to ensure that the program will be enforced, or that the Regional Water Board has sufficient confidence that the program will be implemented such that further regulatory action would be unnecessary and redundant.

Five Counties Salmonid Conservation Program

Five counties in the North Coast Region, four of which are in the Klamath River basin, have already initiated a unified program that addresses sediment discharges on county roads. In 1997, the Counties of Del Norte, Humboldt, Mendocino, Siskiyou, and Trinity agreed to form the Five Counties Salmonid Conservation Program (5C Program) in response to federal Endangered Species Act listings of salmon species as 'Threatened'. The program objectives include: "identify(ing) potential problem sites through systematic inventories of fish passage barriers and potential erosion sources on County maintained roads (Five Counties Salmonid Conservation Program 2009)." The 5C Program includes inventorying road-related sediment sources and implementing management practices to address those sources. The program has made considerable progress, and as of 2007, more than 2113 miles of county roads have been inventoried within the five counties. In consultation with state and federal agencies, the 5C Program has also developed *A Water Quality and Stream Habitat Protection Manual for County Road Maintenance in Northwestern California Watersheds* (5C Manual, Five Counties Salmonid Conservation Program 2002). The 5C Manual prescribes management practices for both routine and emergency repair and maintenance of county roads, bridges and related facilities. The 5C Manual contains a protocol for developing County Road Sediment Source Inventories of portions of county roads in order to set priority locations for erosion and sediment control efforts. The resulting Direct Inventory of Roads and Treatments (DIRT) provides a useful database for the counties' road departments to track progress in treating priority sites and associated sediment savings. The 5C Manual includes implementation and effectiveness monitoring and requires an annual report that summarizes the counties' self-evaluation of the effectiveness of road maintenance BMPs in protecting water quality and stream habitat.

<u>Recommendation</u>

The Regional Water Board staff recommend certifying the 5C Program because it contains measures adequate to meet the TMDL allocations and water quality standards. The certification will require a monitoring plan, and conditions that require trackable progress. The program's success will be assessed by the Regional Water Board every five years and the certification may be revoked if the program is found to be not adequately implemented, not achieving its goals, or is no longer adequate to restore water quality. To receive coverage under the waiver and certified 5C Program, each county must certify its intent to comply with the 5C program or otherwise indicate its intention to participate. This can be accomplished by acceptance and implementation of the 5C Manual by the County Board of Supervisors as a CEQA-exempt project, or other evidence of intent such as an agreement with the Director of Public Works or County Road Department to abide by the practices in the 5C Manual. The certification and waiver will not cover activities that otherwise require coverage under a different permit including the state-wide construction stormwater permit for new construction, or projects that require water quality certification under section 401 of the Clean Water Act. In the alternative, a county may submit a report of waste discharge and the Regional Water Board will process a WDR for county roads. This may be an option for Modoc County, which is not one of the five counties participating in the 5C Program.

<u>Implementation Measures for County Roads</u>

Regional Water Board:

<u>Measure</u>

- The Regional Water Board shall consider adopting a resolution and accompanying waiver for maintenance of county roads certifying the Five Counties Salmonid Conservation Program (5C Program) if it complies with the TMDL and attains standards in accordance with California Impaired Waters Guidance.

<u>Timeline</u>

- December 2010

Measure

- In the event that a county does not show intent to implement the 5C Program, develop Waste Discharge Requirements or a waiver of WDRs for that county.

Timeline

- June 2011

Siskiyou, Humboldt, Del Norte and Trinity Counties:

Measure

- Implement measures through the Five Counties Salmonid Conservation Program.

Timeline

- Pursuant to the 5C Program timelines.

6.5.5.6 California Department of Transportation

In the Klamath River basin within California, Caltrans has jurisdiction over segments of three state highways: State Route 96, State Route 169, and State Route 299. There are also two segments of the federal transportation system that Caltrans manages and maintains within the Klamath River basin in California: U.S. Interstate Highway 5 and U.S Interstate Highway 101. Discharges of waste from Caltrans' facilities are regulated by the State Water Board under the NPDES Permit for Caltrans (Order No. 99-06-DWQ and NPDES No. CAS000003), adopted on July 15, 1999. The State Water Board is in the process of revising the Caltrans NPDES permit with input from the Regional Water Boards.

The Klamath TMDL analysis identified Caltrans facilities as contributing to water temperature impairments mainly through the discharge of excess sediment (e.g. eroding shoulders, failed culverts, and unstabilized cut and fill slopes). The Klamath implementation plan recommends measures for Caltrans to implement basinwide through their Statewide NPDES permit. The Scott and Shasta TMDL implementation plans also address discharges from Caltrans facilities and both require the Regional Water Board to evaluate the adequacy of the Caltrans NPDES permit. Since the permit is being revised, there is an opportunity to incorporate TMDL measures for all three TMDLs into the permit based on the Regional Water Board's evaluation. The Klamath implementation plan makes the following recommendations concerning Caltrans facilities:

1. Include measures in the revised NPDES permit consistent with the Guidance to Control Excess Sediment for Caltrans facilities in the Klamath basin.
2. Incorporate measures to protect riparian shade in the revised NDPES permit and in 401 water quality certifications, and
3. Remove barriers to migratory fish passage associated with Caltrans road and highway facilities in tributary creeks identified in the Thermal Refugia Protection Policy.

Senate Bill 857 (Kuehl 2005), enacted into law effective January 1, 2006, requires Caltrans to prepare a yearly report describing its efforts to assess and remediate the negative impacts of state highway or road structures that serve as barriers to migratory fish passage. This mandate is consistent with the goals of the implementation plan to protect and provide access to thermal refugia in and around the mouths of tributaries to the mainstem Klamath River. There are several barriers to migration along Highway 96 caused by undersized culverts and the presence of the highway. If fish barrier removal in thermal refugia cannot be incorporated into the NPDES permit, the implementation plan contains a recommendation to Caltrans to implement this measure.

<u>Implementation Measures for Caltrans Facilities</u>

State Water Board and Regional Water Board:

<u>Measure</u>

- Incorporate the following measures into the Caltrans NPDES permit:
    1. <u>Inventory</u>: Identify sources of excess sediment discharge or threatened discharge and quantify the discharge or threatened discharge from the source(s).
    2. <u>Prioritize</u>: Prioritize efforts to control the inventoried sediment sources based on, but not limited to, severity of threat to water quality and beneficial uses, the feasibility of source control, and source site accessibility.
    3. <u>Schedule</u>: Develop a schedule to implement the cleanup of excess sediment discharge sites.
    4. <u>Implement</u>: Develop and implement feasible sediment control practices to prevent, minimize, and control the discharge.
    5. <u>Monitor and Adapt</u>: Use monitoring results to direct adaptive management in order to refine excess sediment control practices and implementation schedules.
- Incorporate measures to meet the riparian shade allocation in the statewide Caltrans NPDES permit and 401 water quality certifications.

<u>Timeline</u>

- The revised statewide Caltrans NDPES permit is scheduled for adoption by the State Water Board by August 2010, with USEPA adoption anticipated by December 2010.

Caltrans:

<u>Measure</u>

- Implement the measures outlined above to control the discharge of excess sediment from their facilities and comply with the Klamath TMDL allocations and targets, even if measures are not incorporated into the statewide Caltrans permit.

Measure

- Implement measures to meet the riparian shade allocation, even if measures are not incorporated into the statewide Caltrans permit.

Measure

- Fully assess all barriers and potential barriers to migration caused by Caltrans road and highway facilities along the mainstem Klamath River and in the tributary watersheds identified in the Thermal Refugia Protection Policy. Develop a priority ranking and time schedule for modifying the identified fish passage barriers to accommodate free passage of fish upstream and downstream.

Timeline

- Caltrans shall submit an annual report to the Regional Water Board documenting measures taken to address fish passage barriers caused by its facilities.

6.5.6 Agriculture (Grazing and Irrigated Agriculture)

Agricultural activities in the Klamath River basin have the potential to contribute to TMDL impairments mainly through erosion, alteration of riparian functions, discharge of nutrients and organic matter, and water diversions. Grazing on nonfederal lands in California occurs mostly in the tributary basins in the upper middle reach of the Klamath River from Scott River to Iron Gate dam, including the Scott and Shasta River basins, and in the Lost River basin that drains into the Klamath River in Oregon. Irrigated agriculture occurs in the Klamath River basin in California mostly in the tributary basins in the upper middle reach of the Klamath River from Scott River to Iron Gate dam, including the Scott and Shasta River basins, and in the Lost River basin that drains into the Klamath River in Oregon. The Regional Water Board currently does not regulate agricultural activities in the Klamath River basin, except through waivers of WDRs adopted as part of the Scott River and Shasta River TMDL Action Plans or through an NPDES permit if an operation is classified as a concentrated animal feeding operation (CAFO).

6.5.6.1 Responsible Parties

Parties conducting activities associated with irrigated agriculture and grazing that discharge waste or have the potential to discharge waste in the Klamath River basin in California

6.5.6.2 Implementation

Several changes have been made in the regulatory approach to grazing and irrigated agriculture based on comments received during the public comment period since the last draft. Many of the commenters stated that the draft implementation measures were confusing and did not provide for a streamlined regulatory approach. Staff also received numerous comments on the proposed agricultural waiver and the interim waiver requirements for agriculture proposed in the June 2009 draft. The interim waiver would have required agricultural dischargers to comply with various implementation measures, which included the development of a water quality management plan. Commenters stated that they were not aware that the Klamath TMDL would impose additional requirements on responsible parties in the Scott and Shasta basins, where landowners are already subject to the requirements of previously adopted TMDLs. Staff also received comments stating that stakeholders were not involved enough in the development of the recommended implementation measures for agriculture and called for a public process to develop the waiver.

Staff considered comments and the potential for overlapping regulatory requirements in the Klamath Basin and decided to remove the recommendation of an interim waiver and specific requirements in order to allow time for the agricultural conditional waiver program to be fully developed. It is staff's intention that the stakeholder process will lead to a sensible agricultural program developed in collaboration with the regulated community and all interested stakeholders. The Regional Water Board will initiate the stakeholder process after adoption of the TMDL. In the interim time period before the waiver is adopted, the Klamath implementation plan recommends several steps for landowners to take that will help to develop the waiver program:

1. Document past projects and current practices that address sources of pollution from their operations.
2. Organize into watershed groups to report to the Regional Board as a group as part of the future waiver program.
3. Participate in the development of the conditional waiver through a Technical Advisory Group that will convene to develop the draft waiver by December 2011.
4. Attend water quality training on implementing management practices and/or water quality management plan development.
5. Sign up on the Regional Water Board Klamath River TMDL mailing list to receive information about the development of the waiver and water quality training.

6.5.6.3 Content of the Future Agricultural Waiver

Staff also received comment concerning specific requirements for agriculture and the content of the proposed waiver program. Regional Board staff have not yet decided on the appropriate recommendations, which will depend the outcome of the stakeholder process. The issues that were raised by the commenters will be included on the agenda for the stakeholder meetings. In general, the agricultural waiver would support a locally driven landowner effort to control these sources of pollution and report on progress to the Regional Board. There will also be a provision to define and allow de minimus discharges under the waiver program.

Under the conditions of the waiver, agricultural owner/operators would work towards meeting water quality standards for the State of California. The waiver requirements will be based on meeting applicable water quality standards, and effective implementation will depend on local landowner knowledge in identifying management practices. While the waiver will establish the performance standards that must be met, landowners will have the flexibility to choose the management practices that are appropriate for their operation and protect water quality.

Compliance would be achieved by actively identifying sources of pollution, implementing management practices to control those sources, documenting efforts, monitoring, and reporting to the Regional Water Board. It is generally the owner/operator's responsibility to select the management practices that are most effective at controlling pollution from their lands. The Regional Water Board staff are considering developing a checklist to assist in the selection of the appropriate management practices and also to serve as the reporting mechanism to track compliance.

The Regional Board is flexible in its approach to a waiver and would like to incorporate existing programs and input from the affected communities as part of the process. The information provided below is intended to provide an idea of what a conditional waiver for agricultural activities might look like and to solicit input on its development. These provisions are not requirements of the Klamath TMDL and are provided for informational purposes only.

To address sources of pollution, the waiver may include conditions such as:

1. Minimizing water contact with animal manure and preventing livestock from damaging streams and riparian vegetation
2. Managing riparian areas
3. Controlling nutrients and elevated temperatures in tailwater.

The State Nonpoint Source Program Plan provides performance standards called 'management measures' to guide implementation of water quality control practices. The management measures are grouped into the following categories in the plan:

- Erosion and Sediment Control
- Nutrient Management
- Irrigation Water Management
- Grazing Management
- Pesticide Management

These management measures are available at the following website: http://www.waterboards.ca.gov/water_issues/programs/nps/docs/guidance/agricmms.pdf.

Examples of management practices that may be implemented to meet the NPS Program Plan management measures are provided by the following reference:

- USEPA *National Management Measures for the Control of Nonpoint Pollution from Agriculture* is available from the USEPA or may be printed from the following website: http://www.epa.gov/nps/agmm/index.html.

6.5.6.4 Monitoring and Reporting

The waiver must contain monitoring and reporting conditions to track compliance with water quality standards. Enrollees in the waiver would have the option of reporting to the Regional Water Board either individually or as part of a group organized by a third party such as the local resource conservation district or watershed council. The Regional Water Board would review the effectiveness of the waiver program at least every five years and make changes as needed considering discharger compliance rates and water quality conditions. The monitoring and reporting requirements would be developed to achieve the following objectives:

1. Document the implementation of management practices selected to address water quality problems associated with agricultural operations
2. Evaluate the effectiveness of the selected practices
3. Measure long-term trends in water quality to evaluate the overall effectiveness of the waiver program. Long term trend monitoring may be done through either an existing group monitoring program or a through a group program that is developed to track compliance with the waiver.

6.5.6.5 Other Regional Board Agricultural Programs Around the State

There are agricultural waivers in place for Regions Water Boards 2 (San Francisco), 3 (Central Coast), 4 (Los Angeles), 5 (Central Valley), and 9 (San Diego). A description of the current North Coast Regional Water Board (Region 1) existing interim TMDL waivers and the agricultural waiver programs in Region 2 and 3 is provided below as examples of existing agricultural regulatory programs in California. More information about these programs can be found on each region's respective websites that can all be accessed from www.waterboards.ca.gov.

Region 1

The North Coast Regional Water Board adopted two separate waivers as a part the Scott and Shasta basin TMDL implementation plans. These waivers have been in effect since adoption of those TMDLs in 2005 and 2006 respectively and will expire in five years from the date of adoption. The waiver requires responsible parties in those basins to participate in ongoing programs that address discharges that contribute to TMDL impairments. Staff have periodically updated the Regional Water Board on the progress of implementation in the Scott and Shasta basins. The Regional Water Board will consider whether or not to extend the TMDL waivers when they expire in 2010 for the Scott basin and 2011 for the Shasta basin. The Regional Water Board may decide not to extend the existing TMDL waiver and instead incorporate the measures in the Scott and Shasta implementation plans into the development of the agricultural waiver proposed in the Klamath TMDL to make requirements of agricultural discharges more consistent throughout the basin.

Region 2

The San Francisco Regional Water Board (Region 2) adopted a waiver to regulate discharges associated with grazing activities in the Tomales Bay basin in July 2008 as part of TMDL implementation in that basin. The waiver requires the submittal of a Notice of Intent (NOI) to enroll in the waiver program, due in January 2009. It also requires ranchers to develop a Farm Plan by November 2009 and keep it onsite. The NOI asked for the address of the owner/operator, identification of the receiving water(s), whether a farm plan has been completed or will be by November, and if the facility is in compliance with the waiver conditions. The waiver requires annual certification which consists of the submittal a single page of the farm plan template that was provided to ranchers. The submittal page asks for:

- the name/address/APN
- when a ranch plan is to be completed or when it was completed
- the dates of compliance monitoring inspections performed during the wet season and dry season
- when a survey of streams on the ranch was completed
- whether further BMPs are needed and if yes when such projects will be completed.
- The Farm Plan is a fill in the blank exercise and includes the following required information:
- Property information
- A field assessment with a checklist addressing rangeland conditions, roads, livestock distribution, manure management, and mercury.
- A stream assessment with a similar checklist addressing the stream channel, stream temperature factors, and algae growth in the stream.
- A list of past water quality projects completed is optional but information regarding future water quality projects is required.

Region 3

The Central Coast Regional Water Board (Region 3) adopted a waiver to address all discharges associated with irrigated lands in July, 2004. The waiver required the submittal of an NOI by January 1, 2005; 6 months after adoption of the waiver. Their NOI form requested basic information such as address, whether monitoring would be done as a group or individually, whether a farm plan has been completed, and the hours of water quality education that had been completed. It also required the following to be submitted alongside the NOI:

- A ranch information form that asked for the APN, the types of crops grown, how many acres of sprinkler irrigation, flood irrigation, etc.
- A map of the property
- A certificate of completed education if applicable

- A management practices form that consisted of a checklist of about 40 questions in four categories: pesticide management, irrigation water management, nutrient management, and erosion control. The rancher could circle 'yes, I am doing this', 'no, but I plan to within 3 years', or 'no and not planned'.

Implementation Measures for Agriculture

Regional Water Board:

Measure

- Develop a conditional waiver of WDRs for discharges associated with agricultural activities, including grazing and irrigated agriculture, in the Klamath River basin. The conditional waiver shall require compliance with the Klamath River TMDL load allocations where they apply and will serve as the means of compliance with the Lower Lost River TMDL load allocations associated with agricultural sources. Timeline
- Regional Water Board staff shall propose the conditional waiver for Regional Water Board consideration by December 2012.

Any party conducting activities associated with irrigated agriculture that discharge waste or have the potential to discharge waste in the Klamath River basin in California:

Measures (recommended)

- Document past projects and current practices that address sources of pollution from their operations.
- Organize into watershed groups to report to the Regional Board as a group as part of the future waiver program.
- Participate in the development of the conditional waiver through a Technical Advisory Group that will convene to develop the draft waiver by December 2011.
- Attend water quality training on implementing management practices and/or water quality management plan development.
- Sign up on the Regional Water Board Klamath River TMDL mailing list to receive information about the development of the waiver and water quality training.

Timeline

- From Regional Water Board adoption of the Klamath TMDL Action Plan until adoption of the conditional waiver addressing agricultural discharges

6.5.7 Timber Harvest on Nonfederal Lands

Timber harvest activities can impact water temperature and can contribute to dissolved oxygen and nutrient water quality impairments. The Klamath River TMDL implementation plan focuses on controlling sediment and protecting riparian functions from timber harvest activities to meet the watershed-wide TMDL allocations and targets. Timber harvest on nonfederal lands is currently regulated through a combination of general WDRs (Order No R1-2004-0030) and a conditional waiver of WDRs (Order No R1-2009-0038). The existing general WDRs and waiver contain a requirement that all provisions of the Basin Plan must be met to qualify for enrollment in the WDRs or waiver. By amending the Basin Plan through adoption of the Klamath River TMDL Action Plan, the requirement to meet the TMDL load allocations will be incorporated by reference into the existing general WDRs. The waiver contains TMDL requirements for temperature based on 85%/65% canopy, which is slightly different terminology from the Anadromous Salmonid Protection (ASP) Rules recently adopted by the California Board of Forestry. The implementation recommendations for shade conditions described below are consistent and equally protective as the shade conditions in the existing conditional waiver of WDRs for timber harvest activities on nonfederal lands, and may be used for enrolling THPs under the waiver until the waiver is updated.

6.5.7.1 Responsible Parties

- Regional Water Board
- Any party conducting timber harvest activities that discharge waste or have the potential to discharge waste in the Klamath River basin

6.5.7.2 The General WDRs

In 2004, the Regional Board adopted Order R1-2004-030: *General Waste Discharge Requirements for Discharges Related to Timber Harvest Activities on Non-Federal Lands in the North Coast Region*. These General Waste Discharge Requirements (WDRs) rely on the *Forest Practice Rules* (FPRs) managed by CALFIRE as lead agency, as the baseline requirements to achieve water quality goals. Per CEQA, under separate and concurrent authority established by the Porter-Cologne Water Quality Control Act, the Regional Water Board may impose additional restrictions to achieve compliance with water quality standards. The WDRs require:

1) Notification of a discharge that violates water quality standards, and a schedule for addressing the problem.
2) Implementation of an ECP (similar to the ECP required by NTMP categorical waiver) for the project area.

3) Regular self inspections to track the effectiveness of implementation. Inspections are to take place before, during, and after the winter period.

6.5.7.3 Watershed-wide and Ownership WDRs

Timber companies and larger landholders may also be permitted through watershed-wide or ownership WDRs. Watershed-wide WDRs are issued for timber harvest activities within a specific watershed. The watershed may be fully contained within the permit holder's ownership, or the watershed may cross ownership boundaries. The ownership WDRs, on the other hand, may apply to the permit holder's entire property, crossing watershed boundaries. These WDRs represent a programmatic approach to addressing water quality concerns and are more comprehensive than the general permit or waivers. They can be made more specific to the ownership or watershed as a whole. Future ownership or watershed-wide WDRs adopted will incorporate measures necessary to meet the TMDL load allocations and water quality standards in the Klamath Basin.

6.5.7.4 Individual WDRs

The Regional Board may choose to regulate a given timber harvest project through individual WDRs if the General WDRs are not appropriate. Individual WDRs contain requirements that are more specific to the threats to water quality proposed by the THP. To implement the TMDL, the Regional Board will include Klamath implementation plan measures as part of individual WDRs for timber harvest activities in the Klamath Basin.

6.5.7.5 Board of Forestry Forest Practice Rules

Timber harvest on nonfederal lands is also subject to the requirements of the California FPRs. These rules were recently amended to include the *Anadromous Salmonid Protection Rules* (a subset of the FPRs that applies to CALWATER planning watersheds where populations of anadromous salmonids are currently present or can be restored). The FPRs may be sufficient to implement the Klamath TMDL in many situations; however, the FPRs may not always be protective enough to meet the water quality standards.

6.5.7.6 Riparian Shade Allocation and Temperature Water Quality Standards

The riparian shade allocation in the Klamath TMDL is based on the existing intrastate water quality objective for temperature. The allocation requires the shade provided by topography and full potential vegetation conditions at a site, with an allowance for natural disturbances such as floods, wind throw, disease, landslides, and fire. Regional Water Board staff prefer to rely on the FPRs to address water temperature concerns related to timber harvesting, and wish to avoid establishing different rules governing the same activity. Regional Water Board staff have reviewed the ASP Rules and determined that the new rules substantially increase riparian retention standards, and are much more protective of stream temperatures than the previous rules. In most cases, timber operations occurring in areas where the ASP rule canopy prescriptions apply will achieve compliance with the temperature TMDL. However, while the ASP Rules are expected to address temperature issues in the majority of timber harvest situations, they do not ensure compliance with the temperature water quality objective nor the Klamath TMDL riparian shade allocation in all cases where they apply. There are instances where adherence to the ASP rules would result in a reduction in riparian shade and an increase in water temperature that is not consistent with the allocation or water temperature objective. An example of a circumstance where the ASP Rules are insufficient is in a 'Class II small' stream where they only require 50% canopy retention where cold-water dependent species are present. In addition, nothing in the ASP Rules prevents a five degree increase in water temperature, which the temperature objective specifically prohibits. A noticeable gap in the ASP Rules is that they only apply in watersheds that are within the range of anadromous salmonids, while the water quality objective for temperature applies to all waters of the state, regardless of what species are present. Therefore to comply with the TMDL, responsible parties may be required to implement additional riparian shade protections where Regional Water Board staff determines that the Forest Practice Rules are insufficient to meet the Klamath TMDL allocation. Regional Water Board staff recommend and may require foresters manage riparian areas consistent with the Anadromous Salmonid Protection Rules' riparian prescriptions where salmonids are present regardless of whether a reach is open to anadromy. Foresters proposing to reduce effective shade on watercourses or prevent recovery of site-potential shade must justify such proposals in light of the water quality objective for temperature. To meet the water temperature objective, which applies regionwide, and to address gaps in ASP riparian protections, it is recommended that this approach also be incorporated into all WDRs, and conditional waivers of WDRs regionwide.

6.5.7.7 Existing Plans and Programs

Parties conducting timber harvest activities in the Klamath Basin may have already developed property-wide plans that include water quality protections. Existing plans and programs may be used to fulfill the requirements of the TMDL. For example, industrial timber companies may be implementing a Habitat Conservation Plan (HCP) as part of their Endangered Species Act (ESA) compliance. To obtain a federal incidental take permit, authorizing 'incidental take' of an ESA listed species, an applicant must submit a Habitat Conservation Plan (HCP) outlining what will be done to "minimize and mitigate" the impact of the permitted take. The impact of the 'take' in many cases relates to impacts on water quality, and thus the HCP in many cases contains water quality protections relevant to TMDL implementation. Green Diamond completed their HCP in 2007, which considers impacts to listed species on company lands and includes water quality protections. Another existing management plan that may be used in part to comply with the TMDL is the Non-Industrial Timber Management Plan (NTMP). NTMPs are developed by individual landowners with holdings under 2500 acres to comply with the FPRs and must include water quality protection measures. In either case, plans or programs may need to be updated, and/or additional measures may need to be developed and implemented in order to comply with the TMDLs and water quality standards. Regional Board staff will work with landowners to implement the Klamath TMDLs through these existing programs.

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Implementation Measures for Timber Harvest on Nonfederal Lands

Regional Water Board:

Measure
- The Regional Board shall adopt individual watershed-wide and ownership WDRs, in lieu of the general WDR or conditional waiver of WDRs, to achieve the TMDL load allocations and water quality standards as needed and/or at the request of the discharger.

Measure
- Regional Water Board staff shall make recommendations for additional measures to ensure the water quality objective for temperature is achieved during the timber harvest review process, if necessary

Timeline
- Ongoing

Parties conducting timber harvest activities on nonfederal lands that discharge waste or have the potential to discharge waste in the Klamath River basin:

Measure
- Implement riparian management measures that meet the riparian shade allocations and water quality standards. Where the Forest Practice Rules, including the ASP rules, are not sufficient to meet the TMDL allocations or water quality standards, implement additional measures as directed by Regional Water Board staff during the timber harvest review process.

Timeline
- Ongoing

6.6 TMDL Implementation on Federally Managed Lands

There are two federal land managers in the watershed, BLM and the USFS. The USFS manages over half of the total acreage in the Klamath River basin in California on four National Forests: Six-Rivers, Klamath, Shasta-Trinity, and Modoc. Land use activities on USFS lands that were identified in the Klamath River TMDL as potentially contributing to the TMDL impairments include but are not limited to timber harvest, grazing, and road construction and maintenance. BLM manages small, isolated areas of land in the Klamath

River basin in California, and therefore the implementation plan focuses on the lands managed by the USFS. The approach to regulating USFS activities will inform our approach to BLM in the future.

The Regional Water Board regulates USFS timber harvest activities through an existing regionwide waiver of WDRs, and Regional Water Board staff are in the process of developing a new waiver of WDRs that would be expand oversight to most nonpoint source activities on lands managed by the USFS. The new waiver is scheduled to be considered by the Regional Water Board for adoption in April 2010 and would take the place of the existing timber harvest waiver. The waiver will implement applicable provisions of the State NPS Policy to establish a regulatory mechanism for all nonpoint source discharges. It will contain measures that implement existing TMDLs in the North Coast Region including the proposed Klamath TMDL. Meeting the conditions of the proposed regionwide waiver will be sufficient for TMDL compliance in the Klamath basin in California. The waiver is coordinated with existing USFS plans and programs that address water quality in the Klamath River basin and is being developed with input from the USFS. This section first gives the recommended implementation measures and then describes the water quality elements of existing USFS plans and programs and how they can be coordinated with TMDL requirements.

6.6.1 Responsible Parties

- Regional Water Board
- US Forest Service
- Parties conducting timber harvest activities on federal lands under the terms of a timber harvest sale contract.
- Parties conducting grazing activities on federal lands in designated grazing allotments.

Implementation Actions

Regional Water Board:

Measure
- Develop a conditional waiver of WDRs for nonpoint source activities on USFS lands that includes conditions that implement the Klamath TMDL.

Timeline
- To be proposed for consideration by the Regional Water Board in April 2010.

USFS:

Measure
- Conduct land management activities in compliance with the waiver of WDRs when adopted.

Timeline
- As required in the waiver of WDRs.

6.6.2 USFS Plans and Policies

As a manager of the National Forests, the USFS follows several policy documents and administrative rules that address water quality concerns The guiding policy for USFS water quality management at the statewide level in California is the *Water Quality Management for Forest System Lands in California, Best Management Practices* (USFS 2000) guidance document developed jointly by the State Water Board and the USFS. The USFS adopted the federal *Northwest Forest Plan* (USFS 1994b) standards and guidelines, and the *Aquatic Conservation Strategy*. The National Forests have incorporated this policy direction into their forest level *Land and Resource Management Plans* (USFS 1994a, USFS 1994c, and USFS 1995). While Regional Water Board staff support these plans and policies as viable implementation vehicles, there is also an expectation that the plans be revised as necessary to comply with the TMDL. Regional Water Board staff will continue to work with the USFS to ensure these programs effectively meet TMDL allocations and targets in the Klamath Basin.

6.6.2.1 <u>State Water Board and USFS guidance document</u>

In 1981, the State Water Board and the USFS entered into a Management Agency Agreement (MAA) in which the USFS agreed to implement the 1979 *Water Quality Management for Forest System Lands in California, Best Management Practices* that protect water quality on USFS lands in California (USFS and SWRCB 1981). In 2000, the USFS revised some of the performance standards for meeting water quality standards and released an updated version of the *Water Quality Management for Forest System Lands in California, Best Management Practices* (USFS 2000) guidance document. The performance standards described in this document for different categories of land use are called ‘Best Management Practices’. This terminology is slightly confusing because the document refers to performance standards as ‘Best Management Practices’ (BMPs) that are met through the implementation of appropriate management practices, whereas the term ‘BMP’ usually refers to the practices themselves. For example, in the guidance document, “BMP 2-7 ‘Control of Road Drainage’ dictates that roads will be correctly drained to disperse water runoff to minimize the erosive effects of concentrated water flow” (USFS 2000). This is a performance standard that must be met through the implementation of on-the-ground practices that are not specified in the document, such as the installation of rolling dips or road outsloping. The USFS forms interdisciplinary teams to select the appropriate practices that meet the performance standards based on an assessment of project site conditions. It is essential that the practices selected to meet the water quality ‘BMPs’ be included in any project controlling documents to ensure practices are implemented as part of the project. Regional Water Board staff continues to actively work with the USFS staff to identify where and when the selected management practices are identified in their planning documents.

6.6.2.2 <u>Northwest Forest Plan</u>

The Northwest Forest Plan (NWFP) was adopted by the USFS in 1994 and is implemented by the National Forests in the Klamath River basin. The mission of the NWFP is to adopt coordinated management direction for the lands administered by the Federal government, including the USFS. The Northwest Forest Plan Record of Decision (USFS 1994b) presents a combination of land allocations and "Standards and Guidelines" for the management of those allocations. While the Standards and Guidelines consider more than just water quality protection, the NWFP also includes the Aquatic Conservation Strategy (ACS) that specifically focuses on water quality. Regional Water Board staff support the objectives of the ACS as consistent with the objectives of Klamath TMDL implementation. The ACS can be found at: <http://www.reo.gov/library/reports/newsandga.pdf> (page B-9).

6.6.2.3 Land and Resource Management Plans

The USFS forest-level planning documents are called Land and Resource Management Plans (LRMPs). Each National Forest in the Klamath River basin has their own LRMPs that guide their land management activities. Shortly after the NWFP went into effect, the National Forests updated their LRMPs to incorporate the new Standards and Guidelines and the ACS. The LRMPs also incorporate the State Water Board and USFS guidance document described above. The Regional Water Board staff support the implementation of the LRMPs as a means to achieve the watershed-wide allocations and targets. The Regional Water Board will work with the USFS to update their LRMPs as necessary.

6.6.3 Timber Harvest

Currently, the Regional Water Board regulates timber harvest on federal lands through a conditional waiver of waste discharge requirements (Order No R1-2004-0015). The waiver and its regulatory requirements will be incorporated into the future waiver that addresses other nonpoint source activities conducted by the USFS. The current timber waiver contains requirements that will be carried over into the new waiver and will be coordinated with TMDL implementation. Per the current waiver conditions, the USFS must include water quality control practices from the *Water Quality Management for Forest System Lands in California, Best Management Practices* (USFS 2000) guidance document and conduct an analysis of the cumulative effects of the permitted project. The cumulative effects analysis uses one or more models to determine whether the proposed project will raise the local watershed above a predetermined 'threshold of concern'. If the watershed is found to be above the threshold, or the project will put the watershed over the threshold, the USFS is required to implement a monitoring plan for the project. The monitoring plan should be developed in part to track compliance with TMDL requirements.

6.6.3.1 USFS Water Quality Guidance Document

The 'BMPs' or performance standards for timber harvest activities are organized into the following categories: timber management, road and building site construction (related to timber harvest), vegetation manipulation, fire suppression and fuels management, and watershed management. For every USFS timber harvest project, an interdisciplinary team conducts an onsite evaluation of the project area to identify the applicable performance standards and appropriate management practices. The guidance document establishes the means for implementing the selected practices on the ground. "The appropriate BMPs, and the methods and techniques of implementing the BMPs, are included in the environmental documentation, permit, contract, or other controlling document used to conduct and administer the project" (USFS 2000).

Implementing this process for each USFS timber harvest project is essential to meeting TMDL requirements, and the USFS includes the selected practices in their project document prepared pursuant to the National Environmental Policy Act (NEPA). The selected management practices must also be included in the timber sale contract or other controlling document used to administer the project as stated in the guidance document. Regional Water Board staff will review the NEPA document and any other controlling documents to ensure that the management practices proposed by the USFS meet the TMDL allocations and targets. Regional Water Board staff will continue to coordinate TMDL implementation with the USFS through the future waiver proposed for Regional Water Board consideration in April 2010. There is no need for additional TMDL implementation measures at this time. Regional Water Board staff will also work with the USFS to track progress towards meeting the watershed-wide targets and allocations.

6.6.4 Grazing

Grazing on federal lands principally takes place in the Klamath and Shasta-Trinity National Forests on designated grazing allotments. The allotments have been in use since the early 1900's and are mostly located in high mountain meadows closer to the headwaters of Klamath River tributaries. Grazing is managed by the USFS through the development and implementation of individual Allotment Management Plans (AMPs). Every year, the USFS develops Annual Operating Instructions (AOIs) for each allotment to implement the AMPs based on the current conditions of the allotment. Ranchers grazing animals on federal lands are required to follow the AOIs as well as meet the overall AMP objectives in order to continue grazing the allotment.

6.6.4.1 USFS Water Quality Guidance Document

The agreement on performance standards between the USFS and the State Water Board serves as the basis for controlling water quality impacts from grazing. An interdisciplinary team determines the management practices included in the AMP following an onsite evaluation of the project area. Regional Water Board staff are supportive of this process as a means to meet the TMDL allocations as long as the AOIs are effective and enforceable. The 'BMPs' or performance standards for grazing activities on federal lands identified in the guidance document include the following:

- *Range Analysis and Planning*: The district ranger is responsible for the analysis of range allotments and the preparation of AMPs. The permittee is expected to carry out the AOIs under the immediate direction and supervision of the district ranger.
- *Grazing Permit System*: Field checks and measurements will be made annually by the USFS. The grazing permit will be modified, cancelled or suspended in whole or part as needed to ensure proper use of the range resource and protection of other resources, such as water quality.
- *Rangeland Improvements*: The grazing allotment analysis may indicate the need for certain rangeland improvements such as further protection of sensitive areas, stream channel stabilization measures or water

developments. The district ranger will assure that the permittee is involved as a cooperator in rangeland improvements (USFS 2000).

The LRMP for the Klamath National Forest gives the following goals for grazing management that are consistent with TMDL implementation (USFS 1994a):

- Manage vegetation to provide for healthy ecosystems and to make forage available on a sustainable basis for use by livestock, wildlife and wild horses. Manage vegetation to provide for a desired condition of herbaceous shrub and forested vegetation according to site potential and resource needs.
- Manage grazing activities to not retard or prevent attainment of the Aquatic Conservation Strategy objectives.

Regional Water Board staff recommend that the USFS meet the above performance standards in their project document prepared pursuant to the National Environmental Policy Act (NEPA) as part of Klamath TMDL implementation. The management practices selected to meet the performance standards must be included in the grazing AMP, AOIs, and other controlling document(s) used to manage the allotment. Grazing activities on federal lands will be addressed as part of the proposed waiver of WDRs.

6.6.5 Road Management

The USFS is responsible for managing well over 10,000 miles of roads on federal lands within the Klamath River basin on four National Forests. This extensive road network has been identified in the Klamath technical analysis as contributing to the TMDL impairments. The water quality impacts of roads are described in section 5.2.1.2. The Klamath Implementation Plan focuses on road management in the Klamath, Six Rivers, and Shasta-Trinity National Forests.

Regional Water Board staff recommend that the proposed waiver of WDRs should require the USFS to continuously inventory and address sources of sediment from roads across its ownership as needed; similar to the process outlined in the Guidance to Control Excess Sediment. This approach is consistent with existing USFS programs to inventory and assess roads on federal lands. Existing programs are being coordinated with TMDL implementation and compliance with the proposed waiver.

6.6.5.1 USFS Water Quality Guidance Document

The guidance document describes 28 'BMPs' or performance standards that must be met to control nonpoint source pollution from roads on federal lands. The BMPs address aspects of road management such as planning, erosion control, slope stability, stream crossing installation, riparian management, maintenance, decommissioning, and others. Klamath River TMDL implementation requires the selection and timely implementation of the appropriate management practices that meet the BMP performance standards in the guidance document. Staff recommend that the proposed waivers of WDRs for most nonpoint source activities on federal lands include, as a condition of the waiver, a requirement to meet the performance standards described in the guidance document.

6.6.5.2 USFS Road Maintenance Needs

The National Forests are directed by the USFS Road Management Policy (USFS 2001) to assess the status of the road network on National Forest lands and to minimize the network to the extent feasible. Part of the reason for this is that the National Forests, including those in the Klamath River basin, do not have adequate funding for maintenance of the current road network. Changes in timber harvest practices have also resulted in a reduction of the miles of road needed to manage timberlands. In the Shasta-Trinity National Forest, for example, only 20% of the roads are maintained to design standards, and as of 2002, there was a $76 million backlog of deferred maintenance (USFS 2002b). Without proper maintenance, roads have a higher probability of failing and contributing sediment that can alter stream temperatures. Regional Water Board staff support the USFS Road Management Policy and encourage the USFS to reduce road densities on federal lands through road decommissioning. Reducing road density has the added benefit of increasing infiltration, which can add base flow to Klamath River tributaries. Regional Water Board staff recognize that decommissioning roads is not always the most prudent use of available road maintenance funds.

6.6.5.3 USFS Road Management Policy

The National Forests are directed to reduce the impacts of roads on natural resources in the USFS Road Management Policy and the Northwest Forest Plan. The National Forests in the Klamath River basin are responding to this directive by assessing sediment sources and threats to water quality on National Forest land and implementing road restoration and decommissioning projects as funding permits. This existing assessment and prioritization process can be used to comply with the Klamath River TMDLs. The Regional Water Board will work with the USFS to ensure their efforts are consistent with TMDL implementation and water quality standards. The following are descriptions of the existing road management programs in each of the National Forests.

6.6.5.4 Existing Road Management in the Klamath National Forest

The Klamath National Forest (KNF) developed the *Klamath National Forest Forestwide Roads Analysis* (USFS 2002a) that addresses road impacts to natural resources and guides the restoration actions related to roads. To date, KNF staff have conducted Road and Sediment Source (RSS) inventories in the following watersheds: Elk, Indian, Irving, Ti, Clear, Dillon, upper Beaver, Grider, and Horse Creeks, and the Salmon and Scott Rivers. The RSS inventories identify "specific locations where road drainage structures and fill have the potential to adversely impact watershed processes, then assess the relative environmental risk of each site" (USFS 2002a). The completed inventories and sediment source ratings are used to prioritize road restoration projects in the KNF. KNF has implemented fixes on the top 10% of sediment sources identified in the RSS assessments. Road management measures are recommended as part of watershed levels analyses. Once Environmental Assessments for the analyses are completed, KNF will begin implementing road maintenance measures based on funding and priority.

6.6.5.5 Existing Road Management in Six Rivers National Forest

The Six Rivers National Forest staff analyze the road network by ranger district. *The Orleans Roads Analysis and Off-Highway Vehicle Strategy* (USFS 2006) (Orleans RAP) recommends road management measures in the Orleans Ranger District; the only Six Rivers district in the Klamath River basin. The Orleans RAP tiers to the *Six Rivers National Forest Roads Analysis*, which is a forest-level plan for roads. Where the forest-level plan only evaluates passenger car roads of Maintenance Levels 3-5, the Orleans RAP evaluates high clearance roads (Levels 1-2) and non-system roads in the forest. The findings of the Orleans RAP can be used to develop a prioritization strategy for road restoration work in the Orleans Ranger District. The analysis identified the following items that relate to controlling the impacts of sediment from roads in the Orleans Ranger District:

- needed and unneeded roads,
- site-specific priorities for improvements and decommissioning, and
- roads associated with environmental risk (USFS 2006).

Projects to implement the RAP will be funded based on availability of grants and data from the roads analysis. The Regional Water Board staff will work with the Six Rivers Forest staff on prioritization of road restoration work that will address the impacts of sediment on Klamath River tributaries and thermal refugia in the mainstem Klamath River.

6.6.5.6 Existing Road Management in Shasta-Trinity National Forest

The Shasta-Trinity National Forest staff completed their forest-level roads analysis in July 2002 entitled the *Shasta-Trinity National Forest Roads Analysis Report* (USFS 2002b). This forest-level analysis evaluates passenger car roads of Maintenance Levels 3-5 and makes recommendations regarding road maintenance needs and prioritization. High clearance roads (Levels 1-2) and non-system roads are evaluated in watershed-level analyses that tier to the forest-level analysis.

6.6.6 Fire Management

Wildfires are common during the summer in the Klamath River basin and can lead to severe impacts on water quality through the destruction of riparian vegetation and increased runoff and erosion rates. The fire regime in the Klamath River basin has been altered through years of suppression that has resulted in increased fuel loads and fire severity. The USFS carries out timber harvest projects related to fire management both to control fuel loads and to salvage timber after a fire. The Regional Water Board’s current waiver for timber harvest activities on federal lands covers these projects. The USFS also takes measures to control erosion after a wildfire that focus on maintenance of drainage features and revegetation if needed. The practices for controlling post fire erosion sources are, in most cases, the same as those used to control erosion sources on forestlands with the added consideration of increased runoff volume. Regional Water Board staff recommend that the proposed waiver that will address most nonpoint source activities on federal lands include measures that address post fire sediment sources. The following management measures are recommended to address potential water quality impacts of fire management activities:

- Hydrologically disconnect firelines;
- Remove all temporary crossings;
- Improve the existing road drainage system to handle post-burn flows;
- Clear blockages to restore drainage function;
- Remove minor slumps and slides where needed;
- Ensure the function of drainage systems after storm events; and
- Implement post fire revegetation on severe burns areas (an area where duff and overstory canopy consumption has occurred) considering steep slopes that statistically receive high rainfall as a priority. Burned areas that receive snow are less likely to cause erosion problems.

6.7 Klamath River Water Quality Tracking and Accounting Program

Regional Water Board staff, in coordination with ODEQ, US EPA, and PacifiCorp, have begun developing a Klamath River basin water quality improvement tracking and accounting program. The Klamath River basin has several attributes that could benefit from a water quality improvement tracking and accounting program. This program will provide a record of individual actions and, perhaps, the basis for a market that facilitates a higher level of activity and collaboration than could be achieved by a regulatory approach alone. These attributes include:

- A large, geographically complex watershed that straddles two states, six tribes and two EPA regions thus requiring a framework for project collaboration that extends beyond the jurisdiction of any individual participant;
- Numerous and diverse sources of water quality impairments that vary widely in costs and feasibility of control strategies;
- Significant influence of nonpoint sources of pollutants, particularly from upstream sources in the basin, on water quality throughout the basin;
- The presence of dams that are under consideration for removal in the relatively near future thus reducing the desirability of long-term investments in reducing their near-term water quality impacts; and
- A large number of regulatory programs with overlapping goals and drivers that would benefit from coordinated action.

The Tracking and Accounting Program provides a mechanism that would allow for collaboration among basin stakeholders on common projects while earning credit towards their regulatory requirements related to TMDLs and other mandated programs (e.g., KHSA interim measures, state and federal Endangered Species Acts).

6.7.1 Program Goals

The overall program goals are to provide a program to achieve water quality improvements required in all Klamath Basin TMDLs, in a manner that is consistent with state and federal policy and regulations, is technically sound, and is tailored to meet the specific needs and conditions in the Klamath Basin. More specifically, the goals are to develop a basinwide accountability program to track water quality improvements, facilitate planning, and coordinate TMDL implementation based upon a market-like system. The Tracking and Accounting Program should also:

- Provide a decision tool to guide expenditure of implementation resources towards projects with greatest/earliest impact.
- Encourage the pooling of resources to support engineered solutions and enable the spending of resources across state boundaries by tracking and accounting for the contribution of each project participant.

6.7.2 Program Objectives

Establish and operate a program for tracking water quality improvements that:

- Encourages early reductions and progress towards water quality improvements;
- Reduces the cost of TMDL implementation through greater efficiency and flexible approaches;
- Creates economic incentives for innovation, emerging technology, voluntary pollutant reductions from all sources, and for potential trading and/or offsets amongst these sources;
- Achieves ancillary environmental benefits beyond the required reductions in specific pollutant loads, such as the creation and restoration of wetlands, floodplains and fish and/or waterfowl habitat;
- Establishes an accountability Program whereby a common metric (or sets of metrics) is/are used for estimating and tracking water quality improvements;
- Establishes a credible baseline, linked to the two states' TMDLs, and incorporates effectiveness monitoring and an adaptive management approach;
- Uses standardized protocols to quantify pollutant loads, load reductions, and credits/offsets, or other water quality improvements (e.g., stream channel restoration) that contribute to supporting conditions for beneficial uses;
- Recognizes cross-pollutant benefits (e.g. acknowledges that upstream nutrient reductions can improve downstream low dissolved oxygen levels and algal bloom conditions); and
- Allows participants to contribute to program-sponsored projects without having to develop partner-specific agreements or contracts thus minimizing administrative and transaction costs.
- Provides a mechanism to allow new discharges if sufficient offsets are implemented that would not otherwise be required by law.

6.7.3 Next Steps

Regional Water Board staff are committed to the continued development and implementation of a water quality improvement tracking and accounting program, as stipulated in the Klamath River and Lost River TMDL Implementation MOA signed by the Regional Water Board, ODEQ, and US EPA Regions 9 and 10. The Regional Water Board has received federal funding to hire a contractor to work closely with PacifiCorp's contractors and support the Regional Water Board, ODEQ, and EPA in developing such a program. Regional Water Board staff plan to coordinate with stakeholders and tribal governments interested in the program in 2010.

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CHAPTER 6. REFERENCES

Agreement in Principle (AIP). 2008. Entered into by PacifiCorp, the State of Oregon, the California Resources Agency, and the United States of America on November 13, 2008.

Anderson, John A. PhD. and Gesford, Alan L. P.E. 2007. *Environmentally Sensitive Maintenance for Dirt and Gravel Roads*, compiled for US EPA, December 2007.

Belchik, M. 1997. Summer Locations and Salmonid Use of Cool Water Areas in the Klamath River. Irongate Dam to Seiad Creek, 1996. Yurok Tribal Fisheries Program. Klamath, CA 13pp..

Belchik, Michael. 2003. Use of Thermal Refugial Areas on the Klamath River by Juvenile Salmonids; Summer 1998. Yurok Tribal Fisheries Program. November, 2003.

California Department of Forestry and Fire Protection (CDF). 2010. *California Forest Practice Rules*. Resource Management, Forest Practice Program. January 2010 Version.

California Senate Bill No. 857 (Kuehl). 2005. An act to amend Section 5901 of the Fish and Game Code, and to add Article 3.5 to Chapter 1 of Division 1 of, the Streets and Highways Code.

Five Counties Salmonid Conservation Program. 2002. A Water Quality and Stream Habitat Protection Manual for County Road Maintenance in Northwestern California Watersheds. September 2002. 324 pp. Website accessed June 30, 2009. Available at: <http://www.5counties.org/Projects/FinalGeneralProjectPages/RoadsManual800.htm>.

Five Counties Salmonid Conservation Program. 2009. About us. Website accessed June 30, 2009. Available at: <http://www.5counties.org/AboutUs800.htm>.

Green Diamond Resource Company. 2006. Aquatic Habitat Conservation Plan. October 2006.

Grunbaum, Jon B. 2005. Memo of Recommended Suction Dredging Guidelines for the Happy Camp Ranger District of Klamath National Forest. 2005.

Harvey, B. C. and T. E. Lisle. 1998. Effects of suction dredging on streams: a review and an evaluation strategy. *Fisheries* 23:8–17.

Klamath Basin Restoration Agreement. 2010. February 18, 2010 Draft. Accessed at http://www.edsheets.com/Klamath docs.

Klamath Hydroelectric Settlement Agreement. 2009. September 30, 2009 Draft. Accessed at http://www.edsheets.com/Klamathdocs.

Klamath Hydroelectric Settlement Agreement. 2010. February 18, 2010 Draft. Accessed at http://www.edsheets.com/Klamath docs.

Memorandum of Agreement: Klamath River/Lost River TMDL Implementation. 2009. June 2009.

Moyle, P.B. 2006. Declaration of Peter B. Moyle, Ph.D., in Support of Entry into Stipulated Judgment. Superior Court of California. C/A No. RG 05 211597. January 2006. 10 pp.

North Coast Regional Water Quality Control Board (Regional Water Board). 2007. Water Quality Control Plan for the North Coast Region (Basin Plan). January 2007.

North Coast Regional Water Quality Control Board. 2009. Water Quality Restoration Plan for the Klamath River Basin in California: Draft Scoping for TMDL Implementation. February, 2009 Review Draft.

PacifiCorp. 2004a. Application for New License for Major Project, Klamath Hydroelectric Project (FERC) Project No. 2082, Exhibit E. Portland, Oregon. February 2004.

State Water Resources Control Board. 2004. Policy for Implementation and Enforcement of the Nonpoint Source Pollution Control Program. California Environmental Protection Agency, Sacramento, California.

State Water Resources Control Board (State Water Board). 2008. Notice of Preparation and of Scoping Meetings for an Environmental Impact Report for 401 Water Quality Certification of the Klamath Hydroelectric Project. Compiled by Entrix, Inc. 13 pp.

Superior Court of California, County of Alameda, Hayward Division. 2006. Case No.: RG 05 211597. Declaration of Peter B. Moyle, Ph. D., in Support of Entry of Stipulated Judgment. January 26, 2006.

United States Department of Interior (USDOI). 2000. Record of Decision. Trinity River Mainstem Fishery Resotration. Final Environmental Impact Statement/Environmental Impact Report. December 2000.

United States Environmental Protection Agency (USEPA). 2003. *National Management Measures for the Control of Nonpoint Pollution from Agriculture*. Office of Water. July 2003.

United States Environmental Protection Agency (USEPA). 2005. *National Management Measures to Control Nonpoint Source Pollution from Forestry*. Office of Water. April 2005.

United States Environmental Protection Agency (USEPA). 2008. Lost River, California Total Maximum Daily Loads, Nitrogen and Biochemical Oxygen Demand to address Dissolved Oxygen and pH Impairments. December 2008. 110 pp. Accessed on June 30, 2009. Available at: <http://www.epa.gov/region09/water/tmdl/lost-river/TmdlLostRiver12-30-08.pdf>.

United States Forest Service (USFS) and State Water Resources Control Board (SWRCB) of California. 1981. *Management Agency Agreement between the State Water Resources Control Board, State of California, and the Forest Service, United State Department of Agriculture.*

United States Forest Service (USFS). 1994a. Klamath National Forest Land and Resource Management Plan. Klamath National Forest. 224 pp.

United States Forest Service (USFS). 1994b. Northwest Forest Plan. Standards and Guidelines for Management of Habitat for Late-Successional and Old-Growth Forest Related Species Within the Range of the Northern Spotted Owl. Attachment A. 153 pp.

United States Forest Service (USFS). 1994c. Shasta-Trinity National Forest Land and Resource Management Plan. Shasta-Trinity National Forest. 50 pp.

United States Forest Service (USFS). 1995. Six Rivers National Forest Land and Resource Management Plan. Six Rivers National Forest. 174 pp.

United States Forest Service (USFS). 2000. Water Quality Management for Forest System Lands in California: Best Management Practices. Pacific Southwest Region. 138 pp.

United States Forest Service (USFS). 2001. Road Management Policy. 86 pp. Website accessed June 30, 2009. Available at: < http://www.fs.fed.us/eng/road_mgt/01_03_01_FINAL_disk_ROAD_MGMT_POLICY_NOTICE.pdf>.

United States Forest Service (USFS). 2002a. Klamath National Forest: Forestwide Roads Analysis. Klamath National Forest. 92 pp.

United States Forest Service (USFS). 2002b. Shasta-Trinity National Forest Roads Analysis Report: Forest Scale Analysis. Shasta-Trinity National Forest. 49p. + appendices.

United States Forest Service (USFS). 2003. Six Rivers National Forest Roads Analysis. Six Rivers National Forest. 120 pp.

United States Forest Service (USFS). 2006. The Orleans Roads Analysis and Off-Highway Vehicle Strategy. Six-Rivers National Forest. 25 pp.

Watercourse Engineering, Inc. (Watercourse). 2005. *Klamath River Thermal Refugia Study: Flow and Temperature Characterization: Summer, 2004*. Prepared for the U.S. Bureau of Reclamation with assistance from the Yurok and Karuk Tribes. February 17.

Watershed Sciences. 2004. Aerial Surveys in the Klamath River Basin Thermal Infrared and Color Videography. Report to: U.S. Bureau of Reclamation Klamath Basin Area Office by Watershed Sciences LLC, Corvallis, Oregon.

Weaver, William E., PhD and Hagans, Danny K. 1994. *Handbook for Forest and Ranch Roads.* Pacific Watershed Associates. June 1994.

CHAPTER 7. REASSESSMENT and MONITORING PROGRAM

7.1 Introduction

The Klamath River TMDLs and implementation plan will be adaptively managed in consideration of the changing status of water quality and beneficial uses in the Klamath River basin, the effectiveness of the implementation programs in achieving the TMDL allocations and targets, and any necessary refinements to the technical TMDL analysis. The Klamath River TMDL reassessment and monitoring plan is designed to provide critical feedback to inform the adaptive management process. Because of the linkage between the Klamath River TMDLs and monitoring workgroups such, as the Klamath Basin Monitoring Program (KBMP) and the Statewide and Klamath Blue-Green Algae Work Groups, the Regional Water Board is in a good position to be aware of and act upon any new information or mitigation practices that could help to restore and protect water quality conditions in the Klamath River.

7.2 Klamath River TMDL Reassessment

Within five years of USEPA approval of the Klamath River TMDL, and every five years thereafter, the Regional Water Board staff will conduct a comprehensive assessment of the effectiveness of implementation of the Klamath River TMDL Action Plan and Lost River Implementation Plan. During these reassessments, the Regional Water Board will consider how effective the implementation actions have been at achieving water quality objectives and protecting the beneficial uses of the Klamath River basin.

The primary measure of success for TMDL implementation is attainment of water quality standards. The Klamath River TMDL establishes clear and reasonable numeric targets and allocations that can be used to track progress towards restoration of supporting water quality conditions. However, recognizing that many factors may affect the attainment of water quality standards and the TMDL, other measures of success will also be considered in evaluating the implementation program such as annual reports, nonpoint source pollution control implementation programs, BMP implementation status, evaluations submitted by responsible parties, and other available information.

The Regional Water Board may conclude that ongoing implementation efforts are insufficient to ultimately achieve the allocations and numeric targets. If the Regional Water Board makes this determination, responsible parties may be required to improve and increase their reporting, monitoring, and/or implementation efforts, as necessary, to ensure any applicable allocations and numeric targets are achieved within a reasonable amount of time. Individual landowners conducting nonpoint source discharge activities are only responsible for their own discharges. The Regional Water Board may otherwise conclude, at the time of review, that implementation efforts are expected to result in achieving water quality standards and the allocations and numeric targets. In that case, responsible parties must continue to implement existing and anticipated reporting, monitoring, and implementation efforts. Responsible parties will continue monitoring according to this plan for at least five more years, at which time the Regional Water

Board will determine the need for continuing or otherwise modifying the monitoring requirements. Monitoring and assessment results (see for instance Section 7.8 regarding special study considerations) may also demonstrate that water quality standards can be achieved without full attainment of the TMDL allocations and targets. Alternatively, monitoring and assessment results may demonstrate that although water quality objectives are not being achieved in receiving waters, controllable sources of pollutants are not contributing to the exceedance. In these cases, the Regional Water Board may re-evaluate the numeric targets and allocations in the TMDL.

Regional Water Board staff will also report back to the Regional Board as necessary on the status and progress of the implementation programs, and the timeframes within which current efforts are reasonably expected to achieve water quality standards. The reports will assess:

- Water quality improvement,
- BMP implementation,
- BMP effectiveness/performance,
- Level of compliance with measures and timeframes established in the implementation plan, and
- Level of compliance with measures and timelines agreed to in responsible party water quality management plans developed pursuant to the TMDL implementation plan.

Table 7.1 shows the water quality metrics and initial timelines that will be used to assess TMDL implementation. Collection of water quality data will be coordinated with ongoing Klamath monitoring programs organized through the KBMP as described later in this chapter. The timelines for attainment of the various TMDL allocations and targets are meant as guides for the Regional Water Board to evaluate the success of the Klamath TMDL. They were selected based on staff estimates of the time needed for basinwide implementation of management measures necessary for TMDL attainment. In some cases, the timelines for compliance may be refined based on further evaluation of potential compliance mechanisms and/or refinement of the TMDL analysis. For some larger dischargers, the implementation plan requires the development of implementation plans that include timelines for implementing management measures to achieve the TMDLs. These dischargers will periodically report to the Regional Water Board on progress. The Regional Water Board may at that time require modification of the discharger's plan and/or timelines as necessary.

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Table 7.1: Basinwide water quality trends

Parameter	Water Quality Metric	Location(s)	Timeline
Temperature – Numeric	Numeric targets – Daily average temperatures (use MWAT and MWMT statistics for spring, mid-, and late summer)	Stateline and critical location(s) in mainstem.	40 years
	Numeric targets – Daily average temperatures (use MWAT and MWMT statistics for spring, mid-, and late summer)	Reservoir tailraces	40 years
	Compliance lens biological optimum for different life stages measured as MWAT and MWMT statistics for spring, mid-, and late summer.	In reservoirs	Coinciding with schedule for volitional fish passage if Sec Det. is negative 2020 if Sec Det. is affirmative
	No change in natural temperatures due to reservoirs (use daily mean, max, and minimum statistics).	Upstream and downstream of reservoirs	2014 if Sec Det. is negative 2020 if Sec Det. is affirmative
	Iron Gate Hatchery monthly mean temperature	Hatchery discharge	Per NPDES permit
	Thermal Refugia temperatures	In key thermal refugia in Klamath during critical period	Trend tracking, no TMDL allocation or target
Dissolved oxygen	Monthly means of the daily minimum DO levels.	Stateline, below Salmon River and other critical locations in mainstem Klamath River (summer).	20 years
	Compliance lens	Copco 1 and Iron Gate	Coinciding with schedule for volitional fish passage if Sec Det. is negative 2020 if Sec Det. is affirmative
Dissolved oxygen	Dissolved oxygen as mean and minimum	Reservoir tailraces	2014
	Iron Gate Hatchery dissolved oxygen as monthly mean and minimum	Hatchery discharge	Per NPDES permit
Nutrients and Organic Matter	Numeric targets as monthly mean concentrations	Stateline and below Salmon River. Copco 1 and 2 and Iron Gate Reservoirs and tailraces	20 years
	Nutrient load reductions assigned to KHP facilities in California	Upstream of Copco 1 and at Iron Gate tailrace	Based on PacifiCorp implementation plan, subject to Regional Water Board approval
	Iron Gate Hatchery numeric targets as monthly mean concentrations	Hatchery discharge	Per NPDES permit
Chlorophyll *a*	10 ug/L growing season average	Copco 1 and 2 and Iron Gate Reservoirs	20 years
Microcystis aeruginosa	Cell density relative to blue-green algae biomass and cells/L. Microcystin Toxin	Copco 1 and 2 and Iron Gate Reservoirs and in mainstem at critical locations	Based on PacifiCorp implementation plan subject to Regional Water Board approval
Periphyton Chlorophyll *a*	Numeric targets for chlorophyll *a* density	Below Salmon River and below Iron Gate Dam	20 years
Fish disease spore counts	Per the KBMP – may include other water quality parameters found to be related to spread of fish disease	At disease hot spots	

7.3 Klamath Basin Water Quality Monitoring Program

The purpose of the remainder of this chapter are: 1) to provide a description of a larger basinwide monitoring program; and 2) present an initial design for a monitoring plan that is specific to the California Klamath River TMDL. The two purposes have significant overlap because the Regional Water Board will integrate the California Klamath River TMDL monitoring plan into the larger basinwide program monitoring plan. Both monitoring plans are essential for an adaptive management program to restore and protect beneficial uses within the Klamath River, and are described briefly below:

- The basin wide monitoring plan initiative (described in Section 7.2) is a broader program for monitoring and assessment for the entire Klamath River basin. The basinwide component calls for data collection and compilation into a common database from all of the subbasins within the Klamath River basin, including the Lost River. This component of the monitoring program is based on the *Review Draft: Klamath Basin Water Quality Monitoring Plan*, Prepared for the Klamath Basin Monitoring Program (KBMP) (Royer and Stubblefield 2009).
- The California Klamath River TMDL monitoring plan (described in Sections 7.3-7.5) provides the initial structure and details for a TMDL specific monitoring plan to assess status and trends for compliance with the Klamath River TMDL targets and allocations within California. This component of the monitoring program is based on the recently completed AIP Interim Measure 12[1]: *Water Quality Monitoring Activities – Monitoring Year 2009* (Royer and Stubblefield 2009).

This two-tiered strategy recognizes the need for a coordinated basinwide understanding of the resource use and resource protection issues outlined in the National Research Council recommendations (NRC 2004). The strategy is to integrate the TMDL specific monitoring plan into the emerging more comprehensive basinwide monitoring coordination network.

7.3.1 Components of the TMDL Monitoring Program

The primary purposes of the TMDL monitoring program are to evaluate water quality conditions and trends with respect to the TMDL targets and allocations, and to determine the status of beneficial use support in the California reaches of the Klamath River.

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[1] On November 13, 2008, the United States, the States of California and Oregon, and PacifiCorp executed an Agreement in Principle (AIP) describing the framework for an approach to study the water quality conditions of the Klamath River pursuant to the possible removal of several PacifiCorp's dams on the Klamath River. Interim Measure 12 of the AIP stipulates to a water quality monitoring program, including on-going public health monitoring of blue-green algae (cyanobacteria) and associated toxins. Interim Measure 12 of the AIP further stipulates that PacifiCorp will provide funding of $500,000 per year for this measure, and that monitoring will be performed by an entity or entities agreed upon by the parties to the AIP and in consultation with the appropriate water quality agencies.

Support for these assessments will require various types of monitoring including:

- **Compliance and Trend Monitoring** is intended to determine, on a watershed scale, if water quality objectives are being met, and if beneficial uses are being protected from the adverse effects of one or more pollutants. This will require stations to be established at specific compliance points identified in the TMDL (compliance) and at locations of special beneficial use and water quality condition sensitivity (trend). The sampling frequency and density should be of a high enough resolution so that over a reasonable period time it can be determined whether management actions are having the desired effect on water quality conditions.
- **Public Health Monitoring** is a special subset of compliance and trend monitoring. Due to the seasonal presence of toxins associated with blue-green algae blooms in Iron Gate and Copco Reservoirs and in the river below Iron Gate Dam, the Klamath River TMDL monitoring plan includes public health monitoring activities to alert agencies to potentially hazardous conditions, and will provide them with information for posting health advisories as part of a public outreach and education program.
- **Implementation Monitoring** assesses whether activities and control practices were carried out as planned. For the Klamath River TMDL, examples of control practices may include construction of treatment wetlands, wetland restoration, and follow up to practices covered under existing or new permits. Implementation Monitoring activities are site-specific and can be as simple as a photographic record of activities.
- **Special Studies** address key questions, unknowns, or uncertainties that require more than an ambient water quality monitoring program to provide the information necessary for a more complete understanding of a water quality issue. Special studies can be critical to the adaptive management process to resolve issues related to changes in management practices. Examples of key questions to be addressed through special studies include: the relationship between fish disease and water quality conditions; nutrient mass balance to better understand the sources and sinks of nutrients and organic matter within the Klamath River basin; role of upstream blue-green algal sources for inoculation of downstream waters; improved characterization of periphyton conditions on Klamath River reaches below Iron Gate Dam; among others.
- **Project Effectiveness Monitoring** is similar to Implementation Monitoring and is keyed to an assessment of whether individual projects achieve the environmental benefits expected of them. Constructed wetlands and improvements to irrigation return flow operations are examples of two types of projects that would include project effectiveness monitoring as part of any grant funding.

The primary focus of this section is on public health monitoring (section 7.4), compliance and trend monitoring (Section 7.5), and key questions for future special studies (Section 7.6).

7.3.2 Monitoring Program Organization

Section 7.4 provides an overview of the emerging Klamath Basin Monitoring Program (KBMP) framework. Section 7.5 provides a summary of the monitoring stations, compliance points, and station objectives for the TMDL monitoring plan for California. Section 7.6 describes the public health components of the TMDL monitoring plan for California. Section 7.7 then describes the ambient trend and compliance component of the TMDL monitoring plan for California. Section 7.8 presents key questions to be addressed through recommended special studies. Section 7.9 describes how the Klamath River TMDL will be reassessed and potentially updated in coming years.

7.4. Overview of the Klamath Basin Monitoring Program Framework

The State Water Board and Regional Water Board, with funding and technical support from the USEPA, initiated a contract to facilitate the development of a coordinated monitoring and assessment program within the Klamath River basin. Much of the material in this section is adapted from the *"Review Draft: Klamath Basin Water Quality Monitoring Plan,* Prepared for the Klamath Basin Monitoring Program (KBMP)" (Royer and Stubblefield 2009).

The development of the multi-party Klamath River basin water quality monitoring program has been facilitated by the Klamath Watershed Institute, an affiliate of Humboldt State University. The KBMP consists of representatives from multiple agencies, Tribes, and organizations. A comprehensive list of participating entities is presented in Table 7.2. The KBMP has worked together over the past two years to develop a Draft *Klamath Basin Water Quality Monitoring Plan*. The Draft *Klamath River Basin Water Quality Monitoring Plan is* a working document intended to be updated as the needs of the KBMP change over time. It is the hope that a coordinated monitoring effort will support decisions made in the Klamath River basin regarding resource management, including such things as: implementation measures to achieve TMDL allocations and targets; appropriate conditions for the operation of PacifiCorp's Klamath Hydroelectric Project and the U.S. Bureau of Reclamation's (USBR) Klamath Project; nonpoint source (NPS) pollution controls; and how to expedite the recovery of impaired beneficial uses for the benefit of all California and Oregon residents and Tribal communities.

Many of the goals outlined by the Regional Water Board and ODEQ are echoed in the KBMP goals and objectives. The KBMP Water Quality Subcommittee drafted goals and objectives that seek to develop and maintain a network of sites that capture the status and trends of selected indicators throughout the basin over time and space. The backbone of the network is built on legacy sites identified by organizations conducting monitoring in the basin as well as sites identified in the TMDL implementation plan.

The evaluation of the current monitoring effort was based upon a review of TMDL listings at a subbasin level, and other monitoring conducted by participating organizations within the basin. Since TMDL listings are based on water quality impairment to beneficial uses, sampling at the subbasin scale may be evaluated for meeting the goals and objectives of the Regional Water Board, ODEQ and KBMP.

Table 7.2: Members of the KBMP as of March 18, 2008

Aquatic Ecosystem Sciences, LLC	PacifiCorp
Board of Supervisors Siskiyou Co.	Quartz Valley Indian Reservations
Bureau of Land Management	Resighini Rancheria
California Department of Fish and Game	Salmon River Restoration Council
California Department of Health Services	Scott River Watershed Council
California Dept of Water Resources	Shasta Valley Resource Conservation District
California EPA- State Water Resources Control Board	Siskiyou County
U.S. Dept of the Interior	Siskiyou County Public Health
E&S Environmental	Siskiyou Resource Conservation District
U.S. Environmental Protection Agency	Southern Oregon University
French Creek Watershed Advisory Group	Sprague Watershed Council
Hoopa Valley Tribal EPA	The Nature Conservancy
Humboldt State University	Timber Products Company
Karuk Tribe	U. S. Bureau of Reclamation
Kier Associates	USDA - Natural Resources Conservation Service
Klamath Compact	U. S. Fish and Wildlife Service
Klamath National Forest	U. S. Forest Service
Klamath River Keeper	U. S. Geological Survey
Klamath Tribes	University of California Berkeley
Mid Klamath Watershed Council	University of California Santa Cruz
National Oceanic and Atmospheric Administration	University of Texas
National Park Service	Upper Mid Klamath Watershed Council
North Coast Regional Water Quality Control Board	Watercourse Engineering, Inc
Oregon Department of Environmental Quality	Watershed Initiatives LLC
Oregon State University- Dept of Microbiology	Yurok Tribe Environmental Program

7.4.1 Overview of the Klamath Basin Monitoring Program (KBMP)

The parties comprising the KBMP recognize the value of coordinating monitoring programs throughout the Klamath River basin and that collaboration among agencies, organizations and tribal governments is essential to protecting the health of the basin. Given the complexity and severity of the problems facing the basin, and the decreasing level of available resources at all levels, there is a clear need for this effort. To this end, the KBMP is working to develop a collaborative monitoring program for the basin that will:

- improve short- and long-term collaboration on annual water quality monitoring activities in the Klamath River basin to support beneficial uses and improve understanding of the ecology of the basin;
- develop and maintain a network of long-term monitoring sites that capture status and trends of selected indicators throughout the basin over time and space;
- develop a sustainable monitoring program for the Klamath River basin that does not replace individual water quality monitoring efforts but expands coordinated monitoring in a way that benefits long-term collaboration;

- include all agencies and organizations that engage in water quality monitoring in the Klamath River basin;
- develop consistency in quality assurance and control regarding all monitoring activities;
- develop and maintain a system to encourage the transfer and sharing of fundamental water quantity and quality information amongst monitoring organizations needed to inform water resources studies;
- establish an online clearinghouse for housing and disseminating water quality monitoring data as well as other information about the Klamath River basin and planning and restoration efforts, allowing users to contribute, access and download data;
- create protocols for providing data and information in a timely manner to better inform adaptive management; and
- identify and communicate monitoring program results and research needs to its members, research institutions, the public, and policy makers.

Another common goal of the Regional Water Board and ODEQ is to identify and document the effects of climate change on water quality within the basin. In the state of California, climate change is expected to dramatically alter water resource availability in both time and location. The California Climate Change Center predicts increased temperature, reduced snowpack, truncated rainy season and increased fire frequency and severity (CCCC 2006). There is currently a data gap concerning the implications of climate change on the Klamath River basin.

7.4.2 KBMP Monitoring Plan Statement of Purpose

The purpose of the Klamath River Basin Water Quality Monitoring Plan is to serve as a collaborative and comparable plan for sampling and analyzing water quality in the Klamath River basin.

This comprehensive approach seeks to include all agencies and organizations engaging in water quality monitoring in the Klamath River basin. The Klamath River Basin Water Quality Monitoring Plan is not intended to replace individual water quality monitoring efforts or autonomy, but to expand coordinated monitoring in a way that benefits long-term coordination and collaboration in the basin.

The development of the Klamath River Basin Water Quality Monitoring Plan consists of a review of existing efforts and identification of data gaps, recommended enhancements, implementation of comparable Quality Assurance and Quality Control (QA/ QC) using multistate (Oregon and California) guidelines, and development of a sustainable monitoring and funding framework that addresses both long and short-term needs.

7.4.3 KBMP Monitoring Plan Goals

KBMP members developed the following goals to guide the development of the comprehensive water quality monitoring plan for the Klamath River basin:

- Coordinate monitoring activities to inform TMDL development and progress towards goals;
- Develop and maintain long-term monitoring network of sites that capture status and trends of selected indicators throughout the basin over time and space;
- Frame monitoring objectives by subbasin in terms of supporting beneficial uses and improving the understanding of the ecology of the Klamath basin;
- Strive for consistent quality assurance and control regarding all monitoring activities;
- Provide accessible data in a timely manner to better inform regulatory agencies, organizations, tribal community and the public; and
- Identify and document the effects of climate change and supply data to support climate change models to enhance the understanding of future impacts on water quality within the basin.

7.4.4 Description of Current KBMP Members Monitoring Efforts and Maps

The current collection of water quality data in the Klamath River basin is a multi-organizational effort. While there has been some informal coordination and collaboration amongst members of various organizations, many entities have worked independently on discrete projects addressing water quality issues. The Klamath Watershed Institute (KWI) compiled an inventory of organizations conducting water quality monitoring and the location of these monitoring activities in the Klamath River basin. These organizations are listed in Table 7.3. From this comprehensive list, members of the KBMP selected a subset of sites for inclusion in the Klamath River Basin Water Quality Monitoring Plan that is illustrated in Figure 7.1.

Table 7.3: Organizations collecting water quality data in the Klamath River basin as of February 15, 2009

California Department of Water Resources	The Nature Conservancy
Hoopa Tribe	Timber Products Company
Karuk Tribe	University of California Santa Cruz
Klamath Tribes	U. S. Bureau of Reclamation
Oregon Department of Environmental Quality	U. S. Bureau of Land Management
PacifiCorp	U. S. Environmental Protection Agency
North Coast Regional Water Quality Control Board	U. S. Fish and Wildlife Service
Quartz Valley Indian Reservation	U. S. Forest Service
Salmon River Restoration Council	U. S. Geological Survey
Scott River Conservation District	Yurok Tribe
Shasta Valley Resource Conservation District	

7.4.5 Schedule for Completion of the Klamath River Basin Coordinated Water Quality Monitoring Plan

The final Klamath River Basin Water Quality Monitoring was completed in December 2009. In addition to having the final Klamath River Basin Water Quality Monitoring Plan, the framework will also include a web portal for uploading and accessing data. This portal will be managed by a third party. Regional Water Board staff recommend that the California Klamath River TMDL monitoring recommendations be included in the final Klamath River Basin Water Quality Monitoring Plan.

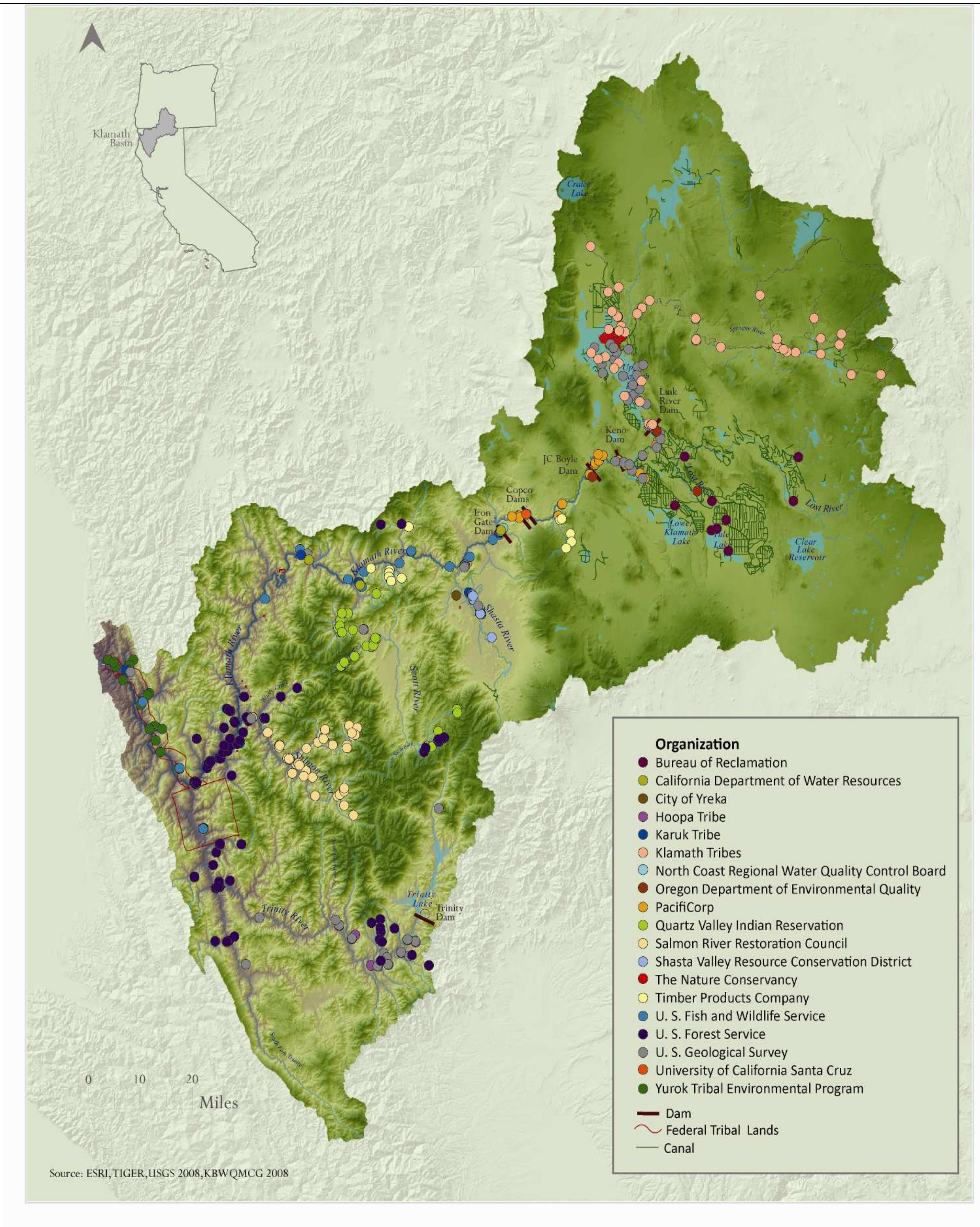

Figure7.1: KBMP monitoring sites in 2008 by organization Source: Royer and Stubbelfield 2009
Note: The sites from the Link Dam to Keno Dam are incorrectly identified as U.S. Geologic Survey sights, and are actually sites monitored by the U.S. Bureau of Reclamation.

7.5 California Klamath River TMDL Monitoring Stations, Compliance Points, and Station Objectives

Chapter 5 presents the allocations and targets for the California Klamath River TMDL. Those allocations (**A**) or targets (**T**) are assigned at specific locations within the Klamath River basin that are considered to be compliance points for the TMDL. That is, sources will be evaluated regarding the success of their controls based on conditions at the compliance locations. This monitoring plan also calls for additional monitoring stations within the Klamath River mainstem. Table 7.4 includes a summary of all of the proposed monitoring locations and monitoring components, and presents a rationale and purpose for each location.

For the purposes of addressing TMDL compliance, the compliance locations are the highest priority for conducting monitoring activities. Stations are also noted for public health (**PH)** and special studies (**SS**). Special study stations have been included to better understand water quality processes, beneficial use support status, and to address key questions (see Section 7.6) important to adaptive management decisions. Not all monitoring objectives described for specific monitoring locations in Table 7.4 are represented by an A, T, PH, or SS indicator. The locations of the compliance monitoring public health and special study stations for the California Klamath River TMDL are illustrated in Figure 7.2. More detailed descriptions of public health and trend monitoring are provided in Sections 7.4 and 7.5.

7.6 Public Health Monitoring

This section addresses monitoring to evaluate risks to public health associated with TMDL impairments. Due to the seasonally high concentrations of cyanobacteria and associated toxins in the reservoirs and downstream of Iron Gate Dam, the Regional Water Board is including a public health monitoring component in the California Klamath River TMDL monitoring plan. This section presents protocols to be used in conducting sampling for public health monitoring, including sampling locations, frequency and procedures. The information included in this section has been adapted from the *AIP Interim Measure 12: Water Quality Monitoring Activities Monitoring Year 2009* (AIP June 2009). This plan was developed through collaboration among the Regional Water Board; ODEQ; PacifiCorp; USEPA Region 9; USBR; Karuk Tribe Natural Resources Department; and Yurok Tribe Environmental Program, with support from the Klamath Watershed Institute. Members of the KBMP reviewed earlier drafts of the AIP 2009 Monitoring Plan. The AIP Monitoring Plan will be updated each year involving the same collaborators listed above with review by other interested parties from the KBMP. As described earlier the plan was developed in part to address TMDL objectives and information needs.

Table 7.4: California Klamath TMDL monitoring locations, parameters, and objectives

Location (River Mile; Station ID)[1]	Monitoring Parameter: Allocations (A); Targets (T); Public Health (PH) & Special Studies (SS)	Rationale / Purpose
Klamath River above Shovel Creek - Stateline (206.4; KR2064)	Temperature[2] **(A & T)** TN, TP, CBOD[3] **(A)** Chlorophyll –a [4] **(T)** Dissolved Oxygen[5] **(T)**	▪ This station is a compliance point for both targets (temperature and dissolved oxygen), and allocations (nutrients and organic matter). ▪ Represents both Klamath River at Stateline and Klamath River above Copco Reservoir. ("Stateline" has been represented by agencies and other entities as the Klamath River above Shovel Creek for several years.) ▪ Location provides opportunity to assess nutrient, organic matter, and chl-a loads generated in the upper basin including Upper Klamath Lake and Lost River and provides information on critical period concentrations entering the reservoirs. ▪ Assessment point for chlorophyll-a concentrations downstream of JC Boyle and prior to entering quiescent waters of Copco and Iron Gate Reservoirs. ▪ Evaluates temperature of that water entering CA which should not be elevated above natural temperature (expressed as monthly average). ▪ Assess if dissolved oxygen concentrations are at or above 85% saturation under natural temperature conditions[6].
Copco Reservoir - several stations including outlet (199.0; KR1990)	Temperature **(A & T)** TN, TP, CBOD **(T)** Chlorophyll –a **(T, PH & SS)** Dissolved Oxygen **(A &T)** *Microcystis aeruginosa* cell density[6] (**T, PH & SS)** Microcystin toxin[6] **(T, PH & SS)**	▪ These stations are compliance points for targets (TN, TP, CBOD, chlorophyll-a, *Microcystis aeruginosa*, and microcystin) and allocations (TN and TP). ▪ Multiple stations to assess public health risk due to cyanobacteria (blue-green algae) critical period blooms in both water column and fish tissue. This objective will require the addition of special studies. ▪ Assess for presence of dissolved oxygen and temperature compliance lens. ▪ Monitor for potential temperature impacts of reservoir impoundments and transfer of these impacts downstream. ▪ Assess nutrient dynamics for potential release of nutrients from reservoir sediments during critical growth period.
Downstream of Copco Reservoir (195.0; KR1950)	TN, TP, CBOD **(A)** Dissolved Oxygen **(A)** *Microcystis aeruginosa* cell density (**T, PH)** Microcystin toxin **(T, PH)** Periphyton **(SS)**	▪ Contribute to an improved nutrient and organic mass balance for the reservoirs.

Table 7.4(cont.): California Klamath TMDL monitoring locations, parameters, and objectives

Location (River Mile; Station ID)[1]	Monitoring Parameter:Allocations (A); Targets (T); Public Health (PH) & Special Studies (SS)	Rationale / Purpose
Iron Gate Reservoir - several stations including outlet (192.0; KR1920)	Temperature **(A & T)** TN, TP, CBOD **(T)** Chlorophyll –a **(T)** Dissolved Oxygen[5] **(A&T)** *Microcystis aeruginosa* cell density (**T, PH)** Microcystin toxin **(T, PH)**	▪ These stations are compliance points for targets (TN, TP, CBOD, chlorophyll-a, *Microcystis aeruginosa*, and microcystin) ▪ Multiple stations to assess public health risk due to cyanobacteria (blue-green algae) critical period blooms in both water column and fish tissue. ▪ Assess for presence of dissolved oxygen and temperature compliance lens. ▪ Monitor for potential temperature impacts of reservoir impoundments and transfer of these impacts downstream. ▪ Assess nutrient dynamics for potential release of nutrients from reservoir sediments during critical growth period.
Iron Gate Hatchery - Discharge locations	Temperature **(A & T)** TN, TP, CBOD **(A & T)** Dissolved Oxygen **(T)**	▪ Track Iron Gate Hatchery discharge to evaluate compliance with NPDES / TMDL discharge requirements for nutrients, organic matter, and temperature. ▪ Monitoring requirements will be specified in revised NPDES permit
Klamath River below Iron Gate Dam -Hatchery Bridge (189.7; KR1897)	TN, TP, CBOD (**SS)** Dissolved Oxygen **(SS)** *Microcystis aeruginosa* cell density (**PH)** Microcystin toxin **(PH)**	▪ Trend monitoring for dissolved oxygen, temperature, nutrients, and organic matter. ▪ Public health water column monitoring related to cyanotoxins generated within reservoirs. ▪ Fish tissue sampling to assess exposure of salmonids to microcystin. ▪ Evaluate temperature regime effect of reservoirs.
Klamath River at Shasta River at Walker Bridge (176.7; KR1767)	TN, TP, CBOD **(SS)** Dissolved Oxygen **(SS)** *Microcystis aeruginosa* cell density (**PH)** Microcystin toxin **(PH)**	▪ Trend compliance monitoring for nutrients, organic matter, dissolved oxygen, and temperature. ▪ Public health monitoring related to cyanotoxins including water and tissue samples.
Klamath river at Brown Bear River Access (157.5; KR1575)	TN, TP, CBOD **(SS)** Dissolved Oxygen **(SS)** *Microcystis aeruginosa* cell density (**PH)** Microcystin toxin **(PH)** Periphyton **(SS)**	▪ Public health monitoring related to cyanotoxins including water and tissue samples. ▪ Trend monitoring for nutrients, organic matter, dissolved oxygen, temperature. ▪ Measure periphyton densities to assess impact on: 1) water quality (e.g., DO, pH); 2) stream nutrient dynamics; and 3) increases in parasite densities. ▪ Special studies to better understand relationship between water quality conditions and prevalence of fish diseases below Iron Gate Dam.

Table 7.4 (cont.): California Klamath TMDL monitoring locations, parameters, and objectives

Location (River Mile; Station ID)[1]	Monitoring Parameter: Allocations (A); Targets (T); Public Health (PH) & Special Studies (SS)	Rationale / Purpose
Klamath River at Seiad Valley (128.5; KR1285)	TN, TP, CBOD **(SS)** Dissolved Oxygen **(SS)** *Microcystis aeruginosa* cell density (**PH**) Microcystin toxin **(PH)**	▪ Trend compliance monitoring for nutrients, organic matter, dissolved oxygen, and temperature. ▪ Public health monitoring related to cyanotoxins including water and tissue samples.
Klamath River at Happy Camp (108.4; KR0935)	TN, TP, CBOD **(SS)** Dissolved Oxygen **(SS)** *Microcystis aeruginosa* cell density (**PH**) Microcystin toxin **(PH)** Periphyton **(SS)**	▪ Trend compliance monitoring for nutrients, organic matter, dissolved oxygen, and temperature. ▪ Public health monitoring related to cyanotoxins including water and tissue samples. ▪ Measure periphyton densities to assess impact on: 1) water quality (e.g., DO, pH); 2) stream nutrient dynamics; and 3) increases in parasite densities. ▪ Special studies to better understand relationship between water quality conditions and prevalence of fish diseases below Iron Gate Dam.
Klamath River at Orleans (59.1; KR0591)	TN, TP, CBOD **(SS)** Dissolved Oxygen **(SS)** *Microcystis aeruginosa* cell density (**PH**) Microcystin toxin **(PH)**	▪ Trend compliance monitoring for nutrients, organic matter, dissolved oxygen, and temperature. ▪ Public health monitoring related to cyanotoxins including water and tissue samples.
Klamath River at Saints Rest Bar (44.5; KR0445)	TN, TP, CBOD **(T)** Dissolved Oxygen **(T)** *Microcystis aeruginosa* cell density **(PH)** Microcystin toxin **(PH)** Periphyton **(T)**	▪ Evaluate compliance with Hoopa Valley Tribe Water Quality Criteria
Klamath River at Weitchpec (43.5; KR00425)	TN, TP, CBOD **(SS)** Dissolved Oxygen **(SS)** *Microcystis aeruginosa* cell density (**PH**) Microcystin toxin **(PH)**	▪ Trend compliance monitoring for nutrients, organic matter, dissolved oxygen, and temperature. ▪ Public health monitoring related to cyanotoxins in water column.
Klamath River below Trinity River – above Tully Creek (38.5; KR0385)	TN, TP, CBOD **(SS)** Dissolved Oxygen **(SS)**	▪ Trend compliance monitoring for nutrients, organic matter, dissolved oxygen, and temperature. ▪ Public health monitoring related to cyanotoxins including water and tissue samples.
Klamath River at Turwar (6.0; KR0060)	TN, TP, CBOD **(SS)** Dissolved Oxygen **(SS)** *Microcystis aeruginosa* cell density (**PH**) Microcystin toxin **(PH)**	▪ Trend compliance monitoring for nutrients, organic matter, dissolved oxygen, *Microcystis aeruginosa* , microcystin, and temperature.

Table 7.4 (cont.): California Klamath TMDL monitoring locations, parameters, and objectives

Location (River Mile; Station ID)[1]	Monitoring Parameter: Allocations (A); Targets (T); Public Health (PH) & Special Studies (SS)	Rationale / Purpose
Klamath River Estuary (0.5; KR0005)	TN, TP, CBOD **(SS)** Dissolved Oxygen **(SS)** *Microcystis aeruginosa* cell density (**PH)** Microcystin toxin **(PH)**	▪ Trend compliance monitoring for nutrients, organic matter, dissolved oxygen, *Microcystis aeruginosa*, microcystin, and temperature.
Shasta River near mouth (SHR00)	TN, TP, CBOD **(A)** Dissolved Oxygen **(T)**	▪ Trend compliance monitoring for nutrients, organic matter, dissolved oxygen, and temperature.
Scott River near mouth (SCR00)	TN, TP, CBOD **(A)** Dissolved Oxygen **(T)**	▪ Trend compliance monitoring for nutrients, organic matter, dissolved oxygen, and temperature.
Salmon River near mouth (SAR00)	TN, TP, CBOD **(A)** Dissolved Oxygen **(T)**	▪ Trend compliance monitoring for nutrients, organic matter, dissolved oxygen, and temperature.
Trinity River near mouth (TR00)	TN, TP, CBOD **(A)** Dissolved Oxygen **(T)** *Microcystis aeruginosa* cell density (**PH)**	▪ Trend compliance monitoring for nutrients, organic matter, dissolved oxygen, and temperature. ▪ Public health monitoring related to cyanotoxins including water and tissue samples (control).
Watershed-wide (N/A)	Riparian Shade and Sediment **(A & T)**	▪ Monitoring to evaluate status of riparian shade conditions relative to site-potential to track trends in effective shade levels for all Klamath tributaries. ▪ Assessment of human-caused mass wasting hazards (e.g., stream crossings) that have potential to contribute sediment delivery to streams above background levels that could contribute to channel alterations that affect stream temperature or fish refugia. ▪ Assess road conditions to ensure that best management practices are being implemented to reduce the incidence of road related landslides.

[1] River miles are approximate, and station ID's are per the KBMP.
[2] Temperature shall be monitored at hourly or sub-hourly interval.
[3] Nutrient and organic matter grab samples shall be analyzed for inorganic nitrogen (ammonia, nitrite, nitrite), organic nitrogen, inorganic phosphorus (orthophosphate) organic phosphorus, and CBOD-ultimate. Allocations and targets expressed as monthly mean concentrations.
[4] Surface grab samples shall be analyzed for chlorophyll-a ; the mean of bi-monthly growing season (June through September) sample results shall be calculated to assess compliance with the chlorophyll-a target.
[5] Dissolved oxygen concentrations shall be monitored at hourly or sub-hourly intervals; targets and allocations based on 85% saturation at natural temperature.
[6] Sampling procedures for Microcystis aeruginosa and microcystin are presented in Section 7.4.1.3.

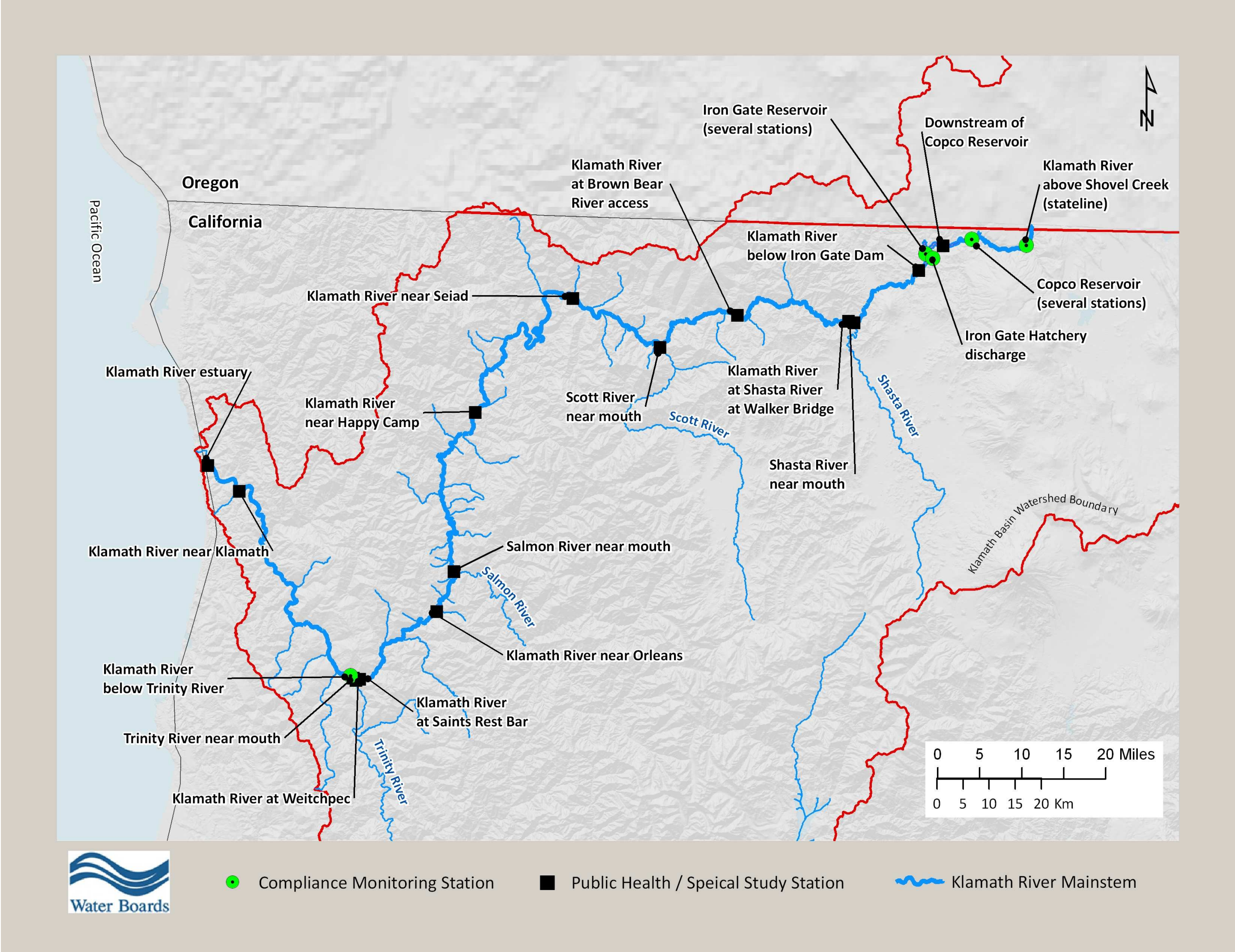

Figure 7.2: Location of California Klamath River TMDL monitoring stations – compliance, public health, and special study

Risks to public and ecological health related to cyanobacteria and cyanotoxin exposure will be evaluated through water sampling, tissue sampling, and identification of the presence of scums, using the monitoring procedures described in the standard operating procedures (SOPs) presented in Appendix A of the AIP 2009 Monitoring Plan (AIP 2009).. Water quality monitoring of cyanobacteria and related cyanotoxins for purposes other than public and ecological health evaluation is addressed in Section 7.5.

The primary concern of this monitoring is public health. In addition to direct exposure to impacted waters (ingestion, inhalation and dermal exposures), exposures to microcystins are possible from ingestion of fish (e.g., caught during recreational fishing in the reservoirs), or consumption of freshwater mussels collected from the Klamath River. Mussels from the Klamath River are part of the traditional diet of tribal people. Additionally, mussels as filter feeders may be sensitive indicators of cyanobacteria levels and toxin levels in ambient water and food sources.

Cyanotoxins can also have an impact on the health of fish and other exposed species, which result in direct impacts to those species, as well as consumers of those impacted species including humans. Additionally, the information from the public health monitoring component can provide valuable information relative to other beneficial uses including the status of both COLD and WARM water beneficial uses. For example, microcystin concentrations in fish tissue can disrupt liver function in fish at levels considered to be moderate or low for human consumption. Therefore these measures should not be interpreted for human health assessments alone. Rather the results also should be applied to determine whether microcystin exposures are a contributing factor to ecological impacts such as fish disease and fish health both within the reservoirs and below Iron Gate Dam.

7.6.1 Water Sampling

7.6.1.1 <u>Sampling Locations</u>

Public health monitoring for cyanobacteria and microcystin toxin in water samples will occur at a total of 12 designated locations used for public access and recreation. These are listed in Table 7.5, and include:

- Four shoreline sites in coves on Copco (Mallard Cove and Copco Cove) and Iron Gate reservoirs (Camp Creek and Williams Boat Ramp). These cove sites provide public access, are known areas of likely accumulation during blooms, and have been monitored since 2005.
- Eight (8) river sites stretching from Iron Gate dam (RM 189.7) to Turwar (RM 6.0). Most of these sites have been monitored since 2005, and all represent areas of public access.

In recent years, monitoring programs have also been conducted to evaluate cyanobacteria and cyanotoxin levels in reaches of the Klamath River upstream of the Copco reservoirs, in Oregon between Upper Klamath Lake (Link River Dam) and Copco 1 Reservoir. Those locations are not addressed in this document.

Table 7.5: 2009 Klamath River sampling sites for public health monitoring of cyanobacteria and cyanotoxins in surface water samples and the entities responsible for 2009 sample collection

Location	Approx RM	Sampling Entity
Copco Reservoir and Mallard Cove	200.8	PacifiCorp
Copco Reservoir at Copco Cove	198.5	PacifiCorp
Iron Gate Reservoir at Camp Creek	192.8	PacifiCorp
Iron Gate Reservoir at Williams Boat Ramp	192.4	PacifiCorp
Klamath River below Iron Gate Dam (Hatchery Bridge)	189.7	PacifiCorp
Klamath River at I-5 Rest Area	176	Karuk
Klamath River at Brown Bear River Access	157.5	Karuk
Klamath River at Seiad Valley	128.5	Karuk
Klamath River at Happy Camp	108.4	Karuk
Klamath River at Orleans	59.1	Karuk
Klamath River at Weitchpec	43.5	Yurok
Klamath River at Turwar	6.0	Yurok

7.6.1.2 <u>Sampling Frequency</u>

Sampling frequencies for public health monitoring for both water and tissue samples under the 2009 plan are summarized in Table 7.6 and briefly discussed below:

1. Prior to and following cyanobacteria blooms, once per month (May and November).
2. During the presence of visible cyanobacterial populations or blooms, and cyanotoxins at levels approaching concentrations that warrant the posting of public health advisories by regulatory agencies (e.g., the Regional Water Board), biweekly (aka, every two weeks) (June through October). Sampling will continue at a biweekly frequency until State Board guidelines for posting have been met for *Microcystis aeruginosa.*
3. Following the posting of public health advisories for *Microcystis aeruginosa*, sampling at selected shoreline locations will be reduced to monthly until bloom densities and toxin levels in those areas have reduced and risks to public health are no longer a concern. Sampling at those locations will then resume as in Items 1 or 2, above, depending on the time of year.

7.6.1.3 <u>Sampling Procedures</u>

Water samples will be collected, by all reach monitoring entities, for species identification/enumeration, and for toxin analysis, in accordance with the *Standard Operating Procedures, Environmental Sampling of Cyanobacteria for cell enumeration, identification and toxin analysis* (AIP 2009 - Appendix A). To address public health concerns, water samples will be collected at sampling depths representative of reasonable maximum exposure by incidental ingestion exposures to sensitive populations (i.e., children).

Under the AIP 2009 Monitoring program, Microcystin toxins in water samples are being analyzed by the U.S. EPA Region 9 laboratory, in accordance with the U.S. EPA Region 9 Laboratory Standard Operating Procedure (SOP 1305 for Microcystin analysis by ELISA). In accordance with the *Environmental Sampling SOP* (Appendix A) samples

Table 7.6: Klamath River AIP monitoring program 2009 – summary table of public health monitoring locations, constituents, method, and frequency

Site ID	Location	Phyto-plankton Species	Microcystin - EPA	Fish Tissue	Mussel Tissue	LCMS microcystin confirmation	LCMS water for mussels	Sampling Entity
KR2008	Copco Reservoir at Mallard Cove	J/J1	M3/BM3	S2	-	BM5	-	PacifiCorp
KR1985	Copco Reservoir at Copco Cove	J/J2	M3/BM3	-	-	-	-	PacifiCorp
KR1928	Iron Gate Reservoir at Camp Creek	J/J2	M3/BM3	-	-	-	-	PacifiCorp
KR1924	Iron Gate Reservoir at Williams Boat Ramp	J/J1	M3/BM3	S2	-	-	-	PacifiCorp
KR1897	Klamath River below Iron Gate Dam (Hatchery Bridge)	BM/W	BM/W	-	-	-	-	PacifiCorp
KR1760	Klamath River at I-5 Rest Area	BM/W	BM/W	-	S4	-	S4	Karuk
KR1575	Klamath River at Brown Bear River Access	BM/W	BM/W	-	S4	-	S4	Karuk
KR1285	Klamath River at Seiad Valley	BM/W	BM/W	-	S4	BM5	S4	Karuk
KR1084	Klamath River at Happy Camp	BM/W	BM/W	-	S4	-	S4	Karuk
KR0591	Klamath River at Orleans	BM/W	BM/W	-	S4	-	S4	Karuk
KR0435	Klamath River at Weitchpec	BM/W	BM/W	-	S4	-	S4	Yurok
KR0060	Klamath River at Turwar	BM/W	BM/W	-	S4	-	-	Yurok
TRR000	Trinity River near mouth	-	-	-	SI	-	S1	Yurok

J/J1 June-July bimonthly rushed, than monthly phytoplankton through Nov

J/J2 June-July bimonthly rushed

M3/BM3 bimonthly June through October and monthly in May and November

BM/W bimonthly June through October, weekly Aug/Sept

S2 Two seasonal sampling events

S4 Four seasonal sampling events

S1 One seasonal sampling event

BM5 bimonthly June through October

should be chilled immediately upon collection and maintained at or below 6 degrees C prior to and throughout shipping to the laboratory.

Water samples are also being collected for cyanobacterial cell identification/enumeration to determine the presence and abundance of cyanobacterial species (e.g., *Anabaena sp.*, *Aphanizomenon sp., Microcystis sp.*, etc). These analyses will be conducted to the species level at minimum. Depending on the severity (e.g., density and size) of the algal bloom, river monitoring entities will specify whether the phytoplankton analysis samples will be rushed and/or enumerated using a 400 cell count protocol.

Analysis and data QA/QC review and reporting are being conducted in accordance with the Quality Assurance (QA) plans requirements for each reach monitoring entity identified in Table 7.6 (QA plans are included in Appendix B to the AIP 2009 Monitoring Plan). Appendix B.

7.6.2 Tissue Sampling

During 2009, public health monitoring includes sampling of yellow perch from Copco and Iron Gate Reservoirs, and mussel sampling from locations on the Klamath River below Iron Gate Dam. Sampling conducted in the summer of 2007, with analysis by CDFG using LC/MS/MS, found levels of microcystin in mussels collected in the Klamath River below Iron Gate Dam, and in fish tissue (yellow perch) collected from Copco and Iron Gate reservoirs, exceeding the advisory level of 26 ng/g wet weight total microcystin/gram tissue, developed by the California Office of Environmental Health Hazard Assessment (letter dated August 6, 2008, to Randy Landolt, PacifiCorp from OEHHA (OEHHA 2008).

In 2008, PacifiCorp collected yellow perch and crappie samples from Iron Gate and Copco reservoirs, and rainbow trout from the Klamath River above Copco Reservoir and below Iron Gate dam prior to, during, and after the algal bloom season. Tissue samples were analyzed by Dr. Greg Boyer, University of Syracuse, New York, using HPLC with UV detection. Fish tissue samples collected in May, July, and September 2008 were below detection for total free microcystins (CH2M HILL 2009). PacifiCorp also collected mussel samples below Iron Gate dam during November 2008. A final report for these samples is expected by the end of 2009.

7.6.2.1 Yellow Perch Tissue Sampling

Yellow perch sampling is being conducted at both Copco and Iron Gate reservoirs. Sampling for yellow perch will occur twice during the anticipated bloom season. One sampling event will occur early in the bloom season (July) and the other towards the end of the bloom season (September). During each sampling event, a minimum of 5 (if possible) and up to 15 yellow perch, will be collected from each reservoir. Samples from each reservoir will be weighed and measured to fork length, wrapped in foil, and shipped in accordance with the SOP in Appendix A of the AIP 2009 Monitoring Plan.

In the future, fish sampling in the reservoirs should also be conducted prior to and soon after the collapse of the bloom, as recommended by OEHHA, to evaluate pre-bloom levels and cumulative impacts to evaluated fish species. Additionally, fish sampling in reaches of the river is anticipated.

7.6.2.2 Mussel Tissue Sampling

Mussel sampling is being conducted from a total of 7 locations and one control location, listed below in Table 7.7. The control sampling location (Trinity River) will only be sampled once during the anticipated bloom season (July through September). For all other locations, there will be 4 sampling events; one pre-bloom (May/June), two during the bloom (August and September) and one post-bloom (late October/November).

The proposed locations on the Klamath River below Iron Gate Dam are known to be fishing/harvesting locations, and will be used to evaluate potential ingestion exposure related to recreational, commercial and subsistence fishing activities. Mussel tissue sampling will also be used to support analysis of elevated concentrations in mussel tissues co-occurring with cyanobacterial abundance and elevated cyanotoxin levels in water samples.

Table 7.7: Sample sites in the Klamath River for 2009-2010 monitoring of cyanotoxins in mussel tissue

Location	Approximate RM	Sampling Entity
Klamath River at I-5 Rest Area	176	Karuk
Klamath River at Brown Bear River Access	157.5	Karuk
Klamath River at Seiad Valley	128.5	Karuk
Klamath River at Happy Camp	108.4	Karuk
Klamath River at Orleans	59.1	Karuk
Klamath River at Turwar	6.0	Yurok
Control sample from Trinity River near mouth	na	Yurok

For each Klamath River sampling event and location, five mussels will be collected from each location, and prepared for submittal to the laboratory in accordance with the *Environmental Sampling SOP* (AIP 2009 - Appendix A). Additionally, two water samples will be collected and analyzed for microcystin toxins by LC/MS/MS, and phytoplankton species and enumeration. The California Department of Fish and Game laboratory, in Rancho Cordova, CA, is providing analytical services for all tissue samples and water samples evaluated by LC/MS/MS.

7.6.2.3 Data Quality

Water quality monitoring data (cell count, and ELISA data presenting total microcystin concentrations) for the protection of public health, will be evaluated against the following water quality criteria and guidance. Data should be of sufficient quality to fully and unquestionably meet the following criteria and guidance.

To evaluate water quality data, criteria to be used for purposes of protecting public health include those presented in the California State Water Board 2008 Guidance about

Harmful Algal Blooms, for Monitoring and Public Notification[2], and criteria issued by California's Office of Environmental Health and Hazard Assessment (OEHHA). Exceedance of any of these criteria for the protection of human health and aquatic life may result in the posting of a waterbody by local health agencies:

- Surface scums are present containing toxigenic species[3];
- *Microcystis aeruginosa* or *Planktothrix* cell densities ≥ 40,000 cells/mL;
- Total microsystin concentrations ≥ 8 µg/L; and
- Others as specified in the California State Water Board 2008 Guidance.

To evaluate tissue samples, the current Advisory Tissue Level for one serving (8 oz uncooked, 6 oz cooked) will be applied to analytical results for cyanotoxin concentrations in mussel tissues (26 ng/g wet weight in June 2009, per OEHHA, August 6, 2008). For the protection of human health from tissue contaminated with microcystins, total microcystin concentrations for three or more individual mussels (samples composited, or discrete mussel data averaged) will be evaluated against the current criteria (OEHHA 2008).

7.7 TMDL Ambient Compliance and Trend Monitoring

7.7.1 Continuous/ Multi-Probe Monitoring

For each of the following parameters, capturing sub-daily variability is important to understanding the dynamics present in the system. Continuous monitoring devices will be deployed to address the period May to November, important for characterizing current conditions. Winter deployments can be minimal (December 1-March 31), with certain exceptions where winter water quality conditions are poorly understood.

- **Temperature -** controls rate reactions in aquatic system and can be a stressor to aquatic life.
- **Dissolved Oxygen -** is important to aquatic ecosystem function. Low concentrations can be a stressor to certain aquatic life.
- **pH -** conditions are important for aquatic life, with typical acceptable pH concentrations in a range of 6 to 9. At elevated pH, unionized ammonia can be toxic to aquatic life, a condition exacerbated by elevated temperatures.
- **Conductance -** represents ions that are in solution. This parameter is often used as a conservative constituent and to identify inputs or effects of land use practices.

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2 Per the posting guidelines established by the Blue Green Algae Work Group of the California State Water Resources Control Board, Department of Public Health, and Office of Environmental Health and Hazard Assessment; *Cyanobacteria in California Recreational Water Bodies; Providing Voluntary Guidance about Harmful Algal Blooms, Their Monitoring, and Public Notification*. Draft, September 2008.

3 When using the presence of scums to establish the need to post, staff trained in recognizing *Microcystis aeruginosa* scums must compile a photographic record as part of the monitoring program.

7.7.2 Water Quality Grab Sample Parameters

For the following parameter, limited sampling (frequency and locations) is proposed:

- **CBOD -** To address TMDL issues, sampling of CBOD will occur every two weeks from June to October, and approximately monthly the remainder of the year. Sampling for CBOD will occur at the following locations below Stateline: Link River Dam, below Keno Dam, above Copco Reservoir at Shovel Creek, and below Iron Gate Dam. Sampling procedures will be based on the USGS National Field Manual (2009) and as part of the studies recently completed by Sullivan (2008). Because many of the CBOD targets and allocations are below the method detection limit (MDL) the Regional Water Board proposes the following procedure for tracking compliance.

  Analytical labs commonly assess results against two precision thresholds. The Method Detection Limit (MDL) is defined as the minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero. The reporting limit (RL) is defined as the lowest concentration at which an analyte can be detected in a sample and its concentration can be reported with a reasonable degree of accuracy and precision. Analytical results between the MDL and RL are often reported as estimated values.

  The MDL and RL for TP are based on procedural results and can vary between laboratories. There are several commercial laboratories that can achieve an RL below the TP concentration targets. For example, the Dept. of Fish and Game laboratory in Rancho Cordova used by the California State SWAMP Program achieves a RL of 0.01o mg/L and a MDL of 0.005 mg/L, well below target concentration.

  The MDL and RL for CBOD are equal at 3 mg/L. These levels are operationally defined and do not vary between laboratories.

  > Option 1) Analytical results of CBOD will be assessed using a 3-month running average for compliance evaluation against concentration targets. Analytical results reported as below the MDL will be assessed at one-half the MDL (i.e., 1.5 mg/L).
  >
  > Option 2) Analytical results reported below the MDL for CBOD will be assumed to represent one-half the MDL (i.e., 1.5 mg/L). This assumption is a commonly used in water quality assessment (Helsel and Hirsch, 1992).

  Alternatively, assessment of compliance with CBOD targets can be conducted using the concentration of Total Organic Carbon (TOC). The target concentrations were derived using a conversion factor applied to particulate and dissolved organic matter. Analytical results of TOC can be converted to an equivalent concentration of CBOD using these conversions.

Sampling for the following parameters will occur from May through December at frequencies noted in Table 7.8. Capturing short term variability (biweekly or daily) may be important for several or all of these parameters, and could be added in future monitoring plans.

- **Inorganic/Organic N (ammonia, nitrate, nitrite, organic N) -** Inorganic nutrients (ammonia, nitrite, nitrate) are readily available for primary production. Total nitrogen (organic plus inorganic forms) is an indicator of overall status of an aquatic system. It is important to collect and assess/consider both organic and inorganic forms. Ammonia can be toxic (unionized ammonia) when elevated pH and temperature conditions are present. The conversion of ammonia to nitrite and nitrate consumes oxygen.
- **Inorganic/Organic P (orthophosphate, organic P) -** Inorganic nutrients (orthophosphate) are readily available for primary production. Total phosphorus (organic plus orthophosphate) is an indicator of overall status of an aquatic system. It is important to collect and assess/consider both organic and inorganic forms.
- **Particulate and Dissolved C (particulate and dissolved organic carbon) -** This is a measure of the organic matter within the system, and is necessary for the partitioning of organic matter fractions into particulate, dissolved, labile, and refractory. Organic matter consumes oxygen during decay and releases nutrients. Analysis of organic carbon is used to determine organic matter loads. Special studies will be used to identify stoichiometry of organic matter (C, N, and P fraction) and to partition particulate and dissolved matter into refractory and labile forms.
- **TSS/VSS (total and volatile suspended solids) -** TSS and VSS together define the organic (VSS) and inorganic (TSS-VSS) fraction of suspended material. This provides insight on bulk organic matter loads, and coupled with inorganic suspended solids can be used to estimate light extinction.
- **Alkalinity -** Understanding alkalinity, helps to identify the buffering capacity of waters and the ability of an aquatic system to resist changes in pH (e.g., in response to primary production).
- **Water Column Chlorophyll-a/Pheophyton -** This measure of chlorophyll-a and pheophyton in reservoirs can be used to estimate the standing crop of phytoplankton. Current modeling estimates of the export of carbon from the reservoirs do not include live algal biomass. An improved understanding of algal biomass export during the summer months would lead to improved estimates of downstream organic matter contributions from the reservoirs. Chlorophyll-a concentrations are also a key indicator of the probability of nuisance blooms dominated by blue-green algae. For the purpose of assessing the TMDL, summer mean target for chlorophyll-a should be calculated using the results of bimonthly surface grab samples from reservoir stations for the growing season (June through

September). Mid-winter measurements are not critical and could be reduced to monthly or once every two months.

- **Phytoplankton species -** The TMDL target for the reservoir for suspended algae chlorophyll-a = 10 µg/L (as a growing season mean - May to October) are linked to the public health monitoring for blue-green algae and the sampling regimen and protocol applies to both. Monitoring requirements to assess these targets for each reservoir with recreational uses are: a minimum of one sample per month at each of 3 near shore reservoir entry areas and 1 open water reservoir sample, collected in accordance with *Standard Operating Procedures, Environmental Sampling of Cyanobacteria for Cell Enumeration, Identification and Toxin Analysis* (June 2099) or other protocol as approved by the Regional Board. Interpretation of monitoring data for these targets will conform to World Health Organization guidance for low probability of adverse health effects, from the *Guidelines for Safe Recreational Water Environments* (Table 8.3), or superseding guidance. (WHO guidelines are also summarized in *Cyanobacteria in California Recreational Water Bodies, Blue-Green Algae Work Group of the State Water Resources Control Board, Department of Public Health, and Office of Environmental Health and Hazard Assessment* (Sept 2008).) Sampling is needed to identify species presence and absence. Determination of population variations can provide insight into trophic status, nutrient availability, blue-green algae species, potential toxins and health advisories. Consideration should be given to further reducing the sampling frequency in mid-winter.
- **Microcystin -** The California 2006 Section 303(d) list identified microcystin as an impairment in the segment from and including the Copco Reservoirs down to Iron Gate Dam, including the segment of Klamath River between those reservoirs. California's 2008 *Public Review Draft Staff Report for the 2008 Integrated Report for the Clean Water Act Section 305(b) Surface Water Quality Assessment and the 303(d) List of Impaired Waters* (Regional Water Board 2008) recommends that the mainstem Klamath River from downstream of Iron Gate Dam to the confluence of the Trinity River be listed as impaired for microcystin (Klamath River from Iron Gate Dam to Scott River - Middle Klamath River HA, and from Scott River to the Trinity River - Middle & Lower Klamath River HA). The target values for these parameters are *Microcystis aeruginosa* cell density = 20,000 cells/mL; and Microcystin = 4 µg/L. The sampling protocol and regimen are consistent with phytoplankton (above). These are minimum requirements, the AIP monitoring plan may exceed the proposed sampling regimen.
- **Preriphyton** (algal biomass) - The reach average is for the summer growing season and will be measured at a minimum of three points during the growing season (e.g., June, August, September) using the protocols described in: *Standard Operating Procedures for Collecting Stream Algae Samples and Associated Physical Habitat and Chemical Data for Ambient Bioassessments in California* (Fetscher et al. 2009). Sampling locations will be in close proximity to TMDL compliance points.

7.7.3 Trend Monitoring Locations, Parameters, Frequency

Table 7.8 provides a summary of the trend monitoring and special study monitoring locations. Several of the trend monitoring stations also double as public health monitoring stations. Some of the trend monitoring stations include public health parameters but are sampled at a reduced frequency compared to the primary public health stations identified in Table 7.6. The Klamath River TMDL monitoring network will require the participation of several organizations to conduct all of the proposed sampling. It may be necessary to reduce the number of stations over time as information regarding the consistency between stations becomes better known.

7.8 Additional Monitoring Needs and Key Questions for Special Study Consideration

Development and implementation of the Klamath River TMDL is an adaptive management process, responding at regular intervals to new information and new findings to ensure that management decisions and actions are directed to the most effective solutions. Following years of study and analysis many questions remain regarding the Klamath River basin water quality conditions. Enough is known that many fundamental decisions regarding load reductions can be safely made, however special studies are recommended. The purpose of this section is to provide a list of topics / issues that can be used to guide the development of future study plan proposals. These studies are described in a conceptual manner. Any final study designs would be developed in coordination with the Klamath Basin Water Quality Monitoring Coordination Group. The key questions are organized by topic or parameter. However, it is possible and desired that any proposed study address as many of the questions as possible.

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Table 7.8: Klamath River TMDL monitoring program trend monitoring location, parameter, frequency – summary table

Monitoring Location	Allocation and Target Compliance (C) Public Health (PH) /Special Study (SS)	Temperature (°C)	Dissolved Oxygen (mg/l)	pH (log[H+])	Conductance (uS/cm)	Inorganic/Organic N (mg/l)	Inorganic/Organic P (,g/l)	Particulate and Dissolved C (mg/l)	TSS/VSS (mg/l)	Alkalinity (mg/l)	Water Column chl_a/Pheo (ug/l)	Phytoplankton species	Microcystin (ug/l)	LCMS confirmation	CBOD, mg/l
Sampling Method:		*T,P*	*P*	*P*	*P*	*G*	*G*	*G*	*G*	*G*	*G*	*G*	*G*	*G*	*G*
KR above Shovel Creek (Stateline) (RM-206.4)	**C**	**H**	**-**	**-**	**-**	**M**	**M**	**M**	**M**	**M**	**M**	**M**	**M**	**M/S**	**M/BM**
Copco Reservoir (RM-199.0)	**C PH SS**	**VP**	**VP**	**VP**	**VP**	**M**	**M**	**M**	**M**	**M**	**M**	**M**	**M**	**-**	
Downstream of Copco Reservoir (RM-195.0)	**SS**	**H**	**-**	**-**	**-**	**M**	**M**	**M**	**M**	**M**	**M**	**M**	**M**	**-**	**-**
Iron Gate Reservoir (RM-192.0)	**C PH SS**	**VP**	**VP**	**VP**	**VP**	**M**	**M**	**M**	**M**	**M**	**M**	**M**	**M**		
Iron Gate Hatchery (discharge)	**C**	Monitoring requirements will be addressed as part of the pending NPDES permit renewal.													
Klamath River below Iron Gate Dam (Hatchery Bridge) (RM-189.7)	**PH SS**	**H**	**H**	**H**	**H**	**M/ BM**	**M/ BM**	**M/ BM**	**M/ BM**	**M/ BM**	**M/ BM**	**M/ BM**	**W/ S**	**M**	**M/ BM**
Klamath River at Shasta River (RM- 176.7)	**PH SS**	**H**	**-**	**-**	**-**	**M**	**M**	**M**	**M**	**M**	**M**	**M**	**M**		**-**
Klamath River at Brown Bear River Access (RM 150.0)	**PH SS**	**P**	**P**	**P**	**P**	**M/ BM**	**M/ BM**	**M/ BM**	**M/ BM**	**M/ BM**	**M/ BM**	**M/ BM**	**W/ S**	**M**	**M/ BM**
Klamath River at Seiad Valley (RM - 128.5)	**PH SS**	**H**	**H**	**H**	**H**	**M**	**M**	**M**	**M**	**M**	**M**	**M**	**M**		**-**
Klamath River at Happy Camp (RM-108.4)	**SS**	**H**	**-**	**-**	**-**	**M**	**M**	**M**	**M**	**M**	**M**	**M**	**M**		**-**
Klamath River at Orleans (RM-59.1)	**SS**	**H**	**H**	**H**	**H**	**M**	**M**	**M**	**M**	**M**	**M**	**M**	**M**		**-**
Klamath River at Saints Rest Bar (RM-44.5)	**C**	**H**	**H**	**H**	**H**	**M**	**M**	**M**	**M**	**M**	**M**	**M**	**M**	**M**	
Klamath River at Weitchpec (RM-43.5)	**SS**	**H**	**H**	**H**	**H**	**M**	**M**	**M**	**M**	**M**	**M**	**M**	**M**		

Table 7.8 (cont.): Klamath River TMDL monitoring program trend monitoring location, parameter, frequency – summary table

Monitoring Location	**Allocation and Target Compliance (C) Public Health (PH) /Special Study (SS)**	**Temperature (°C)**	**Dissolved Oxygen (mg/l)**	**pH (log[H+])**	**Conductance (uS/cm)**	**Inorganic/Organic N (mg/l)**	**Inorganic/Organic P (,g/l)**	**Particulate and Dissolved C (mg/l)**	**TSS/VSS (mg/l)**	**Alkalinity (mg/l)**	**Water Column chl_a/Pheo (ug/l)**	**Phytoplankton species**	**Microcystin (ug/l) [xx]**	**LCMS confirmation**	**CBOD, mg/l**
Sampling Method:		*T,P*	*P*	*P*	*P*	*G*	*G*	*G*	*G*	*G*	*G*	*G*	*G*	*G*	*G*
Klamath River below Trinity River (RM-38.5) > Tully Creek	**SS**	**H**	**-**	**-**	**-**	**M**	**M**	**M**	**M**	**M**	**M**	**M**	**M**	**M**	**-**
Klamath River at Turwar (RM-6.0)	**SS**	**H**	**H**	**H**	**H**	**M**	**M**	**M**	**M**	**M**	**M**	**M**			**-**
Klamath River Estuary (RM-0.5)	**SS**	**-**	**-**	**-**	**-**	**M**	**M**	**M**	**M**	**M**	**M**	**M**	**M**		**-**
Shasta River near mouth	**C**	**H**	**H**	**H**	**H**	**M**	**M**	**M**	**M**	**M**	**M**	**M**	**-**	**-**	**-**
Scott River near mouth	**C**	**H**	**H**	**H**	**H**	**M**	**M**	**M**	**M**	**M**	**M**	**M**	**-**	**-**	**-**
Salmon River near mouth	**C**	**H**	**H**	**H**	**H**	**M**	**M**	**M**	**M**	**M**	**M**	**M**	**-**	**-**	**-**
Trinity River near mouth	**C**	**H**	**-**	**-**	**-**	**M**	**M**	**M**	**M**	**M**	**M**	**M**	**-**	**-**	**-**

Key:

Sampling Method
T – thermistor
P – probe or data sonde (minimum seasonal deployment – April to November)
G – grab sample

Sampling Frequency
VP – vertical profile at stated sampling frequency
H – hourly measurements (in some instances sub-hourly data may be desired)
M – monthly sampling

Sampling Frequency
M/S – monthly sampling, seasonally from May through October
M/BM – Bi-monthly sampling May - October and monthly sampling the remainder of the year
W/S – weekly sampling, seasonally from June through September

7.8.1 Assessment of Primary Productivity Limitation

To address concerns that nutrient and organic matter reductions in the Klamath River basin could lead to limitations on primary productivity in the river system over time, careful monitoring and assessment of primary productivity and associated food web dynamics within the Klamath River is appropriate and warranted. Nutrient and organic matter conditions at Iron Gate tailrace and downstream locations should be compared to the monthly mean TP, TN, and CBOD "trigger" concentrations in Table 7.9. These "trigger" concentrations are based on the California allocation scenario, which represents conditions that comply with water quality standards without dams. If observed nutrient and organic matter conditions at Iron Gate tailrace or downstream locations are comparable to the "trigger" concentrations, and if there is evidence of potential limitations to primary productivity at levels deleterious to water quality standards, then the Regional Water Board should reevaluate the TMDL allocations and targets and nutrient controls in the basin or take other appropriate action.

Table 7.9: Nutrient (TP and TN) and organic matter (CBOD) monthly mean "trigger" concentrations (mg/L) at Iron Gate tailrace

	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**
Average of TP	0.023	0.028	0.029	0.030	0.029	0.025
Average of TN	0.302	0.374	0.383	0.393	0.370	0.272
Average of CBOD	1.668	2.513	2.629	2.472	2.364	1.325
	Jul	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Average of TP	0.025	0.024	0.024	0.023	0.026	0.029
Average of TN	0.238	0.238	0.252	0.284	0.320	0.360
Average of CBOD	1.526	1.442	1.117	1.120	1.076	1.416

7.8.2 Comprehensive Water Quality Monitoring

To bolster modeling analyses and significantly improve our understanding of water quality conditions in the Klamath River basin, an extended monitoring effort that repeatedly and simultaneously evaluates conditions along the entire length of the river, its impoundments, and the estuary, as well as for nearly all boundary conditions, would be ideal. Due to the size and complexity of this system, however, such a long-term and spatially-intense monitoring program is cost-prohibitive. Therefore, it is recommended that intensive monitoring be conducted for a two to three month period during the summer, when water quality conditions are of the most concern. Limiting the time span for data collection would ideally enable more concurrent data to be collected within the system and for critical inputs to the system.

Additionally, less intensive sampling during the fall, winter, and spring seasons is necessary to develop a reliable mass-balance for nutrient related constituents for the Klamath system. Currently the only method to estimate mass-balance conditions for free-flowing reaches and the reservoirs is to interpolate between a very sparse set of data points and limited information on system flows. A more complete mass-balance is of high value to the ongoing TMDL adaptive management program and will be important in evaluating dam operation or removal scenarios. System wide mass balance monitoring will also provide information regarding nutrient and organic matter loading to the estuary.

Key data to collect, listed by location, are as follows:

- **Link River boundary condition:** Collect a full suite of data, including temperature, DO, total PO_4 (PO_4-T), NH_4/NH_3, NO_2/NO_3, $CBOD_5$, $CBOD_{20}$, Inorganic Suspended Solid (ISS), chlorophyll-a, algal biomass : chlorophyll-a ratio, algal C:N:P ratio, dissolved organic matter (C,N, and P), particulate organic matter (C, N, and P), alkalinity, and pH

  Time span and frequency: Data should be collected on a **weekly** basis from approximately **June 1st to July 31st (see footnote[4])**, as this period covers the most critical water quality conditions at this location. For DO and temperature, continuous data (i.e., on an hourly-basis) is recommended. Monitoring pre-dawn and afternoon concentrations of several key nutrients, such as PO_4-T, NH_4/NH_3, NO_2/NO_3, and chlorophyll-a would be ideal, in order to characterize the magnitude of diurnal fluctuation.

- **Lost River Diversion Channel (LRDC):** Data are needed to characterize the contribution of loading to the Klamath River only during the period when water flows from the Lost River to the Klamath River. The same suite of temperature and water quality data recommended for Link River is necessary.

  Again, flow data are necessary and assumed to be available.

- **Klamath Strait Drain (KSD):** The same suite of constituents noted above for Link River are also needed for KSD, in order to better characterize this boundary. Diurnal DO and temperature, and pre-dawn and afternoon nutrient monitoring are not as important.

  The monitoring frequency should be weekly, and the starting time can be 4 days later than that for Link River (i.e., it can start from June 5th and extend to August 4th). This shift in dates takes into account the time of travel from Link River to the KSD entrance location.

- **Lake Ewauna/Keno Reservoir:** Monitoring is recommended at Miller Island and Hwy 66 for temperature (continuous), DO (continuous), NH_4, NO_2/NO_3, PO_4-t, chlorophyll-a, algae biomass, Org-N, Org-P, $CBOD_5$, $CBOD_{20}$, alkalinity, and pH.

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[4] The dates presented in this section are approximate and meant to reflect the recommended shift is sample days for the various monitoring locations.

These data would need to be monitored on a weekly basis. For Miller Island, the monitoring time span should be June 5th to August 4th (the same as for KSD). For the Hwy 66 station, a monitoring time span from June 7th to August 6th would be appropriate.

It would also be valuable to measure hydrogen sulfide levels at least one or two times over the course of the monitoring event, during the anoxic period.

- **Keno Reach:** A monitoring station should be set up at the end of the Keno Reach, before entry to J.C. Boyle Reservoir. Similar constituents and frequency as for KSD would be useful. The starting time, however, can be shifted to June 7th to August 6th (which is the same as for the Hwy 66 location.

  These data would be useful in characterizing water quality processes occurring within the Keno Reach. They would also ensure more accurate representation of boundary conditions for the downstream J.C. Boyle model.

- **J.C. Boyle Reservoir:** Continuation of monitoring at the current location upstream of the dam is recommended. The same suite of parameters as for the Lake Ewauna/Keno Reservoir should be collected. The monitoring should be performed weekly from June 7th to August 6th.

- **Full Flow:** Four monitoring stations are recommended: 100 meters downstream of J.C. Boyle Dam, 100 meters after the Powerhouse return flow enters, within 100 meters of where the last spring enters, and at Stateline. The same suite of constituents as for the Lake Ewauna/Keno Reservoir are recommended. Monitoring should be performed weekly from June 7th to August 6th. Three parcel tracking events at twelve stations along the Klamath River should be initiated from (1) below the JC Boyle and below the last spring. Using the KBMP coordination framework and the model hydraulic simulation parcel sampling could be part of an optimized set of regular sampling events. The following locations should also be included in the parcel tracking sampling events: (2) above Copco; (3) above Iron Gate; (4) below Iron Gate; (5)above Shasta River; above (6) Scott River; (7) at Seiad Valley; (8) above Salmon River; (9) USGS station near Orleans; (10) at Weitchpec (above Trinity); (11) below Trinity River ; and (12) at Turwar. An estuary water quality sampling program needs to be established distinct from the run of river program. However for the parcel tracking events effort should be made to coordinate with ongoing estuary sampling events.

  The purpose of this sampling recommendation is to better understand the nutrient dynamics of the Klamath mainstem (retention and loss) on a seasonal basis.

- **Springs:** Measure, if possible, the major springs along the full flow reach, for PO_4, NH_4, NO_2/NO_3, Alk, pH, temperature, and DO. Two to three weekly monitoring events should be conducted to evaluate the temporal variability of concentration. If concentrations are highly variable, monitoring should be continued for a longer period.

- **Copco Reservoir:** Two monitoring stations are recommended: one at the upstream end and one near the dam. The same suite of constituents collected for Lake Ewauna/Keno Reservoir should be collected here, at a weekly frequency. For the upstream station, samples should be collected from June 7th to August 6th. For the downstream station, data should be collected from June 17th to August 16th.

- **Jenny Creek:** A monitoring station at the mouth of Jenny Creek is recommended. Similar constituents and frequency as for KSD would be useful. The monitoring period should be from June 17th to August 16th.

- **Iron Gate Reservoir:** Two monitoring stations are recommended: one that characterizes the outflow from Copco Reservoir before it enters Iron Gate Reservoir, and one immediately upstream of Iron Gate Dam. Constituents should be the same as for Lake Ewauna/Keno Reservoir and should be collected at a weekly frequency. The upstream station should be monitored from June 17th to August 16th and the downstream station from July 1st to August 31st.

- **Immediately Downstream of Iron Gate Dam**: One monitoring station should be located downstream of Iron Gate Dam - at the end of the turbulent region. Monitoring should include the same parameters collected for Link River. This will help to characterize inputs to the longest uninterrupted reach of the Klamath River. Samples should be collected on a weekly basis, with pre-dawn and post-dawn monitoring, if possible. Diurnal DO and temperature should be included. The time period should extend from July 1st to August 31st.

- **Low Gradient Reach Between Shasta and Scott Rivers**: This station has recently been demonstrated to have the highest rate of parasite infection of fish within the Klamath system. This station would also be crucial to understanding the nutrient dynamics of the reservoirs. To assess nutrient dynamics, diurnal hourly sampling events on three to four days from early spring to mid-fall would be useful. This would help to characterize daily variability in nutrient dynamics. The Iron Gate station should also be located at the same location as the station used by the Humboldt State University / Oregon State University Fish Health research teams. In addition to water chemistry the NNE parameter for benthic algal biomass should be sampled four times (late spring, early summer, late summer, and late fall). Monitoring should be conducted in close collaboration with the Fish Health Research Group (Bartholomew and Foot) to evaluate: planktonic food source enrichment from reservoir discharges; timing and concentration of parasite spore release; and parasite infection rates among fish and polychaetes.

- **Major Tributaries** : Based on modeling to date, it has been found that water quality from the minor tributaries do not have a significant impact on conditions in the

Klamath River. Therefore, monitoring these tributaries is not a high priority for understanding mainstem conditions and water quality drivers.

Monitoring the major tributaries, including Shasta, Scott, Salmon and Trinity, however, is important. Stations for these tributaries should be located as close to the tributary mouths as possible, while avoiding potential backwater effects from the Klamath River. Constituents monitored should be the same as for Lake Ewauna/Keno Reservoir. Monitoring should be conducted weekly from July 1st to August 31st. Additional samples should be collected for the Salmon and Trinity Rivers to evaluate day-to-day variability. These samples should be collected one or two days after the weekly monitoring data are collected at these locations.

- **Iron Gate to Turwar:** Monitoring stations downstream of the Shasta River, downstream of the Scott River, at Seiad Valley, upstream of the Salmon River, downstream of the Salmon River, upstream of the Trinity River, downstream of the Trinity River, and at Turwar are recommended. The same suite of constituents monitored for Lake Ewauna/Keno Reservoir should be monitored at these locations. Sampling should be conducted weekly from July 1st to August 31st.

  These stations should also conduct three to four diurnal hourly sampling events to address daily variability in nutrient dynamics. The Iron Gate station should be located at the same location as the station used by the Humboldt State University / Oregon State University Fish Health research teams. In addition to water chemistry the NNE parameter for benthic algal biomass should be sampled four times (late spring, early summer, late summer, and late fall).

- **Estuary:** Two to three monitoring locations in the estuary should be selected (longitudinally). Constituents monitored should be the same as for Lake Ewauna/Keno Reservoir, with the addition of salinity.

  A periphyton survey, as noted above for Iron Gate to Turwar, should also be conducted. Currently the model cannot accurately reproduce the significant diurnal fluctuation of DO in the estuary. This may be a result of periphyton growth.

- **Open Ocean Boundary Condition:** A monitoring station should be located in the Pacific Ocean, at a distance far enough from the estuary to avoid impacts from flushing. Tidal elevation, temperature, salinity, and the suite of constituents collected for Lake Ewauna/Keno Reservoir should be monitored. Both surface and bottom data are needed. Continuous tidal, temperature, and DO are recommended. The other parameters can be collected weekly. The sampling period should be from July 1st to August 31st.

- **Flow Gages and Flow Analysis:** Additional flow gages along the length of the river would be useful to further understand flow characteristics and the flow balance. This would improve hydrodynamic representation in the model, by refining representation of accretion/depletion. Currently, flow accretion is lumped with the minor tributaries in the model. This introduces some amount of uncertainty. Ideally, a higher resolution survey would reduce the need to lump these accretions, and would serve to better represent their spatial variability.

- **Water Quality Monitoring for Accretions:** In the event that any significant accretions (e.g., springs) are identified, water quality monitoring is recommended. Monitoring should be conducted using a scheme similar to that for the springs downstream of J.C. Boyle Reservoir.

- **Updated Bathymetric Survey**: In 2004, a bathymetric survey was conducted in the estuary. A new survey is recommended to cover a larger area. The area should include that surveyed in 2004, but also extend to the sand bar (and characterize the dimensions of the sand bar opening) and include a survey of the bathymetry in the Pacific Ocean, just outside the estuary (since the model grid extends into the ocean). Conduct additional historical analysis of the pattern and frequency of the status (open or closed) of the estuary mouth. Include measurement of the estuary mouth in the bathometry study. Measure flow at estuary mouth to better characterize tidal exchange with ocean.

7.8.3 Temperature / Fish Refugia

Temperature improvements in the Klamath River basin are contingent upon improvements from several contributing factors throughout the watershed. Achieving temperature standards in the Klamath River basin is critical for protecting beneficial uses of the basin, particularly in light of the real threats associated with global warming. The following are recommended special studies to better understand the opportunities for improving temperature conditions in the Klamath River basin:

- The influence of sediment delivery and tributary flows on thermal refugia volume in the Klamath River. Monitoring thermal refugia dimensions in relation to flows in tributaries, flows in the Klamath River, and sediment loads in the tributaries will lead to a better understanding of the most important factors limiting the availability of thermal refugia in the Klamath River.
- Monitoring of groundwater-surface water interaction in the Scott Valley. This monitoring is being conducted as part of the Scott River Temperature TMDL, and includes instream flow and temperature measurements, as well as monitoring of static water table height. The results of this study will contribute to a better understanding of potential temperature improvements in the Scott River.
- To better understand the status of fish access to the tributaries cross-sections surveys should be conducted at the mouth of each tributary to assess connection status to main stem Klamath. Conduct channel surveys of all major tributaries to assess the impact of excess sediment deposition and flow regime alteration on connection to the main stem Klamath.

7.8.4 Relationship of Water Quality Conditions and Fish Disease

The Klamath Fish Health Research team (Humboldt State University, Oregon State University, USFWS, and CA Fish and Game) is taking the lead on formulating key questions, developing research proposals, and conducting the research to better understand and manage fish disease processes in the Klamath River basin. The annual Klamath Fish Health Conference held in Fortuna, California has provided an excellent forum for presentation and discussion of research results. The questions of interest to the Regional Water Board relate more specifically to how water quality conditions, especially those impacted by TMDL control strategies, affect the severity and magnitude of fish disease processes in the Klamath River. The Klamath Fish Health team is currently developing a fish disease model that eventually will incorporate water quality factors to develop estimates of fish infection and mortality rates within the Klamath mainstem.

- What monitoring information is needed to continue to develop the Klamath fish disease model algorithms?

7.8.5 Blue-Green Algae / Cyanotoxins

The California and Klamath Blue-Green Algae Work Groups meet on a regular basis and discuss results of ongoing monitoring and future research needs. Much is unknown about the algae species dynamics, ecological impacts, and the potential effectiveness of within reservoir mitigation strategies. The following are questions that will be raised at the existing forums for further refinement and possible recommendation for development into special study proposals.

- What environmental factors, or capabilities unique to the blue green algae contribute to the competitive advantage that the blue-green algal species exhibit in the California reservoirs during the peak summer growth period?
- How do environmental factors affect cyanotoxin production?
- How long does microcystin remain in tissue once an organism has been exposed?
- How long are the effects manifested within the affected tissues of various organisms?
- Proposed blue-green algae monitoring should consider tracking the depth that blue-algal cells descend to during their diurnal rising and sinking. Do blue-green algae cells reach the hypoliminion and have access to higher nutrient concentrations than those in the epiliminion? This could be a principal factor leading to their competitive advantage relative to other algal species during the late summer period.

7.8.6 Periphyton Characterization in the Mainstem Klamath River

Attached algae (periphyton) has a major impact on DO and pH diurnal patterns in the mainstem Klamath River. Periphyton is also believed to have a connection to the distribution and abundance of fish parasites (*C. Shasta)*. Periphyton also plays an important role in nutrient dynamics (retention and loss) within the Klamath River. Therefore periphyton density / algal biomass is a key monitoring and TMDL implementation indicator.

- An improved characterization of periphyton / algal biomass conditions is needed on the Klamath River. Algal biomass should be sampled on four dates at seven locations beginning (1) below Iron Gate Dam (below the channelized reach). Other periphyton stations should include: (2) above the Shasta River; (3) above the Scott River; (4) at

Seiad Valley; (5) above Trinity; (6) below Trinity; and (7) at Turwar. The protocol should be consistent with the methods recommended by the Surface Water Ambient Monitoring Program Periphyton Technical Advisory Committee and should include a visual or photographic estimation method for those locations where due to flow conditions sampling in the mainstem is deemed to be unsafe. The sampling dates should include early spring, mid-summer, late summer, and late fall. Sampling events should note any obvious scour (early spring) or desiccation (late summer / late fall).

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CHAPTER 7. REFERENCES

Agreement in Principle Interim. 2009. Measure 12: Water Quality Monitoring Activities, Monitoring Year 2009 (AIP). 2009. Collaboration of CA North Coast Regional Water Quality Control Board; Karuk Tribe Natural Resources Department; Klamath Watershed Institute; Oregon Department of Environmental Quality; PacifiCorp; US EPA Region 9; US Department of Interior Bureau of Reclamation,; and Yurok Tribe Environmental Program. Final June 2009. Available at: <http://www.waterboards.ca.gov/northcoast/water_issues/Programs/tmdls/Klamath_river/AIP_Monitoring_Plan_2009>.

CH2M HILL. 2009. Analysis of Microcystin in Resident Fish and Mussel Tissues in the Vicinity of the Klamath Hydroelectric Project in 2008. Prepared by CH2M HILL Inc. Prepared for PacifiCorp Energy. December 2009.

Helsel, D.R., and R.M. Hirsch. 2002. Techniques of Water-Resources Investigations of the United States Geological Survey - Book 4, Hydrologic Analysis and Interpretation

National Research Council of the National Academies (NRC). 2004. Endangered and Threatened Fishes in the Klamath River Basin. Washington, D.C. National Academies Press.

Office of Environmental Health Hazard Assessment (OEHHA). 2008. Letter dated August 6, 2008, to Randy Landolt, PacifiCorp from OEHHA.

Royer, C.F. and A.P. Stubblefield. 2009. Review Draft: Klamath Basin Water Quality Monitoring Plan, Prepared for the Klamath Basin Monitoring Program (KBMP). Klamath Watershed Institute under contract to the North Coast Regional Water Quality Control Board. October 2009.

Sullivan, A.B., Deas, M.L., Asbill, J., Kirshtein, J.D., Butler, K., Wellman, R.W., Stewart, M.A., and Vaughn, J., 2008, Klamath River water quality and acoustic Doppler current profiler data from Link River Dam to Keno Dam, 2007: U.S. Geological Survey Open File Report 2008-1185, 25 p..

CHAPTER 8. ANTIDEGRADATION ANALYSIS

8.1 Introduction

This chapter briefly describes the state and federal antidegradation policies and how they apply to the Klamath River TMDL Action Plan.

8.2 State and Federal Antidegradation Policies

The state and federal antidegradation policies are independently enforceable requirements, despite being referred to as policies. The state antidegradation policy is titled the *Statement of Policy with Respect to Maintaining High Quality Waters in California*, codified in 23 CCR §2900, and is commonly known as "Resolution 68-16." The California's antidegradation policy is also included in the Basin Plan as a General Objective (Basin Plan pages 3-2.00 to 3-3.00). The federal antidegradation policy is found at 40 CFR §131.12 and it has been incorporated into the Basin Plan.

Although there are some differences, where the state and federal policies overlap they are consistent with each other. Both the state and federal antidegradation policies require that where surface waters are of higher quality than necessary to protect the designated beneficial uses, the high quality of those waters be maintained unless otherwise provided by the policies. Both policies require that certain findings be made before any adverse change to water quality can be permitted. The State Water Board has concluded that Resolution No. 68-16 incorporates the federal Antidegradation Policy (see State Water Board Order No. WQ 2001-16, p. 19, fn 83).

The state antidegradation policy applies to groundwater and surface water whose quality meets or exceeds (is better than) water quality objectives. The state policy establishes several conditions that must be met before the quality of high quality waters may be lowered by waste discharges.

The state must determine that lowering the quality of high quality waters:

1. Will be consistent with the maximum benefit to the people of the state,
2. Will not unreasonably affect present and anticipated beneficial uses of such water, and
3. Will not result in water quality less than that prescribed (e.g., by water quality objectives).

In addition, before any degradation of water quality is permitted, it must be shown that the discharge will be required to meet waste discharge requirements that result in best practicable treatment or control of the discharge necessary to assure that:

1. Pollution or nuisance will not occur;
2. The highest water quality consistent with maximum benefit to the people of the State is maintained.

The federal antidegradation policy applies to surface water regardless of the quality of the water. In allowing an activity to degrade or lower water quality, the federal antidegradation policy requires states to ensure that:

1. The activity is necessary to accommodate important economic or social development in the area,
2. Water quality is adequate to protect and maintain existing beneficial uses fully, and
3. The highest statutory and regulatory requirements and best management practices for pollution control are achieved.

The federal antidegradation policy also applies to surface waters that do not meet the applicable water quality objectives (i.e., impaired waters). Under the federal policy, an activity or discharge would be prohibited if the activity will lower the quality of surface water that does not have assimilative capacity (i.e., the water quality is not sufficient to support designated beneficial uses) with limited exceptions set forth in federal regulations.

Both the state and federal antidegradation policies acknowledge that minor or repeated activities, even if individually small, can result in violation of antidegradation policies through cumulative effects, especially, for example, when the waste is a cumulative, persistent, or bioaccumulative pollutant.

8.3 Applicability to the Klamath River TMDL Action Plan

The proposed Klamath River TMDL Action Plan is based in part on the principles contained in the state and federal antidegradation policies. The recommended alternative – adoption of the proposed Klamath River TMDL Action Plan – will not delete or limit beneficial use designations and will not relax any water quality standard. This proposal will result in water quality improvements; therefore, state and federal antidegradation analyses are not required.

CHAPTER 9. CALIFORNIA ENVIRONMENTAL QUALITY ACT (CEQA) ENVIRONMENTAL ANALYSIS

Staff from the North Coast Regional Water Quality Control Board (Regional Water Board) developed two proposed amendments to the *Water Quality Control Plan for the North Coast Region* (Basin Plan) that would incorporate the *Klamath River Watershed Temperature, Dissolved Oxygen , Nutrient and Microcystin Total Maximum Daily Loads* (hereinafter draft Klamath TMDLs) and the implementation program into the Basin Plan. The Klamath River implementation plan includes the Implementation Plan for the EPA-promulgated Lost River TMDL in California. In addition, the second proposed amendment would modify Table 3-1 of the Basin Plan by eliminating the existing site-specific dissolved oxygen (DO) water quality objectives (objectives) applicable to the Klamath River mainstem and replacing them with an alternate method of calculating objectives based on percent saturation and natural background temperatures. The proposed amendment would also modify Section 4 of the Basin Plan by adding a new *Klamath River Total Maximum Daily Load Action Plan and Lost River Implementation Plan* (hereinafter proposed Action Plan). These proposed amendments are necessary to comply with existing federal and State laws, regulations, plans and policies. In addition, the development of the Klamath TMDLs is mandated under a court-ordered Consent Decree.

9.1 California Environmental Quality Act Requirements for Exempt-Regulatory Programs

The Regional Water Board is the lead agency for evaluating the environmental impacts of Basin Plan amendments pursuant to the California Environmental Quality Act (CEQA). Although subject to CEQA, the Regional Water Board basin planning process is certified by the Secretary for Resources as "functionally equivalent" to CEQA, and therefore exempt from the requirement for preparation of an environmental impact report or negative declaration and initial study[1]. The State Water Resources Control Board (State Water Board) has promulgated guidelines for exempt regulatory programs that describe the documents required for the adoption or approval of standards, rules, regulations or plans[2]. These documents must at least do the following:

1. <u>Provide a brief description of the proposed activity</u>.
   In this case, the proposed activity is the adoption of two Basin Plan Amendments: a) Revised DO objective for the Klamath River mainstem and b) "*Action Plan for the Klamath River Watershed Temperature, Dissolved Oxygen, Nutrient and Microcystin Total Maximum Daily Loads*" (proposed Action Plan). The rationale to support the proposed DO objective and Action Plan is fully described in the Staff Report. A brief description is provided in Section 9.2.

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[1] Cal. Code Regs., tit. 14, § 15251(g).
[2] Cal. Code Regs., tit. 23, § 3777.

2. Provide a reasonable discussion of alternatives to the proposed activity. Discussion is provided in Section 9.4.

3. Provide an analysis of mitigation measures needed to minimize any significant adverse environmental impacts of the proposed activity. Discussion is provided in Section 9.5.

Additionally, for actions by the Regional Water Board that adopt a rule or regulation requiring the installation of pollution control equipment, establish a performance standard or establish a treatment requirement, CEQA[3] and CEQA Guidelines[4] require an environmental analysis of the reasonably foreseeable methods by which compliance with that rule or regulation will be achieved. A Substitute Environmental Document (SED) satisfies this requirement if it contains the following components, some of which are repetitive with the list above:

1. An analysis of the environmental impacts from the reasonably foreseeable methods of compliance. The reasonably foreseeable methods of compliance (hereinafter compliance measures) are the potential actions that responsible parties may employ to comply with the TMDL load allocations, numeric targets and the implementation measures in the proposed Action Plan. This analysis is presented in Section 9.5.
2. An analysis of the reasonably foreseeable feasible mitigation measures relating to the identified environmental impacts. This analysis is presented in Section 9.5.
3. An analysis of reasonably foreseeable alternative means of compliance with the rule or regulation, which would avoid or eliminate any identified impacts. This analysis is presented in Section 9.7.

The environmental analysis must take into account a reasonable range of:[5]

- Environmental factors (see Environmental Setting and Land Use, Section 9.3);
- Technical factors (see Analysis of Compliance Measures, Associated Environmental Impacts, and Potential Mitigation Measures, Section 9.5);
- Population (see Environmental Setting and Land Use, Section 9.3);
- Geographic areas (see Environmental Setting and Land Use, Section 9.3);
- Specific sites (see Analysis of Compliance Measures, Associated Impacts, and Potential Mitigation Measures, Section 9.5); and
- Economic factors (see Economic Considerations, Chapter 10).

While the regulations require consideration of a "reasonable range" of the factors listed above, an examination of every site is not required, only consideration of a reasonably representative sample of them. The statute specifically states that the agency shall not

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3 Cal. Pub. Resources Code, § 21159 (a).
4 Cal. Code Regs., tit.14 § 15187 (c).
5 Cal. Code Regs., tit. 14 § 15187(d); Cal. Pub. Resources Code, § 21159 (c).

conduct a "project level analysis[6]." Rather, in most circumstances, the project level analysis will be performed by the responsible party to be eligible for enrollment/coverage under the applicable permit (e.g., 401 Water Quality Certification, waste discharge requirements [WDRs], or waiver of WDRs).

Notably, the Regional Water Board is prohibited from specifying the manner of compliance with its regulations[7], and accordingly, the actual environmental impacts will necessarily depend upon the compliance strategy selected by the responsible party. There could be adverse environmental impacts from specific methods if inappropriate methods are selected or if the management measures selected are not properly implemented. Regional Water Board staff intends that the compliance measures selected by a responsible party be the most cost effective available with the least potential to adversely impact the environment. Responsible parties will develop the suite of compliance measures they will implement to achieve the TMDL load allocations and be compliant with the proposed implementation plan and the revised DO objective. A number of regulatory approaches are (or will be made) available for responsible parties' use in achieving compliance with the TMDLs. This includes compliance with applicable prohibitions, WDRs or conditional waivers of WDRs.

This Substitute Environmental Document (hereinafter SED) identifies broad mitigation approaches that could be considered for the general categories of land use activity identified in the TMDL pollutant source analysis and implementation plan (Chapters 4 and 6, respectively of this Staff Report). Consistent with CEQA, this document does not engage in speculation or conjecture, but rather considers the reasonably foreseeable environmental impacts of the reasonably foreseeable methods of compliance, and the reasonably foreseeable mitigation measures which would be required to avoid, eliminate, or reduce the identified impacts.

An analysis of the reasonably foreseeable alternative means of compliance is also provided as part of this environmental analysis (see Section 9.7).

9.2 Description of the Proposed Activity

In this case, the proposed activity (or project) is the revision of DO objectives for the Klamath River mainstem; the establishment of the total maximum daily loads (TMDLs) for the temperature, dissolved oxygen, nutrient and microcystin impairments in the Klamath River watershed; and, the adoption of an implementation plan (proposed Action Plan) for the Klamath River watershed necessary to achieve these TMDLs and fully attain water quality standards, including the revised DO objectives. The goal of the proposed implementation plan is to achieve the TMDLs and thereby achieve temperature, dissolved oxygen, nutrient and microcystin-related water quality standards, so as to protect and restore the beneficial uses of water in the Klamath River watershed. The

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[6] Public Resources Code section 21159(d)
[7] Water Code section 13360

proposed Action Plan sets outs the pollutant loads and conditions to be considered and incorporated into regulatory and non-regulatory actions in the Klamath River watershed. The Klamath River Action Plan is not directly and independently enforceable, except as incorporated into permitting or enforcement actions or through the application of waste discharge prohibitions or other permits or orders.

- Regional Water Board staff has developed a proposed site-specific DO objective for the Klamath River in California (Appendix 1 of the TMDL Staff Report) for the Regional Water Board's consideration to address the inaccuracies in the existing Klamath River DO objectives. The Basin Plan Amendment for DO is an amendment to Table 3-1 in which the existing site-specific DO objectives for the Klamath River mainstem are removed and a method for calculating revised site-specific DO objectives is described, based on percent saturation and natural receiving water temperatures.
- Regional Water Board staff has also developed the proposed Klamath River TMDL Action Plan for the Regional Water Board's consideration to address the water quality impairment in the Klamath River watershed downstream of the Oregon border. The proposed Basin Plan Amendment, as developed by staff, is an amendment to Section 4 of the Basin Plan to provide an *"Action Plan for the Klamath River Watershed Temperature, Dissolved Oxygen, Nutrient and Microcystin Total Maximum Daily Loads"* (proposed Action Plan).

The proposed Basin Plan Amendment language, including Table 9.1, for the site-specific Klamath River mainstem DO is as follows:

Site-specific dissolved oxygen water quality objectives for the Klamath River are derived by calculating the daily minimum dissolved oxygen necessary to maintain, at a minimum, the percent DO saturation criteria given in Table 9.1 under site salinity, site atmospheric pressure, and natural receiving water temperatures.

Table 9.1: Percent dissolved oxygen saturation based on natural receiving water temperatures

Location	**Percent DO Saturation based on natural receiving water temperatures***	**Time period**
Stateline to upstream of California- Hoopa boundary	90%	October 1 through March 31
	85%	April 1 through September 30
Downstream of Hoopa-California boundary to Turwar	85%	All year
Upper and Middle Estuary	80%	August 1 through August 31
	85%	September 1 through July 31
Lower Estuary	For the protection of estuarine habitat (EST), the dissolved oxygen content of the lower estuary shall not be depressed to levels adversely affecting beneficial uses as a result of controllable water quality factors.	

*These objectives apply throughout the length of the mainstem Klamath River except for where there is Tribal jurisdiction.

The proposed Action Plan consists of a description of the TMDL temperature, dissolved oxygen, nutrient and microcystin-related load allocations and numeric targets and implementation actions necessary to comply with the TMDLs.

The proposed Action Plan includes the following items as part of the implementation program:

- Adoption of a *Prohibition of Discharges in Violation of Water Quality Objectives in the Klamath River Basin*

  "Discharges of waste that violate any narrative or numerical water quality objectives that are not authorized by waste discharge requirements or other order or action by the regional or state water board, are prohibited."

- Adoption of a Thermal Refugia Protection Policy that provides enhanced protection of thermal refugia in and around the mainstem Klamath River and in the Lower Scott River.

  The policy would be applicable to all tributary streams in the Klamath River basin that provide known thermal (cold-water) refugia

- Adoption of Guidance to Control Sediment Discharges

  The guidance encourages responsible parties to implement specific measures to address sediment source discharges in the Klamath basin.

The SED to support the Regional Water Board's consideration of the draft Klamath River TMDLs includes:

- The draft Staff Report which provides the technical and environmental analysis necessary to support adoption of the revised site specific DO objective for the Klamath River mainstem and the Klamath River TMDLs;
- The proposed Basin Plan Amendment for the revision of the Klamath River DO objectives; and
- The proposed Action Plan that includes, in part, load allocations and implementation actions necessary to achieve the TMDL and attain water quality standards, including the protection and restoration of beneficial uses of water in the Klamath River watershed.

9.3 Environmental Setting and Land Uses

The Klamath River watershed originates in southeastern Oregon and flows through northern California to the Pacific Ocean in Del Norte County, California. The Klamath River watershed is approximately 12,600 square miles in size, with forty-four percent (44%) of the watershed within the boundaries of Oregon, and the remaining fifty-six percent (56%) located in California.

The human population in the Klamath River basin was estimated in the 2000 US Census to be about 114,000 (United States Census Bureau [USCB] 2000). The largest population concentrations lie in the upper Klamath agricultural area, the Shasta River Valley, and Scott Valley. The largest population center is Klamath Falls in Oregon (19,462 people in 2000) followed by Yreka, California (7,290 people). The Klamath River basin can generally be characterized as a rural watershed with limited population-related water quality issues.

The watershed is composed of large tracts of remote forest and wilderness area, as well as agricultural areas and isolated small-scale urban areas. The watersheds support threatened and endangered species of plants and animals, including runs of anadromous salmon and steelhead trout. The principal reaches of the Klamath River are designated as “wild and scenic” under federal and State law and therefore are protected from development of additional large-scale water use projects.

The current air quality in the region is above average to good. However, Humboldt, Del Norte, and Trinity Counties do not fully meet the state health standards[8] for clean air. The two pollutants of greatest concern are ozone and particulate matter. The sunny climate, pollution-trapping mountains and valleys, along with the growing population, all contribute to this problem. Particulate matter is fine mineral, metal, soot, smoke and dust particles suspended in the air. The exceedence of state health standards are most often due to catastrophic wildland fires.

The underlying geology in much of the Upper Klamath basin is of volcanic origin. Soils derived from this rock type are naturally high in phosphorus. Through natural erosion and leaching processes, these soils contribute a high background phosphorus load to Upper Klamath basin waters

The geographic source areas in the Klamath River in California can generally be grouped as follows:

- Stateline – Waters entering California from Oregon at Stateline, which includes the Williamson and Sprague River watersheds; Upper Klamath Lake; the Lost River watershed that drains the U.S. Bureau of Reclamation’s Klamath Project (Reclamation’s Klamath Project) area; municipal and industrial point sources to the Klamath River in Oregon; and Klamath River waters passing through Lake Ewauna, the Keno Reach, and JC Boyle Reservoir. Oregon’s Klamath River TMDL source analysis evaluates the contributions from these various sources on the water quality of the Klamath River in Oregon;
- Reservoirs – The reservoirs on the Klamath River within California: Copco 1 and 2 and Iron Gate Reservoirs. Copco Reservoirs 1 and 2 are treated as a single source for the purposes of this TMDL;

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8 http://www.arb.ca.gov/research/aaqs/caaqs/caaqs.htm

- Iron Gate Hatchery; and
- Tributaries – These include the Lost, Shasta, Scott, Salmon, and Trinity Rivers, and a number of smaller tributary creeks.

The Klamath River has historically been referred to as the “river of renewal”. The Klamath is unusual in that it has its origins in a naturally shallow, eutrophic lake, Upper Klamath Lake, which delivers warm water with high levels of nutrients and organic matter to the Klamath River. Due to an increasing stream gradient and inputs from tributaries with water that is both cooler and generally lower in nutrient content, the Klamath River undergoes a renewal process that leaves it less eutrophic as the river approaches the Pacific Ocean, creating conditions that historically made it one of the most productive cold-water fisheries on the Pacific coast. Despite this unique attribute, current source loads have overwhelmed the historic renewal capabilities of the Klamath, leading to its impaired status. Table 9.2 presents the anthropogenic pollutant source land use categories.

Table 9.2: Anthropogenic pollutant source land use categories[9]

Land Use Source Categories	Temp.	DO	Nutrient	Organic Matter
Wetland conversion		X	X	X
Grazing	X	X	X	X
Irrigated agriculture	X	X	X	X
Timber harvest	X	X	X	X
Roads	X		X	

High ambient air temperatures, coupled with the high levels of biological productivity and respiration that are enhanced by the high levels of biostimulatory nutrients, yield a large mass of organic matter, seasonally high water temperatures, daily low dissolved oxygen, and high pH levels. All of these water quality conditions can be extremely stressful to many forms of aquatic life. These natural background heat, nutrient, and organic matter loads to the Klamath River underscore the very limited capacity of the river to assimilate anthropogenic pollutant sources, and the necessity for establishing load allocations that will result in attainment of water quality standards.

The existing DO objectives for the Klamath River mainstem are based on grab sample data collected in the 1950s and 1960s during daylight hours. They are identified as instantaneous minima. But, because they do not reflect DO conditions during the night time when DO concentrations decrease with the loss of photosynthetic contributions, the existing DO objectives are best applied only during daylight hours. The TMDL analyzes conditions in the Klamath River throughout the day and night and over the course of a year. As such, the model shows that even under natural conditions—in the absence of anthropogenic influences—the Klamath River can not meet the existing DO conditions during the pre-dawn hours of the summer when temperatures are warm and photosynthesis is temporarily arrested. Staff proposes the revision of the DO objectives for the Klamath River to better reflect minima expected across a full 24 hours. The

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9 From Chapter 4 of this Staff Report

TMDLs are calculated based on the proposed revisions to the Klamath River DO objectives.

The States of Oregon and California are responsible for calculating the TMDL load allocation for each of the pollutants of concern that can be discharged to the watershed and still protect and restore the beneficial uses of the water within their respective jurisdictions.

In the California portion of the Klamath River, increased water temperatures, elevated nutrient levels, low dissolved oxygen concentrations, elevated pH, potential ammonia toxicity, increased incidence of fish disease, an abundance of aquatic plant growth, high chlorophyll-a levels (both planktonic and periphytic algae), and high concentrations of potentially toxigenic blue-green algae (microcystin), particularly in the impounded reaches (reservoirs), decrease the quality and quantity of suitable habitat for fish and aquatic life, and have disrupted traditional cultural uses of the river by resident Tribes. These conditions contribute to the non-attainment of beneficial uses, including the most sensitive beneficial uses: those associated with the cold water fishery (specifically the salmonid fishery), and those related to cultural uses and practices.

California listed the portions of the Klamath River within its jurisdiction for water quality impairments due to elevated water temperatures, elevated nutrients, and organic enrichment/low dissolved oxygen. The portion of the Klamath River downstream of the Trinity River, within the Yurok Reservation, was also listed for sedimentation/siltation impairment. In March 2008, the USEPA added the reach of the Klamath River that incorporates the Copco 1 and 2 and Iron Gate Reservoirs (located near the California - Oregon Stateline) to the Clean Water Act 303(d) List of Impaired Waterbodies for the blue-green algae toxin microcystin.

The Klamath River numeric and narrative water quality objectives and beneficial uses that are the comparative benchmarks for the TMDL assessment are described in Table 2-1 of the Basin Plan and in the Hoopa Tribal water quality standards,[10] with the exception of the DO objectives for the Klamath River mainstem which are proposed for revision. The Basin Plan, proposed Basin Plan Amendment for DO, and Tribal water quality standards provided the baseline regulatory context for the TMDL assessment and development.

9.4. Analysis of Reasonable Alternatives to the Proposed Activity

Regional Water Board staff has identified four approaches (or alternatives) to address protection and restoration of the beneficial uses of water in the Klamath River watershed. The purpose of this analysis is to determine if there is an alternative that would feasibly attain the basic objective of the rule or regulation, but would lessen, avoid, or eliminate any identified impacts. The first alternative, as required by law, analyzes a “No Action”

[10] Hoopa Tribe Water Quality Control Plan: http://hoopa-nsn.gov/doccument/WQCP.pdf

alternative with no change to the Basin Plan or program implementation. The second alternative also contemplates no change to the Basin Plan but describes an approach that focuses on implementation of existing Regional and State Water Board programs with a phasing in of new regulatory programs for activities not yet covered under a prohibition, conditional waiver or WDRs. The other two alternatives would include amending the Basin Plan, Table 3-1 and Section 4 – Implementation Plans, in some fashion. Alternative three would be based on the USEPA approving the technical aspects of the TMDL prior to the Regional Water Board concluding their deliberative process. This approach would be based on the Regional Water Board adopting an implementation plan based on the federally approved TMDLs. This approach would not include a revised DO objective. The final alternative, and staff's recommended approach, would be to:

- Revise the Basin Plan (Table 3-1) to include the proposed revision to the site-specific DO objectives for the Klamath River mainstem,
- Amend the Basin Plan Section 4 to include the proposed Action Plan.

The staff report for the "*Proposed Site-Specific Dissolved Oxygen Objective for the Klamath River in California*" is included as Appendix 1 of this Staff Report.

The alternatives are compared on the basis of their ability to protect water quality and beneficial uses (i.e., their likelihood of success), and whether the approach is feasible, flexible and equitable.

9.4.1 No Action - No Change in Basin Plan Language or in Program Implementation

Under the "No Action" alternative, no amendment to the Basin Plan would occur and staff would continue to implement existing Regional and State Water Board programs as in the past. Under this alternative, USEPA, as required under the court-ordered Consent Decree, would approve a TMDL by December 2010. Since USEPA has the authority to approve the technical, science-based portions of the TMDL (e. g., the source analysis and load allocations) but not the implementation program, this alternative would not increase the likelihood of water quality protection nor lead to the restoration of the impaired beneficial uses of water. Nor would it correct the inaccuracies in the existing DO objectives for the Klamath River mainstem. It would also be limited to implementation actions from responsible parties engaged in land use activities that are currently covered by a State or Regional Water Board permit.

Under this alternative, discharges of waste and impacts to water quality will likely continue as no comprehensive program would be put in place that describes the implementation actions necessary to achieve compliance with water quality standards. This is true for a number of reasons. First, there are a number of land use activities identified in the source assessment and implementation plan that have the potential to discharge non-point sources of waste that are not covered by a regulatory program. The No Action approach would allow some dischargers to continue to engage in activities that discharge waste without any control, while other landowners must comply with permits already in place (i.e. timber is already regulated under WDRs and waivers while grazing and irrigated agriculture are not currently). This is not equitable. Moreover, state law requires that unregulated discharge eventually be covered by some permitting mechanism. Allowing some discharges of waste to continue indefinitely is not legally feasible, and will not likely result in the attainment of water quality standards. Second, federal and state implementation grants and other funding sources are typically only available for projects located in watersheds that have an approved TMDL Action Plan or some other effective watershed-scale management plan in place.

Pros:

- Allows re-direction of Basin Planning staff to begin/continue work on the next issue on Triennial Review Priority List.
- Allows TMDL Development staff to begin/continue work on the development of the next TMDL on Impaired Waters List.

Cons:

- No comprehensive watershed program would be put in place.
- Inaccurate DO objectives for the Klamath River mainstem would remain in place.
- Restoration of the suite of beneficial uses of water impaired by controllable water quality factors would be unlikely.
- This alternative would likely result in legal challenge and substantial diversion of Regional Water Board resources.

9.4.2 No Basin Plan Amendment and Increased Staff Focus on Implementation (and Development) of State and Regional Regulatory Programs

As with the "No Action" alternative, this approach would not result in any revision to the Basin Plan and would necessitate USEPA's approval of the TMDLs. This approach is based on using existing State and Regional regulatory programs and permits as the implementation program for the protection and restoration of beneficial uses of water in the Klamath River watershed. This approach would necessitate the re-direction of staff from other programs or geographic areas, to allow for the increased focus necessary to fully engage in the permitting, inspections and enforcement actions (as appropriate) that would be required to fully staff this approach. This approach could include increased staff focus on the statewide Caltrans stormwater NPDES permit, general statewide construction stormwater permit, U.S Forest Service timber waiver, General WDRs – conditional waiver for timber activities on private lands, and 401 water quality certification program. New regulatory programs (i.e. prohibitions, waivers or WDRs) for activities not currently regulated would be developed as staff resources allowed.

Pros:

- As with Alternative 1, would save basin planning resources and allow planning staff to start addressing the next issue on Triennial Review Priority List.
- As with Alternative 1, would save TMDL resources and allow TMDL Development staff to begin/continue development of the next watershed on Impaired Waters List.
- Would allow staff to engage more actively in existing regulatory programs at the watershed scale.

- Would help watershed enforcement priorities due to staff familiarity with the watershed.
- Could result in significant revenue for the State's Cleanup and Abatement Account, through assessment of fines in conjunction with enforcement actions.

Cons:

- Would not address nonpoint sources of discharge from a number of sources identified in the TMDL pollutant source analysis and implementation plan (e.g. grazing, road building, alteration of riparian habitat or impacts to thermal refugia) in the near term.
- Would not correct inaccurate DO objectives for the Klamath River mainstem.
- Would require re-direction of staff from other priority work (e.g. landfills, cleanups, stormwater, etc.).

9.4.3 Adopt Basin Plan Amendments Based on the Federally Approved Klamath River TMDL and Proposed Regionwide DO Objective Revision

This alternative would be predicated on the USEPA approving the Klamath River TMDLs before the Regional Water Board had concluded its deliberative process and adopted its TMDL and DO objective revision. The time frame for final approval of the TMDLs is driven by a court-order Consent Decree. As such USEPA will be required to approve the TMDLs by the end of December 2010, regardless of whether the Regional Water Board has taken formal action or not. Since Regional Water Board and USEPA staff have been working jointly over the preceding six (6) years to develop this draft Klamath River TMDL report, it is likely that USEPA would approve some version of the TMDLs developed by the Regional Water Board. In the event USEPA approves the TMDL, the Regional Water Board could still elect to amend the Basin Plan by: 1) incorporating the federally approved TMDLs and an implementing program as described in Chapter 6 of the Staff Report, or 2) incorporating only the Klamath River implementation plan (as an Action Plan) into the Basin Plan.

Also, Regional Water Board staff intends to propose a regionwide revision to the DO objectives contained in Table 3-1 of the Basin Plan, based on the same rationale for their revision in the Klamath River mainstem. The Regional Water Board could elect to postpone adoption of a Basin Plan Amendment to revise the DO objectives for the Klamath River and wait to adopt a revision to all the DO objectives contained of Table 3-1 of the Basin Plan in concert with USEPA's approval of the technical TMDL.

Pros:

- Would save TMDL Unit staff time and resources, allowing them to focus on next highest priority TMDL.
- Would save Basin Planning staff time and resources by reducing the number of Basin Plan Amendments necessary for processing.
- Deflects threat of litigation and legal challenge on the technical aspects of the TMDLs to USEPA.

Cons:

- Defers establishment of the technical-basis of the TMDL (e.g., load allocations and numeric targets) to the USEPA.
- Postpones correction of the DO objectives for the Klamath River.
- NPDES permits, WDRs, and waivers issued by the Regional Water Board will need to be compliant with federal load allocations.
- Does not honor commitments made to USEPA and the Consent Decree plaintiffs to develop the Klamath River TMDL in a timely fashion.
- Will still require significant Basin Planning Unit staff resources to develop an Action Plan based on the federal TMDL.

9.4.4 Adopt Basin Plan Amendment Based on the Klamath River TMDL developed by Regional Water Board staff (Recommended Alternative)

Staff recommends amending Table 3-1 of the Basin Plan to revise the DO objectives for the Klamath River mainstem and amending Section 4- Implementation Plans of the Basin Plan to include an "*Action Plan for the Klamath River Watershed Temperature, Dissolved Oxygen, Nutrient and Microcystin Total Maximum Daily Loads*". Table 3-1 of the Basin Plan would be amended to eliminate the existing DO objectives for the Klamath River mainstem and replace them with a method for calculating alternate site-specific DO objectives based on percent saturation and natural receiving water temperatures. The Action Plan would include the source assessments for each of the listed impairments, load allocations for each of the identified sources and an implementation program describing the actions likely necessary to achieve the TMDL load allocations and numeric targets. The proposed Action Plan (see Basin Plan language link) can be found at: http://www.waterboards.ca.gov/northcoast/water_issues/programs/tmdls/klamath_river/. The technical support for the proposed Action Plan can be found, in part, in Chapters 1-6 of this Staff Report. The Staff Report is also available at the above referenced Regional Water Board webpage.

Pros:

- Maintains Regional Water Board authority in establishing load allocations, numeric targets, and water quality standards for the Klamath River watershed, in lieu of the establishment of federal load allocations.
- Ensures swift correction of inaccurate DO objectives for the Klamath River to aid in the compliance of the TMDLs with water quality objectives.
- Allows Regional Water Board staff to develop a proposed Action Plan for the Board's consideration based on the information developed by their staff.
- Takes full advantage of the opportunity provided to interested stakeholders, other agencies, and the regulated community, and the input received from these outreach efforts, in the development of the staff-sponsored TMDLs and proposed Action Plan.

Cons:

- Will require extensive Regional Water Board staff resources to develop, bring to the Regional Water Board for their consideration, and prepare the administrative record for the State Water Board's consideration.
- Focuses threat of litigation onto Regional Water Board.

9.5 Analysis of Compliance Measures, Potential Environmental Impacts, and Possible Mitigation Measures

Analysis of the potential environmental impacts resulting from basin planning projects is required by State law and policy (see Section 9.1). This analysis of potential environmental impacts was conducted by considering the numerous alternative methods available to comply with the revised DO objectives and TMDLs. The Regional Water Board is prohibited by law from specifying the means by which responsible parties will comply with water quality requirements, including water quality objectives and TMDL implementation. As such, potential environmental impacts associated with compliance with the revised DO objectives and TMDLs depend, in large part, upon the specific compliance methods selected by the responsible parties, some of whom will be public agencies subject to their own CEQA obligations. (See Pub. Res. Code, § 21159.2). Environmental impacts associated with individual projects that occur on federal land (approximately 66% of the watershed) will be further evaluated under the federal National Environmental Policy Act (NEPA) process.

Because the TMDLs are calculated based on the proposed revisions to the DO objectives for the Klamath River mainstem, the methods chosen to comply with the load allocations identified in the TMDLs will be the same as those appropriate to comply with the revised DO objectives. To assess the potential environmental impacts associated with the various methods of complying with the TMDLs and DO objectives, this environmental analysis first identifies the reasonably foreseeable means (compliance measures) by which a responsible party could achieve compliance. Compliance measures are those actions that will likely be needed, beyond those required under other regulatory programs, to ensure compliance with the TMDLs and revised DO objectives. Second, the environmental effects associated with implementation of the compliance measures are identified. If a potential adverse environmental impact was identified, an analysis was then conducted to determine if feasible mitigation measures could be applied that would lessen the significance of the identified impact. Consistent with Public Resources Code section 21159, this SED does not engage in speculation or conjecture, but rather considers the reasonably foreseeable environmental impacts of the foreseeable methods of compliance. This analysis also considers reasonably foreseeable alternative means of compliance that could avoid or reduce the identified impacts (see Section 9.7).

Specific compliance measures (including best management practices or BMPs and other pollution controls) that likely will be used to comply with requirements of the TMDLs and revised DO objectives will depend on a number of conditions such as the impairment category being addressed (e.g., temperature, dissolved oxygen, nutrients or microcystin), source category (e.g., land use activity such as road and crossing construction, reservoir management, or irrigated agriculture) and environmental setting (such as forestland, grazing lands, or impounded river reaches). A combination of structural (e.g., engineered) and non-structural (e.g., operation and maintenance) compliance measures will likely be used by responsible parties. In response to numerous public comments objecting to additional interim land use requirements for nonpoint source discharges that overlapped with already existing or proposed future basin or region-wide programs, staff has eliminated the proposed interim waiver requirements and Sediment Prohibition to allow time to develop basin or region-wide programs that will address these discharges in a sensible and systematic way. Management measures likely to be included as part of those future programs are analyzed broadly in this document. Landowners may chose to implement measures voluntarily and are encouraged to follow the Sediment Guidance previously articulated in the Sediment Prohibition. Future programs implemented by waste discharge requirements, waivers or certifications will be accompanied by additional CEQA analyses as appropriate.

The measures that could be used to comply with the proposed implementation plan and DO objectives, and the potential environmental impacts associated with their implementation are discussed below. The categories of resources that the Regional Water Board has identified as potentially being impacted by the implementation of the BMPs includes:[11]

- Aesthetics;
- Air quality;
- Biological resources;
- Cultural resources;
- Geology and soils; and
- Hydrology and water quality.

In most cases, any potential impacts would be temporary and the result of installing, maintaining and/or removing structural BMPs. Most of the structural BMPs identified as reasonably foreseeable methods of compliance with the proposed implementation plan would cause very minimal, if any, adverse impacts. Only those BMPs that involve installation of structural features that result in land disturbance or alteration would potentially have the ability to cause adverse environmental impacts. These impacts include such things as air quality impacts from the use of heavy equipment for road construction projects and, impacts to biological resources from disturbance to habitat by heavy equipment, or the installation of fencing for riparian protection or grazing management, and impacts to cultural resources from heavy equipment use. However, it is staffs' judgment that all of these potential impacts can be mitigated to levels expected to be less than significant. Staff has added a programmatic analysis of dam decommissioning in response to public comments on the first circulated draft. Several impacts related to dam decommissioning activities are identified in addition to those

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[11] See CEQA Checklist (Section 9.7.2)

already previously identified, including aesthetics impacts, air quality impacts from blasting and heavy equipment use, and biological and water quality impacts from release of turbid water from dam decommissioning activities. As the decision on whether to decommission the dams has not been made and, therefore, the exact nature of the decommissioning activities has not yet been developed, Regional Water Board staff has based the analysis of potential environmental effects of dam decommissioning on the readily available decommissioning studies conducted in the Klamath River watershed. Staff has determined that potentially significant impacts may occur to biological resources and water quality, and it is unclear without further study whether the potentially significant adverse environmental effects can be fully mitigated to levels of insignificance.

The following examples are not meant to be exhaustive of the suitable suite of compliance measures but rather provide a representative sample with the widest range bracket to accommodate as many compliance scenarios as possible.

This analysis is organized to correspond with the format presented in Chapter 6 – Implementation Plan of the draft Staff Report which lays out implementation actions based on source areas receiving allocations and targets. As described above, the load allocations are calculated based on the proposed revision to the DO objectives for the Klamath River. As such, reasonably foreseeable compliance measures to achieve compliance with the load allocations will necessarily achieve compliance with the proposed revised DO objectives, as well. This format presents the environmental analysis for likely implementation actions from sources associated with the following:

- Stateline (Staff Report Section 6.2)
- Klamath Hydroelectric Project and Iron Gate Hatchery (Staff Report Section 6.3)
- Klamath River tributaries (Staff Report Section 6.4)
  - Lost River
  - Shasta River
  - Scott River
  - Trinity River
- Watershed-wide (Staff Report Section 6.5)
  - Road construction and maintenance
  - Grazing
  - Irrigation agricultural
  - Timber harvest
  - Measure to protect thermal refugia

An analysis is included on the environmental effects from fire management activities on federals lands as the proposed implementation plan recommends actions relative to post-fire treatment in control discharge of nutrients and excess sediment.

9.5.1 Analysis of Compliance Measures, Potential Environmental Impacts, and Possible Mitigation Measures Associated with Actions to Achieve Load Allocations and DO Objectives at Stateline

The Oregon-California stateline (Stateline) is the point at which the Klamath River crosses the Oregon-California border. Stateline is designated as a compliance point in the draft Klamath TMDLs. The pollutant loads in the Klamath River entering California are the result of loadings in Oregon, including the Lost River basin, which is partially in California. Oregon has listed the Klamath River in Oregon on its CWA section 303(d) list as failing to meet Oregon water quality criteria. The Oregon-issued TMDLs will be based on Oregon's water quality standards. Because these TMDLs (and their anticipated load and wasteload allocations) are being developed by Oregon as part of a comprehensive multistate analysis of pollutant loadings to the Klamath River, they are also being designed to meet California water quality standards, including the proposed revised DO objectives, at Stateline. Improvements in water quality in Oregon represent a critical part of the solution in meeting water quality objectives in California.

Oregon is responsible for developing an implementation plan to meet the Klamath and Lost River TMDLs in Oregon. The implementation plan will include the following elements:

- Identification of management measures to meet load allocations;
- A timeline for implementation with measureable milestones;
- A timeline for attainment of water quality standards, including the proposed revised DO objectives;
- A monitoring plan; and
- General discussion of costs and funding for implementation.

The Regional Water Board intends to work closely with Oregon in implementing the Klamath and Lost River TMDLs. One of the purposes of coordination with Oregon is to align each States' approach to controlling nonpoint sources of pollution.

9.5.1.1 <u>Analysis of Compliance Measures Associated with Actions to Achieve Load Allocations and Proposed Revised DO Objectives at Stateline</u>

- Implementation of the Klamath TMDLs will be coordinated with the Regional Water Board, Oregon Department of Environmental Quality and the USEPA. A Memorandum of Agreement (MOA) has been established that provides a framework for joint implementation of the Klamath River and Lost River TMDLs. The MOA includes commitments such as:
  - Work to develop and implement a joint adaptive management program.
  - Work with appropriate entities to develop and implement basin wide monitoring programs.
  - Work jointly with responsible parties to develop effective implementation plans to achieve water quality standards, including the proposed revised DO objectives.

- o Explore centralized treatment options such as treatment wetlands, algae harvesting, and package wastewater treatment systems to reduce nutrient loads to the Klamath River.
- o Work to develop and implement a basin wide water quality tracking and accounting program that would establish a framework to track water quality improvements, facilitate planning and coordinated TMDL implementation, and enable appropriate water quality offsets or trades.

9.5.1.2 Potential Environmental Impacts Associated with Actions to Achieve Load Allocations and Proposed Revised DO Objectives at Stateline

- None identified. It is staffs' judgment that the development of a coordinated program to develop comprehensive basin wide implementations actions will not result in potential environmental impacts. The MOA contemplates the exploration, development and implementation of centralized treatment options which may yield projects that could result in environmental impacts; however, this program is still in the early stage of development and any environmental analyses would be highly speculative and not useful at this time. If a given project is identified in the future that may have associated environmental impacts, the Regional Water Board will conduct a CEQA analysis in accordance with California Code of Regulations, title 14, section 15277 [projects located outside California]. To the extent that some future projects are similar or overlap with those discussed in the context of the Klamath Hydroelectric Project, those impacts are addressed below.

9.5.1.3 Possible Mitigation Measures to Avoid Impacts Associated with Actions to Achieve Load Allocations and Proposed Revised DO Objectives at Stateline

- Not applicable.

9.5.2 Analysis of Compliance Measures, Associated Potential Environmental Impacts, and Possible Mitigation Measures for Klamath Hydroelectric Project

The Klamath Hydroelectric Project (KHP) is a federally licensed project owned and operated by PacifiCorp and consists of eight facilities in California and Oregon. The implementation plan addresses the impacts of the project facilities in California, which include the Copco 1, Copco 2, and Iron Gate dams/reservoirs. As described in the Klamath TMDL Staff Report, the presence of dams impacts water quality by increasing stream temperatures and increasing the bioavailability of sediment-sorbed nutrients. They also serve to alter the natural pattern and range of river flows.

The Klamath River TMDLs assign load allocations and targets at levels necessary to achieve water quality standards within the KHP area, including the proposed revised DO objectives. Regulation and enforcement of the TMDL allocations is traditionally through the State Water Board water quality certification process that accompanies renewal of a license issued by the Federal Energy Regulatory Commission (FERC). As described in more detail below, certain parties have been engaged in settlement negotiations that contemplate the voluntary removal of the KHP. Because the regulatory process and outcome of the settlement negotiations is largely outside of the Regional Water Board's control, the Klamath River TMDL implementation plan is developed to accommodate various alternatives.

To comply with the TMDL, PacifiCorp must implement management measures that result in attainment of the load allocations and targets from the KHP facilities in California, including the proposed revised DO objectives, regardless of whether the dams remain or are ultimately decommissioned. Regulation and enforcement of these TMDL allocations is traditionally through the SWRCB Clean Water Act section 401 water quality certification process, since the Regional Water Board is preempted from issuing a permit to the KHP. The KHP operates under a FERC license that expired on March 1, 2006. The KHP will continue to operate under an annual license until the license is renewed or a decision to decommission the dams is made. Renewal of the license requires compliance with the CEQA and the issuance of a Clean Water Act section 401 water quality certification by the SWRCB. In issuing water quality certification, the state may impose conditions on the KHP in order to certify that the project protects beneficial uses and meets water quality objectives as specified in the Basin Plan. The Klamath TMDLs and proposed revised DO objectives, upon adoption, will become part of the Basin Plan and will thus become part of the comprehensive plan that FERC must consider as part of its licensing decision. In 2004, FERC prepared a Final Environmental Impact Statement (FEIS) that describes the positive and negative environmental effects of the proposed action to relicense the continued operation of the KHP, and alternative actions, including decommissioning all or part of the project. As authorized by section 401, the SWRCB will apply appropriate state water quality requirements through the FERC licensing proceeding as part of its decision to issue or deny water quality certification. SWRCB staff is preparing an Environmental Impact Report (EIR) that relies in part on the FEIS. The EIR will evaluate four alternatives for operating the KHP, two of which include removal of two and four of the KHP dams, respectively.

At the same time, certain parties have been engaged in settlement negotiations that contemplate the voluntary removal of the KHP. These negotiations and subsequent agreements stemmed from a larger negotiation of the Klamath Basin Restoration Agreement (KBRA) that addresses water rights issues in Oregon. Completion of the KBRA was contingent on completion of the Klamath Hydroelectric Settlement Agreement (KHSA). On November 13, 2008, an Agreement in Principle (AIP) to remove four of the Klamath River dams (JC Boyle, Copco 1 and 2, and Iron Gate) was announced after negotiations between the representatives of the federal government, the state of California, [12] the state of Oregon, and PacifiCorp. On September 30, 2009 a draft Klamath Hydroelectric Settlement Agreement (KHSA) was released. (Documents are available at http://www.edsheets.com/Klamathdocs.html.)

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[12] State of California is defined as the State of California Resources Agency and its constituent departments and excludes all other state agencies, departments, boards and commissions. The Regional Water Board is not a constituent department under the Resources Agency.

Under section 3.3 of the draft KHSA, the Secretary of the Department of the Interior will conduct very detailed studies and assessments to determine, *inter alia*, whether dam removal (i) will advance restoration of the salmonid fisheries of the Klamath Basin, and (ii) is in the public interest. The Secretary is to make a determination by March, 2012, subject to various contingencies, on whether to move forward with the project. As part of this process, a detailed plan for facility removal will be developed that describes the " physical methods to be undertaken to effect Facilities Removal, including but not limited to a timetable for Decommissioning and Facilities Removal, which is removal of all or part of each Facility as necessary to effect a free-flow condition and volitional fish passage." (KHSA, § 3.3.2.)

In the absence of the FERC/401 process, the TMDL load allocations (and existing water quality objectives) as they apply to the KHP cannot be directly implemented and enforced. Settlement Parties address TMDL implementation in Oregon and California in section 6.3 of the draft KHSA. Section 6.3.2 of the KHSA describes generally the content of PacifiCorp's implementation plan to include a timeline for implementing management strategies, water quality-related measures in Appendix D and Facilities Removal as the final measure. The proposed plan may further include other planned activities and management strategies developed individually or cooperatively with other sources or designated management agencies. Appendix D contains water-quality measures that could potentially serve to meet TMDL needs in the interim while additional studies are conducted. The interim measures identified in Appendix D of the draft KHSA are taken by Regional Board staff as the compliance measures on which PacifiCorp will base the implementation program designed to meet their TMDL waste load allocations until a decision is made on which regulatory path PacifiCorp will proceed, and if dams are decommissioned, until the dams are finally removed. If the decision is ultimately made not to remove the dams, the interim measures are not presumed to provide final compliance with the TMDL load allocations, and the FERC/401 process resumes.

The Regional Water Board can only determine whether the selected outcome will meet its TMDL needs. The implementation plan provides for Regional Water Board review of more site specific environmental assessments of dam removal. Both dam alteration/modifications and dam removal are recognized as possible strategies by which final compliance with the TMDL load allocations may be accomplished. Whether the dams are ultimately removed is a decision before several federal and state agencies in consideration of other factors in addition to water quality, including water allocations, species protection and power needs. These decisions will necessarily be informed by detailed environmental review.

In the previous draft Klamath TMDL, staff had not attempted to analyze dam removal impacts or permanent infrastructure modifications because the action was indeterminate and would certainly require CEQA compliance before proceeding. In its comments on the draft Klamath TMDL, PacifiCorp submitted that dam removal was a foreseeable means of compliance with the TMDL and requested that it be included in the environmental documentation. PacifiCorp listed a series of studies that have been conducted to date on dam removal that could be appropriately relied upon for a programmatic assessment. Accordingly, the following programmatic environmental analysis will evaluate the potential environmental impacts of dams removal and proposed modifications if dams are not removed in addition to the previous analyses of interim measures (note that reference to Exhibit 1C of the AIP is replaced by Appendix D of the draft KHSA, which are the same in substance). The environmental effects of dam removal are not intended to be site-specific. A detailed environmental analysis of impacts and subsequent Regional Water Board approval is required before this activity may occur.

What follows is an environmental analysis of the potential adverse environmental impacts arising from implementation of two distinct implementation strategies related to attaining TMDL load allocations and meeting water quality standards at the KHP.

The first part of the analysis is an evaluation of the environmental effects associated with interim compliance measures that PacifiCorp has identified as actions that might reasonably be taken to move the existing KHP dams toward compliance with the TMDL load allocations and applicable water quality standards. Section 9.5.2.1 through 9.5.2.10 of this Staff Report presents the analysis of the potential environmental impacts associated with implementation of ten (10) measures identified in Exhibit 1C of the AIP that Regional Water Board staff identified as being viable now or in the near future or measures that will require additional study before implementation is possible. These measures, identified by PacifiCorp as being reasonable compliance measures, are discussed below. Staff has determined that these measures represent reasonable interim measures that could be used to improve water quality and beneficial uses until a final decision is made on the KHP. Exhibit 1C of the AIP is included in this Staff Report by reference.

The second part of this assessment analyzes the environmental effects of the decommissioning or removal or one or more of the three KHP dams located in California. Section 9.5.2.11 contains an environmental analysis of the effects of a dam(s) removal scenario. Several dam decommissioning studies have been conducted over the past few years, many of them focused on removal of dams on the Klamath River system. These studies evaluated various scenarios for dam removal, physical methods of dam decommissioning, identification of reasonable compliance measures to mitigate for effects associated with dam removal and an estimate of costs associated with different aspects of dam removal and decommissioning. The list of studies Regional Water Board staff relied on in preparation of the programmatic environmental analysis for a dam removal scenario is presented below in section 9.5.2.11, and incorporated herein by reference. These studies are available for review online (see page 9-34 of this Staff Report) and at the Regional Water Board office.

This analysis does not include consideration of any of the measures to be taken in Oregon.

9.5.2.1 Analysis of Compliance Measures, Potential Environmental Impacts, and Possible Mitigation Measures for Constructed Wetlands Treatment

The feasibility of constructed treatment wetlands has been considered as a potential action for use PacifiCorp in the Klamath Hydroelectric Project. Three different types of constructed treatment wetlands were considered. They include:

- Upstream “preventative” wetlands;
- In-reservoir treatment through vegetative swales; and
- In-reservoir floating wetlands.

Analysis of Compliance Measures Associated with Constructed Wetlands Treatment

- The upstream “preventative” treatment wetlands would be constructed on sites upstream of the Copco Reservoir and downstream of Upper Klamath Lake. Surface flow would be routed through the treatment wetlands in multiple cells and with multiple parallel flow paths using existing and new river diversions for irrigation and existing irrigation canals. Pumping from the river would be a last resort. If necessary, alum or aluminum polymers could be added to enhance phosphorus and particulate removal. Mulch gabions could also be distributed throughout the wetlands to deliver a steady flow of carbon to enhance microbial denitrification.
- The in-reservoir approach consists of the potential removal of cyanobacteria biomatter from reservoir coves into adjacent subsurface flow or infiltration-based vegetated swales. Algae would be removed by surface skimming and then pumped into adjacent gravel-filled gabions planted with native grasses (bioswale).
- The floating treatment wetlands would be built directly in the reservoirs. The complex aquatic root systems serve to filter out particulate matter, take up nutrients, and provide habitat and shelter for zooplankton and fish that consume algae. Floating treatment wetlands also can provide shade that helps to reduce algae development.

Potential Environmental Impacts Associated with Constructed Wetlands Treatment

- Temporary construction-related discharges of sediment.
- Temporary air quality impacts from heavy equipment use.
- Impacts to archaeological and cultural resources.
- Temporary impacts to plant and animal species, including disturbance to habitat.
- Temporary impacts to water quality from construction-related increases in turbidity.
- Impacts to water quality from the release of soil-sequestered nutrients once land is flooded to create wetlands.

Possible Mitigation Measures to Avoid Impacts Associated with Constructed Wetlands Treatment

- Restrict work to days in which soil detachment by wind or water is not expected.

- Time the completion of work to coincide with planting to reduce the length of time in which bare soil is exposed.
- Cover exposed soil that will not receive immediate planting with straw or other suitable erosion control material.
- Protect drainage channels from sediment contributions with vegetated buffers, wattles, or similar erosion control devices.
- Time heavy equipment use to occur during period of good air quality.
- Conduct a project-level CEQA analysis to identify archaeological and cultural resources requiring protection.
- Conduct a project-level CEQA analysis to identify biological resources, including threatened and endangered species and their habitat, requiring protection.
- A turbidity curtain can be used to contain turbidity effects within an acceptable minimum location during construction activities.
- Amend constructed wetland soil with alum, calcium carbonate (calcite), or calcium-magnesium carbonate (dolomite) to bind labile phosphorus and prevent it from entering the water column.

9.5.2.2 Analysis of Compliance Measures, Potential Environmental Impacts, and Possible Mitigation Measures for Mechanical Removal of Algae Biomatter

PacifiCorp is evaluating the efficacy of mechanical removal of algae biomatter from Copco and Iron Gate reservoirs as a technique for improving water quality conditions in localized places such as near picnic sites or boat launches. According to PacifiCorp (2009), they have not yet identified specific harvesting techniques. Nor have they evaluated the alternatives for disposal, except the use of bioswales.

The mechanical removal of algae biomatter is described in wastewater treatment literature, as well as literature associated with the production of algae as a food source. Harvesting techniques may include three steps: 1) methods for concentrating algae into a harvestable mat, 2) removal of algae mats from the water column, and 3) disposing of waste.

Analysis of Compliance Measures Associated with Mechanical Removal of Algae Biomatter

- Concentrate algae into harvestable mats using:
  - Air bubbles
  - pH adjustment
  - Coagulants (e.g., alum or ferric chloride)
- Removal of algae mats can be accomplished by using:
  - Suction equipment
  - Mechanical harvesting equipment.
- Disposal of waste is accomplished by:
  - Dewatering
  - Landfill disposal
  - Use as a soil amendment.

Potential Environmental Impacts Associated with Mechanical Removal of Algae Biomatter

- Temporary effects of elevated turbidity resulting from compressed air, coagulants, suctioning, and/or mechanical harvest.
- Effects of pH adjustment, alum or ferric chloride on aquatic species.
- Disturbance of habitat important to threatened or endangered species, or other sensitive species or species of special concern.
- Temporary effects of elevated odors associated with algae disposal in bioswales, dewatering sites, and/or land application as fertilizer.
- Effects on native species associated with the potential increase in pest species drawn to decomposing algae.
- Increase in microcystin toxic concentration in the column from disturbance of algal cells.
- Increase in waste loads to the local solid waste handling facility.

Possible Mitigation Measures to Avoid Impacts Associated with Mechanical Removal of Algae Biomatter

- A turbidity curtain can be used to contain turbidity effects within an acceptable minimum location during construction activities.
- Only use pH adjustment, alum or ferric chloride in locations and during times when harmful effects on aquatic species can be avoided.
- Only harvest algae from locations where threatened and endangered species habitat will not be disturbed. Alternatively, apply to the appropriate wildlife agency for an incidental take permit.
- Choose locations for algae dewatering that are suitably downwind of any population center.
- Actively compost algae to ensure a reduction in odors and development of a product suitable for land application and/or to prevent overwhelming local solid waste facilities.
- Stop work if bioswales, dewatering sites, or compost piles are attracting pest species that harm native species.
- Stop work if harvesting of algae results in an increase in the microcystin toxin concentration.

9.5.2.3 Analysis of Compliance Measures, Potential Environmental Impacts, and Possible Mitigation Measures for Conventional Wastewater Treatment

Conventional wastewater treatment involves primary treatment (e.g., screening, grit removal, and primary sedimentation), secondary treatment (e.g., attached growth process or suspended growth process of biological treatment), advanced treatment (e.g., nitrification/denitrification, coagulation-sedimentation, carbon adsorption), and disinfection (e.g., chlorination/declorination, ozone), as appropriate.

Analysis of Compliance Measures Associated with Conventional Wastewater Treatment

- The installation of a wastewater treatment system is a major construction project, involving all the environmental risks common to large-scale construction. If chosen as a preferred alternative and once the design of the project is complete, a project-level CEQA analysis will be required.

Potential Environmental Impacts Associated with Conventional Wastewater Treatment

- Construction and excavation activities have the potential to result in soil erosion, which could adversely impact nearby waterways as a result of siltation and water quality degradation.
- Construction and excavation activities have the potential to result in disturbance to cultural and archaeological resources.
- Construction could result in impacts to threatened, endangered species, or candidate species.
- Construction could result in impacts to nesting birds.
- Construction could result in impacts to wetlands.
- During the construction phase of the project, construction noise would dominate the noise environment in the immediate area.
- Construction of a wastewater treatment plant would not introduce any uses that would generate long-term changes in traffic. Construction of the treatment plant would temporarily increase traffic along haul routes and the main access roads to the WWTP property.
- Construction of a wastewater treatment plant would not change the design of existing roadways and does not include any operational features that would impact traffic or increase hazards. However, large truck traffic associated with the import of material for the construction of the plants could accelerate the deterioration of the roadway surface due to the high number of trips.
- Construction activities will likely generate fugitive dust and diesel exhaust emissions from construction/excavation activities and vehicle/equipment operation.

Possible Mitigation Measures to Avoid Impacts Associated with Conventional Wastewater Treatment

- Off-site impacts due to erosion must be prevented by implementation of a Stormwater Pollution Prevention Plan (SWPPP) as required under the Clean Water Act. Measures to consider in a SWPPP are those related to: grading, existing vegetation, land disturbance during peak runoff periods, utility installations, control of runoff velocity and quality, truck traffic, storage of construction materials, permits, spill prevention, fuel and vehicle maintenance areas, sanitary facilities for construction works.
- In the event of any inadvertent discovery of archaeological resources, all such finds shall be subject to PRC 21083.2 and CEQA *Guidelines* 15064.5, including cessation of work until professional archaeologist or paleontologist can evaluate the significance of the find, professional curation of significant finds, and notification of county coroner and Native American Heritage Commission, if appropriate, if find is a human remain.
- A qualified biologist should be present during initial grubbing and clearing activities to ensure that species identified during the project-level CEQA analysis are not harmed by construction activities. If threatened, endangered, or candidate species are observed, one potential mitigation would be for the

biologist to relocate it to suitable habitat outside of the construction zone.

- If feasible, grubbing and grading activities should be conducted outside of the nesting season. If initial tree-removal, grubbing or clearing activities will occur during the nesting season, a pre-construction survey for nesting bird species should be conducted by a qualified biologist within proposed vegetation removal areas, including a substantial buffer from construction activities.
- Construction activities resulting in the discharge of dredged or fill material into Waters of the US will require permit approval from the US Army Corps of Engineers and water quality certification from the Regional Water Board pursuant to Section 401 of the Clean Water Act. Any compensatory mitigation shall be provided as required by regulatory permits to offset impacts to Waters of the US. Compliance with full mitigation, as required by regulatory permits, would ensure that measures are implemented to avoid, compensate, or offset impacts to Waters of the US.
- Any project in California which will cause alteration to the bed, bank, or channel of a stream will require a Streambed Alteration Agreement pursuant to Section 1600 of the California Fish and Game Code.
- Construction contractors should be required to implement mitigation measures to reduce daytime noise levels resulting from construction, such as:
  - Fixed construction equipment (such as compressors and generators) and construction staging areas located as far as feasible from the nearest dwellings.
  - Equipment and trucks used for project construction should utilize the best available noise control techniques (e.g., improved mufflers, equipment redesign, use of intake silencers, ducts, engine enclosures and acoustically-attenuating shields or shrouds, wherever feasible).
  - Construction equipment noise shall be minimized during project construction by muffling and shielding intakes and exhaust on construction equipment (per the manufacturer's specifications) and by shrouding or shielding impact tools.
  - Notification should be given to public transportation providers, school districts, emergency service provides, and affected private residents at least one month prior to commencement of construction to minimize traffic congestion issues.
  - Construction related truck trips shall be limited to the hours between 9:00 a.m. to 3:00 p.m., Monday through Friday to the extent possible. No construction traffic should be permitted between the hours of 10 pm. To 7 a.m.
  - Construction traffic shall comply with the California Vehicle Code (CVC) sections related to vehicle weight and width.
  - The construction contractor should implement best management practices designed to reduce the effects of dust and diesel exhaust, including:
    - Water all active construction areas at least twice daily.
    - Cover all trucks hauling soil and other loose materials or require all trucks to maintain at least 2 feet of freeboard.

- Apply water as needed on a daily basis, or apply (nontoxic) soil stabilizers on all unpaved access roads, parking areas, and staging areas at construction sites.
- Sweep daily (with water sweepers) all paved access roads, parking areas, and staging areas at construction sites.
- Sweep streets daily (with water sweepers) if visible soil material is carried onto adjacent public streets.
- Maintain equipment according to the manufacturer's specifications.
- Restrict idling of construction equipment and vehicles to 10 minutes.
- Gasoline powered equipment and vehicles shall have catalytic converters installed prior to their use on the project site.

9.5.2.4 Analysis of Compliance Measures, Potential Environmental Impacts, and Possible Mitigation Measures for Wetlands Restoration

One of the implementation measures considered for achieving compliance with the proposed revised DO objectives, TMDL load allocations and numeric targets is the restoration of wetlands. A large scale restoration project on the Williamson River delta undertaken by Nature Conservancy of Oregon was used as an example in identifying compliance measures.

A project-level CEQA analysis will likely be necessary to ensure that any wetland restoration project is conducted in such a manner as to provide adequate environmental protection. The list of potentially significant environmental impacts below is not intended in any way to restrict the scope of any future project-level CEQA analysis. It is intended only to provide a framework of issues to consider.

Analysis of Compliance Measures for Wetlands Restoration

- Re-establish native wetland and upland vegetation.
- Recreate historic channels.
- Restore historic oxbow channels to allow continuous flow.
- Breach lakeshore levees to create diverse habitat features.
- Lower lake levees to create riparian fringe habitat.

Potential Environmental Impacts Associated with Wetlands Restoration

- Use of heavy equipment to divert flows and dig new channels.
- Use of explosives and/or mechanical equipment to open passages in the levees sufficiently large for water to flow and reconfigure the landscape.
- Large scale planting and temporary irrigation facilities for re-establishing native wetland and upland vegetation.
- Construction and excavation activities have the potential to result in soil erosion, which could adversely impact nearby waterways as a result of siltation and water quality degradation.
- Construction and excavation activities have the potential to result in disturbance to cultural and archaeological resources.
- Construction could result in impacts to threatened, endangered species, or candidate species.

- Construction could result in impacts to nesting birds.
- Construction could result in impacts to existing wetland habitat.
- During the construction phase of the project, construction noise would dominate the noise environment in the immediate area, particularly with the use of explosives.
- Construction of a wetland restoration project would not introduce any uses that would generate long-term changes in traffic. Construction of a wetland restoration project would temporarily increase traffic along haul routes and the main access roads to the restoration site.
- Construction activities will likely generate fugitive dust and diesel exhaust emissions from construction/excavation activities and vehicle/equipment operation.
- Hazards associated with the transport and use of explosives.

<u>Possible Mitigation Measures for Wetlands Restoration</u>

- Off-site impacts due to erosion must be prevented by implementation of a Stormwater Pollution Prevention Plan (SWPPP) as required under the Clean Water Act. Measures to consider in a SWPPP are those related to: grading, existing vegetation, land disturbance during peak runoff periods, utility installations, control of runoff velocity and quality, truck traffic, storage of construction materials, permits, spill prevention, fuel and vehicle maintenance areas, sanitary facilities for construction works.
- In the event of any inadvertent discovery of archaeological resources, all such finds shall be subject to PRC 21083.2 and CEQA *Guidelines* 15064.5, including cessation of work until professional archaeologist or paleontologist can evaluate the significance of the find, professional curation of significant finds, and notification of county coroner and Native American Heritage Commission, if appropriate, if find is a human remain.
- A qualified biologist should be present during initial grubbing and clearing activities to ensure that species identified during the project-level CEQA analysis are not harmed by construction activities. If threatened, endangered, or candidate species are observed, one potential mitigation would be for the biologist to relocate it to suitable habitat outside of the construction zone.
- If feasible, grubbing and grading activities should be conducted outside of the nesting season. If initial tree-removal, grubbing or clearing activities will occur during the nesting season, a pre-construction survey for nesting bird species should be conducted by a qualified biologist within proposed vegetation removal areas, including a substantial buffer from construction activities.
- Construction activities resulting in the discharge of dredged or fill material into Waters of the US will require permit approval from the US Army Corps of Engineers and water quality certification from the Regional Water Board pursuant to Section 401 of the Clean Water Act. Any compensatory mitigation shall be provided as required by regulatory permits to offset impacts to Waters of the US. Compliance with full mitigation, as required by regulatory permits, would ensure that measures are implemented to avoid, compensate, or offset impacts to Waters of the US.

- Any project in California which will cause alteration to the bed, bank, or channel of a stream will require a Streambed Alteration Agreement pursuant to Section 1600 of the California Fish and Game Code.
- Construction contractors should be required to implement mitigation measures to reduce daytime noise levels resulting from construction, such as:
  - Fixed construction equipment (such as compressors and generators) and construction staging areas located as far as feasible from the nearest dwellings.
  - Equipment and trucks used for project construction should utilize the best available noise control techniques (e.g., improved mufflers, equipment redesign, use of intake silencers, ducts, engine enclosures and acoustically-attenuating shields or shrouds, wherever feasible).
  - Construction equipment noise shall be minimized during project construction by muffling and shielding intakes and exhaust on construction equipment (per the manufacturer's specifications) and by shrouding or shielding impact tools.
  - Notification should be given to public transportation providers, school districts, emergency service provides, and affected private residents at least one month prior to commencement of construction to minimize traffic congestion issues.
  - Construction related truck trips shall be limited to the hours between 9:00 a.m. to 3:00 p.m., Monday through Friday to the extent possible. No construction traffic should be permitted between the hours of 10 pm. To 7 a.m.
  - Construction traffic shall comply with the California Vehicle Code (CVC) sections related to vehicle weight and width.
- The construction contractor should implement best management practices designed to reduce the effects of dust and diesel exhaust
- Restrict work to days in which soil detachment by wind or water is not expected.
- Time the completion of work to coincide with planting to reduce the length of time in which bare soil is exposed.
- Cover exposed soil that will not receive immediate planting with straw or other suitable erosion control material.
- Protect drainage channels from sediment contributions with vegetated buffers, wattles or similar erosion control devices.
- Time heavy equipment use to occur during period of good air quality.
- A turbidity curtain can be used to contain turbidity effects within an acceptable minimum location during construction activities.
- Adherence to the industry safety standards for the transport and use of explosives.

9.5.2.5 Analysis of Compliance Measures, Potential Environmental Impacts, and Possible Mitigation Measures for Hypolimnetic Oxygenation

Hypolimnetic oxygenation is a technique that adds oxygen to the deeper part of the reservoirs (hypolimnion) without disrupting stratification of the reservoir. This technique increases the amount of oxygenated water available to organisms that use the deeper and cooler waters of the reservoir, and retards the buildup of un-decomposed organic matter and compounds (e.g., ammonium) in the hypolimnion.

Analysis of Compliance Measures for Hypolimnetic Oxygenation

- Application of fine bubbles
  - Using unconfined fine bubble diffuser
  - Using unconfined and diffuse bubble curtain
- Use of a bubble-free system in which a pressurized container placed at the bottom of the reservoir is used to mix water with gas and the mixture is dispersed over the sediments. The system is operated as soon as monitoring indicates that dissolved oxygen levels in the hypolimnion are starting to drop (early spring) and through the summer/fall.
- Oxygen supply facilities would include a liquid oxygen storage tank, vaporizers, and trucked-in oxygen to be used at locations midway along the reservoirs.
- Small onsite oxygen generators might also be used to supply oxygen near the dams

Potential Environmental Impacts Associated with Hypolimnetic Oxygenation

- Construction of underwater facilities
- Temporary increases in turbidity.
- Disturbance to endangered, threatened or sensitive species.
- Temporary increases in traffic
- Temporary increases in noise
- Increased need for sanitary services
- Liquid oxygen storage tanks present the risk of fire and explosion.

Possible Mitigation Measures for Hypolimnetic Oxygenation

- Iron Gate Reservoir, install 3 long diffuser lines:
  - One upstream end of the reservoir to provide initial oxygenation of incoming organics
  - One upstream of the dam
  - One in the metalimnion along the side of the reservoir
- For Copco Reservoir, install five (5) long diffuser lines:
  - Two (2) at the upstream end of the reservoir to provide initial oxygenation of incoming organics
  - Two (2) upstream and downstream of the bathymetric outcropping
  - One in the metalimnion along the side of the reservoir.
- Install turbidity curtains around construction area to contain any turbidity resulting from construction activities.
- Conduct a project-level CEQA analysis to identify biological resources, including threatened and endangered species and their habitat, requiring protection.
- Avoid construction during periods in which threatened or endangered species are present and/or apply to the appropriate resource agencies for an incidental take permit, if threatened or endangered species may be present.

- Implement best management practices for the reduction and control of vehicle noise, traffic, dust and need for sanitary services, as described above.
- Observe standard safety procedures for the locating, installation, and use of liquid oxygen, including:
  - Keep combustibles away and eliminate ignition sources.
  - Keep the area and exterior surfaces clean to prevent ignition.
  - Maintain adequate ventilation.
  - Ensure personnel use proper safety gear when there is any risk of splashing or spilling liquid oxygen.
  - Ensure replacement parts are suitable for oxygen service.

9.5.2.6 Analysis of Compliance Measures, Potential Environmental Impacts, and Possible Mitigation Measures for Epilimnion Circulation

The epilimnion is the upper layer of a thermally stratified lake or reservoir where photosynthetic activity takes place. Epilimnion circulation is intended to induce vertical circulation thereby reducing cyanobacteria by reducing their light exposure and disrupting the generally quiescent conditions that may contribute to bloom formation.

Analysis of Compliance Measures Associated with Epilimnion Circulation

- Use solar-powered water circulators.

Potential Environmental Impacts Associated with Epilimnion Circulation

- Disruption of cyanobacteria by agitation may result in the lysing of cell membranes and release of microcystin toxin to the water column.

Possible Mitigation Measures with Epilimnion Circulation

- Conduct a demonstration installation of a higher-energy circulator in a selected cove and compare water quality outcomes to an untreated cove.
- Monitor microcystin levels, upon full-scale installation.
- Stop mechanical circulation if microcystin levels increase as a result of the activity.

9.5.2.7 Analysis of Compliance Measures, Potential Environmental Impacts, and Possible Mitigation Measures for Riparian Restoration

Responsible parties in the Klamath River basin, including PacifiCorp, may use riparian restoration to improve in-stream temperature conditions by restoring the site-potential for riparian shade. Restoration activities will generally include the reduction of activities in a riparian buffer zone. Tree planting may include the importation of saplings, equipment and personnel; the hand digging of holes; and the installation of irrigation facilities. Measures to stabilize a stream bank and/or remove/repair riparian roads may include the use of heavy equipment, importation of rip rap or other materials, and/or temporary rerouting of stream flow.

Analysis of Compliance Measures Associated with Riparian Restoration

- Reduction of tree harvesting, grazing, and irrigated agricultural activities.
- Stream bank stabilization to support shade species.

- Include tree planting, and where necessary.
- Removal or repair of roads in riparian areas.

Potential Environmental Impacts Associated with Riparian Restoration

- Temporary construction-related discharges of sediment
- Temporary air quality impacts from heavy equipment use
- Impacts to archaeological and cultural resources
- Temporary impacts to plant and animal species, including disturbance to habitat.
- Temporary impacts to water quality from construction-related increases in turbidity.

Possible Mitigation Measures with Riparian Restoration

- Restrict work to days in which soil detachment by wind or water is not expected.
- Time the completion of work to coincide with planting to reduce the length of time in which bare soil is exposed.
- Cover exposed soil that will not receive immediate planting with straw or other suitable erosion control material.
- Protect drainage channels from sediment contributions with vegetated buffers, wattles or similar erosion control devices.
- Time heavy equipment use to occur during period of good air quality.
- Conduct a project-level CEQA analysis to identify archaeological and cultural resources requiring protection.
- Conduct a project-level CEQA analysis to identify biological resources, including threatened and endangered species and their habitat, requiring protection.
- A turbidity curtain can be used to contain turbidity effects within an acceptable minimum location during construction activities.

9.5.2.8 Analysis of Compliance Measures, Potential Environmental Impacts, and Possible Mitigation Measures for Selective Withdrawal from a Variable Outlet Structure

PacifiCorp will evaluate the installation of a variable outlet structure from which to selectively withdraw water for release. A variable outlet structure is constructed on the inside of the dam face. To retrofit an existing dam with a variable outlet structure requires that the reservoir water be held back from the inside of the dam by such means as a coffer dam while the infrastructure is installed. Once infrastructure construction is completed, the coffer dam is removed, and the release of water downstream is resumed.

A variable outlet structure allows the operator to draw water from various depths in the reservoir. This flexibility allows the operator to respond to water quality conditions of the reservoir and the water quality needs of the river downstream so as to release water that most closely meets the overall environmental objectives.

A rigorous monitoring program is required to provide the operator with sufficient information regarding the temperature, DO concentration, *Microcystis* concentrations, microcystin concentrations, and other water quality characteristics.

Analysis of Compliance Measures Associated for Selective Withdrawal from a Variable Outlet Structure

- Install coffer dam.
- Install necessary infrastructure for outlet.

Potential Environmental Impacts for Selective Withdrawal from a Variable Outlet Structure

- Impacts as typically associated with construction activities.

Possible Mitigation Measures Protection for Selective Withdrawal from a Variable Outlet Structure

- Mitigations for construction activities such as described above.

9.5.2.9 Analysis of Compliance Measures, Potential Environmental Impacts, and Possible Mitigation Measures for Curtain Installation at Iron Gate Dam

In 2008, PacifiCorp installed a floating barrier curtain along the log boom in the Iron Gate reservoir near the dam intake. The primary objective of the barrier curtain was to enhance water quality in the vicinity of the dam intake by excluding or reducing the potential entrainment of biomass from blooms of cyanobacteria such as *Microcystis* and potential associated algal toxins (i.e., microcystin).

Use of a turbidity curtain is often for the purpose of controlling the release of sediment to the water column as a result of instream work. The turbidity curtain acts to slow and contain turbidity until it can settle out of the water column. It is unclear whether use of the turbidity curtain for controlling algae is intended to work in the same way. The Reservoir Management Plans for 2008 and 2009 do not describe the details of use. This analysis is based on the assumption that algal cells, when contained by a turbidity curtain, will decompose and settle out of the water column, and remain in the reservoir as settled organic matter, rather than be released downstream. A project level CEQA analysis must clarify the details of this implementation measure.

PacifiCorp proposes to monitor its effectiveness during 2009, including:

1. Water quality monitoring within and without the curtained area;
2. Current monitoring in the vicinity of the curtain to characterize vertical velocity profiles; and,
3. Modeling to assess curtain effects on water quality under varying conditions.

Analysis of Compliance Measures Associated for Curtain Installation at Iron Gate Dam

- Install turbidity curtain made of synthetic fabric material, suspended down 10 feet and across the width of the reservoir, a distance of 1100 feet, approximately 1800 feet upstream of the dam

Potential Environmental Impacts for Curtain Installation at Iron Gate Dam

- Release of microcystin toxin to the water column as algal cells lyse.
- Interference of fish movement through a compliance lens, if lens occupies a space within 10 feet of the surface.

Possible Mitigation Measures Protection for Curtain Installation at Iron Gate Dam

- Implement monitoring program sufficiently rigorous to detect increases in microcystin toxin to the water column. Post public warnings if microcystin concentrations exceed target levels as described in the Klamath TMDL.
- Remove turbidity curtain and evaluate alternative microcystin controls if turbidity curtain does not meet the objective of excluding or reducing the potential entrainment of algal toxins.
- Implement a monitoring program sufficiently rigorous to detect the dimensions of the compliance lens (i.e., water quality conditions meeting both DO and temperature objectives) and if within 10 feet of the surface, whether fish movement is impaired.
- Remove turbidity curtain and evaluate alternative Microcystis and microcystin controls if turbidity curtain impairs fish movement through the compliance lens.

9.5.2.10 Analysis of Compliance Measures, Potential Environmental Impacts, and Possible Mitigation Measures for Turbine Venting

According to PacifiCorp, the Klamath River downstream of Iron Gate dam periodically experiences during summer months, low dissolved oxygen emanating from the deep reservoir intake on Iron Gate Reservoir. PacifiCorp conducted turbine venting tests in the summer of 2008 to determine if full air admission through the existing turbine vent valve could positively improve the dissolved oxygen (DO) of discharged water. The tests indicated that DO could be increased up to 2 mg/L and 20% saturation. PacifiCorp plans to install a forced-air blower on an existing (but previously closed) air introduction manifold to increase air entrainment into the turbine draft tube. This should then increase DO concentration below the Iron Gate powerhouse. Should these tests prove further success with the technique, turbine venting will be used as an interim implementation measure to improve DO conditions downstream of Iron Gate Dam.

Analysis of Compliance Measures Associated for Turbine Venting

- Install a forced-air blower on an existing, but previously closed, air introduction manifold.

Potential Environmental Impacts for Turbine Venting

- None identified.

Possible Mitigation Measures Protection for Turbine Venting

- Not applicable.

9.5.2.11 Analysis of Compliance Measures, Potential Environmental Impacts and Possible Mitigation Measures for Dam Decommissioning Activities

As described previously (see section 9.5.2) the decommissioning (or removal) of one or more of the existing dams that comprise the KHP have been the subject of much discussion and investigation as part of PacifiCorp's FERC relicensing efforts. A number of reports have been produced by various groups evaluating the potential environmental effects of a number of dam removal scenarios. The reports used in the preparation of this CEQA analysis are incorporate herein by reference and include:

- *The Final Environmental Impact Statement for Relicensing of the Klamath Hydroelectric Project No. 2082-027* (FEIS) released by the Federal Energy Regulatory Commission on November 16, 2007 (FERC 2007). This FEIS contains, in part, evaluations of two dam removal scenarios. One alternative involves the retirement of the Iron Gate and Copco No. 1 developments (dams and associated hard structures). The other involved the retirement of Iron Gate, Copco No. 2, Copco No. 1, and J.C. Boyle developments. This report[13] is available at the following web site: http://www.ferc.gov/industries/hydropower/enviro/eis/2007/11-16-07.asp.

- *Klamath River Dam and Sediment Investigation* (November 2006) prepared by Gathard Engineering Consulting, at the request of the California State Coastal Conservancy and the Ocean Protection Council (Gathard Engineering Consulting 2006). This report characterized the sediment behind Iron Gate, Copco No. 1 and 2, and J.C. Boyle and examined the possibility of removing these dams removal. This report[14] is available at the following web site: http//www.fws.gov/yreka/KRI/GECFinalReport.pdf.

- *Dam Removal and Klamath River Water Quality: A Synthesis of the Current Conceptual Understanding and an Assessment of Data Gaps*. This report was prepared by Stillwater Sciences (2009a) at the request of the State Coastal Conservancy and describes, in part, potential water quality impacts of dam removal. This report[15] is available from the following web site: http://www.stillwatersci.com/resources/2009klamathWQsynthesis.pdf.

- *Effects of Sediment Release following Dam Removal on the Aquatic Biota of the Klamath River* (January 2009) prepared by Stillwater Sciences (2009b) at the request of the State Coastal Conservancy and describes, in part, potential water quality impacts to aquatic biota from dam removal. This report[16] is available at the following web site: http://www.stillwatersci.com/resources/2009klamathdamremovalBA.pdf.

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[13] Report downloaded, November 23, 2009.
[14] Report downloaded, November 23, 2009.
[15] Report downloaded, November 23, 2009.
[16] Report downloaded, November 23, 2009.

All of these reports make clear that additional studies and more detailed project designs are needed before a complete environmental analysis of any dam decommissioning scenario can be completed. However the reports also contain as thorough an evaluation of the environmental impacts and costs associated with dam removal as is possible at this time due to the speculative nature of the actual project(s). Any dam decommissioning activity would require a full environmental analysis of the decommissioning plan as part of the federal and/or state permitting process. (For a more detailed discussion on dam removal scenarios, compliance measure, environmental effects and potential costs, please see these reports above, which are incorporated here by reference.)

Most of the dam removal scenarios evaluated in these reports consists of decommissioning either two or four of the dams and reservoirs by removal of the dam structures and most of the appurtenant structures. Physical removal of the dam structure will require drawing down (lowering) of each reservoir sufficiently to allow safe access to the dam structure. Approximately 1.3 to 2.9 million metric tons of fine-grained sediment (sand, silt and clay) is estimated to be stored behind the four dams associated with the KHP. Dam removal studies done on the Klamath indicate that the greatest potential for adverse environmental effects is from the release of fine grained sediment during the lowering of the reservoir surface water elevation. Removal of the dam structures would involve either demolishing most concrete structures at the dam sites or excavating earth embankment at earthen structure dams. Drilling and blasting techniques, followed by heavy equipment operations would likely be used in the removal of concrete structures. Earthen material in embankment dams and on dam approaches would be removed using heavy equipment or in other cases may be removed through stream erosion. Drawdown of the reservoirs would be implemented through a progressive series of actions, including breaching the dams in a planned sequence and in such a way as to establish a rate of reservoir lowering that will result in the most controlled discharge of the fine grained sediment.

All the studies recommend allowing natural erosion of in-reservoir sediment by the stream system rather than relying on mechanical excavation of the sediment, unless contaminated sediments are present. Previous cost analysis have shown that the cost of mechanically excavating in-reservoir sediment is cost prohibitive and can result in more discharge of uncontrolled fine sediment. It is expected that not all sediment trapped behind the reservoirs would be delivered to the river. Sediment outside of the active river channel(s) will likely remain in place. The limited studies conducted to date do not indicate that significant source of contaminated sediments are present behind the reservoirs. However, additional characterization of the sediments would be required prior to any dam decommissioning operations.

<u>Analysis of Compliance Measures Associated with Dam Decommissioning</u>

- Develop a dam decommissioning plan which would contain at a minimum:
  - Clearly stated goals and objectives for decommissioning;
  - Specific and detailed decommissioning methods (blueprints) containing relevant information such as:

        - Drawdown plan to lower reservoir surface water level to allow safe access to dam structures.
        - Remove concrete dam and appurtenant structures by drilling, blasting, and mechanical removal.
        - Remove earthen dam and appurtenant structures by mechanical removal and/or erosion by river.
        - Identification of mitigation measures such as timing requirements, sequential decommissioning of dams to control release of turbid and consideration of ocean conditions to lessen adverse environmental impacts; and a
    - Monitoring and reporting component to document compliance with the goals and objectives.

Potential Environmental Impacts from Dam Decommissioning

- Short term aesthetics impacts from freshly exposed reservoir bottom and sides.
- Long term aesthetics impacts from the presence of dam and appurtenant structures on the landscape.
- Short term air quality impacts from greenhouse gas emissions from heavy equipment and blasting operations.
- Short term air quality impacts from release of air-born particle matter from blasting activities.
- Short term air quality impacts from offensive odors affecting the surrounding community from exposure of anaerobic sediments.
- Short term biological impacts due to increased duration and concentration of in-stream fine sediment (total suspended sediment). Studies indicate between 1.3 and 2.9 million metric tons of fine sediment are stored behind four of the dams associated with the KHP (J.C. Boyle in Oregon and the three California dams Copco 1 and 2 and Iron Gate).
- Short term biological impacts due to increased turbidly and total suspended sediment loads from erosion of earthen dams and approaches.
- Short term and long term biological impacts from release of contaminated sediments (e.g., metals, VOCs, pesticides and herbicides, dioxin).
- Short term biological impacts due to loss of riparian habitat surrounding the reservoirs.
- Short term biological impacts from heavy equipment used to install structural compliance measures such riparian fencing, erosion control on road systems and reconstruction of failed/failing stream crossings.
- Long term biological impacts from transmission of fish disease upstream and from increased water temperatures during the spring time downstream of the dams.
- Long term biological impacts from introduction of invasive species on exposed reservoir surfaces.
- Long term biological impacts from loss of reservoir acres available for resting of migratory waterfowl and foraging on open water by piscivorous birds and bats.
- Long term cultural impacts from exposure of previously submerged cultural

resources, subject them to looting.

- Short term hydrology/water quality impacts from release of in-reservoir stored organic carbon (including nitrogen and phosphorus), which could also include dissolved oxygen conditions below the proposed DO objective of 85% saturation and lower than the current 8.0 mg/L due to increased oxygen demand from the decomposition of organic material in suspended sediment.
- Long term hydrology/water quality impacts from increased wintertime total suspended sediment and turbidity, with peak levels associated with storm events.
- Long term hydrology/water quality impacts from episodic increased levels of total suspended sediment and turbidity during late spring and summer due to transport of algae blooms from the upper Klamath River.
- Long term hydrology/water quality impacts on the annual nutrient budget.
- Long term hydrology/water quality impacts from increased average annual flow and magnitude and frequency of floods.
- Short term impact from noise generating activities such as heavy equipment use and blasting activities.
- Long term recreation impacts from decreases acres of reservoir available for flat-water recreation and warm water fishing and the subsequent re-direction of reservoir users to other neighborhood or regional recreation areas.

Possible Mitigation Measures for Dam Removal Activities

- Include a native vegetation management as part of any dam decommissioning actions to mitigate any short term aesthetics and long term biological impacts from introduction of invasive species on exposed reservoir surfaces.
- Remove all hardscape (e.g. dams, powerhouses, power lines, etc) associated with the dam and hydroelectric project to mitigate for long term aesthetics impacts from the presence of dam and appurtenant structures on the landscape.
- Conduct activities on days when inversion layer is not present and basin air quality is good, use fuel efficient equipment, and limit number of vehicle trips to the sites to offset short term air quality impacts from greenhouse gas emissions from blasting and heavy equipment operations.
- Control access to site, conduct activities when wind direction will not take particle matter into populated areas to mitigate short term air quality impacts from release of air-born particle matter from blasting activities.
- Inform surrounding communities of dam decommissioning plans to allow voluntary re-location during periods when offensive odors from exposure of anaerobic sediments from dam removal are present.
- Design reservoir drawdown plans to limit the duration of the increased turbidity and total suspended sediment loads to mitigate for the short term biological and water quality impacts from release of in-reservoir fine grained sediment.
- Divert surface water away from construction sites to decrease turbidity and total suspended sediment loads to mitigate for the short term biological and water quality impacts from removal of the dam and appurtenant structures.
- Conduct dam decommissioning operations to coincide with a strong year class of fall Chinook to allow for rapid re-colonization to mitigate for a long term

biological impacts from transmission of fish disease upstream and from increased water temperatures during the spring time downstream of the dams.

- Coordinate with local tribes to develop a cultural resources management plan that contains mitigation measures such as relocation, reburial or other protection strategies to mitigate for long term cultural impacts from exposure of previously submerged cultural resources.
- Time dam decommissioning to "wet" hydrologic year to facilitate flushing to mitigate for the short term hydrology/water quality impacts from release of in-reservoir stored organic carbon (including nitrogen and phosphorus). The multi-year analysis of Asarian et al. (2009) shows the combined annual retention for Copco and Iron Gate reservoirs is nine percent (9%) for total phosphorous and thirteen percent (13%) fro total nitrogen. These increased nutrient loads will likely have minimal, if any, water quality impacts downstream. The minimal water quality impact can be attributed to the following:
  - Retention within the reservoirs occurs largely in the winter and early spring when nutrients exist in a particulate form which is less bioavailable;
  - The higher flows (as a result of a dams out scenario) will carry most of the nutrient load through the system and out to the ocean.
  - The winter and early spring loading period is not a critical growth period for periphyton or phytoplankton; and
  - Increase scouring of the downstream periphyton as a result of increase flow.
- The impacts on organic matter cycling from dam removal activities is offset in part due to the export of organic carbon (phytoplankton) in the summer months that will occur if dams are not in place. The increased nutrient and organic matter load without reservoirs can be mitigated through the development of treatment wetlands and restored natural wetlands.
- Prevent the development of hard structures in the floodplain that are not designed to handle the anticipated increased floods to mitigate for the long term hydrology impacts from increase average annual flow and magnitude and frequency of floods. Iron Gate, Copco 1 and Copco 2 reservoirs are small and have not been managed to attenuate peak flows. In addition a very small percentage of the flood flows ($\leq$ 10%) originate upstream of the reservoirs. The vast majority of flood flows ($\geq$ 90%) originate downstream of Iron Gate dam.
- Re-vegetate exposed soils along the river banks and floodplains to prevent the long term hydrology/water quality impacts from increased wintertime total suspended sediment and turbidity, which have peak levels during storm events.
- Time dam decommissioning to "wet" hydrologic year to facilitate flushing to mitigate for the long term hydrology/water quality impacts from episodic increased levels of total suspended sediment and turbidity during late spring and summer due to transport of algae blooms from the upper Klamath River.
- Staff has determined that no compliance measures are necessary to mitigate for the long term hydrology/water quality impacts from increase average annual flow and magnitude and frequency of floods in large part as the reservoirs were not designed for flood protection. These reservoirs were designed to have a low residence time and especially under peak flows they did little to reduce peak

hydrograph flows downstream.

- Notify landowners adjacent to blasting sites of the planned use of explosives, restrict public access to the sites and plan explosives operations to take into account noise considerations to mitigate for the short term impacts from noise generating activities such as heavy equipment use and blasting activities.
- Redirect existing reservoir (flatwater) users to the twelve (12) other existing reservoirs/lakes in the region, conduct a survey of the existing recreation facilities at the other reservoir/lakes as part of any dam decommissioning plan, include recreational facility installation/upgrade at the existing flatwater areas to mitigate for any long term recreation impacts from decreased acres of reservoir available for flat-water recreation and warm water fishing and the subsequent re-direction of reservoir users to other neighborhood or regional recreation areas.

Although potentially significant adverse impacts from dam removal were identified, it is impossible without further study to know whether those impacts may be able to be mitigated to less than significant levels. If the Settlement Parties decide to go forward with decommissioning of one or more of the dams, additional environmental review will be required at that time. If, at that time, adverse environmental impacts are identified that cannot be mitigated to less than significant levels, the Regional Water Board, when required to take a discretionary action for approval of dam decommissioning as a final TMDL compliance measure, will balance the economic, legal, social, technological, or other benefits of removing the dams against any identified unavoidable environmental risks when determining whether to approve the project, and make a statement of overriding considerations, if it finds that the adverse environmental impacts are acceptable given the identified benefits. At this time, however, the Regional Water Board is not taking any action to approve decommissioning of one or more of PacifiCorps' dams and there is insufficient information for the Regional Water Board to know what potential impacts exist, if they can be mitigated to less than significant levels, and if not, whether the benefits outweigh those potential impacts.

9.5.3 Analysis of Compliance Measures, Potential Environmental Impacts, and Possible Mitigation Measures for Iron Gate Hatchery

Iron Gate Fish Hatchery is owned by PacifiCorp and operated by the California Department of Fish and Game (CDFG). The hatchery is located at the base of Iron Gate Dam and discharges effluent into the mainstem Klamath River. The TMDL assigns temperature, nutrient, and organic matter waste load allocations, as well as temperature, DO, nutrient and organic matter targets to discharges from Iron Gate Hatchery. The waste load allocations, based in part on the proposed revised DO objectives, to the Iron Gate Hatchery discharges will be implemented through the federal NPDES permit, which is held jointly by CDFG and PacifiCorp.

The issues associated with the Iron Gate Hatchery are complex due to the location and issues surrounding the hatchery operation. Site-constraints and technical factors make it necessary for an engineering study to be completed before a full environmental analysis can be completed for the hatchery aspect of the TMDL.

The TMDL compliance schedule to accompany the new permit may allow additional time needed for CDFG to make any infrastructure improvements to the hatchery and to implement management measures that meet TMDL allocations. The time schedule will include specific intermediate milestones with the final goal of meeting the Klamath TMDL allocations and targets. Intermediate milestones for pollutant reductions in the hatchery discharges may include:

1. Improving effluent water quality to the level of the intake water to the hatchery; and
2. Meeting current receiving water quality in the Klamath River at the point of discharge.

The hatchery may have the option of achieving some or all of its waste load reductions through offset mitigation if the potential changes to hatchery operations are limited in their ability to effectively reduce pollutant loads.

9.5.3.1 Analysis of Compliance Measures Associated for Iron Gate Hatchery

- Improvements to settling ponds.
- Improvement in treatment technologies (such as installation of a package treatment plant).
- Modifications to plant operations.
- Engage in potential off-sets program, including up-stream treatment activities.

9.5.3.2 Potential Environmental Impacts for Iron Gate Hatchery

- Impacts as typically associated with construction activities.

9.5.3.3 Possible Mitigation Measures Protection for Iron Gate Hatchery

- See mitigations below (Section 9.5.5) for use of heavy equipment and other infrastructure impacts.

9.5.4 Analysis of Compliance Measures, Potential Environmental Impacts, and Possible Mitigation Measures for Tributaries

The tributaries to the Klamath River include five major tributaries and numerous minor tributaries. The major tributaries are the Trinity, Salmon, Scott, Shasta and Lost Rivers. All the major tributaries, except the Lost River, join the Klamath River in California and are also wholly contained within California. The Lost River traverses the Oregon/ California border three times and ultimately joins the Klamath River in Oregon via the Klamath Straits Drain. The major tributaries each have had technical TMDLs completed that are specific to the tributary basin. The Regional Water Board has adopted TMDL implementation plans for the Shasta, Scott, and Salmon River basins. The Trinity, South Fork Trinity, and Lost River basins have had TMDLs promulgated by the USEPA without associated implementation plans. Lost River actions are included in those contained in the Stateline discussion.

The Klamath River TMDLs assign nutrient and organic matter load allocations to all the major Klamath tributaries in California and eighteen (18) specified minor tributaries to ensure that water quality standards in the mainstem, including the proposed revised DO objective, of the Klamath River are met. The Shasta River is the only tributary in California that has an existing TMDL with nutrient and organic matter-related allocations.

The Klamath River TMDL allocations to the Shasta River are consistent with the allocations assigned in the Shasta River TMDLs.

The Lost River discharges to the Klamath River in Oregon and as such the allocations for the Lost River are included as part of the Oregon Klamath River TMDLs.

It is anticipated that the Scott River TMDL includes the necessary sediment and temperature control measures to meet the Klamath River TMDL watershed-wide temperature allocations and targets and will be consistent with the proposed prohibition on the discharge of excess sediment.

Regional Water Board staff is currently working with the U. S. Forest Service on the development of a Memorandum of Understanding (MOU) that would provide the framework for the implementation (compliance) measures that would be undertaken in the Salmon River basin. These compliance measures would be formalized in WDRs/waiver that would require compliance with the proposed revised DO objectives, Klamath TMDL allocations and targets.

The Trinity River is assigned nutrient and organic matter allocations in the Klamath River TMDL. The implementation measures described in Section 6.5 apply to the Trinity River watershed. Implementation of sediment and riparian control measures to meet the watershed-wide temperature allocations and targets applicable to the Trinity River are expected to be sufficient to meet the nutrient and organic matter allocations for the Trinity River. The Klamath River TMDLs was modeled on the Trinity River Restoration Program (TRRP) Record of Decision, including flows. These actions, including flow levels were previously analyzed under NEPA, therefore no CEQA analysis is required for these actions. The restoration portion of TRRP (EIS circulating now

The compliance measures that might reasonably be implemented in the eighteen (18) minor tributaries are discussed below in the section on compliance measures for the proposed watershed wide allocations and targets.

9.5.4.1 Analysis of Compliance Measures Associated for Tributaries

- No additional compliance measures identified beyond those required under existing TMDLs, watershed programs or with the application of the watershed wide allocations discussed below.

9.5.4.2 Potential Environmental Impacts for Tributaries

- Not applicable.

9.5.4.3 Possible Mitigation Measures Protection for Tributaries

- Not applicable.

9.5.5 Analysis of Compliance Measures, Potential Environmental Impacts, and **Possible** *Mitigation Measures for Actions to Comply with the Watershed Wide Allocations and Targets and Proposed Revised DO Objective*

The environmental analysis of the compliance measures, potential impacts and possible mitigation measures to avoid those impacts is presented below. It is generally organized to correspond with the organization of the proposed implementation actions present in Chapter 6 of this Staff Report. This analysis includes a discussion on:

- Road construction and maintenance (on both public and private lands, unlike the Staff Report).
- Grazing.
- Irrigated Agriculture.
- Timber Harvest (on both public and private lands).
- Fire Management on U.S. Forest Service Lands (a component of the discussion on land management activities on Federal lands in Chapter 6 of the Staff Report).

9.5.5.1 Analysis of Compliance Measures, Potential Environmental Impacts, and Possible Mitigation Measures for Road and Crossing Construction and Maintenance Activities

Discharge of sediment from roads and watercourse crossings was identified during development of the TMDLs as contributing to the temperature impairment of the Klamath River. The draft Klamath River TMDLs (Chapter 5, Allocations and Numeric Targets, page 5-14) concludes that "stream temperature increases from human-caused discharge of sediment constitute an exceedence of the water quality objective for temperature" and establishes a temperature-related load allocation. The proposed temperature-related load allocation equals:

- Zero (0) temperature increase caused by substantial human-caused sediment-related channel alteration[17].

The draft Klamath River TMDLs also proposes the inclusion of three road and crossing related targets to control temperature impacts from human–caused sediment sources. The crossing related targets (or goals) include:

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[17] As used in this analysis, substantial human-caused sediment-related channel alteration is defined as "A human-caused alteration of stream channel dimensions that increase channel width, decrease depth, or remove riparian vegetation to a degree that alters stream temperature dynamics and is caused by increased sediment loading".

- Zero (0) miles of substantial human-caused sediment related channel alteration.
- Less than one percent (1%) of all stream crossings divert or fail as a result of a 100-year or smaller flood.

The proposed road-related target is as follows:

Decreasing number of potential road-related landslide source areas.
See Chapter 5 of this Staff Report for more on load allocations and numeric targets.

To attain the load allocations and reach the proposed targets, the draft implementation program (see Chapter 6 of the Staff Report for more information) proposes the use of all three of the regulatory approaches mandated by the California Water Code and reaffirmed in the State's 2004 Non-Point Source Policy (i.e., application of prohibitions, WDRs, and conditional waivers of WDRs) to control discharge of excess sediment from road and crossing construction and maintenance activities. See Chapter 6 for more on the Non-Point Source Policy.

The Klamath TMDLs identify the following parties as responsible for road and crossing construction and maintenance activities:

- US Forest Service (USFS)
- US Bureau of Land Management (BLM)
- State of California (Caltrans)
- Del Norte, Humboldt, Siskiyou and Trinity Counties (Counties)
- Private landowners, including timber, agricultural and residential

New road construction, except for on statutorily exempt land uses (e.g. agricultural and timber) are required to obtain coverage under the Statewide construction stormwater permit if the road results in point source discharge to waters of the State.

The USFS currently has waiver coverage for the roads associated with their silvicultural activities (Order Nos. R1-2004-0015 and R1-2009-0028). The conditional waiver is based on the understanding that the existing USFS road-related BMP program is implemented. The existing waiver will expire on December 10, 2009. Regional Water Board staff is currently working with the USFS on a revised permit which would include, in part, additional categories of land use (e.g., pre- and post-fire treatment), road design and construction standards, and a monitoring program. The suite of compliance measures that will be used on USFS roads likely will be similar regardless of the land use associated with the road use (e.g. timber, recreation, or grazing) or the regulatory approach that is used (e.g. prohibitions, WDRs, or conditional waivers of WDRs). The proposed implementation plan recommends the use of the proposed "*Prohibition of Discharges in Violation of Water Quality Objectives in the Klamath River Basin*" for those roads (including on USFS lands) that are not covered by an applicable State or Regional Water Board permit. As staff resources are made available, new or revised permits will be developed to cover a wider range of activities providing additional coverage options. Because road-related compliance measures are not currently required for roads not covered by the USFS silvicultural waiver, the full suite of road-related compliance measures, potential impacts and possible mitigation measures will be evaluated in this environmental analysis.

Currently, discharge of excess sediment from roads on lands managed by the US Bureau of Land Management (BLM) is unregulated. As stated above, the implementation plan proposes the application of the "*Prohibition of Discharges in Violation of Water Quality Objectives in the Klamath River Basin"* until such time as applicable permits are developed. Because the implementation of road-related compliance measures to control excess sediment is currently not required for roads under BLM's jurisdiction, the full suite of road-related compliance measures will be evaluated for potential adverse impacts and possible mitigation measures as part of this environmental analysis.

Discharges of waste from roads under the control of the State of California are the responsibility of Caltrans. These discharges are regulated under the State Water Board *NPDES Permit for Storm Water Discharges from the State of California, Department of Transportation (Caltrans) Properties, Facilities and Activities* (Order No. 99–06-DWQ). The draft Klamath River TMDL and implementation plan proposes the inclusion of three measures to address water quality impacts of Caltrans facilities and activities in the Klamath River watershed. One addresses the control of excess sediment, the second addresses barriers to migratory fish, and the third is addresses riparian shade to meet the temperature load allocation. Thus, this environmental analysis will evaluate likely compliance measures designed to control excess sediment discharge and to alleviate barriers to migratory fish passage and to protect or restore riparian shade.

No formally adopted regulatory framework currently exists for discharges of excess sediment from existing county-controlled road systems in the Klamath River watershed. However, the Counties (Humboldt, Del Norte, Trinity and Siskiyou) are all participants in the Five Counties Salmonid Conservation Program (5C Program). The 5C Program is guided by a management practices manual titled "*A Water Quality and Stream Habitat Protection Manual for County Road Maintenance in Northwestern California Watersheds*" which was endorsed by the National Marine Fisheries Service (NMFS) in 1999. As part of their approval, NMFS made the following determination: "all adverse impacts of the proposed action have been addressed to reach the conclusion of no significant impacts". The compliance measures (BMPs) recommended in the Road Management Plan are widely recognized as being effective in the control of sediment discharge from roads and watercourse crossings and are used by a number of responsible parties throughout California to control sediment discharges from rural road networks, and associated sediment-related impacts to water quality and aquatic resources. Since the implementation proposes certification of the 5C Program, the likely suite of compliance measures will be evaluated as part of this environmental analysis.

The final category of roads considered as part of this environment analysis includes roads owned by private landowners such as timberland owners, ranchers, farmers and rural residents. Roads on privately owned timberlands are covered under the existing timber WDRs or conditional waiver. The discharge of excess sediment from the remainder of these existing road systems is currently unregulated. As with the other categories of roads described above, the proposed implementation plan recommends the application of the "*Prohibition of Discharges in Violation of Water Quality Objectives in the Klamath River Basin"*, until such time as additional permits are developed.

Regional Water Board staff have identified a broad range of compliance measures to be analyzed as part of this environmental analysis. The compliance measures identified by Regional Water Board staff as likely being needed to meet the TMDL load allocation and numeric targets are presented below. An evaluation of the environmental impacts associated with implementation of specific measures or groups of measures and potential mitigation measures to decrease environmental impacts is also provided below.

As part of the Klamath River TMDL implementation plan, all landowners in the Klamath River watershed are encouraged to implement measures to control the discharge of excess sediment from their road systems. This includes the treatment of the road surfaces, cut and fill slopes, and drainage facilities, as appropriate, to prevent discharge of excess sediment. A number of compliance measures are available to control the discharge of excess sediment from the road system. Selection of compliance measures depends on a number of site specific factors including, but not limited to:

- Road surface material;
- Road drainage design;
- Timing and intensity of road use;
- Proximity of roads to watercourses;
- Proximity of roads to unstable or landslide prone areas; and
- Public health and safety concerns.

All of these factors should be considered during the selection, design and implementation of appropriate compliance measures. Due to the comparable nature of many of the identified compliance measures, potential environmental impacts will be analyzed in groups, regardless of who owns or controls the road system.

<u>Analysis of Compliance Measures, Potential Environmental Impacts and Possible Mitigation Measures to Control Impacts from Road Construction and Maintenance Activities</u>

Depending in part on the factors described above, a number of compliance measures to control excess sediment from the road surfaces (or the travelled portion of the road way) are available and routinely implemented by those parties responsible for roads in California.

<u>Analysis of Compliance Measures to Control Impacts from Road Construction and Maintenance Activities</u>

Compliance measures include treating the surface with the appropriate material to prevent expected road use from destabilizing the road surface. Surface stabilization measures include:

- Paving the road (asphalt)
- Chip sealing (gravel and petroleum-based binder)
- Rocking
- Dust abatement of native surface roads

Discharge of excess sediment from road fill slopes and cutbanks will require the implementation of compliance measures to prevent soil erosion or mass wasting. Fill slope and cut slope compliance measures include:

- Removal/stabilization of unstable fill
- Soil stabilization (mulching/vegetation) of fill and cut slopes.

An important factor in controlling discharge of excess sediment from road systems is properly designed road drainage and an active maintenance program. Compliance measures to control discharge of excess sediment as a result of drainage treatments are presented below based on road drainage design.

Insloped roads are those roads designed and constructed to drain the road surface towards the cutbank. Road and cutbank runoff is collected in an inboard ditch and drained with a series of cross drains, either directly to watercourses or onto the hillslope. Compliance measures to control discharge of excess sediment from insloped roads include:

- Disconnect road drainage from watercourses (drain to hillslopes).
- Install drainage structures at intervals that prevent erosion of the inboard ditch or gully formation at the hillslope outfall.
- Outslope the road.

Outsloped roads are those roads designed and constructed to drain the road surface towards the hillslope and away from the cutslope. This type of road design prevents the concentration of road surface runoff that could result in hillslope gully formation or discharge of road surface material directly into watercourses. Compliance measures to control discharge of excess sediment from outsloped roads include:

- Maintain outslope to prevent the concentration of road runoff.

Crowned roads are those roads designed and constructed to drain the road surface in two directions. Part of the road prism is drained towards the hillslope with the remainder of the road prism drained towards the cutslope. Hence, compliance measures to control discharge of excess sediment from crowned roads are the same as those identified above for insloped and outsloped roads.

Potential Environmental Impacts Associated with Road Related Compliance Measures

- Excess sediment discharge in violation of prohibition and exceedence of objectives from soil disturbance, earth movement and mass wasting or landslide events.
- Air quality impacts from heavy equipment use.

- Impacts to cultural sites from equipment use.
- Wildlife species impacts from disturbance to habitat.
- Increase in landslide hazard from placement of road cut and fill.
- Decrease in instream flows from water withdrawal for dust abatement.
- Alteration of natural hydrology by concentrating or redirecting road runoff.

Possible Mitigation Measures to Avoid Environmental Impacts Associated with Road Related Compliance Measures

- Install and maintain erosion control measures (e.g. waterbars, rolling dips, mulch, rock rip-rap) to prevent discharge of excess sediment from soil disturbing activities.
- Relocate roads away from unstable and landslide prone terrain.
- Drain roads away from unstable areas during construction, reconstruction of maintenance activities.
- Locate new roads on stable ground to the maximum extent practicable. Consult with professional geologist or engineer if road must be construction across landslide prone terrain.
- Time heavy equipment use to occur during periods of good air quality.
- Consult with Tribes, historical societies, federal, state and local agencies regarding location of cultural resources prior to use of heavy equipment in areas with known or suspected cultural resources.
- Consult with federal, state and local agencies regarding location of sensitive (e.g., threatened or endangered) wildlife resources.
- Minimize cutbank height and avoid placement of fill on steep slopes.
- Use off-channel water collection features for dust abatement purposes.
- Install adequate number/type of road drainage features to prevent concentration of road runoff.

Analysis of Compliance Measures, Associated Environmental Impacts and Potential Mitigation Measures to Avoid Impacts from Stream Crossing Activities

Discharge of excess sediment and loss of fisheries habitat from undersized, failing or poorly maintained watercourse crossings and crossing approaches is a high priority in the implementation of the Klamath TMDLs due to the high delivery potential associated with failing crossings and the loss of habitat created by human-caused fish migration barriers. As such, additional measures , identified below, likely will be required of all responsible parties in the Klamath River watershed who own or control these features.

Analysis of Compliance Measures to Avoid Impacts Associated with Crossing Activities

- Stabilize/treat crossing approach (road surface draining directly to crossing).
    - Rock road surface,
    - Use water for dust abatement,
    - Install additional road drainage features (e.g., waterbars, rolling dips, cross drains)
- Stabilize/treat crossings and associated fills.
    - Remove undersized/failing culverts
    - Remove unstable fill

    - Rock armor, rip rap fill slopes
    - Provide "fail safe" road drainage on crossings with diversion potential
    - Drain road away from unprotected fills
    - Install bioengineered structures (e.g. willow wattles)
    - Mulch, vegetate or rock exposed soil with access to watercourses
- Construct storm-proof (or fail-safe) crossings and associated fills.

Potential Environmental Impacts Associated with Crossing Related Compliance Measures

- Excess sediment discharge in violation of prohibition and exceedence of objectives from soil disturbance and earth movement.
- Air quality impacts from heavy equipment use.
- Impacts to cultural sites from equipment use.
- Wildlife species impacts from disturbance to habitat.
- Impacts to sensitive (e.g., threatened or endangered) wildlife resources.
- Creation of migration barriers to aquatic species, including cold water fisheries.
- Decrease in riparian vegetation needed to prevent temperature impacts.

Possible Mitigation Measures Associated with Crossing Related Environmental Impacts

- Avoid construction within wetted channel. Divert stream flow around crossing site, if necessary.
- Install and maintain compliance measures to prevent discharge of excess sediment from soil disturbing activities.
- Consult with Tribes, historical societies, federal, state and local agencies regarding location of cultural resources prior to use of heavy equipment in areas with known or suspected cultural resources.
- Consult with federal, state and local agencies regarding location of sensitive (e.g., threatened or endangered) wildlife resources.
- Time heavy equipment use to occur during period of good air quality (e.g.,. no air quality impacts from wildland fires).
- Size and construct stream crossing to allow unrestricted passage of aquatic species.
- Re-vegetate disturbed stream banks with native species.

Analysis of Compliance Measures, Potential Environmental Impacts and Possible Mitigation Measures to Avoid Impacts from Road Planning Activities

Good road planning can result in decreased road construction costs, lower maintenance requirements, and greater protection for the environment, including water quality. The compliance measures associated with good road planning are presented below.

Analysis of Compliance Measures to Avoid Road Planning Related Impacts

- Design road to support intended use (e.g., winter use, high traffic, etc.).
    - Surface material (e.g., pavement, chip seal, rock, native material).
    - Road width (e.g., single lane, double lane).
- Design road drainage to prevent road runoff concentration.
    - Drain road away from watercourses.

    - Drain road away from unstable areas.
    - Install sufficient drainage to prevent erosion at outfall.
- Locate roads on stable ground.
- Minimize crossing number and size of fill, to the extent feasible.
- Design crossing to handle anticipated stream flow and to prevent diversion of stream down the road.
- Avoid sensitive areas (wildlife, cultural).

Potential Environmental Impacts Associated with Road Planning Related Compliance Measures

- Staff has not identified any environmental impact from road planning activities.

Possible Mitigation Measures to Avoid Impacts with Road Planning Related Compliance Measures

- Not applicable.

Analysis of Compliance Measures, Potential Environmental Impacts and Possible Mitigation Measures to Avoid Impacts from Road Decommissioning

Road decommissioning may be a necessary action as part of a responsible party's management program to achieve the applicable TMDL load allocation. Road decommissioning may be appropriate if maintaining the road is cost prohibitive, if the road is not needed for access or public health and safety, or if it is a source of uncontrollable excess sediment discharge.

Analysis of Compliance Measures Associated with Road Decommissioning Activities

- Re-contour road to provide for a stable, hydrologically "invisible" site (e.g., remove perched fill, outslope old road prism, remove crossings).
- Minimize road system (density) to correspond with maintenance resources.
- Decommission roads adjacent to watercourse and relocate to midslope or ridgetop if possible.

Potential Environmental Impacts Associated with Road Decommissioning Compliance Measures

- Excess sediment discharge in violation of prohibition and exceedence of objectives from hillslope, in-channel and stream bank activities.
- Air quality impacts from heavy equipment use.
- Impacts to cultural sites from equipment use.
- Wildlife species impacts from disturbance to habitat.
- Cultural impacts from soil disturbance.
- Decrease in riparian vegetation needed to prevent temperature impacts.

Possible Mitigation Measures to Avoid Impacts from Road Decommissioning Compliance Measures

- See the mitigation measures identified above for road and crossing related activities.

9.5.5.2 Analysis of Compliance Measures, Potential Environmental Impacts, and Possible Mitigation Measures for Grazing Activities

The draft Klamath River TMDL recommends adoption of two temperature-related load allocations that are applicable to grazing activities on both federal and non-federal (private) land in the Klamath River watershed. One is a load allocation for excess solar radiation (expressed as its inverse, shade) and the other is related to sediment discharge related to human activity. See the discussion above in Sections 9.5.5.1 for more on these allocations and targets.

The draft Klamath River TMDL recommends adoption of one load allocation relative to nutrients/organic matter and two nutrient-related numeric targets. See Table 5.18 and 5.19 in Chapter 5 of this Staff Report for more information on load allocations and numeric targets. The load allocation and targets are designed to achieve the proposed revised DO objective. As such, the compliance measures discussed here are appropriate for both compliance with the TMDL and with the DO objective.

The load allocation is expressed as "*TN, TP, and CBOD concentrations expressed as monthly mean concentrations*".

The nutrient-related numeric targets include:

- Expressed as monthly mean concentrations of TP, TN, and CBOD below the Salmon River (Table 5.17 in the Staff Report).
- Reach-averaged maximum density of 150 mg of chlorophyll-a /m2 below the Salmon River.

For the purpose of this analysis a discussion of environmental impacts associated with irrigated agricultural is presented separately below in Section 9.5.5.3.

Grazing on federal land is regulated primarily by the USFS under Rangeland Project Decision documents and Annual Operating Instructions designed to meet the "*Northwest Forest Plan*" objectives for individual public forests. In addition, through the execution of a formal Management Agency Agreement with the USFS in 1981, the State Water Board designated the USFS as the Water Quality Management Agency for National Forest System lands in California. A document entitled "*Water Quality Management for Forest System Lands in California: Best Management Practices*" (USDA 2000) describes the means by which the USFS endeavors to meet their responsibility with respect to water quality protection.

Grazing on non-federal lands in the Klamath River Basin goes largely unregulated, except in the Scott and Shasta River watersheds (as a result of ongoing implementation of the approved Scott and Shasta River TMDLs and on concentrated animal feeding operations (CAFOs)). TMDL implementation plans adopted by the Regional Water Board in the Scott and Shasta River watersheds provide a waiver of WDRs for activities, including grazing, that implement measures contained in the applicable plan. NDPES permits are issued to CAFOs.

In the Klamath River TMDL, staff proposes the development of a conditional waiver of WDRs for discharges associated with agricultural activities that will include grazing as a means of implementing the TMDL and water quality standards. The Regional Water Board does not typically specify those measures necessary to achieve compliance with WDRs. Instead, the Regional Water Board typically allows land owners/managers to apply their own expertise and ingenuity to determine the best means of compliance. With respect to the TMDL, the waiver will be designed to implement the watershed-wide allocations, and the numeric nutrient and organic matter allocations.

For the purpose of CEQA, Regional Board staff must identify the reasonably foreseeable compliance measures that could be employed to achieve compliance with the TMDL and analyze their potential to cause environmental impact. With respect to the field of grazing on non-federal land, staff has used USEPA's (2003) *National Management Measures to Control Nonpoint Pollution from Agriculture* for guidance on the compliance measures that could be implemented to comply with a grazing waiver or WDR.

Four separate areas of management necessary to reduce the environmental harm resulting from grazing activities are described below. They include:

A. Grazing Management Practices
B. Alternative Water Supply Practices
C. Riparian Grazing Practices
D. Monitoring Grazing Land Condition

Grazing management practices are well suited to address the sediment–related temperature allocations proposed under the Klamath TMDL. Alternative water supply practices are well suited to address both the sediment–related temperature allocations and the nutrient and organic matter allocations. The riparian grazing practices are well suited to address the riparian shade allocation. The land and stream bank stabilization practices are also well suited to address the sediment-related temperature allocation. Monitoring is an activity necessary to ensure that the predicted effects are in fact occurring.

<u>Analysis of Compliance Measures, Potential Environmental Impacts, and Possible Mitigation Measures for Grazing Management Practices</u>
USEPA (2003) states that appropriate grazing management systems ensure proper grazing use by adjusting grazing intensity and duration to reflect the availability of forage and feed designated for livestock uses, and by controlling animal movement through the operating unit of grazing land. The use of grazing management systems can help maintain riparian and other resource objectives and can help meet the specific management objectives of the desired quality, quantity, and age distribution of vegetation.

<u>*Analysis of Compliance Measures Associated with Grazing Management Practices*</u>

- Develop a grazing management plan for upland and riparian management.

- Calculate the number of livestock that can be maintained while maintaining adequate vegetative cover, stream corridor integrity, and water resources.

- Establish native or introduced forage species (grasses, forbs, legumes, shrubs, and trees) through pasture, hay field and rangeland planting.
- Implement the controlled harvest of vegetation with grazing or browsing animals to achieve a specific objective.
- Exclude animals, people, or vehicles from an area to protect, maintain, or improve the quantity and quality of plant, animal, soil, air, water, and aesthetic resources and human health safety.
- Manage the amount, source, placement, form and timing of the application of nutrients and soil amendment through nutrient management.

Potential Environmental Impacts Associated with Grazing Management Compliance Measures

- Introduction of invasive (introduced) species thorough pasture, hay and rangeland planting and management.
- Decrease standing cover crop from removal of forage.
- Increase risk of soil compaction from heavy equipment use.
- Risk of increase soil erosion from fence installation.
- Risk of disturbing cultural/archaeological resources from fence installation
- Risk of disturbing threatened or endangered species or their habitat from installation of fencing.

Possible Mitigation Measures to Avoid Impacts from Grazing Management Practices

- Use certified weed-free grass and seed mix to prevent the introduction of invasive species.
- Manage livestock numbers and grazing patterns to retain adequate standing or cover crop,
- Limit the use of heavy equipment for grazing management activities to dry conditions.
- Consult with Tribes, historical societies, federal, state and local agencies regarding location of cultural resources prior to use of heavy equipment in areas with known or suspected cultural resources.
- Consult with federal, state and local agencies regarding location of sensitive (e.g. threatened or endangered) wildlife resources.
- Plant a cover crop on exposed soil to reduce the length of time in which soil is exposed to wind and water.
- Cover exposed soil that will not receive immediate planting with straw or other suitable erosion control material; and
- Protect drainage channels from sediment contributions with vegetated buffers, wattles or similar erosion control devices.

Analysis of Compliance Measures, Potential Environmental Impacts, and Possible Mitigation Measures for Alternative Water Supply Practices

USEPA (2003) states that providing water and mineral supplement facilities away from streams will help keep livestock away from stream banks and riparian zones, thereby protecting water quality. In some locations, artificial shade may also be constructed to encourage use of upland sites for shading and loafing, rather than the stream corridor. Installing alternate water supplies for livestock is an essential component of this measure.

Analysis of Compliance Measures Associated with Alternative Water Supply Practices

- Install a pipeline to convey livestock water to an off-stream pond, trough or tank.
- Construct/improve system (well, pump, etc) to provide groundwater for irrigation, livestock, wildlife, or recreation in lieu of instream withdraws.
- Improve springs and seeps by excavating, cleaning, capping, or providing collection and storage facilities. To facilitate off-stream watering.
- Place water, shade, and mineral supplements in locations separate from one another to encourage livestock dispersal.
- Ensure water, shade and mineral supplements are not placed on unstable areas, including gullies and landslides.

Potential Environmental Impacts Associated with Alternative Water Supply Practices

- Increased risk of short-term erosion impacts from construction activities.
- Increased risk of disturbing archaeological or cultural artifacts.
- Increased risk of disturbing threatened or endangered species and their habitat.
- Increased risk of soil disturbance that comes from the concentration of animals in a limited area.

Possible Mitigation Measures for Alternative Water Supply Practices

- Exercise surface erosion control measures, such as laying out straw or downslope wattles, where necessary.
- Restricting work to days in which soil detachment by wind or water is not expected.
- Timing the completion of work to coincide with planting to reduce the length of time in which bare soil is exposed.
- Covering exposed soil that will not receive immediate planting with straw or other suitable erosion control material.

Analysis of Compliance Measures, Potential Environmental Impacts, and Possible Mitigation Measures for Riparian Grazing Practices

The TMDL implementation plan includes an allocation intended to protect riparian vegetation from disturbance and preserve shade potential along the stream corridor. As such, any grazing in the riparian zone where this allocation applies must be conducted within certain parameters designed to protect the shade potential. Protection of specific trees, groves, or a streamside buffer zone may be necessary to accomplish this goal. The identification of the shade producing elements within the riparian zone will be necessary.

Analysis of Compliance Measures Associated with Riparian Grazing Practices

- Minimize livestock access to riparian zones, ponds or lake shores, wetlands, and stream banks to protect these areas from physical disturbance.
- Construct animal trails to provide movement of livestock through difficult or ecologically sensitive terrain.

- Stabilize stream crossings to provide controlled access across a stream for livestock and farm machinery.

Potential Environmental Impacts Associated with Riparian Grazing Practices

- See impacts identified above for grazing management in general.
- An analysis of the environmental impacts of stream crossings is provided in the section on roads and crossings.

Possible Mitigation Measures to Avoid Impacts from Riparian Grazing Practices

- See mitigation measures identified above for grazing management in general.
- See mitigation measures identified above for crossing management in general.

Analysis of Compliance Measures, Potential Environmental Impacts, and Possible Mitigation Measures for Monitoring Grazing Land Condition

The grazing management strategy as described by USEPA (2003) seeks to protect water quality by encouraging the development of an understanding of the carry capacity of a piece of land and the site specific land management measures necessary for grazing operations to be conducted within the limitations of the carrying capacity. A critical piece of this kind of management is the collection and analysis of environmental data from which to measure the conditions of the land. USEPA (2003) recommends an integrated approach to monitoring to evaluate nutrient cycling, soil and water quality, and plant community dynamics. Monitoring should be conducted on both a site specific level and at the subwatershed level to determine rangeland conditions status and trends. Monitoring can include photo points, vegetation sampling, soil assessments, water quality and quantity analyses and assessments of watershed, riparian and stream conditions.

Analysis of Compliance Measures Associated with Monitoring Condition of Grazing Lands

- None identified.

Potential Environmental Impacts Associated with Monitoring Conditions of Grazing Lands

- Not applicable.

Possible Mitigation Measures to Avoid Impacts from Monitoring Condition of Grazing Lands

- Not applicable.

9.5.5.3 Analysis of Compliance Measures, Potential Environmental Impacts, and Possible Mitigation Measures for Irrigated Agriculture

Irrigated agriculture is identified in the Klamath River TMDL as a category of anthropogenic pollutant loads (source category) impacting water quality parameters of concern. The draft TMDL Implementation Plan identifies the development of a general conditional waiver of WDRs for the purpose of controlling discharges associated with agricultural activities that includes irrigated agriculture.

Staff has turned to USEPA's (2003) *National Management Measures to Control Nonpoint Pollution from Agriculture* for guidance on the compliance measures that reasonably could be implemented to comply with the Klamath River TMDL. USEPA (2003) identifies four categories of management measures responsible parties should consider when attempting to reduce nonpoint source pollution from their farms. These measures include:

- Nutrient management
- Pesticide management
- Erosion and sediment control
- Irrigation water management

Staff judges each of these areas of management to be relevant to implementing the Klamath River TMDLs for temperature, dissolved oxygen, organic matter, nutrients and microcystin-related load allocations and numeric targets, as well as the proposed revised DO objectives. In addition, staff encourages riparian management to achieve the temperature-excess sediment TMDL allocation.

<u>Analysis of Compliance Measures, Potential Environmental Impacts, and Possible Mitigation Measures from Nutrient Management Practices</u>

The goal of proper nutrient management is "to minimize nutrient losses from agricultural lands occurring by edge-of-field runoff and by leaching from the root zone" (USEPA 2003). USEPA (2003) describes four important elements to successful nutrient management: 1) determine realistic yield goals, preferably on a field-by-field basis, 2) account for available nutrients from all sources before making supplemental applications, 3) synchronize nutrient applications with crop needs (nitrogen is needed most during active crop growth and may be lost at other times), and 4) reduce excessive soil-phosphorus levels by balancing phosphorus inputs and outputs. Where nutrients are in the dissolved phase, source reduction and reduction of water runoff or leaching are important goals. For nutrients adsorbed to soil particles, the prevention and control of soil erosion is important.

<u>Analysis of Compliance Measures Associated with Nutrient Management</u>

- Monitor soil, irrigation water, and residual plant matter for nutrient content.
- Time fertilizer application to be consistent with plant needs to avoid runoff of excess nutrients to surface waters or leaching of excess nutrients to groundwater.
- Use appropriately sized vegetated buffers to prevent discharge of nutrients to surface waters.

<u>Potential Environmental Impacts Associated with Nutrient Management</u>

- None identified. It is staff's judgment that monitoring, timing, use of cover crops and a vegetated buffer have no reasonable potential to cause environmental harm.

<u>Possible Mitigation Measures to Avoid Impacts from Nutrient Management Practices</u>

- Not applicable.

Analysis of Compliance Measures, Potential Environmental Impacts, and Possible Mitigation Measures from Pesticide Management

The goal of proper pesticide management is to reduce contamination of ground and surface water from pesticides by using less pesticide (quantity), less toxic (toxicity) pesticides, and applying pesticides in a manner that reduces the risk of runoff, leaching or air-borne transport.. With respect to the Klamath River TMDL, the application of herbicides is of most relevance. For example, herbicides applied to drainage channels or applied in such a manner as to risk overspray to a water body or riparian zone, could result in an increased risk of organic matter loading as treated plants die and their organic matter is available for delivery to a stream. Similarly, the spraying of herbicides in a riparian zone or overspray from adjacent fields could result in the temporary loss or harm to riparian shade.

Analysis of Compliance Measures Associated with Pesticide Management

- Inventory pest problems.
- Evaluate the soil and physical characteristics of the site, including locations for safe mixing, loading, and storage of pesticides.
- Use integrated pest management strategies that apply pesticides only to the area of need, only when there is an economic benefit to the grower, and at times when runoff losses are least likely, including losses of organic matter from dead plant material.
- Consider the persistence, toxicity, runoff potential, and leaching potential of pesticide products.
- Periodically calibrate pesticide application equipment.
- Use anti-backflow devices on water supply hoses, and other mixing/loading practices designed to reduced the risk of runoff and spills.

Potential Environmental Impacts Associated with Implementation of Compliance Measures for Pesticide Management

- None identified. It is staff's judgment that none of the identified compliance measures have a reasonable potential to cause environmental harm.

Possible Mitigation Measures to Avoid Impacts Associated with Implementation of Compliance Measures for Pesticide Management

- Not applicable.

Analysis of Compliance Measures, Potential Environmental Impacts, and Possible Mitigation Measures from Erosion and Sediment Control Measures

USEPA (2003) describes two general strategies for controlling erosion and the deposition of sediment to waters of the State from irrigated agricultural operations. These strategies can be used singly or in combination. The first, and most desirable, is "to implement practices on the field to minimize soil detachment, erosion, and transport of sediment from the field" (USEPA 2003).

Analysis of Compliance Measures Associated with Erosion and Sediment Control Practices

- Maintain crop residue or vegetative cover on the soil.
- Improve soil properties by tilling or otherwise loosening the soil.
- Reduce field slope length, steepness, or unsheltered distance.
- Reduce effective water velocities.
- Reduce effective wind velocities by installing windbreaks (e.g. trees).
- Direct field runoff to areas that filter, trap, or settle soil particles.

Potential Environmental Impacts Associated with Implementation of Compliance Measures for Erosion and Sediment Control

- Short term increases in sediment discharge from wind and water erosion from soil disturbance activities.
- Short term increases in sediment discharge from heavy equipment use.
- Increased short-term risk of soil erosion from re-contouring of fields.
- Air quality impacts from use of heavy equipment
- The construction of measures designed to filter, trap or settle sediment could result in short-term increased risk of erosion.
- Impacts to cultural resources from heavy equipment use.
- Impacts to threatened or endangered species or their habitat from heavy equipment use.

Possible Mitigation Measures to Avoid Impacts Associated with Implementation of Compliance Measures for Erosion and Sediment Control

- Avoid soil disturbing activities on windy and wet days.
- Design measures to filer, trap or settle sediment particles (sediment and/or water basins, field borders, and filter strips and the protection and management of natural wetland and riparian areas).
- Restrict work to days in which soil detachment by wind or water is not expected.
- Time the completion of work to coincide with planting to reduce the length of time in which bare soil is exposed.
- Cover exposed soil that will not receive immediate planting with straw or other suitable erosion control material.
- Protect drainage channels from sediment contributions with vegetated buffers, wattles or similar erosion control devices.

9.5.5.4 Analysis of Compliance Measures, Potential Environmental Impacts, and Possible Mitigation Measures for Irrigation Management

According to USEPA (2003), “a primary concern for irrigation water management is the discharge of salts, pesticides, and nutrients to ground water and discharge of these pollutants plus sediment to surface water.” The goal of managing irrigation water is to reduce the movement of pollutants from land into ground or surface water as a result of irrigation. This is accomplished by:

1. Irrigation scheduling;
2. Efficient application of irrigation water;

3. Efficient transport of irrigation water;
4. Use of runoff or tailwater; and
5. Management of drainage water.

It is staff's judgment that irrigation scheduling involves monitoring and planning and has no environmental impacts. Staff has also concluded that efficient application of irrigation water similarly has no environmental impacts. As such, no further analysis of these two activities will be provided.

<u>Analysis of Compliance Measures, Potential Environmental Impacts, and Possible Mitigation Measures Associated with Efficient Transportation of Irrigation Water</u>
The efficient transport of irrigation water could include the construction or modification of a number of engineered features.

<u>*Analysis of Compliance Measures Associated with Efficient Transportation of Irrigation Water*</u>

- Lining of an irrigation channel.
- Installation of a pipeline in lieu of an uncovered channel.

<u>*Potential Environmental Impacts Associated with Compliance Measures for the Efficient Transportation of Irrigation Water*</u>

- Use of heavy equipment and soil movement resulting in soil erosion.

<u>*Possible Mitigation Measures to Avoid Impacts from Implementation of Compliance Measures for the Efficient Transportation of Irrigation Water*</u>

- See discussion on wetland restoration, roads, grazing above for potential mitigation measures to address environmental impacts associated with heavy equipment use.

<u>Analysis of Compliance Measures, Potential Environmental Impacts, and Possible Mitigation Measures Associated with Use of Runoff or Tailwater</u>
For irrigation systems that use runoff or tailwater, a tailwater management program could be developed and implemented. This could include the construction of a tailwater recovery system designed to collect, store and transport irrigation tailwater (or runoff) for reuse/use in the irrigation distribution system.

Use of runoff or tailwater may be restricted in some areas, depending on legal issues associated with downstream water rights. But, where it is possible the reuse of tail water as irrigation water can serve to reduce the load of agricultural chemicals and sediment that are ultimately delivered to a stream.

<u>*Analysis of Compliance Measures Associated with Use of Runoff or Tailwater*</u>

- Operate the irrigation system so that the timing and amount of irrigation water applied matches crop needs.
- Use backflow flow preventers for wells protection.
- Minimize discharge from edge of fields.

- Construct tailwater management system.
  - Construction of a reservoir and pumping facilities.
- Land leveling to prevent discharge from field edges to surface waters.

Potential Environmental Impacts Associated with Compliance Measures for Use of Runoff or Tailwater

- Increased risk of soil or groundwater contamination with concentrated minerals, salts, or persistent pesticides.
- Loss of wetlands habitat from repair of leaky conveyance system.

Possible Mitigation Measures to Avoid Impacts from Installation of Compliance Measures for Use of Runoff or Tailwater

- Use precision (site specific) farming techniques; monitor chemical condition of soil, water, and plant residuals carefully prior to applying fertilizers, pesticides, or water, including tailwater.
- Leach soils within the root zone as necessary to prevent salt build up in that portion of the soil profile. Monitor ground water to ensure no salt (or other constituents) accumulate in ground water.
- Divert "saved" water (or portion thereof) to a wetland or wildlife refuge.
- Avoid introduction of storm water into tailwater system to prevent impacts to storm water.
- Maintain filter strips between fields and surface water to prevent discharge of tailwater directly into surface waters.
- Install surface drainage field ditch to collect excess water.

Analysis of Compliance Measures, Potential Environmental Impacts, and Possible Mitigation Measures Associated with the Management of Drainage Water

Drainage from irrigation systems should be managed to reduce deep percolation, move water to reuse system, reduce erosion and help control adverse impacts to surface and ground water.

Analysis of Compliance Measures Associated with the Management of Drainage Water

- Construct vegetated filter strips.
- Construct surface drainage field ditch.

Potential Environmental Impacts Associated with Compliance Measures for the Management of Drainage Water

- Cause a temporary increased risk of soil erosion from soil disturbance.
- Leaching of pesticides, fertilizers, and trace minerals through an under drain system.

Possible Mitigation Measures to Avoid Impacts from Compliance Measures for the Management of Drainage Water

- Don't concentrate drainage such that toxic levels of constituents are discharge to waters.

9.5.5.5 Analysis of Compliance Measures, Potential Environmental Impacts, and Possible Mitigation Measures for Timber Harvest Activities on Public and Private Land

Timber harvest and related activities are identified in the Klamath River TMDL as an anthropogenic (human-caused) pollutant source category impacting water quality parameters of concern. The draft Klamath River TMDLs identifies a number of allocation and numeric targets that are applicable to timber harvest activities. See the discussion in Section 9.5.5.1 for a discussion of the sediment-related allocations and targets. The draft TMDL also recommends a temperature-related load allocation for excess solar radiation. This proposed allocation for excess solar radiation is expressed as its inverse "effective shade" and is as follows:

- The shade provide by topography and full potential vegetation conditions at a site, with an allowance for natural disturbance such as floods, wind throw, disease, landslides, and fire.

The draft implementation plan recommends actions for the purpose of controlling water quality impacts emanating from activities associated with timber harvest activities. It is staff's judgment that these actions are likely necessary to achieve compliance with the Klamath TMDL load allocations and numeric targets.

With respect to timber harvest activities on land managed by the USFS, staff has not identified any additional compliance measures beyond the USFS and the Regional Water Board's existing regulatory framework. This framework includes, in part, the Regional Water Board conditional waivers (Resolutions R1-2004-0015 and R1-2009-0028), the USFS "*Water Quality Management Plan for the Forest System Lands in California, Best Management Practices*" (USDA, 2000) and the "*Northwest Forest Plan*" and "*Aquatic Conservation Strategy*". See Chapter 6 of this Staff Report for details on the existing USFS/Regional Water Board regulatory program for timber harvest activities on USFS lands. As such, there is no additional analysis of management measures required under CEQA. Staff is currently working with the USFS to develop a WDR/waiver for the Regional Water Board's consideration that will potentially cover all their land use activities involving the discharge of nonpoint source of pollution. As envisioned by staff, the proposed permit would include, in part, silvicultural activities, roads construction and maintenance, post fire treatment and a monitoring and reporting program.

The California Forest Practice Rules (2009) describe the intent of the watercourse protection regulations and provides specific measures (narrative or numeric) to ensure adequate protection to the beneficial uses of water from sediment and temperature impacts. As part of the development of the Klamath River TMDL, staff has identified the need to ensure that watercourses that deliver surface (or hyporheic) flows to fish bearing streams have additional requirements in place beyond those required by the 2009 FPR to meet the TMDL temperature load allocation.

Regional Water Board staff identified an implementation action (beyond measures required by other regulatory programs) that likely will be necessary to comply with the TMDL allocations and numeric targets for timber activities on privately owned lands.

See Chapter 6 of this Staff Report for details on the existing CalFire/Regional Water Board regulatory program for timber harvest activities on private land. The compliance measure pertains to the possibility that staff may require additional riparian protections beyond those required by the Anadromous Salmonid Protection Rules (ASP Rules), which take effect on January 1, 2010, in order to meet the Klamath TMDL temperature allocation. Additional riparian protections will be required by Regional Water Board staff on a timber harvest plan-specific basis as part compliance with applicable WDRs and waivers of WDRs for timber harvest activities.

Analysis of Compliance Measures Associated with Timber Harvest Activities on Private Land

- Increased riparian canopy retention for surface waters that support beneficial uses (e.g. Class I[18] and II[19] watercourses) on private timberland.
- Retain in-channel trees following timber operations on private timberlands.

Potential Environmental Impacts Associated with Timber Harvest Activities on Private Land

- Staff has not identified any adverse environmental impacts associate with increasing the post-harvest riparian canopy retention.

Possible Mitigation Measures to Avoid Impacts Associated with Timber Harvest Activities on Private Land

- Not applicable. It is staff's judgment that the retention of additional post-harvest riparian canopy does not have a reasonable potential to cause any environmental harm.

9.5.5.6 Analysis of Compliance Measures, Associated Environmental Impacts, and Potential Mitigation Measures Associated with Fire Management on Federal Lands

The fire regime in the Klamath River basin has been altered through years of suppression that has resulted in increased fuel loads and fire severity. The USFS carries out timber harvest projects related to fire management both to control fuel loads and to salvage timber after a fire.

The practices for controlling post fire erosion sources are, in most cases, the same as those used to control erosion sources on forestlands with the added consideration of increased runoff volume. Regional Water Board staff recommends that the WDRs/waiver address all activities on federal lands including measures that address post fire sediment sources.

Analysis of Compliance Measures Associated with Fire Management on Federal Land

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18 For the purpose of this report, a Class I watercourse is defined as being a "Domestic supplies or having fish always or seasonally present".

19 For the purpose of this report, a Class II watercourse is defined as "Aquatic habitat for nonfish aquatic species".

- Hydrologically disconnect firelines.
- Remove all temporary crossings.
- Improve the existing road drainage system to handle post-burn flows.
- Clear blockages to restore drainage function.
- Remove minor slumps and slides where needed.
- Ensure the function of drainage systems after storm events.
- Implement post fire re-vegetation on severe burns areas.

Potential Environmental Impacts Associated with Fire Management on Federal Land

- See discussion on potential impacts in the sections on road construction and maintenance and soil and erosion control practices for identification of possible impacts.

Possible Mitigation Measures to Avoid Impacts Associated with Fire Management on Federal Land

- See discussion on mitigation measures in the sections on road construction and maintenance and soil and erosion control practices for identification of potential mitigation measures.

A discussion on the significance (or level) of environmental impact on specific environmental factors such as air, biologic resources, and water quality associated with likely implementation actions are provided in Section 9.7.3 below.

9.5.5.7 Analysis of Compliance Measures, Potential Environmental Impacts, and Possible Mitigation Measures for Thermal Refugia Protection

Suction dredging is identified in the Klamath River TMDL as contributing to impacts on the critical functions associated with thermal refugia in moderating mainstem Klamath River temperatures for salmonids and other species of concern.

No regulatory program is currently in place for permitting instream suction dredging activities. CDFG, required under the Fish and Game Code with developing the program, is currently working on developing CEQA compliant regulation to implement the program.

The proposed implementation plan includes the Thermal Refugia Protection Policy that would be applied in certain locations to all tributary streams in the Klamath River watershed that provide known thermal (cold water) refugia (see Appendix 9 for identified locations of thermal refugia).

The application of the Thermal Refugia Protection Policy will not require implementation of any compliance measures as all responsible parties would be restricted from discharging waste within the prescribed buffer area.

In addition to protecting the quality of cold water by restricting the discharge of waste within an instream buffer zone, staff also proposes the protection of the quantity of cold water delivered by tributaries to the Klamath River mainstem. Staff proposes that the

State Water Resources Control Board ensure that any water rights decisions on refugia tributary streams be made only after an analysis of the individual and cumulative effects of water diversion on tributary and mainstem stream temperatures. Staff proposes that a water right not be granted if the loss of cold water flow would conflict with the temperature goals of the TMDL.

Analysis of Compliance Measures Associated with Thermal Refugia Protection

- None required.

Potential Environmental Impacts Associated with Thermal Refugia Protection

- No environmental impacts identified.

Possible Mitigation Measures Protection of Thermal Refugia

- Not applicable.

9.6 Alternative Means of Compliance

The CEQA requires an analysis of reasonably foreseeable alternative means of compliance with the rule or regulation, which would avoid or eliminate the identified impacts[20]. Responsible parties can use the structural and non-structural BMPs (compliance measures) described above in Section 9.5, or other structural and non-structural BMPs, to control and prevent pollution, and meet the requirements of the proposed Action Plan and revised DO objectives. The alternative means of compliance with the proposed Action Plan and revised DO objectives consist of the different combinations of structural and non-structural BMPs that responsible parties might use. Because there are innumerable ways to combine compliance measures, all of the possible arrangements of alternative means of compliance cannot be discussed here. However, because most of the adverse environmental effects are associated with the construction and installation of large scale structural BMPs to avoid or eliminate impacts, compliance alternatives should minimize structural BMPs, maximize non-structural BMPs, and site, size, and design structural BMPs in ways to minimize environmental effects.

9.7. Environmental Checklist and Discussion of Findings

9.7.1 Environmental Checklist Cover Form

1. Project title:

Proposed Amendment to the *Water Quality Control Plan for the North Coast Region* to Revise the DO objectives for the Klamath River mainstem as contained in Table 3-1 and add a *Klamath River Total Maximum Daily Load Action Plan and Lost River Implementation Plan* (Action Plan),

[20] Cal. Code Regs., tit. 14, § 15187(c)(3).

2. Lead agency name and address:
North Coast Regional Water Quality Control Board
5550 Skylane Blvd., Suite A
Santa Rosa, CA 95403

3. Contact person and phone number:
Matt St John (707) 576-3762

4. Project location:
The project would be applicable to the California portion of the Klamath River watershed under jurisdiction of the North Coast Regional Water Quality Control.

5. Description of the project: (Describe the whole action involved, including but not limited to later phases of the project, and any secondary, support, or off-site features necessary for its implementation).
The proposed project is the adoption of a Basin Plan Amendment, which consists of revised DO objectives for the Klamath River as contained in Table 3-1 and a new *Klamath River Total Maximum Daily Load Action Plan and Lost River Implementation Plan*. The proposed revision to the DO objectives involves the elimination of the existing DO objectives for the Klamath River mainstem as contained in Table 3-1 and their replacement with new site-specific DO objectives based on percent saturation, natural receiving water temperatures and salinity. The goal of the revised DO objectives for the Klamath River mainstem is to correct existing inaccuracies and allow for the application of the DO objectives regardless of the time of day.

The Action Plan includes TMDLs for temperature, dissolved oxygen, nutrients and microcystin and the implementation actions necessary to achieve these TMDLs and attain water quality standards in the Klamath River watershed. The goal of the Action Plan is to fully protect and restore the beneficial uses of water in the Klamath River watershed. The Action Plan sets outs the pollutant loads and conditions to be considered and incorporated into regulatory and non-regulatory actions in the Klamath River watershed. The Klamath River Action Plan is not directly and independently enforceable, except as incorporated into appropriate permitting or enforcement action or through the applicable of waste discharge prohibitions.

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9.7.2 Environmental Checklist

	Potentially Significant Impact	Less Than Significant with Mitigation Incorporated	Less Than Significant Impact	No Impact
I. AESTHETICS -- Would the project:				
a) Have a substantial adverse effect on a scenic vista?	☐	☐	☑	☐
b) Substantially damage scenic resources, including, but not limited to, trees, rock outcroppings, and historic buildings within a state scenic highway?	☐	☐	☑	☐
c) Substantially degrade the existing visual character or quality of the site and its surroundings?	☐	☑	☐	☐
d) Create a new source of substantial light or glare which would adversely affect day or nighttime views in the area?	☐	☐	☑	☐
II. AGRICULTURE RESOURCES: In determining whether impacts to agricultural resources are significant environmental effects, lead agencies may refer to the California Agricultural Land Evaluation and Site Assessment Model (1997) prepared by the California Dept. of Conservation as an optional model to use in assessing impacts on agriculture and farmland. Would the project:				
a) Convert Prime Farmland, Unique Farmland, or Farmland of Statewide Importance (Farmland), as shown on the maps prepared pursuant to the Farmland Mapping and Monitoring Program of the California Resources Agency, to non-agricultural use?	☐	☐	☑	☐
b) Conflict with existing zoning for agricultural use, or a Williamson Act contract?	☐	☐	☑	☐
c) Involve other changes in the existing environment which, due to their location or nature, could result in conversion of Farmland, to non-agricultural use?	☐	☐	☑	☐
III. AIR QUALITY -- Where available, the significance criteria established by the applicable air quality management or air pollution control district may be relied upon to make the following determinations. Would the project:				
a) Conflict with or obstruct implementation of the applicable air quality plan?	☐	☐	☑	☐
b) Violate any air quality standard or contribute substantially to an existing or projected air quality violation?	☐	☑	☐	☐
c) Result in a cumulatively considerable net increase of any criteria pollutant for which the project region is non-attainment under an applicable federal or state ambient air quality standard (including releasing emissions which exceed quantitative thresholds for ozone precursors)?	☐	☑	☐	☐
d) Expose sensitive receptors to substantial pollutant concentrations?	☐	☐	☑	☐

	Potentially Significant Impact	Less Than Significant with Mitigation Incorporated	Less Than Significant Impact	No Impact
III. AIR QUALITY (cont.)-- Where available, the significance criteria established by the applicable air quality management or air pollution control district may be relied upon to make the following determinations. Would the project:				
e) Create objectionable odors affecting a substantial number of people?	☐	☑	☐	☐
IV. BIOLOGICAL RESOURCES -- Would the project:				
a) Have a substantial adverse effect, either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special status species in local or regional plans, policies, or regulations, or by the California Department of Fish and Game or U.S. Fish and Wildlife Service?	☑	☐	☐	☐
b) Have a substantial adverse effect on any riparian habitat or other sensitive natural community identified in local or regional plans, policies, regulations or by the California Department of Fish and Game or US Fish and Wildlife Service?	☐	☑	☐	☐
c) Have a substantial adverse effect on federally protected wetlands as defined by Section 404 of the Clean Water Act (including, but not limited to, marsh, vernal pool, coastal, etc.) through direct removal, filling, hydrological interruption, or other means?	☐	☑	☐	☐
d) Interfere substantially with the movement of any native resident or migratory fish or wildlife species or with established native resident or migratory wildlife corridors, or impede the use of native wildlife nursery sites?	☐	☑	☐	☐
e) Conflict with any local policies or ordinances protecting biological resources, such as a tree preservation policy or ordinance?	☐	☑	☐	☐
f) Conflict with the provisions of an adopted Habitat Conservation Plan, Natural Community Conservation Plan, or other approved local, regional, or state habitat conservation plan?	☐	☐	☑	☐
V. CULTURAL RESOURCES -- Would the project:				
a) Cause a substantial adverse change in the significance of a historical resource as defined in § 15064.5?	☐	☑	☐	☐
b) Cause a substantial adverse change in the significance of an archaeological resource pursuant to § 15064.5?	☐	☑	☐	☐
c) Directly or indirectly destroy a unique paleontological resource or site or unique geologic feature?	☐	☐	☑	☐
d) Disturb any human remains, including those interred outside of formal cemeteries?	☐	☑	☐	☐

	Potentially Significant Impact	**Less Than Significant with Mitigation Incorporated**	**Less Than Significant Impact**	**No Impact**
VI. GEOLOGY AND SOILS -- Would the project:				
a) Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving:	☐	☐	☐	☐
i) Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault? Refer to Division of Mines and Geology Special Publication 42.	☐	☐	☐	☑
ii) Strong seismic ground shaking?	☐	☐	☐	☑
iii) Seismic-related ground failure, including liquefaction?	☐	☐	☐	☑
iv) Landslides?	☐	☑	☐	☐
b) Result in substantial soil erosion or the loss of topsoil?	☐	☑	☐	☐
c) Be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the project, and potentially result in on- or off-site landslide, lateral spreading, subsidence, liquefaction or collapse?	☐	☑	☐	☐
d) Be located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1994), creating substantial risks to life or property?	☐	☐	☐	☑
e) Have soils incapable of adequately supporting the use of septic tanks or alternative waste water disposal systems where sewers are not available for the disposal of waste water?	☐	☐	☑	☐
VII. HAZARDS AND HAZARDOUS MATERIALS -- Would the project:				
a) Create a significant hazard to the public or the environment through the routine transport, use, or disposal of hazardous materials?	☐	☐	☑	☐
b) Create a significant hazard to the public or the environment through reasonably foreseeable upset and accident conditions involving the release of hazardous materials into the environment?	☐	☑	☐	☐
c) Emit hazardous emissions or handle hazardous or acutely hazardous materials, substances, or waste within one-quarter mile of an existing or proposed school?	☐	☐	☑	☐
d) Be located on a site which is included on a list of hazardous materials sites compiled pursuant to Government Code Section 65962.5 and, as a result, would it create a significant hazard to the public or the environment?	☐	☐	☑	☐
e) For a project located within an airport land use plan or, where such a plan has not been adopted, within two miles of a public airport or public use airport, would the project result in a safety hazard for people residing or working in the project area?	☐	☐	☐	☑

	Potentially Significant Impact	Less Than Significant with Mitigation Incorporated	Less Than Significant Impact	No Impact
VII. HAZARDS AND HAZARDOUS MATERIALS (cont.)-- Would the project:				
f) For a project within the vicinity of a private airstrip, would the project result in a safety hazard for people residing or working in the project area?	☐	☐	☑	☐
g) Impair implementation of or physically interfere with an adopted emergency response plan or emergency evacuation plan?	☐	☐	☐	☑
h) Expose people or structures to a significant risk of loss, injury or death involving wildland fires, including where wildlands are adjacent to urbanized areas or where residences are intermixed with wildlands?	☐	☐	☐	☑
VIII. HYDROLOGY AND WATER QUALITY -- Would the project:				
a) Violate any water quality standards or waste discharge requirements?	☑	☐	☐	☐
b) Substantially deplete groundwater supplies or interfere substantially with groundwater recharge such that there would be a net deficit in aquifer volume or a lowering of the local groundwater table level (e.g., the production rate of pre-existing nearby wells would drop to a level which would not support existing land uses or planned uses for which permits have been granted)?	☐	☐	☑	☐
c) Substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, in a manner which would result in substantial erosion or siltation on- or off-site?	☑	☐	☐	☐
d) Substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, or substantially increase the rate or amount of surface runoff in a manner which would result in flooding on- or off-site?	☑	☐	☐	☐
e) Create or contribute runoff water which would exceed the capacity of existing or planned storm water drainage systems or provide substantial additional sources of polluted runoff?	☐	☐	☑	☐
f) Otherwise substantially degrade water quality?	☐	☐	☑	☐
g) Place housing within a 100-year flood hazard area as mapped on a federal Flood Hazard Boundary or Flood Insurance Rate Map or other flood hazard delineation map?	☐	☐	☑	☐
h) Place within a 100-year flood hazard area structures which would impede or redirect flood flows?	☐	☐	☐	☑
i) Expose people or structures to a significant risk of loss, injury or death involving flooding, including flooding as a result of the failure of a levee or dam?	☐	☐	☑	☐
j) Inundation by seiche, tsunami, or mudflow?	☐	☐	☐	☑

	Potentially Significant Impact	Less Than Significant with Mitigation Incorporated	Less Than Significant Impact	No Impact
IX. LAND USE AND PLANNING -- Would the project:				
a) Physically divide an established community?	☐	☐	☐	☑
b) Conflict with any applicable land use plan, policy, or regulation of an agency with jurisdiction over the project (including, but not limited to the general plan, specific plan, local coastal program, or zoning ordinance) adopted for the purpose of avoiding or mitigating an environmental effect?	☐	☐	☑	☐
c) Conflict with any applicable habitat conservation plan or natural community conservation plan?	☐	☐	☑	☐
X. MINERAL RESOURCES -- Would the project:				
a) Result in the loss of availability of a known mineral resource that would be of value to the region and the residents of the state?	☐	☐	☐	☑
b) Result in the loss of availability of a locally-important mineral resource recovery site delineated on a local general plan, specific plan or other land use plan?	☐	☐	☐	☑
XI. NOISE -- Would the project result in:				
a) Exposure of persons to or generation of noise levels in excess of standards established in the local general plan or noise ordinance, or applicable standards of other agencies?	☐	☐	☑	☐
b) Exposure of persons to or generation of excessive groundborne vibration or groundborne noise levels?	☐	☐	☑	☐
c) A substantial permanent increase in ambient noise levels in the project vicinity above levels existing without the project?	☐	☐	☑	☐
d) A substantial temporary or periodic increase in ambient noise levels in the project vicinity above levels existing without the project?	☐	☑		☐
e) For a project located within an airport land use plan or, where such a plan has not been adopted, within two miles of a public airport or public use airport, would the project expose people residing or working in the project area to excessive noise levels?	☐	☐	☑	☐
f) For a project within the vicinity of a private airstrip, would the project expose people residing or working in the project area to excessive noise levels?	☐	☐	☑	☐

	Potentially Significant Impact	Less Than Significant with Mitigation Incorporated	Less Than Significant Impact	No Impact
XII. POPULATION AND HOUSING -- Would the project:				
a) Induce substantial population growth in an area, either directly (for example, by proposing new homes and businesses) or indirectly (for example, through extension of roads or other infrastructure)?	☐	☐	☐	☑
b) Displace substantial numbers of existing housing, necessitating the construction of replacement housing elsewhere?	☐	☐	☐	☑
c) Displace substantial numbers of people, necessitating the construction of replacement housing elsewhere?	☐	☐	☐	☑
XIII. PUBLIC SERVICES				
a) Would the project result in substantial adverse physical impacts associated with the provision of new or physically altered governmental facilities, need for new or physically altered governmental facilities, the construction of which could cause significant environmental impacts, in order to maintain acceptable service ratios, response times or other performance objectives for any of the public services:				
Fire protection?	☐	☐	☐	☑
Police protection?	☐	☐	☐	☑
Schools?	☐	☐	☐	☑
Parks?	☐	☐	☐	☑
Other public facilities?	☐	☐	☐	☑
XIV. RECREATION				
a) Would the project increase the use of existing neighborhood and regional parks or other recreational facilities such that substantial physical deterioration of the facility would occur or be accelerated?	☐	☑	☐	☐
b) Does the project include recreational facilities or require the construction or expansion of recreational facilities which might have an adverse physical effect on the environment?	☐	☐	☐	☑

	Potentially Significant Impact	Less Than Significant with Mitigation Incorporated	Less Than Significant Impact	No Impact
XV. TRANSPORTATION/TRAFFIC -- Would the project:				
a) Cause an increase in traffic which is substantial in relation to the existing traffic load and capacity of the street system (i.e., result in a substantial increase in either the number of vehicle trips, the volume to capacity ratio on roads, or congestion at intersections)?	☐	☐	☑	☐
b) Exceed, either individually or cumulatively, a level of service standard established by the county congestion management agency for designated roads or highways?	☐	☐	☐	☑
c) Result in a change in air traffic patterns, including either an increase in traffic levels or a change in location that results in substantial safety risks?	☐	☐	☐	☑
d) Substantially increase hazards due to a design feature (e.g., sharp curves or dangerous intersections) or incompatible uses (e.g., farm equipment)?	☐	☐	☑	☐
e) Result in inadequate emergency access?	☐	☐	☐	☑
f) Result in inadequate parking capacity?	☐	☐	☐	☑
g) Conflict with adopted policies, plans, or programs supporting alternative transportation (e.g., bus turnouts, bicycle racks)?	☐	☐	☐	☑
XVI. UTILITIES AND SERVICE SYSTEMS -- Would the project:				
a) Exceed wastewater treatment requirements of the applicable Regional Water Quality Control Board?	☐	☐	☑	☐
b) Require or result in the construction of new water or wastewater treatment facilities or expansion of existing facilities, the construction of which could cause significant environmental effects?	☐	☑	☐	☐
c) Require or result in the construction of new storm water drainage facilities or expansion of existing facilities, the construction of which could cause significant environmental effects?	☐	☐	☑	☐
d) Have sufficient water supplies available to serve the project from existing entitlements and resources, or are new or expanded entitlements needed?	☐	☐	☑	☐
e) Result in a determination by the wastewater treatment provider which serves or may serve the project that it has adequate capacity to serve the project's projected demand in addition to the provider's existing commitments?	☐	☐	☑	☐
f) Be served by a landfill with sufficient permitted capacity to accommodate the project's solid waste disposal needs?	☐	☐	☑	☐
g) Comply with federal, state, and local statutes and regulations related to solid waste?	☐	☐	☑	☐

	Potentially Significant Impact	Less Than Significant with Mitigation Incorporated	Less Than Significant Impact	No Impact
XVII. MANDATORY FINDINGS OF SIGNIFICANCE				
a) Does the project have the potential to degrade the quality of the environment, substantially reduce the habitat of a fish or wildlife species, cause a fish or wildlife population to drop below self-sustaining levels, threaten to eliminate a plant or animal community, reduce the number or restrict the range of a rare or endangered plant or animal or eliminate important examples of the major periods of California history or prehistory?	☑	☐	☐	☐
b) Does the project have impacts that are individually limited, but cumulatively considerable? ("Cumulatively considerable" means that the incremental effects of a project are considerable when viewed in connection with the effects of past projects, the effects of other current projects, and the effects of probable future projects)?	☑	☐	☐	☐
c) Does the project have environmental effects which will cause substantial adverse effects on human beings, either directly or indirectly?	☐	☐	☑	☐

9.7.3 Discussion of Environmental Checklist Findings

As stated previously, the environmental analysis must include an analysis of the reasonably foreseeable environmental impacts of the methods of compliance and the reasonably foreseeable feasible mitigation measures relating to those impacts. This section provides answers to the questions presented in the environmental checklist.

In formulating these answers, the impacts of implementing structural and non-structural BMPs described in Section 9.5 were evaluated. At this time, the exact type, size, and location of BMPs that might be implemented for future proposed projects to comply with the proposed Action Plan and revised DO objectives are unknown. This analysis considered a range of structural and non-structural BMPs that might be used by responsible parties, but is by no means an exhaustive list of available BMPs. Responsible parties will be required to develop and implement site-specific BMPs to control the discharge of waste from their activities.

Potential impacts of the reasonably foreseeable compliance measures were evaluated with respect to earth, air, water, plant life, animal life, noise, light, land use, natural resources, risk of upset, population, housing, transportation, public services, energy, utilities and services systems, human health, aesthetics, recreation, and archeological/historical concerns. Additionally, mandatory findings of significance regarding short-term, long-term, cumulative and substantial impacts were evaluated. Based on this review, staff concluded that any potentially significant impacts can be mitigated to less than significant levels with the exception of several impacts resulting from dam decommissioning activities.

The evaluation considered whether the construction or implementation of the BMPs would cause a substantial, adverse change in any of the physical conditions within the area affected by the BMP. In addition, the evaluation considered environmental effects in proportion to their severity and probability of occurrence. For the dam decommissioning activities, the environmental analysis was based upon several reports that have analyzed generally the effects of taking out one or more of the dams. Because there is not a proposed project for decommissioning at this time, the evaluation of potential impacts was general in nature and any specific plan for dam removal would require additional analysis.

A significant effect on the environment is defined in statute as "*a substantial, or potentially substantial, adverse change in the environment*" where "*Environment*" is defined by Public Resources Code section 21060.5 as "*the physical conditions which exist within the area which will be affected by a proposed project, including air, water, minerals, flora, fauna, noise, objects of historic or aesthetic significance*."[21]

Social or economic changes related to a physical change of the environment were also considered in determining whether there would be a significant effect on the environment. However, adverse social and economic impacts alone are not significant effects on the environment.

In this analysis, the level of significance was based on baseline or current conditions. Short-term impacts associated with the construction of structural BMPs (with the exception of dam decommissioning activities) were considered less than significant because the impacts due to construction activities are temporary and similar to typical capital improvement projects and maintenance activities currently performed throughout the region. All of the identified impacts are, however, short-term. Until the actual design for dam decommissioning activities is available for review it is impossible to make a determination that all adverse impacts can be mitigated to a less than significant level. Because of this, where it is uncertain whether the potential impacts could be mitigated to levels of insignificance, the Regional Water Board acted conservatively and concluded in this analysis that decommissioning of one or more of the dams would result in a potentially significant impact.

1. Aesthetics: a.) Have a substantial adverse effect on a scenic vista?

Answer: Less than significant.

Discussion: None of the identified compliance measures (e.g. structural and non-structural BMPs) would cause a substantial adverse effect on a scenic vista. None require the permanent construction of a sizable structure that would either block a scenic vista or substantially degrade the vista.

[21] Pub. Resources Code §21068

1. Aesthetics: b.) Substantially damage scenic resources, including, but not limited to, trees, rock outcroppings, and historic buildings within a state scenic highway?

Answer: Less than significant.

Discussion: There are no officially designated state scenic highways in the Klamath River watershed. However, the measures that may be implemented to comply with the Klamath River TMDL and revised DO objectives would not be expected to have an adverse effect on scenic resources.

If a BMP was selected that required land disturbance, such as the construction of a settling basin or a riparian fence, there may be minor surface soil excavation or grading during construction of these structural BMPs, which could result in increased disturbance of the soil. If, however, scenic resources were identified at the site, they would be avoided, and standard construction techniques should not result in damage to scenic resources.

1. Aesthetics: c.) Substantially degrade the existing visual character or quality of the site and its surroundings?

Answer: Less than significant with mitigation.

Discussion: Neither the structural nor the non-structural BMPs that would potentially be used to comply with the requirements of the proposed Action Plan and revised DO objectives would be expected to degrade the existing visual character or quality of a site and its surroundings with the application of appropriate mitigation measures.

Although implementation of structural BMPs could result in some change in visual character or ground surface relief features, most of the compliance measures identified as part of the environmental analysis are of relatively small scale, such as installation of road drainage features, riparian fencing, or tailwater retention systems, that changes to the visual character or quality of the site and its surroundings will not be noticeable. The larger scale projects, such as dam decommissioning, road decommissioning on USFS land, construction of treatment wetlands, or construction of a conventional wastewater treatment facility, will require a project-level analysis of potential environmental effects, including effects on aesthetic resources. Visual impacts associated with dam decommissioning can be addressed through the decommissioning plan by including mitigation measures such as early establishment of native vegetation (grass, forbes and trees) on exposed surfaces.

1. Aesthetics: d.) Create a new source of substantial light or glare which would adversely affect day or nighttime views in the area?

Answer: Less than significant.

Discussion: Neither the structural nor the non-structural compliance measures that would potentially be used to comply with the requirements of the proposed Action Plan and revised DO objectives would be expected to create a new source of substantial lighting or glare.

2. Agriculture Resources: a.) In determining whether impacts to agricultural resources are significant environmental effects, lead agencies may refer to the California Agricultural Land Evaluation and Site Assessment Model (1997) prepared by the California Dept. of Conservation as an optional model to use in assessing impacts on agriculture and farmland. Would the project:

Convert Prime Farmland, Unique Farmland, or Farmland of Statewide Importance (Farmland), as shown on the maps prepared pursuant to the Farmland Mapping and Monitoring Program of the California Resources Agency, to non-agricultural use?

Answer: Less than significant.

Discussion: Staff judges that there may be incidental loss of agricultural use in lands mapped as Prime Farmland, Unique Farmland or Farmland of Statewide Importance. These losses, however, would be less than significant because not only do they affect a very narrow band of land on either side of the watercourse. But, as derived from the readily accessible information from the Farmland Mapping and Monitoring Program, no more than 5% of the Klamath River basin is mapped as Prime Farmland, Unique Farmland, and Farmland of Statewide Importance.

2. Agriculture Resources: b.) In determining whether impacts to agricultural resources are significant environmental effects, lead agencies may refer to the California Agricultural Land Evaluation and Site Assessment Model (1997) prepared by the California Dept. of Conservation as an optional model to use in assessing impacts on agriculture and farmland. Would the project:

Conflict with existing zoning for agricultural use, or a Williamson Act contract?

Answer: Less than significant.

Discussion: Neither the structural nor the non-structural BMPs that would potentially be used to comply with the requirements of the proposed Action Plan and revised DO objectives would be expected to conflict with existing zoning for agricultural use, or a Williamson Act contract.

2. Agriculture Resources: c.) In determining whether impacts to agricultural resources are significant environmental effects, lead agencies may refer to the California Agricultural Land Evaluation and Site Assessment Model (1997) prepared by the California Dept. of Conservation as an optional model to use in assessing impacts on agriculture and farmland. Would the project:

Involve other changes in the existing environment which, due to their location or nature, could result in conversion of Farmland, to non-agricultural use?

Answer: Less than significant.

Discussion: Neither the structural nor the non-structural BMPs that would potentially be used to comply with the requirements of the proposed Action Plan or revised DO objectives would be expected to result in changes to the existing environment which, due to their location or nature, could result in conversion of Farmland, to non-agricultural use. The three KHP dams located in California were built as part of a hydroelectric system and not as part of irrigation deliver system. As such, even in the event of dam decommissioning, no impacts are expected to arise that would result in the conversion of Farmland to non-agricultural use.

3. Air Quality: a.) Where available, the significance criteria established by the applicable air quality management or air pollution control district may be relied upon to make the following determinations. Would the project:

Conflict with or obstruct implementation of the applicable air quality plan?

Answer: Less than significant.

Discussion: Neither the structural nor the non-structural BMPs that would potentially be used to comply with the requirements of the proposed Action Plan and revised DO objectives would be expected to result in any conflicts with or obstruction to the implementation of the applicable air quality plan.

Implementation of structural BMPs that require the use of heavy equipment, such as the dam decommissioning, construction of settling basins, road drainage installation or re-contouring of existing road prisms, could result in vehicle emissions during construction; however, these impacts would be short-term, and would not result in conflicts with, or obstruction of the implementation of the applicable air quality plan.

3. Air Quality: b.) Violate any air quality standard or contribute substantially to an existing or projected air quality violation?

Answer: Less than significant with mitigation.

Discussion: Neither the structural nor the non-structural BMPs that would potentially be used to comply with the requirements of the proposed Action Plan and revised DO objectives would be expected to result in any violation of air quality standards or contribute substantially to an existing or projected air quality violation if appropriate mitigation measures are applied.

The implementation of structural BMPs in order to comply with the requirements of the Action Plan and revised DO objectives could result in the generation of fugitive dust and particulate matter during construction or maintenance activities, which could temporarily impact ambient air quality. Any such impacts would be temporary, and would be controlled with standard construction operations, such as the use of moisture to reduce the transfer of particulates and dust to air and conducting operations when the air quality in the basin is good (i.e. no catastrophic wildfires). The emission of air pollutants during short-term construction activities associated with reasonably foreseeable methods of compliance would not likely change ambient air conditions, because long-term ambient air quality would not change after short-term construction activities are completed.

3. Air Quality: c.) Result in a cumulatively considerable net increase of any criteria pollutant for which the project region is non-attainment under an applicable federal or state ambient air quality standard (including releasing emissions which exceed quantitative thresholds for ozone precursors)?

Answer: Less than significant with mitigation.

Discussion: Neither the structural nor the non-structural BMPs that would potentially be used to comply with the requirements of the proposed Action Plan and revised DO objectives will result in a cumulatively considerable net increase of any criteria pollutant for which the region is non-attainment under an applicable federal or state ambient air quality standard.

The implementation of BMPs that could result in fine particulate matter and vehicle emissions, such as the BMPs associated with earth movement and dam decommissioning, could contribute to the problems with these pollutants. However, any contribution would be very small, given both the temporary nature of any such impacts and the fairly small nature of any such construction activity given the size of the basin.

3. Air Quality: d.) Expose sensitive receptors to substantial pollutant concentrations?

Answer: Less than significant.

Discussion: Neither the structural nor the non-structural BMPs that would potentially be used to comply with the requirements of the proposed Action Plan and revised DO objectives would be expected to expose sensitive receptors to substantial pollutant concentrations. The primary BMPs expected to be implemented would be to control discharge of earthen and organic matter and are not related to conventional pollutants.

3. Air Quality: e.) Create objectionable odors affecting a substantial number of people?

Answer: Less than significant with mitigation.

Discussion: The majority of the structural and non-structural BMPs that would potentially be used to comply with the requirements of the proposed Action Plan and revised DO objectives would not be expected to result in objectionable odors affecting a substantial number of people.

Construction and installation of structural BMPs may result in objectionable odors in the short-term due to exhaust from construction equipment and vehicles, but no more so than during typical construction and maintenance activities currently performed throughout the region. However, certain structural BMPs, such as settling basins and filtration basins, could become a source of objectionable odors if the BMP designs allow for water stagnation or collection of water with sulfur-containing compounds. This could also be the case if anaerobic sediment is exposed to the air as a result of dam removal operations. The application of mitigation measures designed to offset the number of people impacted will likely decrease this to a less than significant effect. Any odors would be very short-lived. Dischargers will be required to monitor the implementation of BMPs to ensure they are working correctly. If a discharger found that odors were occurring from implementation of a settling or filtration basin, measures, such as proper BMP design to eliminate standing water, covers, aeration, filters, barriers, and/or odor suppressing chemical additives, would be required if the odors were becoming a nuisance to the community. The Regional Water Board will require structural BMPs that could result in stagnant water to be inspected regularly to ensure that treatment devices are not clogged, pooling water, odorous, or mosquito vectors.

4. Biological Resources: a.) Would the project:

Have a substantial adverse effect, either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special status species in local or regional plans, policies, or regulations, or by the California Department of Fish and Game (CDFG) or U.S. Fish and Wildlife Service (USFWS)?

Answer: Potentially significant impact.

Discussion: The measures that may be implemented to comply with the proposed Action Plan and revised DO objectives may have a potential impact upon species identified as a candidate, sensitive, or special status species in local or regional plan, policies or regulations or by the CDFG or USFWS if they occur in an area where such species are located.

Non-structural BMPs will not have a substantial adverse effect, either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special status species in local or regional plans, policies, or regulations, or by the CDFG or USFWS.

BMPs that may not have an impact when implemented in one area could potentially have an impact if they are implemented in a sensitive area. Therefore, when installing structural BMPs that involve substantial earth moving, responsible parties will be required under their applicable permit to consult with federal, state and local agencies, including but not limited to the county the project is located in, CDFG and the USFWS, and implement mitigation identified by the agencies to avoid impacts to rare, threatened or endangered species. If no such mitigation is available, the activity would not be permitted without additional review and findings. For example, the Regional Water Board is considering the development of a Basin Plan amendment to provide "Exception Criteria for Restoration Projects" as part of the 2007-2010 Triennial Review process to establish procedures for approving projects that have potentially significant short-term water quality impacts if certain findings can be made after site –specific environmental analysis. USFS and the TRRP both provided comments in support of the development of this amendment during the Triennial Review hearing. In most cases the installation of structural BMPs would be of relatively small scale and any impacts could be avoided by adjusting the timing and/or location of the BMPs to take into account candidate, sensitive, or special status species or their habitats.

Because of these mitigation requirements, substantial adverse effects either directly or through habitat modifications, on any species identified as a candidate, sensitive or special status species in local or regional plans, policies, or regulations, or by the CDFG or USFWS are not expected to occur.

4. Biological Resources: b.) Would the project:

Have a substantial adverse effect on any riparian habitat or other sensitive natural community identified in local or regional plans, policies, regulations, or by the California Department of Fish and Game or US Fish and Wildlife Service?

Answer: Less than significant with mitigation.

Discussion: Substantial adverse effects on any riparian habitat or other sensitive natural community are not expected because the proposed Action Plan requires protection of riparian areas through the application of a temperature-related load allocation for solar radiation (expressed as its inverse shade).

According to one of the dam decommissioning studies approximately 480 acres of riparian area surrounding the three reservoirs could be lost through dam removal. If wetland construction, watershed-wide riparian protection and replanting, and re-vegetation of the exposed reservoir surfaces are applied as mitigation measures the impact from the loss of riparian habit from these sites will likely be less than significant.

The actual impacts associated with this activity would need to be fully evaluated under a federal and/or state environmental impact analysis before decommissioning could occur.

None of the proposed non-structural BMPs would have the potential to adversely affect any riparian habitat or other sensitive natural community of plants identified in local or regional plans, policies, regulations, or by the CDFG or USFWS.

BMPs that may not have an impact when implemented in one area could potentially have an impact if they are implemented in a sensitive area. Therefore, when installing structural BMPs that may include substantial earth moving or other alteration to riparian habitat, responsible parties will be required under their applicable permit, to avoid riparian habitat or other sensitive natural communities.

Because of these mitigation requirements, substantial adverse effects either directly or through habitat modifications, on any species identified as a candidate, sensitive or special status species in local or regional plans, policies, or regulations, or by the California Department of Fish and Game or U.S. Fish and Wildlife Service are not expected to occur.

4. Biological Resources: c.) Would the project:

Have a substantial adverse effect on federally protected wetlands as defined by Section 404 of the Clean Water Act (including, but not limited to, marsh, vernal pool, coastal, etc.) through direct removal, filling, hydrological interruption, or other means?

Answer: Less than significant with mitigation.

Discussion: The application of compliance measures in federally protected wetland areas would not be allowed if doing so would affect the beneficial uses associated with that wetland. All activities in federally protected wetlands, except those statutory exemption like agricultural, require the responsible party to obtain a Clean Water Act 404 permit. The federal permit must include compliance measures that ensure that all water quality objectives for the wetland are protected. Implementation of most BMPs would not be allowed within a wetland because doing so would interfere with the protection of the beneficial uses of that wetland. For example, any BMP that required construction, such as a filtration or siltation basin, would not be allowed in the wetland because it would interfere with the beneficial uses of the wetland.

4. Biological Resources: d.) Would the project:

Interfere substantially with the movement of any native resident or migratory fish or wildlife species or with established native resident or migratory wildlife corridors, or impede the use of native wildlife nursery sites?

Answer: Less than significant with mitigation.

Discussion: The Klamath River and its tributaries provides habitat, including the migration, for both native resident and migratory fish. Most of the reasonably foreseeable compliance measures identified as part of this environmental analysis will likely not interfere with the movement of these species. However, although dam removal would ultimately result in greater movement for spawning fish, significant adverse effects on fish movement could occur at least temporarily unless appropriate mitigation is implemented to limit the duration of increased turbidly associated with dam removal and the decommissioning activities are timed to protect the most sensitive species/life stages.

A migratory corridor is generally described as a landscape feature (such as a ridgeline, canyon, or riparian strip) within a larger natural habitat area that is used frequently by animals to facilitate movement and provide access to necessary resources such as water, food, or den sites. Wildlife corridors are generally an area of habitat, usually linear in nature, which connect two or more habitat patches that would otherwise be fragmented or isolated from one another. It is unlikely that construction of structural BMPs for compliance with the proposed Action Plan and revised DO objectives would restrict wildlife movement because the sizes of the compliance measures are generally too small to obstruct a corridor.

However, if a responsible party will be conducting substantial earth movement to implement BMPs, they are encouraged to consult with various Federal, State and local agencies, including but not limited to the CDFG and the USFWS to confirm that the BMPs would not substantially interfere with movement of any native resident or migratory fish or wildlife species or with established native resident or migratory wildlife corridors and native wildlife nursery. If there was the potential for an adverse impact to wildlife migration and/or use of a native wildlife nursery, the timing of the discharge or the location of the BMP would have to be changed to avoid the impact. None of the structural BMPs would, therefore, result in direct or reasonably foreseeable indirect impacts to fish and wildlife movement, migration or use of a native wildlife nursery site.

None of the non-structural BMPs that are reasonably foreseeable means of compliance with the Basin Plan Amendments will result in a barrier to the migration or movement of aquatic or wildlife species.

4. Biological Resources: e.) Would the project:

Conflict with any local policies or ordinances protecting biological resources, such as a tree preservation policy or ordinance?

Answer: Less than significant with mitigation.

Discussion: The reasonably foreseeable compliance measures that would be implemented to comply with the proposed Action Plan and revised DO objectives are not expected to conflict with ordinances protecting biological resources, such as a tree preservation policy.

4. Biological Resources: f.) Would the project:

Conflict with the provisions of an adopted Habitat Conservation Plan, Natural Community Conservation Plan, or other approved local, regional, or state habitat conservation plan?

Answer: Less than significant.

Discussion: It is unlikely that the implementation of compliance measures as recommended under the proposed implementation plan and as necessary to comply with the revised DO objectives would conflict with the provisions of an adopted Habitat Conservation Plan (HCP), Natural Community Conservation Plan or other approved local, regional, or state habitat conservation plan. More likely the compliance measures would be similar to measures already committed to under other plans. Such similarities are likely to ensure that compliance measures are in alignment with any adopted Habitat Conservation Plan, Natural Community Conservation Plan or other approved local, regional, or state habitat conservation plan.

5. Cultural Resources: a.) Would the project:

Cause a substantial adverse change in the significance of a historical resource as defined in § 15064.5

Answer: Less than significant with mitigation.

Discussion: The implementation of compliance measures as recommended under the proposed implementation plan and as necessary to comply with the TMDL load allocations and revised DO objectives would not result in the alteration of a significant historical resource. Non-structural BMPs will not result in the alteration of a significant historical resource because none of the non-structural BMPs would involve any physical effects.

Similarly, it is unlikely that implementation of any structural BMP would result in a substantial adverse change in the significance of a historical resource. However, in cases where the installation of structural BMPs may involve large scale excavation activities or the construction of a large scale infrastructure, a cultural resources investigation should be conducted before any substantial disturbance of land that has not been disturbed previously. The cultural resources investigation will include, at a minimum, a records search for previously identified cultural resources and previously conducted cultural resources investigations of the project parcel and vicinity.

5. Cultural Resources: b.) Would the project:

Cause a substantial adverse change in the significance of an archaeological resource pursuant to § 15064.5?

Answer: Less than significant with mitigation.

Discussion: It is unlikely that the implementation of compliance measures as recommended under the proposed implementation plan and as necessary to comply with the TMDL load allocations and revised DO objectives would cause a substantial adverse change in the significance of an archaeological resource pursuant to section 15064.5. Non-structural BMPs will not cause a substantial adverse change in the significance of an archaeological resource pursuant to section 15064.5.

Similarly, it is unlikely that implementation of any structural BMP would cause a substantial adverse change in the significance of an archaeological resource pursuant to section 15064.5. However, in cases where the installation of structural BMPs may involve excavation activities (such as dam decommissioning), a cultural resources investigation should be conducted before any substantial disturbance of land that has not been disturbed previously. The cultural resources investigation should include, at a minimum, a records search for previously identified cultural resources and previously conducted cultural resources investigations of the project parcel and vicinity. This record search should also include, at a minimum, contacting the appropriate information center of the California Historical Resources Information System, operated under the auspices of the California Office of Historic Preservation. In coordination with the information center or a qualified archaeologist, a determination regarding whether previously identified cultural resources will be affected by the proposed project must be made and if previously conducted investigations were performed to satisfy the requirements of CEQA. If not, a cultural resources survey would need to be conducted. The purpose of this investigation would be to identify resources before they are affected by a proposed project and avoid the impact. If the impact is unavoidable, mitigation will be determined on a case-by-case basis, as warranted.

5. Cultural Resources: c.) Would the project:

Directly or indirectly destroy a unique paleontological resource or site or unique geologic feature?

Answer: Less than significant.

Discussion: The implementation of compliance measures as recommended under the proposed implementation plan and as necessary to comply with the TMDL load allocations and revised DO objectives would not directly or indirectly destroy a unique paleontological resource or site or unique geologic feature. Non-structural BMPs will not result in the direct or indirect destruction of a unique paleontological resource or site or unique geologic feature.

Similarly, it is unlikely that implementation of any structural BMP would result in the destruction of a unique paleontological resource or site or unique geologic feature. However, in cases where the installation of structural BMPs may involve excavation activities, an investigation of paleontological resources would need to be conducted by a trained professional before any substantial disturbance of land that has not been disturbed previously.

5. Cultural Resources: d.) Would the project:

Disturb any human remains, including those interred outside of formal cemeteries?

Answer: Less than significant.

Discussion: It is staff's judgment the selection and implementation of appropriately designed measures to comply with the proposed Action Plan and revised DO objectives will not directly or indirectly result in the disturbance of any human remains, including those interred outside of formal cemeteries.

Similarly, it is unlikely that implementation of any structural BMP would cause a substantial adverse change in the significance of an archaeological resource pursuant to section 15064.5. However, in cases where the installation of structural BMPs or dam decommissioning may involve excavation activities, a cultural resources investigation should be conducted before any substantial disturbance of land that has not been disturbed previously. The cultural resources investigation should include, at a minimum, a records search for previously identified cultural resources and previously conducted cultural resources investigations of the project parcel and vicinity. This record search should also include, at a minimum, contacting the appropriate information center of the California Historical Resources Information System, operated under the auspices of the California Office of Historic Preservation. In coordination with the information center or a qualified archaeologist, a determination regarding whether previously identified cultural resources will be affected by the proposed project must be made and if previously conducted investigations were performed to satisfy the requirements of CEQA. If not, a cultural resources survey would need to be conducted. The purpose of this investigation would be to identify resources before they are affected by a proposed project and avoid the impact. If the impact is unavoidable, mitigation will be determined on a case-by-case basis, as warranted.

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6. Geology and Soils: a.)(i) Would the project:

Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault? Refer to Division of Mines and Geology Special Publication 42.

Answer: No impact.

Discussion: Implementation of compliance measures as recommended under the proposed implementation plan and as necessary to comply with the TMDL load allocations and revised DO objectives would not result in exposing people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault as there will be no means of compliance involving moving permanent structures or people onto an earthquake fault.

6. Geology and Soils: a)(ii) Would the project:

Expose people or structures to potential substantial adverse effects, including the risk of loss, injury or death involving strong seismic ground shaking?

Answer: No impact.

Discussion: Implementation of compliance measures as recommended under the proposed implementation plan and as necessary to comply with the TMDL load allocations and revised DO objectives would not expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving strong seismic ground shaking as there will be no implementation of compliance measures involving moving permanent structures or people onto an earthquake fault.

6. Geology and Soils: a.)(iii) Would the project:

Expose people or structures to potential substantial adverse effects, including the risk of loss, injury or death involving seismic-related ground failure, including liquefaction.

Answer: No impact.

Discussion: Implementation of compliance measures as recommended under the proposed implementation plan and as necessary to comply with the TMDL load allocations and revised DO objectives would not expose people or structures to potential substantial adverse effects, including the risk of loss, injury or death involving seismic-related ground failure, including liquefaction as none of the reasonably foreseeable compliance measures involves moving permanent structures or people into an area potential susceptible to liquefaction.

6. Geology and Soils: a.)(iv) Would the project:

Expose people or structures to potential substantial adverse effects, including the risk of loss, injury or death involving landslides?

Answer: Less than significant with mitigation.

Discussion: Implementation of compliance measures as recommended under the proposed implementation plan and as necessary to comply with the TMDL load allocations and revised DO objectives would not expose people or structures to potential substantial adverse effects, including the risk of loss, injury or death involving landslides as none of the reasonably foreseeable compliance measures involves moving permanent structures or people into an area potentially subject to landslides.

6. Geology and Soils: b.) Would the project:

Result in substantial soil erosion or the loss of topsoil?

Answer: Less than significant with mitigation.

Discussion: Implementation of compliance measures as recommended under the proposed implementation plan and as necessary to comply with the TMDL load allocations and revised DO objectives may result in minor, temporary soil excavation or disturbance during implementation of compliance measures that involve construction of structural BMPs such as road drainage installation, field leveling for irrigation management or installation of off channel stock watering ponds. However, construction related erosion impacts will cease with the cessation of construction activity. Appropriate selection, implementation and maintenance of mitigation measures to prevent concentration of water and exposure of disturbed (unprotected) soil to rainfall and winds will result in less than significant loss of top soil or substantial soil erosion.

6. Geology and Soils: c.) Would the project:

Be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the project, and potentially result in on- or off-site landslide, lateral spreading, subsidence, liquefaction or collapse?

Answer: Less than significant with mitigation.

Discussion: Most structural BMPs that were recommended under the proposed implementation plan and as necessary to comply with the TMDL load allocations and revised DO objectives would not have any significant adverse effect if located on unstable soil, nor would they cause soil to become unstable. The road related compliance measures encourage locating roads on stable terrain and preventing the placement of road material on unstable slopes that could cause a landslide or other type of mass wasting event.

> **6. Geology and Soils: d.)** Would the project:
>
> Be located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1994), creating substantial risks to life or property?
>
> **Answer**: No impact.

Discussion: Even if structural BMPs that were recommended under the proposed implementation plan as necessary to comply with the TMDL load allocations and revised DO objectives were located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1994), they would not create substantial risks to life or property. The structural BMPs that have been identified as the foreseeable means of compliance do not involve moving permanent structures or people into a new area, and so there would be no risk to life or property created.

> **6. Geology and Soils: e.)** Would the project:
>
> Have soils incapable of adequately supporting the use of septic tanks or alternative waste water disposal systems where sewers are not available for the disposal of waste water?
>
> **Answer**: Less than significant.

Discussion: There is no data to date that indicates that septic tanks are contributing to the impairment of the Klamath River due to soil conditions. It is staff's judgment that the proposed Action Plan (and the identified compliance measures) will not result in significant impacts from septic tanks or alternative waste water disposal systems.

> **7. Hazards and Hazardous Materials: a.)** Would the project:
>
> Create a significant hazard to the public or the environment through the routine transport, use, or disposal of hazardous materials?
>
> **Answer**: Less than significant.

Discussion: It is staff's judgment that none of the identified compliance measures would create a significant hazard to the public or the environment through the routine transport, use or disposal of hazardous materials. There is the possibility that hazardous materials (e.g., oil, gasoline) may be transported to a site and be present during compliance measure construction and installation activities. Any potential risks of exposure would be small, especially with proper handling and storage procedures. All risks of exposure would be short term and would be eliminated with the completion of compliance measure construction and installation activities.

7. Hazards and Hazardous Materials: b.) Would the project:

Create a significant hazard to the public or the environment through reasonably foreseeable upset and accident conditions involving the release of hazardous materials into the environment?

Answer: Less than significant with mitigation.

Discussion: The implementation of non-structural BMPs to comply with the requirements of the proposed Action Plan and revised DO objectives would not create a significant hazard to the public or the environment through reasonably foreseeable upset and accident conditions involving the release of hazardous materials into the environment.

The structural compliance measures that may be used to comply with the requirements of the proposed Action Plan, with the exception of dam decommissioning, would not be subject to explosion or the release of hazardous substances in the event of an accident because these types of substances would not be present. Again, there is the possibility that hazardous materials (e.g., oil, gasoline) may be present during construction and installation activities, but potential risks of exposure would be small, especially with proper handling and storage procedures. All risks of exposure would be short term and would be eliminated with the completion of construction and installation activities.

The dam decommissioning studies evaluated to develop this environmental analysis were all premised on the use of blasting (explosives) to remove the concrete dam and related structures. Any blasting activities would need to be conducted by a licensed professional and mitigation measures clearly described in the dam decommissioning plan, including a transportation plan for the explosive materials. At a minimum these measures should include, all non-essential workers being prohibited from entering the site and stationed downwind at a safe distance away from blasting operations.

The presence of hazardous materials stored in the sediments trapped behind the reservoirs would need to be thoroughly analyzed prior to any dam decommissioning that proposed the release of sediment and associated waste into the Klamath River. The dam decommissioning plan would need to include a proposal to allow for the characterization of the in-reservoir sediment to ensure that any material identified as hazardous is not released into the environment.

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7. Hazards and Hazardous Materials: c.) Would the project:

Emit hazardous emissions or handle hazardous or acutely hazardous materials, substances, or waste within one-quarter mile of an existing or proposed school?

Answer: Less than significant.

Discussion: The implementation of non-structural and structural BMPs that would potentially be used to comply with the requirements of the proposed Action Plan and revised DO objectives would not reasonably emit hazardous emissions or result in the handling of hazardous or acutely hazardous materials, substances, or waste within one-quarter mile of an existing or proposed school. Again, there is the possibility that hazardous materials (e.g., oil, gasoline) may be present during construction and installation activities, but potential risks of exposure would be small, especially with proper handling and storage procedures. All risks of exposure would be short term and would be eliminated with the completion of construction and installation activities.

7. Hazards and Hazardous Materials: d.) Would the project:

Be located on a site which is included on a list of hazardous materials sites compiled pursuant to Government Code Section 65962.5 and, as a result, would it create a significant hazard to the public or the environment?

Answer: Less than significant.

Discussion: The measures that may be reasonably used to comply with the requirements of the proposed Action Plan and revised DO objectives would not likely be located on a site which is on a list of hazardous materials sites. The location of these sites are well known throughout the Region and are subject to regulation by the Regional Water Board and/or USEPA.

7. Hazards and Hazardous Materials: e.)
For a project located within an airport land use plan or, where such a plan has not been adopted, within two miles of a public airport or public use airport, would the project result in a safety hazard for people residing or working in the project area?

Answer: No impact.

Discussion: It is unlikely that the compliance measures identified in this SED would result in a safety hazard for people residing or working in the project area due to the relatively small scale of the structural BMPs contemplated for use by responsible parties.

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7. Hazards and Hazardous Materials: f.)
For a project within the vicinity of a private airstrip, would the project result in a safety hazard for people residing or working in the project area?

Answer: Less than significant.

Discussion: Under the unlikely possibly that installation of compliance measures involving structural BMPs were located in the vicinity of a private airstrip, they would not result in a safety hazard for people residing or working in the project area due to the relatively small scale of the structural BMPs contemplated for use by responsible parties.

7. Hazards and Hazardous Materials: g.) Would the project:
Impair implementation of or physically interfere with an adopted emergency response plan or emergency evacuation plan?

Answer: No impact.

Discussion: None of the compliance measures identified in this SED contemplate the use of structural or non-structural BMPs that would impair implementation of or physically interfere with an adopted emergency response plan or emergency evacuation plan. Consideration of public health and safety is a key component in the development of site specific compliance measures for road construction and maintenance activities.

7. Hazards and Hazardous Materials: h.) Would the project:
Expose people or structures to a significant risk of loss, injury or death involving wildland fires, including where wildlands are adjacent to urbanized areas or where residences are intermixed with wildlands?

Answer: No impact.

Discussion: None of the structural and non-structural BMPs identified in this SED would expose people or structures to a significant risk of loss, injury or death involving wildland fires, including where wildlands are adjacent to urbanized areas or where residences are intermixed with wildlands.

8. Hydrology And Water Quality: a.) Would the project:
Violate any water quality standards or waste discharge requirements?

Answer: Potentially significant impacts.

Discussion: By requiring the implementation of compliance measures to reduce pollutants and the implementation of management plans to control all sources of non-point pollution, it is anticipated that compliance with the proposed TMDL Action Plan and revised DO objectives will have an overall beneficial impact on water quality in the Klamath River watershed. The creation of a comprehensive regulatory process by which the implementation of compliance measures (non-structural and/or structural BMPs) by all responsible parties in the watershed for all non-point sources of pollution will dramatically minimize the level of pollutants discharged to waterbodies and will help ensure that waterbodies will meet water quality objectives and that beneficial uses are protected and restored.

If a decision is reached by the KHSA Settlement Parties that one or more of PacifiCorps dams in California will be decommissioned, then potentially significant adverse impacts to the water quality standards in place for the Klamath River could likely occur.

The dam decommissioning studies used to develop this environmental analysis indicate that the primary environmental impact associated with dam removal is the short term impact to water quality from the release of the stored in-reservoir sediment. The studies indicate that the material is primarily fine grained and will likely stay in suspension until it reaches the ocean. Based on conditions in the watershed (e.g. “wet” versus “dry” water year) the increase turbidity and suspended sediment loads could last from weeks to months. It is almost certain that dam decommissioning will result in potentially significant environmental impacts due to in increased turbidity and suspended sediment loads, which would likely violate Basin Plan water quality standards for turbidity and suspended sediment. Short term water quality violations may be acceptable in cases where long term benefits to be beneficial uses outweigh short term impacts, based on detailed, site-specific information and findings.

8. Hydrology And Water Quality: b.) Would the project:
Substantially deplete groundwater supplies or interfere substantially with groundwater recharge such that there would be a net deficit in aquifer volume or a lowering of the local groundwater table level (e.g., the production rate of pre-existing nearby wells would drop to a level which would not support existing land uses or planned uses for which permits have been granted)?

Answer: Less than significant.

Discussion: The proposed implementation plan has only identified one compliance measure that could potentially affect ground water supplies. This measure contemplates the use of groundwater (via well construction) in lieu of on-stream livestock watering. Due to the likely dispersed nature of this compliance measure and the relatively high cost in well development, it is staff’s judgment that the use of wells in lieu of other off-stream watering systems (e.g. spring development) will result in a less than significant risk of substantially depleting groundwater.

8. Hydrology And Water Quality: c.) Would the project:
Substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, in a manner which would result in substantial erosion or siltation on- or off-site?

Answer: Potentially significant impacts.

Discussion: This SED has identified a number of compliance measures that could result in the construction of structural BMPs, such as infiltration basins, field leveling or road construction, which could potentially cause an alteration of the existing drainage pattern of a site. In most cases however, these measures would be small and installed with appropriately designed mitigation measures, which would limit any alteration of the existing drainage pattern, and therefore would not result in substantial erosion of siltation on- or off-site.

The exception would be in the event of dam decommissioning when the Klamath River would establish a new channel through the reservoirs. The studies evaluated by Regional Water Board staff indicated that the greatest impacts from erosion or siltation would be during drawing down of the reservoir water level. However, once a new channel was established, the erosion of the in-reservoir sediment would dissipate.

8. Hydrology And Water Quality: d.) Would the project:
Substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, or substantially increase the rate or amount of surface runoff in a manner which would result in flooding on- or off-site?

Answer: Less than significant.

Discussion: This SED has identified a number of compliance measures that could result in the construction of structural BMPs such as infiltration basins, field leveling or road construction, which could potentially cause an alteration of the existing drainage pattern of a site. In most cases however, these measures would be small and be installed with appropriately designed mitigation measures, which would reduce the chance of alterations of the existing drainage pattern causing an increased rate or amount of surface runoff in a manner which would result in flooding on- or off-site.

8. Hydrology And Water Quality: e.) Would the project:
Create or contribute runoff water which would exceed the capacity of existing or planned storm water drainage systems or provide substantial additional sources of polluted runoff?

Answer: Less than significant.

Discussion: It is unlikely that the compliance measures identified in this SED would be located in either an area that was serviced by an existing or a planned storm water drainage system due to the lack of urbanized areas with storm drain systems in the Klamath River watershed. In addition, the implementation of properly designed compliance measures would not result in the concentration of runoff.

8. Hydrology And Water Quality: f.) Would the project:
Otherwise substantially degrade water quality?

Answer: Less than significant impact.

Discussion: As the goal of this project is to develop and implement a comprehensive watershed recovery plan for the restoration of the beneficial uses of water in the Klamath River, it is staff's judgment that it is extremely unlikely that thoughtfully selected, well-designed and implemented compliance measures would result in the substantial degradation of water quality. The exception to this is dam decommissioning and its impacts are addressed above under 8a and 8c above.

8. Hydrology And Water Quality: g.) Would the project:
Place housing within a 100-year flood hazard area as mapped on a federal Flood Hazard Boundary or Flood Insurance Rate Map or other flood hazard delineation map?

Answer: Less than significant impact.

Discussion: None of the compliance measures identified in this SED would place housing within a 100-year flood hazard area as mapped on a federal Flood Hazard Boundary or Flood Insurance Rate Map or other flood hazard delineation map.

Staff has determined that this finding is still appropriate even under a dam decommissioning scenario as the dams were not designed nor operated as flood control structures. As such their ultimately removal would not significant impact housing with a flood area as described above.

8. Hydrology And Water Quality: h.) Would the project:
Place within a 100-year flood hazard area structures which would impede or redirect flood flows?

Answer: No impact.

Discussion: None of the compliance measures identified in this SED would place structures within a 100-year flood hazard area which would impede or redirect flood flows.

8. Hydrology And Water Quality: i.) Would the project:
Expose people or structures to a significant risk of loss, injury or death involving flooding, including flooding as a result of the failure of a levee or dam?

Answer: Less than significant.

Discussion: None of the compliance measures identified in this SED contemplate the use of non-structural or structural BMPs that would expose people or structures to a significant risk of loss, injury or death involving flooding, including flooding as a result of the failure of a levee or dam.

8. Hydrology And Water Quality: j.) Would the project:
Cause inundation by seiche, tsunami, or mudflow?

Answer: No impact.

Discussion: None of the compliance measures identified in this SED contemplate the use of non-structural or structural BMPs that would cause inundation by seiche, tsunami, or mudflow.

9. Land Use And Planning: a.) Would the project:
Physically divide an established community?

Answer: No impact.

Discussion: None of the compliance measures identified in this SED contemplate the use of non-structural or structural BMPs that would physically divide an established community.

9. Land Use And Planning: b.) Would the project:
Conflict with any applicable land use plan, policy, or regulation of an agency with jurisdiction over the project (including, but not limited to the general plan, specific plan, local coastal program, or zoning ordinance) adopted for the purpose of avoiding or mitigating an environmental effect?

Answer: Less than significant.

Discussion: The primary goal of this project is the protection and restoration of water quality and beneficial uses of water in the Klamath River watershed.

Therefore, it is staff's judgment that it is unlikely that compliance with the proposed Action Plan and revised DO objectives would conflict with any applicable land use plan, policy, or regulation of an agency with jurisdiction over the project (including, but not limited to the general plan, specific plan, local coastal program, or zoning ordinance) adopted for the purpose of avoiding or mitigating an environmental effect

9. Land Use And Planning: c.) Would the project:
Conflict with any applicable habitat conservation plan or natural community conservation plan?

Answer: Less than significant.

Discussion: It is unlikely that measures implemented to comply with this proposed Action Plan and revised DO objectives could conflict with the provisions of an adopted Habitat Conservation Plan or Natural Community Conservation Plan, as explained previously in the question 4(f), above.

Depending on the structural BMPs selected, direct or indirect impacts to existing fish or wildlife habitat may occur; however, any such impact would be temporary. BMPs that may not have an impact when implemented in one area could potentially have an impact if they are implemented in a sensitive area. Therefore, when installing structural BMPs that may include substantial earth movement, responsible parties will be required under their applicable permit (or as necessary to comply with applicable prohibitions), to consult with various Federal, State and local agencies, including but not limited to the county the project is located in, CDFG and the USFWS. If appropriate to avoid conflicts with any Habitat Conservation Plan or Natural Community Conservation Plan, the timing and/or location of the BMPs may be adjusted to reduce any potential conflict with any Habitat Conservation Plan or Natural Community Conservation Plan. If, however, such adjustments could not be made, the BMP would have to be changed to avoid any adverse impacts to rare, threatened or endangered species, or the discharge would not be permitted to occur.

Because of these mitigation requirements, conflict with the provisions of an adopted Habitat Conservation Plan or Natural Community Conservation Plan is not likely to occur.

10. Mineral Resources: **a.)** Would the project:
Result in the loss of availability of a known mineral resource that would be of value to the region and the residents of the state?

Answer: No impact.

Discussion: None of the compliance measures identified in this SED contemplate the use of non-structural or structural BMPs that would result in the loss of availability of a known mineral resource that would be of value to the region and the residents of the state.

10. Mineral Resources: b.) Would the project:
Result in the loss of availability of a locally-important mineral resource recovery site delineated on a local general plan, specific plan or other land use plan?

Answer: No impact.

Discussion: None of the compliance measures identified in this SED contemplate the use of non-structural or structural BMPs that would result in the loss of availability of a locally-important mineral resource recovery site delineated on a local general plan, specific plan or other land use plan.

11. Noise: a.) Would the project result in:
Exposure of persons to or generation of noise levels in excess of standards established in the local general plan or noise ordinance, or applicable standards of other agencies?

Answer: Less than significant.

Discussion: None of the compliance measures identified in this SED contemplate the use of structural BMPs that would result in an increase in exposure of persons to, or generation of, noise levels in excess of standards established in the local general plan or noise ordinance, or applicable standards of other agencies.

The implementation of some structural BMPs may result in localized increased noise levels. Such increased noise levels would likely be associated with heavy equipment operation associated with construction of structural BMPs. These impacts would be temporary, associated with the use of heavy equipment and would, therefore, not considered to be a significant impact.

11. Noise: b.) Would the project result in:
Exposure of persons to or generation of excessive ground-borne vibration or ground-borne noise levels?

Answer: Less than significant.

Discussion: None of the compliance measures identified in this SED contemplate the use of structural BMPs that would result in the exposure of persons to or generation of excessive ground-borne vibration or ground-borne noise levels.

The implementation of some structural BMPs may result in localized increased ground-borne vibration or ground-borne noise levels. Such increased levels would likely be associated with heavy equipment operation associated with construction of structural BMPs. These impacts would, however, be temporary and associated directly with the use of heavy equipment. Therefore, staff judges that the impact would not be considered significant.

11. Noise: c.) Would the project result in:
A substantial permanent increase in ambient noise levels in the project vicinity above levels existing without the project?

Answer: Less than significant.

Discussion: None of the compliance measures identified in this SED contemplate the use of structural BMPs that would result in a substantial permanent increase in ambient noise levels in the project vicinity above levels existing without the project as noise generation is associated with the short term, temporary use of heavy equipment.

11. Noise: d.) Would the project result in:
A substantial temporary or periodic increase in ambient noise levels in the project vicinity above levels existing without the project?

Answer: Less than significant with mitigation.

Discussion: None of the compliance measures identified in this SED contemplate the use of structural BMPs that would result in a substantial temporary or periodic increase in ambient noise levels in the project vicinity above levels existing without the project with the exception of a dam decommissioning scenario.

The construction and installation of some structural BMPs, such as filtration or settling basins, could result in temporary increases in existing noise levels, but this would be short term and only exist until construction is completed. The noise associated with the construction and installation of structural BMPs would be the same as typical construction activities in rural and urbanized areas, such as ordinary road and infrastructure maintenance and building activities. Although noise will be increased in the vicinity of where BMPs requiring heavy equipment use are constructed, these noise impacts will not be substantial.

Dam decommissioning activities will likely involve drilling and blasting of the concrete structures, this will likely cause an impact to the noise level in the surrounding communities. With the application of appropriate mitigation measures, such as notifying the community of noise generating activities such as drilling and blasting to allow for those sensitive to high noise levels to voluntarily be re-located during those periods or protect their hearing in other ways (e.g. staying indoors, using hearing protection), the impact would be less than significant.

11. Noise: e.) Would the project result in:
For a project located within an airport land use plan or, where such a plan has not been adopted, within two miles of a public airport or public use airport, would the project expose people residing or working in the project area to excessive noise levels?

Answer: Less than significant.

Discussion: None of the compliance measures identified in this SED contemplate the use of structural BMPs that would likely be located within an airport land use plan or within two miles of a public airport or public use airport. However, even if this were to occur, the implementation of the compliance measures would not result in excessive noise levels. The use of heavy equipment for the construction and installation of some structural BMPs could result in temporary increases in existing noise levels, but the noise associated with heavy equipment use is not any louder than noises that would typically occur within two miles of an airport.

11. Noise: f.) Would the project result in:
For a project within the vicinity of a private airstrip, would the project expose people residing or working in the project area to excessive noise levels?

Answer: Less than significant.

Discussion: None of the compliance measures identified in this SED contemplate the use of structural BMPs that would likely be located in the vicinity of a private airstrip.

However, even if this were to occur, the compliance measures identified in this SED would not result in excessive noise levels. The use of heavy equipment for the construction and installation of some structural BMPs could result in temporary increases in existing noise levels, but the noise associated with heavy equipment use is not any louder than noises that would typically occur within the vicinity of a private airstrip.

12. Population And Housing: a.) Would the project:
Induce substantial population growth in an area, either directly (for example, by proposing new homes and businesses) or indirectly (for example, through extension of roads or other infrastructure)?

Answer: No impact.

Discussion: None of the compliance measures identified in this SED contemplate the use of structural BMPs that would induce substantial population growth in an area, either directly (for example, by proposing new homes and businesses) or indirectly (for example, through extension of roads or other infrastructure).

12. Population And Housing: b.) Would the project:
Displace substantial numbers of existing housing, necessitating the construction of replacement housing elsewhere?

Answer: No impact.

Discussion: None of the compliance measures identified in this SED contemplate the use of structural BMPs that would displace substantial numbers of existing housing, necessitating the construction of replacement housing elsewhere.

12. Population And Housing: c.) Would the project:
Displace substantial numbers of people, necessitating the construction of replacement housing elsewhere?

Answer: No impact.

Discussion: None of the compliance measures identified in this SED would displace substantial numbers of people, necessitating the construction of replacement housing elsewhere.

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13. Public Services: a.)
Would the project result in substantial adverse physical impacts associated with the provision of new or physically altered governmental facilities, need for new or physically altered governmental facilities, the construction of which could cause significant environmental impacts, in order to maintain acceptable service ratios, response times or other performance objectives for any of the public services:

Fire protection?

Answer: No impact.

Discussion: None of the compliance measures identified in this SED contemplate the use of structural BMPs that would have an effect upon, or result in a need for new or altered fire protection services.

13. Public Services: b.)
Would the project result in substantial adverse physical impacts associated with the provision of new or physically altered governmental facilities, need for new or physically altered governmental facilities, the construction of which could cause significant environmental impacts, in order to maintain acceptable service ratios, response times or other performance objectives for any of the public services:

Police protection?

Answer: No impact.

Discussion: None of the compliance measures identified in this SED contemplate the use of structural BMPs that would have an effect upon, or result in a need for new or altered police protection services.

13. Public Services: c.)
Would the project result in substantial adverse physical impacts associated with the provision of new or physically altered governmental facilities, need for new or physically altered governmental facilities, the construction of which could cause significant environmental impacts, in order to maintain acceptable service ratios, response times or other performance objectives for any of the public services:

Schools?

Answer: No impact.

Discussion: None of the compliance measures identified in this SED contemplate the use of structural BMPs that would have an effect upon, or result in a need for new or altered schools or school services.

13. Public Services: d.)

Would the project result in substantial adverse physical impacts associated with the provision of new or physically altered governmental facilities, need for new or physically altered governmental facilities, the construction of which could cause significant environmental impacts, in order to maintain acceptable service ratios, response times or other performance objectives for any of the public services:

Parks?

Answer: No impact.

Discussion: None of the compliance measures identified in this SED contemplate the use of structural BMPs that would have an effect upon, or result in a need for new or altered parks.

13. Public Services: e.)

Would the project result in substantial adverse physical impacts associated with the provision of new or physically altered governmental facilities, need for new or physically altered governmental facilities, the construction of which could cause significant environmental impacts, in order to maintain acceptable service ratios, response times or other performance objectives for any of the public services:

Other public facilities?

Answer: No impact.

Discussion: None of the compliance measures identified in this SED contemplate the use of structural BMPs that would have an effect upon public facilities.

14. Recreation: a.)

Would the project increase the use of existing neighborhood and regional parks or other recreational facilities such that substantial physical deterioration of the facility would occur or be accelerated?

Answer: Less than significant with mitigation.

Discussion: None of the compliance measures identified in this SED, with the exception of dam decommissioning, contemplate the use of structural BMPs that would increase the use of existing neighborhood and regional parks or other recreational facilities such that substantial physical deterioration of the facility would occur or be accelerated.

In the event that the three reservoirs are decommissioned, flatwater recreation users will have to use the other flatwater facilities in the region. Once a decommissioning plan is developed, mitigation measures identified in the plan must include measures to ensure that the other regional facilities have the infrastructure in place to support the increased user base. Likely mitigation measures could include such things as installation of restrooms, boat ramps, garbage service, etc.

14. Recreation: b.)

Does the project include recreational facilities or require the construction or expansion of recreational facilities which might have an adverse physical effect on the environment?

Answer: No impact

Discussion: None of the compliance measures identified in this SED contemplate the use of structural BMPs that would require the construction or expansion of recreational facilities which might have an adverse physical effect on the environment.

15. Transportation/Traffic: a.) Would the project:

Cause an increase in traffic which is substantial in relation to the existing traffic load and capacity of the street system (i.e., result in a substantial increase in either the number of vehicle trips, the volume to capacity ratio on roads, or congestion at intersections)?

Answer: Less than significant.

Discussion: None of the compliance measures identified in this SED, other than for centralized treatment, contemplate the use of structural BMPs that would cause an increase in traffic which is substantial in relation to the existing traffic load and capacity of the street system (i.e., result in a substantial increase in either the number of vehicle trips, the volume to capacity ratio on roads, or congestion at intersections). If the centralized treatment option is pursued a site specific environmental analysis to comply with CEQA would be required. This site specific analysis would provide the level of detail needed to evaluate the related traffic impacts and potential mitigation measures.

15. Transportation/Traffic: b.) Would the project:

Exceed, either individually or cumulatively, a level of service standard established by the county congestion management agency for designated roads or highways?

Answer: No impact.

Discussion None of the compliance measures identified in this SED, other than for centralized treatment, contemplate the use of structural BMPs that would exceed, either individually or cumulatively, a level of service standard established by the county congestion management agency for designated roads or highways. See discussion above more on centralized treatment analysis.

15. Transportation/Traffic: c.) Would the project:

Result in a change in air traffic patterns, including either an increase in traffic levels or a change in location that results in substantial safety risks?

Answer: No impact.

Discussion: None of the compliance measures identified in this SED contemplate the use of structural BMPs that would result in a change in air traffic patterns, including either an increase in traffic levels or a change in location that results in substantial safety risks.

15. Transportation/Traffic: d.) Would the project:

Substantially increase hazards due to a design feature (e.g., sharp curves or dangerous intersections) or incompatible uses (e.g., farm equipment)?

Answer: Less than significant.

Discussion: None of the compliance measures identified in this SED contemplate the use of structural BMPs that would substantially increase hazards due to a design feature (e.g., sharp curves or dangerous intersections) or incompatible uses.

15. Transportation/Traffic: e.) Would the project:

Result in inadequate emergency access?

Answer: No impact.

Discussion: None of the compliance measures identified in this SED contemplate the use of structural BMPs that would result in inadequate emergency access.

15. Transportation/Traffic: f.) Would the project:

Result in inadequate parking capacity?

Answer: No impact.

Discussion: None of the compliance measures identified in this SED contemplate the use of structural BMPs that would result in inadequate parking capacity.

15. Transportation/Traffic: g.) Would the project:

Conflict with adopted policies, plans, or programs supporting alternative transportation (e.g., bus turnouts, bicycle racks)?

Answer: No impact.

Discussion: None of the compliance measures identified in this SED contemplate the use of structural BMPs that would conflict with adopted policies, plans, or programs supporting alternative transportation (e.g., bus turnouts, bicycle racks).

> **16. Utilities and Service Systems: a.)** Would the project:
>
> Exceed wastewater treatment requirements of the applicable Regional Water Quality Control Board?
>
> **Answer:** Less than significant.

Discussion None of the compliance measures identified in this SED contemplate the use of structural BMPs would cause any exceedence of wastewater treatment requirements.

> **16. Utilities and Service Systems: b.)** Would the project:
>
> Require or result in the construction of new water or wastewater treatment facilities or expansion of existing facilities, the construction of which could cause significant environmental effects?
>
> **Answer:** Less than significant.

Discussion: None of the compliance measures identified in this SED contemplate the use of structural BMPs that would result in a wastewater treatment provider needing to expand existing treatment facilities.

> **16. Utilities and Service Systems: c.)** Would the project:
>
> Require or result in the construction of new storm water drainage facilities or expansion of existing facilities, the construction of which could cause significant environmental effects?
>
> **Answer:** Less than significant.

Discussion: None of the compliance measures identified in this SED contemplate the use of structural BMPs that would result in a need for new storm water systems or the expansion of existing facilities.

> **16. Utilities and Service Systems: d.)** Would the project:
>
> Have sufficient water supplies available to serve the project from existing entitlements and resources, or are new or expanded entitlements needed?
>
> **Answer:** Less than significant.

Discussion: None of the compliance measures identified in this SED contemplate the use of structural BMPs that would require new or expanded entitlements for water supplies.

A number of compliance measures identified in this SED include use of water supplies for such things as dust abatement on native surface roads, construction of off-channel livestock watering facilities or temporary irrigation for riparian restoration (tree planting) activities. The selection of the appropriate compliance measures by responsible parties will need to take into consideration their existing water resources. Basing selection of compliance measures on existing water resources will prevent the need to seek new entitlements.

16. Utilities and Service Systems: e.) Would the project:

Result in a determination by the wastewater treatment provider which serves or may serve the project that it has adequate capacity to serve the project's projected demand in addition to the provider's existing commitments?

Answer: Less than significant.

Discussion: It is unlikely that the implementation of compliance measures identified in this SED as would be located in areas serviced by a wastewater treatment provider. Therefore it is unlikely that implementation of the structural BMPS identified in this SED will have resulted in the need for the treatment provider to make this determination.

16. Utilities and Service Systems: f.) Would the project:

Be served by a landfill with sufficient permitted capacity to accommodate the project's solid waste disposal needs?

Answer: Less than significant.

Discussion: Other than the discussion of compliance measures for algae dewatering and disposal, none of the compliance measures identified in this SED contemplate the use of structural BMPs that would generate a significant source of solid waste contemplate. Not much information was provide on the solid waste disposal aspects of the algae dewatering options, as such analysis of the possible impacts and potential mitigation measures would be based on conjecture and speculation. If this option were selected a site specific environmental analysis (most likely an environmental impact report [EIR]) would be required to comply with CEQA.

Construction and implementation of structural BMPs may generate solid wastes requiring disposal such as earthen material or erosion control materials (e.g. silt fences, temporary fencing, rusted out culverts). The amount of waste needing disposal, however, will be very minimal, and could therefore be served by an existing landfill.

16. Utilities and Service Systems: g.) Would the project:

Comply with federal, state, and local statutes and regulations related to solid waste?

Answer: Less than significant.

Discussion: As noted above, implementation of structural BMPs to comply with requirements of the proposed Action Plan and revised DO objectives will generate very little solid waste. There will, therefore, be no problems with compliance with federal, state, and local statutes and regulations related to solid waste disposal. See discussion above for more on potential impacts related to landfills.

In the event of dam decommissioning, a disposal site for the waste concrete will need to be designated. Given the re-use of concrete debris for building material (riprap, reuse at concrete batch plants) it is unlikely that a significant amount of solid waste would be generated from dam decommissioning.

17. Mandatory Findings of Significance:

Does the project have the potential to degrade the quality of the environment, substantially reduce the habitat of a fish or wildlife species, cause a fish or wildlife population to drop below self-sustaining levels, threaten to eliminate a plant or animal community, reduce the number or restrict the range of a rare or endangered plant or animal or eliminate important examples of the major periods of California history or prehistory?

Answer: Potentially significant impacts.

Discussion: All of these compliance measures identified in this environmental analysis will likely improve water quality from the current baseline, where many discharges of pollutants are currently occurring in the watershed and will likely continue without the application of these additional protections. This also would be the case if the Parties involved in the AIP decide to decommission one of more of PacifiCorps' dams in California.

Non-structural BMPs will not result in the substantial degradation of the environment for plant and animal species because none of the non-structural BMPs would have any physical effects that could degrade the environment or impact plant or animal species.

As discussed above, under Biological Resources- Category 4d, plant and animal species could potentially be adversely affected by the installation and operation of structural BMPs that involve substantial earth movement. If a responsible party proposed installation of a BMP that would require substantial earth movement, the discharger would be required to consult with federal, state and local agencies, including but not limited to the county the project is located in, CDFG and the USFWS, and implement mitigation identified by the agencies to avoid impacts to rare, threatened or endangered species. If no such mitigation is available, the use of that compliance measure in the specific area should not be implemented. In most cases the installation of structural

BMPs would be temporary, and any impacts could be avoided by adjusting the timing and/or location of the BMPs to take into account any candidate, sensitive, or special status species or their habitats.

The exception to this would be short term impacts associated with dam decommissioning which has the potentially to significantly impact water quality from the release of increased loads of fine grained sediment. It is estimated that impacts to water quality would range from weeks to months with the application of appropriate mitigation measures.

The potential impacts of the project will not cause a significant cumulative impact in the environment with the exception of a dam decommissioning scenario. In fact, the adoption of the proposed Action Plan and revised DO objectives should result in improved water quality in the Klamath River watershed and will have significant beneficial affects on the environment over the long term.

17. Mandatory Findings of Significance:

Does the project have impacts that are individually limited, but cumulatively considerable? ("Cumulatively considerable" means that the incremental effects of a project are considerable when viewed in connection with the effects of past projects, the effects of other current projects, and the effects of probable future projects)?

Answer: Potentially significant impacts.

Discussion: Cumulative impacts, defined in section 15355 of the CEQA Guidelines, refer to two or more individual effects, that when considered together, are considerable or that increase other environmental impacts. Cumulative impact assessment must consider not only the impacts of the proposed Action Plan and revised DO objectives, but also the impacts from other Basin Plan Amendments, municipal, and private projects, which have occurred in the past, are presently occurring, and may occur in the future, in the watershed during the period of implementation.

Structural BMPs that may be implemented are not likely to have cumulative impacts on the environment. Implementation of most of the structural BMPs will be short-term, temporary and spatially distributed across the watershed, and will not have significant adverse effects on the environment. BMPs that involve substantial earth movement could have potentially significant cumulative impacts. However, many of these activities will be regulated under existing State and Regional permits, including but not limited to state-wide CalTrans stormwater permit, stormwater permit for construction sites over one (1) acre or timber harvest operations on public and private lands. The likelihood of installation of structural BMPS on federal land is quite high as 66% of the watershed is in federal ownership. Compliance measures implemented for activities such as significant road construction projects will be subject to NEPA requirements. It is also important to note that Regional Water Board staff is currently developing a permit (WDR/waiver) for the Regional Water Board's consideration to regulate all sources of non point source pollution from lands managed by the USFS. Regional Water Board staff's engagement in these regulatory programs will provide an opportunity to limit the potential for cumulative impacts by ensuring that multiple projects proposing implementation of BMPs with the potential to cause short-term impacts are phased appropriately to limit potential cumulative impacts.

Based on a review of the referenced dam removal studies, Regional Water Board staff has determined that short term impacts from elevated turbidity and suspended sediment loads as a result of dam decommissioning will potentially result in a significant cumulative impact to the already stressed fisheries and aquatic resources in the Klamath River. As there is no decommissioning plan available for review, the actual environmental impacts are difficult to determine.

17. Mandatory Findings of Significance:

Does the project have environmental effects which will cause substantial adverse effects on human beings, either directly or indirectly?

Answer: Less than significant

Discussion: As explained previously, the proposed Action Plan, including measures to comply with the revised DO objectives, will improve long term water quality by providing a regulatory program designed to protect and restore water quality and the beneficial uses of water in the Klamath River watershed. An important objective of the Klamath River TMDLs is the restoration of a healthy and viable salmonid fishery. This important beneficial use is critical for the subsidence and health of the Tribes in the watershed.

9.8 Alternative Means of Compliance

The CEQA requires an analysis of reasonably foreseeable alternative means of compliance with the rule or regulation, which would avoid or eliminate the identified impacts[22]. The responsible parties can use the structural and non-structural compliance measures (BMPs) described in section 9.5, or other structural and non-structural BMPs, to control and prevent pollution, and meet the requirements of the proposed Action Plan and revised DO objectives. The alternative means of compliance with the proposed Action Plan and revised DO objectives consist of the different combinations of structural and non-structural BMPs that the responsible parties might use to meet their load allocations and achieve the numeric targets and revised DO objectives. Because there are innumerable ways to combine BMPs, all of the possible alternative means of compliance cannot be discussed here. However, because most of the adverse environmental effects are associated with the construction and installation of structural BMPs related to earth movement or construction of infrastructure (e.g., fencing) to avoid or eliminate impacts,

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[22] Cal. Code Regs., tit. 14, § 15187(c)(3).

compliance alternatives should maximize the use of non-structural BMPs to the extent feasible, minimize use of structural BMPs to the extent feasible, and design structural BMPs to take into consideration site-specific conditions to minimize environmental effects.

9.9 CEQA Determination

Adoption of the proposed Action Plan and revised DO objectives is both necessary and beneficial. Currently the Basin Plan does not include a comprehensive regulatory program designed to protect and restore the beneficial uses of water in the Klamath River basin. The Klamath TMDL implementation plan would provide the framework for this comprehensive program. The implementation of compliance measures that likely may be implemented to comply with the proposed Action Plan and revised DO objectives will not result in significant adverse impacts that cannot be reduced to levels of insignificance with the implementation of thoughtfully designed and executed mitigation measures with the exception of several potentially significant adverse environmental impacts associated with dam decommissioning. Implementation of many of the identified compliance measures, including dam decommissioning, could result in temporary (short term) adverse impacts to the environment. Most of these impacts, however, can be reduced to levels of less than significant with mitigation. For example, implementation of BMPs that require substantial earth movement, such as construction of filtration or settling basins, and road construction, reconstruction and maintenance could result in significant impacts if they were conducted in sensitive areas or during time periods when the most sensitive life stages of fall Chinook salmon are present. To alleviate any such impacts, dischargers will be required to consult with federal, state and local agencies, including but not limited to the county the project is located in, CDFG and the USFWS, and implement mitigation identified by the agencies to avoid impacts to rare, threatened or endangered species. In most cases the installation of structural BMPs would be small scale in size and application, and any impacts could avoided by adjusting the timing and/or location of the BMPs to take into account any candidate, sensitive, or special status species or their habitats.

If the KHSA Parties decide to move forward with dam decommissioning, a plan would have to be developed, which would then require a thorough environmental review (EIS and/or EIR) prior to the federal and/or state agencies permitting the activity. Only once a plan has been developed will it be possible to assess potentially significant adverse effects and mitigation measures that could reduce impacts to levels of insignificance. If no such mitigation is available, the activity would not be authorized until such time as a regulatory path was made available to allow for large-scale restoration projects such as dam decommissioning, Trinity River restoration actions and restoration work on USFS lands.

The Staff Report, the draft Basin Plan Amendments, and the Environmental Checklist and associated analysis provide the necessary information pursuant to state law to conclude that the proposed Action Plan, revised DO objectives, and the associated reasonably foreseeable methods of compliance (i.e. BMPs) will not have a significant adverse effect on the environment with the exception of potentially significant impacts associated with a dam decommissioning. Regional Water Board staff have made this determination based on best available information in an effort to fully inform the interested public and the decision makers of potential environmental impacts.

In accordance with state law, the North Coast Regional Water Board finds that with the exception of activities connected with dam decommissioning, the proposed Action Plan and DO objectives, with the implementation of the mitigation measures identified in this SED, will not have a significant adverse impact on the environment. This finding is supported by the evidence provided in the impact evaluation section of this document, which indicates that all foreseeable impacts are either short-term or can be readily mitigated.

Although potentially significant adverse impacts from dam removal were identified, it is impossible without further study to know whether those impacts may be able to be mitigated to less than significant levels. If the KHSA Parties decide to move forward with decommissioning of one or more of the dams, additional environmental review will be required at that time. If, at that time, adverse environmental impacts are identified that cannot be mitigated to less than significant levels, the Regional Water Board, when required to take a discretionary action for approval of dam decommissioning, will balance the economic, legal, social, technological, or other benefits of removing the dams against the unavoidable environmental risks when determining whether to approve the project, and make a statement of overriding considerations, if it finds that the adverse environmental impacts are acceptable given the identified benefits. At this time, however, there has been no decision to decommission one or more of PacifiCorps' dams and there is insufficient information for the Regional Water Board to know what potential impacts exists, if they can be mitigated to less than significant levels, and if not, whether the benefits outweigh those potential impacts. A detailed environmental analysis of impacts and subsequent Regional Water Board approval is required before dam removal activity may occur for TMDL compliance.

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CHAPTER 9. REFERENCES

Federal Energy Regulatory Commission (FERC). 2007. Final Environmental Impact Statement for Relicensing of the Klamath Hydroelectric Project No. 2082-027. Federal Energy Regulatory Commission Office of Energy Projects Division of Hydropower Licensing. November 2007.

Five Counties Salmonid Conservation Program (5C). 2009. About us. Website accessed June 30, 2009. Available at <http://www.5counties.org/AboutUs800.htm>.

Gathard Engineering Consulting. 2006. Klamath River Dam and Sediment Investigation. Prepared for the California State Coastal Conservancy and the Ocean Protection Council. November 2006.

Klamath Hydroelectric Settlement Agreement (KHSA). 2009. Draft agreement dated September 30, 2009 to be signed by numerous federal government, state government, local government, tribal government, and non-profit organizations.

Stillwater Sciences. 2009a. Dam Removal and Klamath River Water Quality: A Synthesis of the Current Conceptual Understanding and an Assessment of Data Gaps. Prepared for the Coastal Conservancy. Revised February 2009.

Stillwater Sciences. 2009b. Effects of Sediment Release Following Dam Removal on the Aquatic Biota of the Klamath River. Final Technical Report. Prepared for the State Coastal Conservancy. January 2009.

United States Forest Service (USFS). 2000. Water quality management for forest systems lands in California: Best management practices. Forest Service, Pacific Southwest Region 138 pp.

United States Environmental Protection Agency (USEPA). 2003. *National Management Measures for the Control of Nonpoint Pollution from Agriculture*. Office of Water. July 2003.

CHAPTER 10. ECONOMIC ANALYSIS

10.1 Introduction

The Regional Water Boards are legally required to consider economics in Total Maximum Daily Load (TMDL) development and water quality control planning (basin planning), as described in a memorandum from Sheila K. Vassey, Senior Staff Counsel in the Office of Chief Counsel of the State Water Resources Control Board (Vassey 1999). Under state law, there are three triggers for Regional Water Board consideration of economics or costs in basin planning. They are:

- The Regional Water Boards must estimate costs and identify potential financing sources in the basin plan before implementing any agricultural water quality control program.
- The Board must consider economics in establishing water quality objectives that ensure the reasonable protection of beneficial uses.
- The Boards must comply with the California Environmental Quality Control Act (CEQA) when they amend their basin plans. CEQA requires that the Boards analyze the reasonably foreseeable methods of compliance with proposed performance standards and treatment requirements. This analysis must include economic factors.

Chapter 9 is the analysis of potential environmental impacts associated with implementation of the TMDL and compliance with the recalculated Site Specific Objectives (SSOs) for dissolved oxygen (D0) as required under CEQA. In Chapter 9, staff identifies the reasonably foreseeable compliance measures necessary of land owners/dischargers to achieve compliance with the TMDLs and the proposed revised DO objectives. These compliance measures, or best management practices, are not requirements of individual landowners/dischargers. They are simply those management practices most likely to be necessary to achieve compliance. Land owners/dischargers have the responsibility of identifying the means of achieving compliance best suited to the site specific characteristics of their particular land and operation.

What follows is an estimate of the costs associated with those management practices which are reasonably foreseeable as necessary to achieve compliance with the TMDL and proposed revised DO objectives. The costs are given as a range, dependent on the specific characteristics of the land or operation to which a given management practices is applied. A list of potential funding sources is also given.

The Regional Water Board is not obligated to consider the balance of costs and benefits associated with implementation of a TMDL or basin plan amendment. It is only obligated to consider economic factors and may adopt a TMDL or basin plan amendment even if the costs are significant.

10.2 Scope of the Economic Analysis

10.2.1 Existing Requirements

Landowners and dischargers are bound by various existing regulatory requirements that involve water quality and natural resource protection. The economic impact of existing obligations should not be attributed to the costs of compliance with the proposed Klamath River TMDL Action Plan and revised DO objectives. But, limiting the scope of the economic analysis is difficult given the similarity of measures necessary to achieve a wide range of water quality and wildlife protection goals. To remain as focused as possible, this economic analysis only contemplates the costs of measures identified as reasonably foreseeable (see Chapter 9) in the implementation of the Klamath River TMDL Action Plan and revised DO objectives. But, if taken as a whole, they are likely an overestimate of the actual costs of compliance. This is because of the multiple and overlapping regulatory programs under which the same measures are reasonably foreseeable.

For example, some temperature, nutrient, or dissolved oxygen control costs are related to actions necessary to avoid a violation of the sediment prohibitions in the Basin Plan and to avoid a taking under the Endangered Species Act or to fully mitigate impacts of authorized takes. Other costs may be incurred as a result of compliance with the Clean Water Act, other related statutes and regulations, or local land use ordinances. Conversely, compliance with the proposed Klamath River TMDL Action Plan will help dischargers comply with the other regulatory requirements.

Applicable existing requirements include:

- Existing Basin Plan requirements (such as the federal and state antidegradation policies, the controllable factors requirement, the general Waste Discharge Requirements and general waiver for timber harvest activities, and the existing water quality objectives for temperature, dissolved oxygen).
- State nonpoint source program requirements.
- Porter-Cologne Act requirements (such as the requirement of Section 13260 for every person who discharges a waste that impacts water quality to file a report of waste discharge with the Regional Water Board, and the cleanup and abatement requirements of Section 13304).
- The California Department of Forestry and Fire Protection requirements for timber harvest activities.
- The federal and state endangered and threatened species requirements.
- Obligations imposed by other local, state and federal natural resource agencies.

As discussed in Chapter 9, the decommissioning of one or more of PacifiCorp's dams is being contemplated in other forums and not in the context of the TMDL Action Plan and revised mainstem Klamath River DO objectives. Whether the dams are ultimately removed is a decision before several federal and state agencies in consideration of other factors in addition to water quality, including water allocations, species protection and

power needs. Both dam alteration/modifications and dam removal are recognized as possible strategies by which final compliance with the TMDL load allocations may be accomplished. The Regional Water Board can only determine whether a selected outcome will meet its TMDL. The implementation plan provides for Regional Water Board review of more site specific environmental assessments of dam removal.
Dam removal is something that may or may not occur, and is separate and independent of the TMDL. Nonetheless, at PacifiCorp's request and consistent with the Chapter 9 CEQA analysis, economic considerations from the Final Environmental Impact Statement for Relicensing of the Klamath Hydroelectric Project No. 2082-027 have been incorporated into this analysis. Because there is not yet a plan for dam decommissioning, the proposed costs are very broad, and actual costs remain uncertain.

10.2.2 Geographic Scope

The implementation actions proposed by the Klamath River TMDL Action Plan for compliance with the TMDLs and revised DO objectives (see Chapter 6) are not uniformly required across the Klamath River watershed or even across properties with similar land uses. Instead, many of the implementation actions will be required of landowners/dischargers on an as-needed, site-specific basis or are simply activities that are encouraged by the Regional Water Board. While this flexibility adds greatly to the effectiveness of the Klamath River TMDL Action Plan, it is one factor preventing this economic analysis from totaling costs on a watershed scale. Another factor preventing the development of watershed scale costs is the lack of a watershed scale inventory of pollution-causing activities/features (e.g., miles of roads requiring decommissioning).

Additionally, more intensive land use activities will face greater costs than less intensive land use activities. Activities on steep, erosive slopes in proximity to waterbodies will require greater care and higher costs than activities on lands that do not deliver to a water body or on lands that are not highly erosive.

10.2.3 Methodology

The costs identified in this chapter primarily come from four sources of information: the Natural Resources Conservation Service (NRCS) ProTracts cost dataset; California Department of Fish and Game (CDFG) Salmonid Stream Habitat Restoration Manual (2006) (Manual) for road-related costs, estimates provided by PacifiCorps for reservoir-related measures and the *Final Environmental Impact Statement for Relicensing of the Klamath Hydroelectric Project No. 2082-027* released by the Federal Energy Regulatory Commission on November 16, 2007. ProTracts is a national dataset maintained by NRCS to assist local NRCS Districts in setting cost shares for implementing conservation practices. Cost estimates are provided at the county level and the data used for this analysis are specific to Siskiyou County, as described in their California Approved Fiscal Year 2008 Payment Schedule.

The costs included in the CDFG Manual are described as upslope erosion inventory and sediment control guidance. The numbers are based on estimates from Pacific Watershed Associates, a consulting firm specializing in erosion control work. Actual costs can vary considerably depending on operator skill and experience, equipment types, local site conditions, and regional location.

The cost estimates for interim measures to work toward compliance with the TMDL and DO objectives while it is determined whether PacifiCorp will decommission one or more of its dams are set forth in the AIP. Despite the fact that the parties to the AIP have not yet decided whether or not to decommission one or more of PacifCorp's dams and no plans for how that process will look have yet been created, the Regional Water Board has nonetheless attempted to consider economics of dam decommissioning, as those costs have been reported in the Final Environmental Impact Statement for Relicensing of the Klamath Hydroelectric Project No. 2082-027, prepared by FERC, which is incorporated herein by reference.

10.3 Estimated Costs of Compliance

10.3.1 PacifiCorp

PacifiCorp has entered into an agreement in principle (AIP) with the State of Oregon, the State of California, and the federal government to resolve "certain litigation and other controversies in the Klamath Basin, including a path forward for possible Facilities removal" (AIP 2008).[1] The AIP constitutes PacifiCorp's interim funding commitments while the negotiations continue on the topic of dam removal. Table 10.1 presents the costs associated with the measures related to interim compliance with the TMDL while decisions are being made to determine which regulatory path to pursue. Costs for the breadth of interim measures discussed in Chapter 6 (Implementation Plan) and Chapter 9 (CEQA Environmental Analysis) are included as a lump sum in item #11. Costs for dam removal are taken from the Final Environmental Impact Statement for Relicensing of the Klamath Hydroelectric Project No. 2082-027 (page 4-6 of the EIS). Costs to remove Copco 1 and 2 and Iron Gate dams range from $51 million to 75.3 million with additional decommissioning costs (e.g. re-vegetation) of between $9.2 million to to 55.3 million depending on individual site constraints.

Table 10.1: Costs to PacifiCorp of interim compliance measures

#	Interim Measure Task Title	Funding Commitment
9	California Klamath Restoration Fund/Coho Enhancement Fund	$500,000 annually until dams removed
10	Iron Gate Turbine Venting	$73,310 annually
11	Nutrient Reduction Measures	$5 million plus $500,000 annually
12	Water Quality Monitoring	$500,000 annually
13	Fish Tissue Consumption Risk Analysis	$250,000 one time cost
21	Iron Gate Gravel Placement	$7,131 annually
23	Water Quality Technical Conference	$100,000 one time cost
	One time costs	$5,350,000
	Annual costs	$1,580,441

[1] State of California is defined as the State of California Resources Agency and its constituent departments and excludes all other state agencies, departments, boards and commissions. The Regional Water Board is not a constituent department under the Resources Agency.

10.3.2 Irrigated Agriculture

Irrigated agriculture occurs primarily in the upper Klamath Basin, including the Lost, Shasta and Scott River valleys. USBR reports that approximately 225,000 acres of rangeland in the upper Klamath Basin (south-central Oregon and north-central California) have been transformed into productive farmland due to the availability of irrigation water provided by USBR. Principal irrigated crops are barley, irrigated pasture, alfalfa hay and other hay, oats, potatoes, and wheat (http://www.usbr.gov/dataweb/html/klamath.html). Table 10.2 presents the estimated costs to irrigated agriculture in California of reasonably foreseeable compliance measures for the Klamath River TMDL, and are taken from the Natural Resources Conservation Service (NRCS) Siskiyou County District Office Fiscal Year 2008 payment schedule. For most of the management practices, a range of costs is given, depending on numerous site-specific factors to be determined by landowners/dischargers.

Table 10.2: Estimated costs to irrigated agriculture of reasonably foreseeable compliance measures

Reasonably Foreseeable Compliance Measure	NRCS Practice Name	NRCS Practice Cost	NRCS Practice Code
Nutrient Management			
Comprehensive Nutrient Management Plan	Nutrient management	$2000-6000/plan	#100
Monitor soil, irrigation water and residual plant matter	To	be determined	
Time fertilizer application with plant needs	Timing No	cost	NA
Water Management (see below)	See below	See below	See below
Cover crops	Irrigated or non-irrigated	$61-112/acre	#340
Buffer areas	Non-native or native seedbed preparation; tree/shrub establishment	$75-371/acre #	386, #612
Pest Management			
Precision Pest Control Application	Precision pest control	$30/acre	#718
Pest Management	IPM, reduced risk, or transition to organic certification	$30-125/acre #	595
Erosion and Sediment Control			
Maintain crop residue or vegetative cover	Cover crop	$60-112/acre	#340
Improve soil properties	Deep tillage Mulch till Cover crop	$55-105/acre $30/acre $60-112/acre	#324 #345 #340
Reduce slope length, steepness, or unsheltered distance	Precision land forming	$175/acre	#462
Practices to reduce detachment	Chiseling and subsoiling Conservation cover Conservation crop rotation Residue management Cover crop Critical area planting Seasonal residue management Diversion Windbreak/shelterbelt establishment	$55-106/acre $97-750/acre $50/acre $60-113/acre $249-1,229/acre $30/acre $10/ft $0.08-1.47/ft	#324 #327 #328 #329 #340 #342 #344 #362 #380

Table 10.2 (cont.): Estimated costs to irrigated agriculture of reasonably foreseeable compliance measures

Reasonably Foreseeable Compliance Measure	NRCS Practice Name	NRCS Practice Cost	NRCS Practice Code
Erosion and Sediment Control (cont.)			
Practices to reduce detachment (cont.)	Windbreak/shelterbelt renovation Mulching Irrigation water management Cross wind ridges/stripcropping/trap strips Surface roughening Tree planting Waste utilization Wildlife upland habitat management	$0.13-0.57/ft $78-299/acre $5-50/acre Not available Not available $75-283/acre $30-50/acre $10-50/acre	#650 #484 #449 #589 #609 #612 #633 #645
Practices to reduce transport within the field	Contour farming Field windbreak Grassed waterway Contour stripcropping Herbaceous wind barriers Field stripcropping Terrace Contour buffer strips	Not available Not available $250-470/acre Not available $400/acre Not available $5/acre Not available	#330 #392 #412 #585 #442A #586 #600 #332
Practices to trap sediment below the field or critical area	Sediment basins Field border Filter strip Water and sediment control basin	$4701/no. $82-370/acre $117-393/acre $245-4,902/no.	#350 #386 #393 #638
Protect and manage existing wetland and/or riparian areas for their natural filtering functions	Riparian herbaceous cover/forest buffer, wetland restoration	$75-1,200/acre #	390, #391, #657
CEQA Mitigation Measures			
Mulch exposed areas	Mulching	$78-299/acre	#484
Protect drainage channels from sediment contributions with vegetated buffers, wattles, or similar erosion control devices	Filter strip	$117-393/acre	#393
Wetland wildlife habitat management	Low, medium or high intensity	$10-50/acre	#644
Installation of grade stabilization structures	Grade stabilization structure	$250-10,000/no.	#410
Streambank and shoreline protection	Low-high complexity	$24-122/ft	#580
Stream channel stabilization	Stream channel stabilization	$25/ft	#584
Use exclusion	Forage exclusion, wetlands	$15/acre	#472
Riparian forest buffer/herbaceous cover	Riparian forest buffer/herbaceous cover	$75-1170/acre #	390, #91
Control of streambank erosion via vegetative or structural practices	Streambank and shoreline protection	$23-122/ft #	580

Table 10.2 (cont.): Estimated costs to irrigated agriculture of reasonably foreseeable compliance measures

Reasonably Foreseeable Compliance Measure	NRCS Practice Name	NRCS Practice Cost	NRCS Practice Code
Irrigation Management			
Irrigation scheduling	Irrigation water management	$5-50/acre	#449
Efficient application of irrigation water	Microirrigation, sprinklers	$250-1250/acre	#441, 442
Efficient transport of irrigation water	Installation of piping to replace open ditches	$2-5/ft #	516
Use of runoff or tailwater	Irrigation system/tailwater recovery	$77-102/acre #	447
Management of drainage water	Runoff management system	$5000/no.	#570
CEQA Mitigation Measures			
Vegetated filter strips	Filter strip	$117-393/acre	#393
Surface field ditch	Field ditch	$3/cy	#607
Water table control, controlled drainage	Subsurface drain	$1-2/ft	#606

Source: California Approved Fiscal Year 2008 Payment Schedule for Siskiyou County District of the Natural Resources Conservation Service.

10.3.3 Grazing

Grazing activities occur throughout the Klamath River basin both on private and public lands. As with the estimated costs to the irrigated agricultural community to comply with the Klamath River TMDL and revised DO objectives, the estimates to the grazing community are derived from NRCS Fiscal Year 2008 Payment Schedule for Siskiyou County. Costs for each of the reasonably foreseeable compliance measures identified in Chapter 9 are provided in Table 10.3

Table 10.3: Costs to grazing of reasonably foreseeable compliance measures

Reasonable Foreseeable Compliance Measure	NRCS Practice Name	NRCS Practice Cost	NRCS Practice Code
Grazing Management Practices			
Grazing Management Plan		To be determined	
Pasture and hay planting	Seedbed preparation, see and seeding, non-native	$125/acre #	512
Rangeland planting	Drill or broadcast, native or non-native	$26-644/acre #	550
Forage harvest management	Forage harvest management	Not available	#511
Vegetation control with grazing	Prescribed grazing	$10/acre	#528A
Use exclusion	Forage exclusion	$15/acre	#472
Nutrient management	AFO Manure Management	$25/acre	#590

Table 10.3 (cont.): Costs to grazing of reasonably foreseeable compliance measures

Riparian Grazing Practices			
Use exclusion	Fence	$0.39-5.25/ft	#382
Animal trails and walkways	Animal trails and walkways	$3/ft	#575
Stream crossing	Ford, culvert, bridge	$1000-50,000	#578
Alternate Water Supply Practices			
Irrigation management	Irrigation water management	$5-50/acre	#449
Installation of pipeline for off-channel water	Pipeline, rough terrain, steel or plastic	$2-5/ft #	516
Constructing off-stream pond	Pond up to 50 AcFt	$4,534-23,625/no.	#378
Installing trough or tank for off-channel water	Watering facility	$245-1,230/no.	#614
Constructing well	Water well	$990-9,905/no.	#642
Improving springs	Spring development	$981-1,981/no.	#574
Land and Streambank Stabilization Practices			
Nutrient management	AFO Manure Management-North Coast	$25/acre #5	90
Channel vegetation	Channel bank herb., tree, shrub vegetation	$321-536/acre #	322
Pasture and hay planting	Seedbed preparation, see and seeding, non-native	$125/acre #	512
Rangeland planting	Drill or broadcast, native or non-native	$26-644/acre #	550
Critical area planting	Tackifier, erosion blanket, strawmulch	$248-1,229/acre	#342
Brush management	Biological, mechanical	$47-462/acre	#314
Grazing land mechanical treatment		To be determined	#548
Grade stabilization structure	Grade stabilization structure	$250-10,000/no.	#410
Prescribed burning	Prescribed burning	$70/acre	#338
Stream corridor improvement Str	eam crossing	$1000-50,000/no.	#578
Land reclamation	Landslide treatment No	t available	#453
Sediment basin	Sediment basin	$4701/no.	#350
Wetland wildlife habitat management	Low-high intensity	10-50/acre	#644
Stream channel stabilization	Stream channel stabilization	$25/ft	#584
Wetland restoration	Northern CA, coast, planting only, shaping/grading	$157-1,200/acre	#657
Streambank and shoreline protection	Low-high complexity	$24-122/ft	#580
Riparian forest buffer/herbaceous cover	Riparian forest buffer/herbaceous cover	$203-971/acre #	391A #390
CEQA mitigations			
Mulch	Moisture and erosion control	$299/acre	#484B
Protecting drainage channels from sediment contributions	Channel bank vegetation	$321/acre	#322B

Source: Source: California Approved Fiscal Year 2008 Payment Schedule for Siskiyou County District of the Natural Resources Conservation Service.

10.3.4 Suction Dredging

Staff recommends to the Regional Water Board the limitation of suction dredging in the Klamath River Basin to certain times and locations in order to protect thermal refugia that mitigate water temperatures that are stressful to salmonids. Staff concludes that there are no specific costs to the suction dredging community associated with the TMDL or revised DO objectives. This is because the prohibition proposed for adoption does not prohibit suction dredging throughout the watershed; only in those tributaries in which thermal refugia exists.

10.3.5 Iron Gate Hatchery

The issues associated with the Iron Gate Hatchery are complex due to the location and issues surrounding the hatchery operation. Site-constraints and technical factors make it necessary for an engineering study to be completed before an economic analysis can be completed for the hatchery aspect of the TMDL and revised DO objectives. Some of the potential improvements that might be required in order for the hatchery to meet the TMDL requirements and revised DO objectives under a revised NPDES permit, could include improvements to settling ponds, treatment technologies (such as installation of a package treatment plant), modifications of operations, additional monitoring and laboratory analyses, and a potential off-sets program including up-stream treatment.

PacifiCorp has agreed to provide certain funding to the hatchery including "100% of the hatchery operations and maintenance necessary to fulfill annual mitigation objectives developed by the California Department of Fish and Game in consultation with the National Marine Fisheries Service (AIP 2008)." There may be some overlap in the requirements of these agencies and those of the Regional Water Board under the Klamath TMDL Action Plan. Further, some of these costs to the hatchery associated with water quality protection would be required as part of the upcoming NPDES permit update, regardless of the TMDL or revised DO objectives.

At present both the reasonably foreseeable compliance measures and their costs are too speculative to include here. Staff concludes that addressing these complex issues and creating an effective implementation plan is likely to be costly. The Regional Water Board has already begun working with the CDFG to address these difficult issues.

10.3.6 Roads

The road networks in the Klamath Basin contribute to elevated temperatures in tributary watersheds through the discharge of excess sediment. The implementation plan requires parties responsible for managing roads in the Klamath Basin to implement measures that meet the TMDL allocations, TMDL targets, and revised DO objectives. In some cases, an inventory of roads will determine that decommissioning or upgrading of roads is required. Table 10.4 outlines the estimated costs for this type of work. The targets, rationale for the targets, and the specific implementation measures that will be required under the TMDL for private, county, state (Caltrans) and federal (USFS, BLM) maintained roads are discussed in Chapter 6.

Regardless of the method of regulation or the responsible party, the requirements for controlling sources of sediment from roads are similar and implementation will potentially focus on the following process:

1. Inventory: Identify sources of excess sediment discharge or threatened discharge and quantify the discharge or threatened discharge from the source(s).
2. Prioritize: Prioritize efforts to control discharge of excess sediment based on, but not limited to, severity of threat to water quality and beneficial uses, the feasibility of source control, and source site accessibility.
3. Implement: Develop and implement feasible sediment control practices to prevent, minimize, and control the discharge. Road decommissioning may be required as part of a responsible parties' load allocation if maintaining the road is cost prohibitive, road is not needed or is a source of uncontrollable excess sediment discharge.
4. Monitor and Adapt: Use monitoring results to direct adaptive management in order to refine excess sediment control practices and implementation schedules until discharges are reduced to a level that meets the TMDL load allocations and water quality standards.

Table 10.4: Estimated costs for reasonably foreseeable compliance measures for roads

Reasonably Foreseeable Compliance Measure	Best Management Practice	BMP estimated cost	Source of data
Costs for Road and Crossing Construction and Maintenance Activities			
Surface stabilization	Asphalt paving	$238,000/mile	Siskiyou County Public Works
	Chip sealing	$57,000/mile	Siskiyou County Public Works
	Rocking	$4,250-10,000/1000 ft	Weaver, et. al. (2006)
	Dust abatement	$90hr	Harris Blade Rental, Livermore - operated water truck
Fill slope/cutbank compliance measures	Removal/stabilization of unstable fill.	$2-5/cubic yard	Weaver, et. al. (2006)
	Soil stabilization (mulch/vegetate) of fill and cut slopes.	$19-22/1000 ft.	Weaver, et. al. (2006)
Control sediment discharge from insloped or crowned roads	Disconnect road drainage from watercourses (drain to hillslopes).	$170/1000 ft	Weaver, et. al. (2006)
	Install rolling dip	$85-170/ each	Weaver, et. al. (2006)
	Install ditch relief culvert	$645-825/ each	Weaver, et. al. (2006)
	Install stream crossing	$3,270/each	Weaver, et. al. (2006)
CEQA mitigation measures	Conservation cover	$189-509/acre	NRCS#327
Mu	lching	$299/acre	NRCS #484

Table 10.4 (cont.): Estimated costs for reasonably foreseeable compliance measures for roads

Reasonably Foreseeable Compliance Measure	Best Management Practice	BMP estimated cost	Source of data
Costs for Stream Crossing Activities			
Stabilize/treat crossing approach	Rock road surface	$4,250-10,000/1000 ft	Weaver, et. al. (2006)
	Water for dust abatement	To be determined	
	Install additional road drainage: waterbars, rolling dips, cross drains	$85-3,270/each Weave	r, et. al. (2006)
	Mulching $	299/acre	NRCS #484
	Streambank and shoreline protection	$24-122/ft N	RCS #580
Stabilize/treat crossings and associated fills	Remove undersized/failing culverts	$3-10/cubic yard	Weaver, et. al. (2006)
	Remove unstable fill	$2-5/cubic yard	Weaver, et. al. (2006)
	Rock armor, rip rap fill slopes	To be determined	
	Provide "fail safe" road drainage on crossings with diversion potential	To be determined	
	Drain road away from unprotected fills	$10,000-75,000/mile	Weaver, et. al. (2006)
	Bioengineered structures (e.g. willow waddles)	To be determined	
	Mulch, vegetate or rock exposed soil with access to watercourses	To be determined	
Construct storm-proof crossings and associated fills		To be determined	
CEQA mitigation measures	Conservation cover	$189-509/acre	NRCS#327
	Mulching $	299/acre	NRCS #484
	Streambank and shoreline protection	$24-122/ft N	RCS #580
Costs of Road Planning Activities			
Develop a Road System Plan	Erosion Control Plan, non-timber land use	$3528-7,740/100 acres	R. Fitzgerald Memo dated August 6, 2005
	Erosion Control Plan, timber land use	$2,370-7,740/100 acre	
	Road System Plan	To be determined	
Road decommissioning	Recontour road to provide for a stable, hydrologically "invisible" site (e.g. remove perched fill, outslope old road prism, remove crossings)	$2,000-$50,000/mile depending on steepness and location of road	Weaver, et. al. (2004)
	Minimize road system (density) to correspond with maintenance resources	$2,000-$50,000/mile to recontour unnecessary roads	Weaver, et. al. (2004)
	Decommission roads adjacent to watercourse and relocate to midslope or ridgetop if possible	To be determined	
CEQA mitigation measures	Conservation cover	$189-509/acre	NRCS#327

10.3.7 Timber

Timber harvest activities can substantially impact water temperature. The Klamath implementation plan focuses on controlling sediment and protecting riparian functions from timber harvest activities to meet the watershed-wide TMDL allocations for temperature described earlier in this section. Timber harvest on nonfederal lands is currently regulated by the Regional Board through a combination of general WDRs and conditional waivers of WDRs. The costs associated with WDRs are not outlined here as they are a current requirement. Roads that are part of a timber harvest plan or Non-Industrial Timber Management Plan (NTMP) area require an erosion control plan to be implemented by the WDRs and waivers for timber harvest on nonfederal lands. Table10.5 includes the reasonably foreseeable compliance measures identified in Chapter 9. However, staff judges that there are no additional costs to timber operators associated with TMDL compliance.

Table 10.5: Estimated costs to timber operators of reasonably foreseeable compliance measures

Reasonably Foreseeable Compliance Measures	**Best Management Practice**	**Estimated cost of BMP**	**Source of data**
Compliance measures on private land	Increased riparian canopy retention in Class I and II watercourses	None St	aff judgment
	Retain in-channel trees following timber operations	None St	aff judgment
	No timber harvest activities (including tree felling) within the channel zone of a Class III watercourse except for use and maintenance of road and crossings.	None St	aff judgment
	Implement Threatened and Impaired Rules (Forest Practice Rules, 2009, section 916.9, 936.9) watershed-wide in the Klamath River watershed.	No additional cost	Staff judgment

10.3.8 Summary

Sunding and Zwane (2004) produced the Recovery Strategy for California Coho Salmon: Report to the California Fish and Game Commission (Strategy) in which they assessed the costs of implementing the Strategy in each hydrologic unit, including the Klamath River. The main activities associated with implementation of the Strategy are similar to those associated with compliance with the Klamath River TMDL and revised DO objectives, the estimated costs of which are reproduced in Table 10.6. As described above, where costs are incurred as a result of the implementation/enforcement of another program, they can not be attributed to the Klamath River TMDL and revised DO objectives. However, because these costs were estimated for the whole watershed, they are included here for illustration purposes.

Table 10.6: Estimated costs of coho recovery actions for the Klamath River basin

Action	Potential Sites (#)	Actual Sites (#)	Estimated Cost ($)	Unit Cost ($/unit)
Barrier removal (dam)	31	16	7,137,216	460,456
Barrier removal (non-structural sites)	752 37	6	3,635,213	9,668
Barrier removal (stream crossings)	291	146	18,220,276	125,225
Barrier removal (unknown/other barriers)	17 9		94,292	37,367
Barrier removal (water diversions)	78	39	1,344,905	34,485
Riparian revegetation	NA	103 stream miles	18,721,487 1	80,993
Streambank restoration	NA	20 stream miles	25,893,312 1,	316,722
Fencing NA		1,748 stream miles	12,830 7	
Klamath Basin Total			75,059,531	

Monies spent under the Strategy are monies saved under the Klamath River TMDL and revised DO objectives for the following categories of expenditures:

- Non-structural barrier removal to temperature refugia,
- Stream crossing repairs,
- Riparian revegetation,
- Streambank restoration, and
- Fencing.

10.4 Sources of Funding

Potential sources of funding include monies from private and public sources. Public financing includes, but is not limited to: grant funds, as described below; single-purpose appropriations from federal, state, and/or local legislative bodies; and, bond indebtedness and loans from government institutions.

10.4.1 Funding Source Provided through the Agreement In Principle (AIP)

The United States, State of California, State of Oregon, and PacifiCorp signed an Agreement In Principle (AIP) on November 13, 2008 in which certain interim provisions are made with respect to the hydroelectric facilities on the Klamath River prior to final agreement on the decommissioning of the dams.[2] In the AIP, PacifiCorp agreed to provide $500,000 annually to the California Klamath Restoration Fund/Coho Enhancement Fund (Restoration and Enhancement Fund) to be administered jointly by

[2] State of California is defined as the State of California Resources Agency and its constituent departments and excludes all other state agencies, departments, boards and commissions. The Regional Water Board is not a constituent department under the Resources Agency.

the California Department of Fish and Game (in conjunction with the State Water Resources Control Board) and NOAA Fisheries. The Restoration and Enhancement Fund is intended to fund habitat and fish restoration actions within the Klamath Basin that will benefit coho salmon.

10.4.2 Summary of Pertinent State Funding Programs

There are several potential sources of public financing through grant and funding programs administered, at least in part, by the Regional Water Board and the State Water Board. These programs vary over time depending upon federal and state budgets and ballot propositions approved by voters. State funding pertinent to the proposed Action Plan for the Klamath River are summarized and described below. Additional information can be found on the State Water Resources Control Board webpage (http://www.waterboards.ca.gov/water_issues/programs/grants_loans/).

10.4.2.1 Agricultural Drainage Loan Program

The Agricultural Drainage Loan Program was created by the Water Conservation and Water Quality Bond Act of 1986 to address treatment, storage, conveyance, or disposal of agricultural drainage water that threatens waters of the State. There is a funding cap of $20 million for implementation projects and $100,000 for feasibility studies. Loan repayments are for a period of up to 20 years.

10.4.2.2 Agricultural Drainage Management Loan Program

The Agricultural Drainage Management Loan Program, created by Proposition 204 and distributed through the Agricultural Drainage Management Subaccount, provides loan and grant funding for Drainage Water Management Units. Drainage Water Management Units are land and facilities for the treatment, storage, conveyance, reduction or disposal of agricultural drainage water that, if discharged untreated, would pollute or threaten to pollute the waters of the State. This program is available to any city, county, district, joint power authority, or other political subdivision of the State involved with water management.

10.4.2.3 Agricultural Water Quality Grants Program

The Agricultural Water Quality Grant Program provides funding for projects that reduce or eliminate non-point source pollution discharge to surface waters from agricultural lands. Funding from Propositions 40 and 50 were administered through two solicitations, most recently the 2005-2006 Consolidated Grants Process. Additional funds will be made available in the future through Proposition 84.

10.4.2.4 Federal Clean Water Act Section 319 Nonpoint Source Implementation Program

This program is an annual federally funded nonpoint source pollution control program that is focused on controlling activities that impair beneficial uses and on limiting pollutant effects caused by those activities. States must establish priority rankings for waters on lists of impaired waters and develop action plans, known as Total Maximum Daily Loads (TMDLs), to improve water quality. Project proposals that address TMDL implementation and those that address problems in impaired waters are favored in the selection process. There is also a focus on implementing management activities that lead to reduction and/or prevention of pollutants that threaten or impair surface and ground waters.

10.4.2.5 Clean Water State Revolving Fund

The Federal Water Pollution Control Act (Clean Water Act or CWA), as amended in 1987, provides for establishment of a Clean Water State Revolving Fund (CWSRF) program. The program is funded by federal grants, State funds, and Revenue Bonds. The purpose of the CWSRF program is to implement the CWA and various State laws by providing financial assistance for the construction of facilities or implementation of measures necessary to address water quality problems and to prevent pollution of the waters of the State.

The CWSRF Loan Program provides low-interest loan funding for construction of publicly-owned wastewater treatment facilities, local sewers, sewer interceptors, water recycling facilities, as well as, expanded use projects such as implementation of nonpoint source (NPS) projects or programs, development and implementation of estuary Comprehensive Conservation and Management Plans, and storm water treatment.

10.4.3 Summary of Pertinent Federal Funding Programs

Several federal agencies, including but not limited to the U.S. Environmental Protection Agency, NOAA Fisheries, U.S. Fish and Wildlife Service, and USDA Natural Resources Conservation Service, also provide grants and other funding opportunities. The U.S. Environmental Protection Agency provides access through its webpage to a catalog of federal funding opportunities: <http://cfpub.epa.gov/fedfund/>. Table 10.7 lists the federal funding programs pertinent to the water quality protection work required in the Klamath River watershed.

Table 10.7: Summary of pertinent federal funding programs

Funding Program	Program Description	FY2009 Funds
Aquatic Ecosystem Restoration (CAP Section 206)	Work under this authority may carry out aquatic ecosystem restoration projects that will improve the quality of the environment, are in the public interest, and are cost-effective. There is no requirement that an existing Corps project be involved	$28.7 million
Bring Back the Natives Grant Program	The Bring Back the Natives initiative (BBN) funds on-the-ground efforts to restore native aquatic species to their historic range. Projects should involve partnerships between communities, agencies, private landowners, and organizations that seek to rehabilitate streamside and watershed habitats. Projects should focus on habitat needs of species such as fish, invertebrates, and amphibians that originally inhabited the waterways across the country. Funding for the BBN program is administered through NFWF from federal agencies cooperating to support this program. Cooperating agencies and organizations include the US Fish and Wildlife Service (USFWS), Bureau of Land Management (BLM), USDA Forest Service (USFS), and Trout Unlimited (TU).	TBD

Table 10.7 (cont.): Summary of pertinent federal funding programs

Funding Program	Program Description	FY2009 Funds
Coastal Program	The U.S. Fish and Wildlife Service (USFWS) Coastal Program works to conserve healthy coastal habitats on public or private land for the benefit of fish, wildlife, and people in 22 specific coastal areas. The program forms cooperative partnerships designed to (1) protect costal habitats by providing technical assistance for conservation easements and acquisitions; (2) restore coastal wetlands, uplands, and riparian areas; and (3) remove barriers to fish passage in coastal watersheds and estuaries. Program biologists provide restoration expertise and financial assistance to federal and state agencies, local and tribal governments, businesses, private landowners, and conservation organizations such as local land trusts and watershed councils.	$14.74 million
Community-based Habitat Restoration Partnership Grants	The NOAA Community-based Restoration Program (NOAA CRP) provides funds for small-scale, locally driven habitat restoration projects that foster natural resource stewardship within communities. The program seeks to bring together diverse partners to implement habitat restoration projects to benefit living marine resources. Projects might include restoring salt marshes, mangroves, and other coastal habitats; improving fish passage and habitat quality for anadromous species; removing dams; restoring and creating oyster reefs, removing exotic vegetation and replanting with native species; and similar projects to restore habitat or improve habitat quality for populations of marine and anadromous fish.	$6.3 million
Conservation Reserve Program	The Conservation Reserve Program (CRP) is a voluntary program for agricultural landowners. Through CRP, you can receive annual rental payments and cost-share assistance to establish long-term, resource conserving covers on eligible farmland.	$1.9 billion
Conservation Security Program	The Conservation Security Program (CSP) is a voluntary conservation program that supports ongoing stewardship of private lands by providing payment for maintaining and enhancing natural resources. CSP identifies and rewards those farmers and ranchers who are meeting the highest standards of conservation and environmental management on their operations.	$283 million
Emergency Watershed Protection	The USDA Natural Resources Conservation Service's Emergency Watershed Protection (EWP) program helps protect lives and property threatened by natural disasters such as floods, hurricanes, tornadoes, droughts, and wildfires. EWP provides funding for such work as clearing debris from clogged waterways, restoring vegetation, and stabilizing river banks. The measures that are taken must be environmentally and economically sound and generally benefit more than one property owner. EWP also provides funds to purchase floodplain easements as an emergency measure. Floodplain easements restore, protect, maintain, and enhance the functions of the floodplain; conserve natural values including fish and wildlife habitat, water quality, flood water retention, ground water recharge, and open space; reduce long-term federal disaster assistance; and safeguard lives and property from floods, drought, and the products of erosion. EWP can provide up to 90 percent cost share in limited resource areas as determined by the US Census.	TBD (Total funding depends on the amount of emergency funds requested during the fiscal year)

Table 10.7 (cont.): Summary of pertinent federal funding programs

Funding Program	Program Description	FY2009 Funds
Environmental Quality Incentives Program	The USDA Natural Resources Conservation Service's Environmental Quality Incentives Program (EQIP) was established to provide a voluntary conservation program for farmers and ranchers to address significant natural resource needs and objectives. EQIP offers contracts with a minimum term that ends one year after the implementation of the last scheduled practices and a maximum term of ten years. These contracts provide financial assistance to program participants to implement conservation practices. Persons or legal entities, who are owners of land under agricultural production or who are engaged in livestock or agricultural production on eligible land may participate in EQIP. EQIP activities are carried out according to an environmental quality incentives program plan of operations developed in conjunction with the producer that identifies the appropriate conservation practice or practices to address the resource concerns. The practices are subject to NRCS technical standards adapted for local conditions. NRCS approves the plan of operations and obligates contract funds for the conservation practices listed in the plan of operations.	$1.067 billion
Farm and Ranch Lands Protection Program (FRPP)	The USDA Natural Resources Conservation Service's Farmland Protection Program (FPP) is a voluntary program that helps farmers and ranchers keep their land in agriculture and prevents conversion of agricultural land to non-agricultural uses. The program provides matching funds to organizations with existing farmland protection programs that enable them to purchase conservation easements. These entities purchase easements from landowners in exchange for a lump sum payment, not to exceed the appraised fair market value of the land's development rights. The easements are for perpetuity unless prohibited by state law. Eligible land is land on a farm or ranch that has prime, unique, statewide, or locally important soil or contains historical or archaeological resources; supports the policy of a State or local farm and ranch land protection policy; is subject to a pending offer by an eligible entity; and includes cropland, rangeland, grassland, pasture land, forest land and other incidental land that is part of an agricultural operation.	$105 million (for technical and financial assistance)
Five-Star Restoration Program	The EPA supports the Five-Star Restoration Program by providing funds to the National Fish and Wildlife Foundation and its partners, the National Association of Counties, NOAA's Community-based Restoration Program and the Wildlife Habitat Council. These groups then make subgrants to support community-based wetland and riparian restoration projects. Competitive projects will have a strong on-the-ground habitat restoration component that provides long-term ecological, educational, and/or socioeconomic benefits to the people and their community. Preference will be given to projects that are part of a larger watershed or community stewardship effort and include a description of long-term management activities. Projects must involve contributions from multiple and diverse partners, including citizen volunteer organizations, corporations, private landowners, local conservation organizations, youth groups, charitable foundations, and other federal, state, and tribal agencies and local governments. Each project would ideally involve at least five partners who are expected to contribute funding, land, technical assistance, workforce support, or other in-kind services that are equivalent to the federal contribution.	$300,000

Table 10.7 (cont.): Summary of pertinent federal funding programs

Funding Program	Program Description	FY2009 Funds
Healthy Forests Reserve Program	The Healthy Forests Reserve Program (HFRP) is a voluntary program established for the purpose of restoring and enhancing forest ecosystems to: 1) promote the recovery of threatened and endangered species, 2) improve biodiversity; and, 3) enhance carbon sequestration. Program implementation has been delegated by the Secretary of Agriculture to the Natural Resources Conservation Service.	TBD
Forest Legacy Program	Through its Forest Legacy Program (FLP), the USDA Forest Service supports state efforts to protect environmentally sensitive forest lands from the conversion to non-forest uses through the use of conservation easements and fee-simple purchase. Designed to encourage the protection of privately owned forest lands, FLP is an entirely voluntary program. The program enables landowners to retain ownership of their land and continue to earn income from it while keeping drinking water safe and clean, conserving valuable open space as well as protecting critical wildlife habitats and outdoor recreation opportunities. The program promotes professional forest management and requires forest management plans. The program emphasizes strategic conservation - working in partnership with States, local communities and non-governmental organizations to make a difference on the land and for communities by conserving areas of unbroken forest, watershed or river corridor forests or by complimenting existing land conservation efforts. FLP conservation easements restrict development, protect a range of public values and many require public access for recreation.	$57 million
NOAA Open Rivers Initiative	The NOAA Open Rivers Initiative (ORI) provides funding and technical expertise for community-driven, small dam and river barrier removals, primarily in coastal states. Projects are expected to provide an economic boost for communities, enhance public safety, and improve populations of NOAA trust resources such as striped bass, Atlantic and shortnose sturgeon, Atlantic and Pacific salmon, American eel, American shad, blueback herring, and alewife. Proposals selected will be implemented through a cooperative agreement	$7 million
National Integrated Water Quality Program (NIWQP)	The National Integrated Water Quality Program (NIWQP) provides funding for research, education, and extension projects aimed at improving water quality in agricultural and rural watersheds. The NIWQP has identified eight "themes" that are being promoted in research, education and extension. The eight themes are (1) Animal manure and waste management (2) Drinking water and human health (3) Environmental restoration (4) Nutrient and pesticide management (5) Pollution assessment and prevention (6) Watershed management (7) Water conservation and agricultural water management (8) Water policy and economics. Awards are made in four program areas - National Facilitation Projects, Regional Coordination Projects, Extension Education Projects, and Integrated Research, Education and Extension Projects. Please note that funding is only available to universities.	$12 million

Table 10.7 (cont.): Summary of pertinent federal funding programs

Funding Program	Program Description	FY2009 Funds
National Wildlife Refuge Friends Group Grant Program	The National Fish and Wildlife Foundation provides grants for projects that help organizations to be effective co-stewards of our Nation's important natural resources within the National Wildlife Refuge System. This program provides competitive seed grants to help increase the number and effectiveness of organizations interested in assisting the refuge system nationwide. The program will fund: (1) Start-up Grants to assist starting refuge support groups with formative and/or initial operational support (membership drives, training, postage, etc.); (2) Capacity Building Grants to strengthen existing refuge support groups' capacity to be more effective (outreach efforts, strategic planning, membership development); and (3) Project Specific Grants to support a specific project (conservation education programs for local schools, outreach programs for private landowners, habitat restoration projects, etc.)	TBD
Native Plant Conservation Initiative	The National Fish and Wildlife Foundation's Native Plant Conservation Initiative (NPCI) supports on-the-ground conservation projects that protect, enhance, and/or restore native plant communities on public and private land. Projects typically fall into one of three categories and may contain elements of each: protection and restoration, information and education, and inventory and assessment. Applicants are encouraged, when appropriate, to include a pollinator component in their project. This program is funded by the Bureau of Land Management, Forest Service, Fish and Wildlife Service, and National Park Service.	TBD
North American Wetlands Conservation Act Grants Program	The U.S. Fish and Wildlife Service's Division of Bird Habitat Conservation administers this matching grants program to carry out wetlands and associated uplands conservation projects in the United States, Canada, and Mexico. Grant requests must be matched by a partnership with nonfederal funds at a minimum 1:1 ratio. Conservation activities supported by the Act in the United States and Canada include habitat protection, restoration, and enhancement. Mexican partnerships may also develop training, educational, and management programs and conduct sustainable-use studies. Project proposals must meet certain biological criteria established under the Act. Visit the program web site for more information. (Click on the hyperlinked program name to see the listing for "Primary Internet".)	$83 million
Partners for Fish and Wildlife Program	The Partners for Fish and Wildlife Program provides technical and financial assistance to private landowners to restore fish and wildlife habitats on their lands. Since 1987, the program has partnered with more than 37,700 landowners to restore 765,400 acres of wetlands; over 1.9 million acres of grasslands and other upland habitats; and 6,560 miles of in-stream and streamside habitat. In addition, the program has reopened stream habitat for fish and other aquatic species by removing barriers to passage.	TBD

Table 10.7 (cont.): Summary of pertinent federal funding programs

Funding Program	Program Description	FY2009 Funds
Pesticide Environmental Stewardship Grants	EPA's Pesticide Environmental Stewardship Program (PESP) offers grants to support the reduction of risks from pesticides in agricultural and non-agricultural settings, and to implement pollution prevention measures. All organizations with a commitment to pesticide risk reduction are eligible to join PESP as members, either as Partners or as Supporters. For more information about membership requirements and available grants, click on the program name and refer to the link listed under "Primary Internet."	$500,000
Project Modifications for Improvement of the Environment (CAP Section 1135)	Work under this authority provides for modifications in the structures and operations of water resources projects constructed by the Corps of Engineers to improve the quality of the environment. Additionally, the Corps may undertake restoration projects at locations where an existing Corps project has contributed to the degradation. The primary goal of these projects is ecosystem restoration with an emphasis on projects benefiting fish and wildlife. The project must be consistent with the authorized purposes of the project being modified, environmentally acceptable, and complete within itself	$28.7 million
Pulling Together Initiative	The National Fish and Wildlife Foundation's Pulling Together Initiative (PTI) provides a means for federal agencies to partner with state and local agencies, private landowners, and other interested parties to develop long-term weed management projects within the scope of an integrated pest management strategy. The goals of PTI are: (1) to prevent, manage, or eradicate invasive and noxious plants through a coordinated program of public/private partnerships; and (2) to increase public awareness of the adverse impacts of invasive and noxious plants. PTI provides support on a competitive basis for the formation of local weed management area (WMA) partnerships, allowing them to demonstrate successful collaborative efforts and develop permanent funding sources for the maintenance of WMAs from the involved parties. Successful projects will serve to increase public awareness and interest in future partnership projects.	TBD
Watershed Protection and Flood Prevention Program	Also known as the 'Watershed Program' or the 'PL 566 Program,' this program provides technical and financial assistance to address water resource and related economic problems on a watershed basis. Projects related to watershed protection, flood mitigation, water supply, water quality, erosion and sediment control, wetland creation and restoration, fish and wildlife habitat enhancement, agricultural water conservation, and public recreation are eligible for assistance. Technical and financial assistance is also available for planning new watershed surveys.	$40 million

Table 10.7 (cont.): Summary of pertinent federal funding programs

Funding Program	Program Description	FY2009 Funds
Sustainable Agriculture Research and Education	The Sustainable Agriculture Research and Education (SARE) program of the U.S. Department of Agriculture works to advance farming systems that are more profitable, environmentally sound and good for communities through an innovative grants program. More specifically, SARE funds scientific investigation and education to reduce the use of chemical pesticides, fertilizers, and toxic materials in agricultural production; to improve management of on-farm resources to enhance productivity, profitability, and competitiveness; to promote crop, livestock, and enterprise diversification and to facilitate the research of agricultural production systems in areas that possess various soil, climatic, and physical characteristics; to study farms that have are managed using farm practices that optimize on-farm resources and conservation practices; and to promote partnerships among farmers, nonprofit organizations, agribusiness, and public and private research and extension institutions. Click on program name and check the link in the Primary Internet box for more information about grant opportunities and program results.	$14.4 million
Watershed Rehabilitation Program	This program provides Federal cost-share funding for the rehabilitation of aging dams that were installed primarily through the Watershed Protection and Flood Prevention Program over the past 55 years. The purpose for rehabilitation is to extend the service life of dams and bring them into compliance with applicable safety and performance standards or to decommission the dams so they no longer pose a threat to life and property.	$40 million through the FY2009 Appropriations, $50 million through the American Recovery and Reinvestment Act
Watershed Rehabilitation Program	This program provides Federal cost-share funding for the rehabilitation of aging dams that were installed primarily through the Watershed Protection and Flood Prevention Program over the past 55 years. The purpose for rehabilitation is to extend the service life of dams and bring them into compliance with applicable safety and performance standards or to decommission the dams so they no longer pose a threat to life and property.	$40 million through the FY2009 Appropriations, $50 million through the American Recovery and Reinvestment Act
Wetlands Reserve Program	Through this voluntary program, the USDA Natural Resources Conservation Service (NRCS) provides landowners with financial incentives to restore and protect wetlands in exchange for retiring marginal agricultural land. To participate in the program landowners may sell a conservation easement or enter into a cost-share restoration agreement (landowners voluntarily limit future use of the land, but retain private ownership). Landowners and the NRCS jointly develop a plan for the restoration and maintenance of the wetland.	$500 million

Table 10.7 (cont.): Summary of pertinent federal funding programs

Funding Program	Program Description	FY2009 Funds
Wildlife Habitat Incentives Program	The Wildlife Habitat Incentives Program (WHIP) is a voluntary program for people who want to develop and improve wildlife habitat on private lands. It provides both technical assistance and cost sharing to help establish and improve fish and wildlife habitat. Participants work with USDA's Natural Resources Conservation Service to prepare a wildlife habitat development plan in consultation with a local conservation district. The plan describes the landowner's goals for improving wildlife habitat, includes a list of practices and a schedule for installing them, and details the steps necessary to maintain the habitat for the life of the agreement.	$74 million

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CHAPTER 10. REFERENCES

Agreement In Principle. 2008. Entered into by PacifiCorp, the State of Oregon, the California Resources Agency, and the United States of America on November 13, 2008.

Fitzgerald, R. 2005. Memorandum from R. Fitzgerald of the North Coast Regional Water Quality Control Board to Gerald Horner, OSI regarding Erosion Control Plan costs for the Scott TMDL. August 29, 2005.

Harris Blade Rental. Personal communication from Lauren Clyde of the North Coast Regional Water Quality Control Board via telephone to Harris Blade Rental, Livermore, CA on June 30, 2009.

Natural Resources Conservation Service. 2008. "California Approved Fiscal Year 2008 Payment Schedule" provided by Jim Patterson of the Siskiyou County District of the Natural Resources Conservation Service.

Siskiyou Country Public Works. 2008. Road Cost Information. Facsimile sent by Scott Sumner, Deputy Director of Public Works, Siskiyou County, 9/12/2008.

Sunding, D. and A. P. Zwane. 2004. Cost and Socioeconomic Impacts of Implementing the California Coho Salmon Recovery Strategy. *IN:* California Department of Fish and Game. Recovery Strategy for California Coho Salmon: Report to the California Fish and Game Commission. Sacramento, CA. 1Appendix 1.

Vassey, Sheila K. 1999. Memorandum to Stefan Lorenzato, TMDL Coordinator, Division of Water Quality, State Water Resources Control Board from Sheila K. Vassey, Senior Staff Counsel, Office of Chief Counsel, State Water Resources Control Board regarding "Economic Considerations in TMDL Development and Basin Planning" dated October 27, 1999.

Weaver, W. and D. Hagans. 2004. Road Upgrading, Decommissioning and Maintenance—Estimating Costs on Small and Larges Scales. *IN:* Allen, S.T., C. Thomson, and R. Carlson, eds. Proceedings of the Salmon Habitat Restoration Cost Workshop. November 14-16, 2000; Gladstone, OR. Pacific States Marine Fisheries Commission

Weaver, B., Hagans, D., and Weppner, E. 2006. Salmonid Stream Habitat Restoration Manual Part X: Upslope Erosion Inventory and Sediment Control Guidance. California Department of Fish and Game, Inland Fisheries Division. Sacramento, CA.

CHAPTER 11. PUBLIC PARTICIPATION

This chapter describes some of the opportunities that have been made available to the public for comment on and participation in the development of the Klamath River TMDL Staff Report and Action Plan as well as the recalculated Site Specific Objective (SSO) for dissolved oxygen (DO). (See Appendix 1)

11.1 Public Outreach

Regional Water Board staff have held numerous meetings to update and inform the public throughout the Klamath River TMDL development process and recalculated SSO for DO in the mainstem Klamath. Opportunities for public participation in the recalculation of the SSOs for DO in the mainstem Klamath began in 2009 when staff efforts first began on this separate project. The first public outreach meeting related to the Klamath River TMDLs was held on February 25, 2004 in Yreka, California. Since that time there have been 17 additional outreach meetings held in various locations throughout the Klamath River basin and the North Coast Region, the most recent meeting occurring on July 9, 2009. A complete list of the public meetings that have been held about the Klamath River TMDL is presented in Table 11.1.

Table 11.1: Public meetings for the Klamath River TMDL

Subject	Date	Location
Klamath and Lost River TMDL Development Kick-off	February 25, 2004	Yreka, CA
	February 26, 2004	Klamath Falls, OR
	March 2, 2004	Fortuna, CA
Klamath River TMDL Water Quality Models Scoping Meeting	August 4, 2005	Yreka, CA
CEQA Scoping Meetings for the Klamath River TMDL	February 16, 2006	Yreka, CA
	March 1, 2006	Eureka, CA
	July 18, 2006	Orleans, CA
	January 11, 2007	Santa Rosa, CA
	January 12, 2007	San Francisco, CA
Scoping for Klamath River TMDL Implementation	March 3, 2009	Klamath, CA
	March 3, 2009	Arcata, CA
	March 4, 2009	Tulelake, CA
	March 5, 2009	Montague, CA
	March 12, 2009	Santa Rosa, CA
June 2009 Public Review Draft of the Klamath River TMDL and SSO for DO	July 6, 2009	Klamath Falls, CA
	July 7, 2009	Yreka, CA
	July 8, 2009	Orleans, CA
	July 9, 2009	Klamath, CA

11.1.1 CEQA Scoping Meetings

The purpose of the California Environmental Quality Act (CEQA) Scoping Meetings was to solicit public comments to help staff assess the potential environmental scope of the environmental analysis. Holding a scoping meeting is a requirement of the CEQA. Given the vast expanse of the Klamath River basin and the statewide and national interest in Klamath River issues, Regional Water Board held several Scoping Meetings throughout the basin, as well as meetings outside the basin, to ensure that all parties who wished to give input would have an opportunity to do so. Table 11.1 summarizes the scoping meetings for the Klamath River TMDL. The comments received at the CEQA Scoping Meetings that concerned the scope of the environmental review are summarized in Chapter 9. These comments, and others, helped to shape the scope of the environmental review and specific aspects of the analysis.

11.1.2 Klamath River TMDL Webpage

In addition to holding public meetings, Regional Water Board staff have maintained a webpage on the North Coast Regional Water Quality Control Board's website where the latest, up-to-date information on the Klamath River TMDL development process can be found. Fact Sheets, which contain summary information on the TMDL development process in the Klamath River basin, are also located on the website. The first Fact Sheet was posted in November 2004. There have been six updates to the fact sheets since that time, the latest on January 27, 2006. The website can be accessed at: <http://www.waterboards.ca.gov/northcoast/water_issues/programs/TMDL/klamath_river/>.

11.2 Presentations to the Regional Water Board

Periodically, Regional Water Board staff have presented updates and status reports to the Regional Water Board and interested members of the public on the Klamath River TMDL. The presentations were opportunities for the public and Board members to hear status updates and background information regarding progress and emerging issues related to the TMDL development process. At each of these meetings, the public also had the opportunity to give comment before the Board. All such comments are part of the public record. Table 11.2 presents a complete list of the presentations given to the Regional Water Board about various aspects of Klamath River TMDL development.

Table 11.2: Presentations given at Regional Water Board meetings

Subject	Date	Location
Status Report on TMDL Development	February 10, 2004	Santa Rosa, CA
Update on Issues and Activities in the Klamath River Basin	August, 25, 2004	Crescent City, CA
Update on Klamath Basin TMDL	May 4, 2005	Weaverville, CA
Klamath River TMDL, Klamath River Fish Kill and Fish Disease Overview, & Update on Klamath River Blue Green Algae	November 29, 2006	Santa Rosa, CA
Update on Development of Klamath River TMDL	July 24, 2008	Santa Rosa, CA
Update on Administrative Draft Klamath River Temperature TMDL	September 11, 2008	Santa Rosa, CA
Update on Administrative Draft Klamath River DO, Organic Matter, Nutrients, and Chlorophyll-a TMDL	December 11, 2008	Santa Rosa, CA
Klamath River TMDL Implementation Plan Summary/Scoping	January 29, 2009	Santa Rosa, CA
Workshop on the Klamath River TMDLs and SSO for DO	July 23, 22009	Santa Rosa, CA

Table 11.2 (cont.): Presentations given at Regional Water Board meetings

Subject	Date	Location
Workshop on the Klamath River TMDLs and SSO for DO	September 10, 2009	Grenada, CA
Update on Klamath River TMDLs and Site Specific Dissolved Oxygen Objective Schedule	October 1, 2009	Santa Rosa, CA
Update on Klamath River TMDLs Water Quality Modeling Technical Analysis	December 10, 2009	Santa Rosa, CA

11.3 Presentations to Various Organizations and Conferences

In order to reach a broad audience regarding the details of the Klamath River TMDL, Regional Water Board staff have presented updates on the TMDL at public meetings held by other organizations and agencies. Additionally, staff have given presentations at conferences specifically focused on the Klamath River basin, as well as science conferences pertaining to water quality protection. A complete list of these presentations is available in Table 11.3.

Table 11.3: Presentations given at other organization's public meetings and conferences

Subject	Date	Venue
Klamath Basin TMDL	October 1, 2002	Siskiyou County Board of Supervisors, Yreka, CA
Klamath and Lost River TMDLs	January 22, 2004	Klamath Environmental Coalition, Yreka, CA
Klamath, Shasta, Scott, and Salmon River TMDLs	June 9, 2004	Lower Klamath Basin Science Conference, Arcata, CA
Klamath River TMDL	June 24, 2004	Klamath River Basin Fisheries Task Force Meeting, Klamath Falls, OR
Klamath River TMDL	December 7, 2004	Klamath River Technical Work Group, Yreka, CA
Klamath River TMDL	June 15, 2005	Klamath River Basin Fisheries Task Force Meeting, Yreka, CA
Klamath River TMDL	October 19, 2005	Klamath River Basin Fisheries Task Force Meeting, Klamath Falls, OR
Klamath River TMDL	February 9, 2006	Klamath River Basin Fisheries Task Force Meeting, Brookings, OR
Klamath River TMDL	September 13, 2006	Protecting California's Waters, University of California Davis
Klamath River TMDL and 401 Certification	October 12, 2006	Klamath Basin Informational Policy Tour, Klamath, CA
Klamath River TMDL	November 7, 2006	Klamath Watershed Conference, Redding, CA
Klamath River TMDL	January 29, 2007	National Research Council, Committee on Hydrology, Ecology, and Fishes of the Klamath River Basin, Klamath Falls, OR
Characterizing Natural Conditions of Klamath River for TMDL Development	June 25, 2007	Water Environment Federation, TMDL 2007 Conference, Seattle, WA
Klamath River TMDL	December 2007	Presentation by ODEQ at Upper Klamath Basin Annual Science Review, Klamath Falls, OR

Table 11.3 (cont.): Presentations given at other organization's public meetings and conferences

Subject	Date	Venue
Klamath River TMDL Draft Monitoring Framework	December 4, 2008	Klamath Basin Water Quality Monitoring Coordination Group, Ashland, OR
Klamath River TMDL	April 6, 2009	Upper Mid Klamath Watershed Council, Montague, CA
Klamath River TMDL	April 7, 2009	Siskiyou County Board of Supervisors, Yreka, CA

11.4 Other Meetings about the Klamath River TMDL

There have been numerous targeted stakeholder meetings to discuss the progress of the Klamath River TMDL and SSOs for DO with individual agencies and organizations including, but not limited to, PacifiCorp, California Department of Fish and Game, U.S. Forest Service, U.S. Bureau of Reclamation, the North Coast California Consent Decree Plaintiffs, and watershed groups such as the Upper Mid Klamath Watershed Council.

The USEPA and the Regional Water Board have initiated an informal consultation process with the U.S. Fish and Wildlife Service (USFWS) and the National Oceanic and Atmospheric Administration, Fisheries (NOAA Fisheries) on Klamath River TMDL and SSOs for DO. Regional Water Board and USEPA staff have used this process to provide information and updates on the TMDL and SSOs for DO.

The USEPA and Regional Water Board have also held regular meetings with representatives of the Klamath River basin tribes in California to provide updates on the TMDL process, as part of USEPA's tribal trust responsibilities. These meetings have been held approximately quarterly since 2004.

Finally, there has been and continues to be informal contact with many individuals and organizations active in the Klamath River basin.

11.5 Peer Review

Prior to development of the Public Review Draft of the Klamath River TMDL Staff Report, a peer- review draft report was reviewed by the following four PhDs as part of a formal state-mandated peer-review process:

- Dr. Gregory Characklis, Professor of Environmental Sciences and Engineering at the University of North Carolina;
- Dr. G. Mathias Kondolf, Professor of Environmental Planning and Geography at the University of California, Berkeley;
- Dr. Christopher A. Myrick, Associate Professor of Fishery Biology at Colorado State University; and
- Dr. Desiree Tullos, Assistant Professor of Biological and Ecological Engineering at Oregon State University.

Responses to the peer-review comments from these reviewers are presented in Appendix 8.
For a discussion of peer review of the revised DO objective, please see Appendix 1.

11.6 June 2009 Public Review Draft

Chapters 1-3 and five appendices of the June 2009 Public Review Draft of the Staff Report were posted on the Regional Water Board website on June 15, 2009. Additional Chapters and Appendices were posted as they were completed, with the final Chapters of the Staff Report and the Action Plan available for public review and comment on July 9, 2009.

The public review period for the Staff Report and Action Plan was initially set to close on August 17, 2009. However, the review period was extended twice to allow for the full legally required review period. The first extension was to August 23, 2009, and finally the public review and comment period was extended to August 27, 2009. This final extension allowed for a 74 day review period from the time the first Chapters and appendices were posted (June 15, 2009), and a 50 day review period once the complete Staff Report and Action Plan were available on the Regional Water Board website (July 9, 2009).

The June 2009 Public Review Draft release and public comment period dates are summarized below.

June 2009 Public Review Draft Release: First Postings:....... June 15, 2009
Final Chapters Posted: ....July 9, 2009

End of June 2009 Public Review Draft Comment Period ....August 27, 2009
Total Comment Period: 50 days

11.7 December 2009 Public Review Draft and Opportunities for Input

The December 2009 Public Review Drafts, including Appendix 1 (recalculated SSO for DO in the mainstem Klamath) was released on December 23, 2009 for public review and comment. Throughout the Basin Plan amendment process, there are opportunities for public participation and comment, including at the CEQA scoping meetings, at the Regional Water Board and associated workshops prior to the Regional Water Board hearing for the proposed TMDL Basin Plan amendment, at the Regional Water Board hearing to consider adoption of the TMDL Basin Plan amendment, before the State Water Board, and during public forum at any Regional Water Board meeting. The following opportunities and their estimated dates remain for public comment on the proposed Klamath River TMDL Basin Plan amendment. Please note that the following dates and meeting locations may change and additional meetings may be scheduled. Interested parties should check the Regional Water Board website for announcements regarding Regional Water Board meetings, revisions to the DO objectives, and the Klamath River TMDL at: http://www.waterboards.ca.gov/northcoast/.

End of December 2009 Public Review Draft Comment Period	February 9, 2010
December 2009 Public Review Draft Regional Water Board Workshop in Yreka, CA	January 27, 2010
Public Adoption Hearing before the Regional Water Board in Eureka, CA	March 24-25, 2010
Public Adoption Workshop and Hearing before the State Water Resources Control Board in Sacramento, CA	To Be Determined

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APPENDIX 1

STAFF REPORT
for the
PROPOSED
SITE SPECIFIC DISSOLVED OXYGEN OBJECTIVES
for the
KLAMATH RIVER IN CALIFORNIA

March 2010

State of California
North Coast Regional Water Quality Control Board
5550 Skylane Boulevard, Suite A
Santa Rosa, California 95403
707-576-2220
www.waterboards.ca.gov/northcoast

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EXECUTIVE SUMMARY

Ambient water quality objectives for the Klamath River are contained in Table 3-1 of the *Water Quality Control Plan for the North Coast Region* otherwise known as the Basin Plan. The existing site specific objectives (SSOs) for dissolved oxygen (DO) in the Klamath River were developed based on grab sample data collected during the 1950s and 1960s and represent the elevated, sometime supersaturated, DO conditions typically found during the day when photosynthesis is active. Twenty four-hour DO data collected using DataSonde data probes can not reasonably be compared to the existing SSOs for DO. Further, conditions of barometric pressure and temperature prevent the attainment of the existing SSOs for DO in some locations during some times of the year. Finally, the T1BSR natural conditions run of the *Klamath TMDL model* indicates that under natural conditions, the ambient DO concentrations are frequently less than the existing SSOs for DO.

This Staff Report assesses the DO objectives for the mainstem Klamath, analyzes new DO information, evaluates several alternative methods for recalculating the SSOs for DO, and proposes a recalculated SSO for DO in the mainstem Klamath River. The proposed recalculated SSOs for DO are achievable under natural conditions and are protective of the beneficial uses of the watershed. The proposed recalculated SSOs for DO are based on the natural DO conditions in the basin as estimated using percent saturation and natural receiving water temperatures. Based on natural conditions, the recalculated SSOs for DO necessarily protect any beneficial uses which naturally are or were present in the basin prior to anthropogenic disruption. In a memorandum dated November 5, 1997, Tudor Davies, Director of the Office of Science and Technology at USEPA headquarters in Washington, D.C. corroborates this approach by saying: “For aquatic life uses, where the natural background concentration for a specific parameter is documented, by definition that concentration is sufficient to support the level of aquatic life expected to occur naturally at the site absent any interference by humans.” (p. 2)

The proposed alternative is Alternative 3 which is summarized below. It is to apply to the maximum extent allowed by law. To the extent that the State lacks jurisdiction, the proposed SSO is extended as a recommendation to the applicable regulatory authority."

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Location	Percent DO Saturation Based on natural receiving water temperatures	Time period
Stateline to Scott River	90%	October 1 through March 31
	85%	April 1 through September 30
Scott River to Hoopa	90%	Year round
Hoopa to Turwar	90%	September 1 through May 31
	85%	June 1 through August 31
Upper and Middle Estuary	80%	August 1 through August 31
	85%	September 1 through October 31 and June 1 through July 31
	90%	November 1 through May 31
Lower Estuary	For the protection of estuarine habitat (EST), the dissolved oxygen content of the lower Klamath estuary shall not be depressed to levels adversely affecting beneficial uses as a result of controllable water quality factors.	

Table 7.4 of the Staff Report presents the DO concentrations corresponding to the percent saturation criteria as based on estimates of natural receiving water temperatures contained in the *Klamath TMDL model.*

National Criteria for the protection of early life stages of coldwater organisms require: 9.5 mg/L DO as a 7-day mean in the water column, 6.5 mg/L as a 7-day mean in the intergravel environment, 8.0 mg/L as a 1-day minimum in the water column and 5.0 mg/L as a daily minimum in the intergravel environment. For the protection of other life stages of coldwater organisms, the National Criteria require 6.5 mg/L DO as a 30-day mean, 5.0 mg/L as a 7-day mean of the daily minima, and 4.0 mg/L as a 1-day minimum. US Environmental Protection Agency (USEPA 1986) provides guidance on the development of alternate aquatic life criteria for DO based on the degree to which local criteria must protect against any production impairment, or can allow for slight or moderate production impairment. USEPA (1986) also allows that "where natural conditions alone create dissolved oxygen concentrations less than 110 percent of the applicable criteria means or minima or both, the minimum acceptable concentration is 90 percent of the natural concentration." (p. 35)

Staff compared simulated DO concentrations under natural conditions as produced by the T1BSR natural conditions run of the *Klamath TMDL model* to the National Criteria. Simulated DO concentrations under natural conditions meet a 4.0 mg/L daily minimum all year long, as well as 6.5 mg/L as a 30-day mean. From October to March, simulated natural DO concentrations also meet an 8.0 mg/L daily minimum protecting incubating salmonids. An 8.0 mg/L daily minimum is even met from September through May with exceptions from a location upstream of Iron Gate Dam to a location upstream of the Shasta River. The spawning and incubation period in the Klamath mainstem is generally estimated to last from October 1 through April 30, with the possibility of inter-annual variation.

The DO modeling output does not provide a convenient way of assessing consistency with the 7-day mean National Criteria. But, if the 9.5 mg/L DO criteria is increased to 10.0 and applied as a 30-day mean, simulated DO concentrations under natural conditions as produced by the T1BSR natural conditions run of the *Klamath TMDL model* meets the criteria from November 1 through March 31 at all locations and from October 1 through April 1 at all locations from Seiad to the Lower Estuary.

While simulated natural DO concentrations generally meet the National Criteria, staff believe that the threatened and endangered status of salmonids in the basin require the establishment of DO objectives based on protection against any further production impairment. The T1BSR run of the *Klamath TMDL model,* however, demonstrates that the mainstem Klamath River under natural conditions does not consistently produce DO consistent with no production impairment, as defined by USEPA (1986). As such, staff proposes DO criteria based on natural conditions. As described by Davies (1997) for aquatic life uses, by definition natural conditions are sufficient to support the level of aquatic life expected to occur naturally at the site absent any interference by humans.

The biochemical processes influencing ambient DO concentrations are complex and difficult to simulate site-specifically with perfect accuracy. As such, staff estimated natural DO conditions using percent saturation and natural receiving water temperatures. Receiving water temperatures can be estimated with greater accuracy than can DO and are comparatively consistent in pattern and range from year to year. The *Klamath TMDL model* simulates percent saturation at various locations throughout the mainstem Klamath as a result of barometric pressure, salinity, and natural temperatures at those locations, as influenced by boundary conditions for percent saturation estimated from historical data. The mainstem Klamath under natural conditions meets a minimum percent DO saturation of 85% throughout its length (with an exception during August in the estuary) and 90% during the winter months.

The proposed recalculated SSOs for DO are protective of the beneficial uses for the following reasons:

- They are based on natural conditions, thereby providing water quality comparable to the water quality in which the beneficial uses naturally exist.
- They result in DO concentrations that vary with the seasons, thereby ensuring greater DO concentrations in the winter months when salmonids embryos and alevin reside in the gravels.
- They result in daily minimum DO concentrations greater than 4.0 mg/L throughout the year (National Criteria).
- They result in daily minimum DO concentrations greater than 8.0 mg/L at all locations and throughout all of the identified incubation season (National Criteria).
- They result in 30-day means greater than 6.5 mg/L DO all year and greater than 10.0 mg/L at most locations during the identified spawning and incubation season (National Criteria).
- The transfer of DO from the water column to the intergravel environment may be more efficient than predicted by USEPA (1986) indicating a difference between the water column and intergravel environment of less than 3.0 mg/L, on average. Monitoring data should be collected to determine the relationship between water column DO and intergravel DO at key locations throughout the mainstem Klamath. In this way, staff could better define the DO conditions

required in the water column to ensure no production impairment in the intergravel environment.

- They include protections, through the implementation of the Klamath River TMDLs of thermal refugia in the tributaries where most of the spawning and incubation in the basin actually occurs. In addition, they are companions to the TMDL load allocations and source control measures, including measures designed to reduce sediment, decrease temperatures, and decrease organic matter and nutrient inputs.
- They are companions to other water quality objectives contained in the Basin Plan such as narrative objectives that protect natural temperature conditions and protect against suspended sediment, turbidity and settleable matter in quantities that harms beneficial uses.

Further, the proposed recalculated SSOs for DO in the mainstem Klamath River are consistent with the Hoopa Valley Tribe's water quality objectives for DO. That is, though the T1BSR run of the *Klamath TMDL model* indicates that natural conditions prevent the attainment of the life cycle-based DO requirements contained in the Hoopa Valley Tribe's Basin Plan, the proposed 90% DO saturation criteria based on natural receiving water temperatures from the Scott River to Hoopa is identical to the natural conditions clause included in Hoopa's Basin Plan. Staff proposes the T1BSR run of the *Klamath TMDL model* as the tool for quantifying natural DO conditions.

This Staff Report incorporates by reference several chapters of the Klamath TMDL Staff Report of which it is a part. For example, Chapters 6 (Implementation Plan), 7 (Monitoring Plan), 9 (CEQA Analysis), 10 (Economic Analysis), and 11 (Public Participation) describe factors related to both the Klamath TMDL and the recalculated SSOs for DO.

CHAPTER 1.
INTRODUCTION

The purpose of this Staff Report is to present the scientific justification for a recalculation of the existing Site Specific Objectives (SSO) for Dissolved Oxygen (DO) in the Klamath River mainstem (Klamath). Staff to the North Coast Regional Water Quality Control Board (Regional Water Board) has:

1. Reviewed the existing SSO for DO in the Klamath;
2. Analyzed new sources of data and information related to DO conditions in the Klamath; and
3. Recalculated an SSO for DO in the Klamath based on a series of water quality models used to establish the Total Maximum Daily Loads (TMDL) for organic matter, nutrients, temperature, dissolved oxygen, and microcystin necessary to achieve water quality objectives, including objectives for DO.

This Staff Report is an appendix to the Klamath River Total Maximum Daily Load (TMDL) Staff Report which includes an implementation plan, monitoring plan, economic analysis, discussion of public participation, and California Environmental Quality Act (CEQA) analysis applicable to both the proposed TMDL and DO SSO basin plan amendments for the Klamath River.

1.1 Description of the Klamath River Watershed

The Klamath River basin[1] is 12,680 square miles in area. The Klamath River originates in southern Oregon and flows through northern California to meet the Pacific Ocean at Requa in Del Norte County, California. Forty-four percent of the watershed lies within the boundaries of Oregon, while the remaining 56% of the basin lies within the boundaries of California. Figure 1.1 is a map of the Klamath River basin.

The Klamath River basin is of vital economic and cultural importance to the states of Oregon and California, as well as to the Klamath Tribes in Oregon; the Hoopa, Karuk, and Yurok Tribes in California; the Quartz Valley Indian Reservation in California; and the Resighini Rancheria in California. It provides fertile lands for a rich agricultural economy in the upper basin. Irrigation facilities, known as the Klamath Project, owned by the U.S. Bureau of Reclamation, support this economy as does hydroelectric power provided via a system of five dams operated by PacifiCorp. The basin is the home spawning grounds of a once vast tribal, sport, and commercial fishery and provides other aquatic resources of cultural significance to the local tribes. The watershed supports an active recreational industry, including activities that are specific to the Wild and Scenic portions of the river designated by both the state and federal governments in Oregon and California. Finally, the watershed continues to support what were once historically significant mining and timber industries.

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[1] For the purposes of this report, the terms "basin" and "watershed" are synonymous and will be used to refer to the area that drains flows to the Pacific Ocean at Requa.

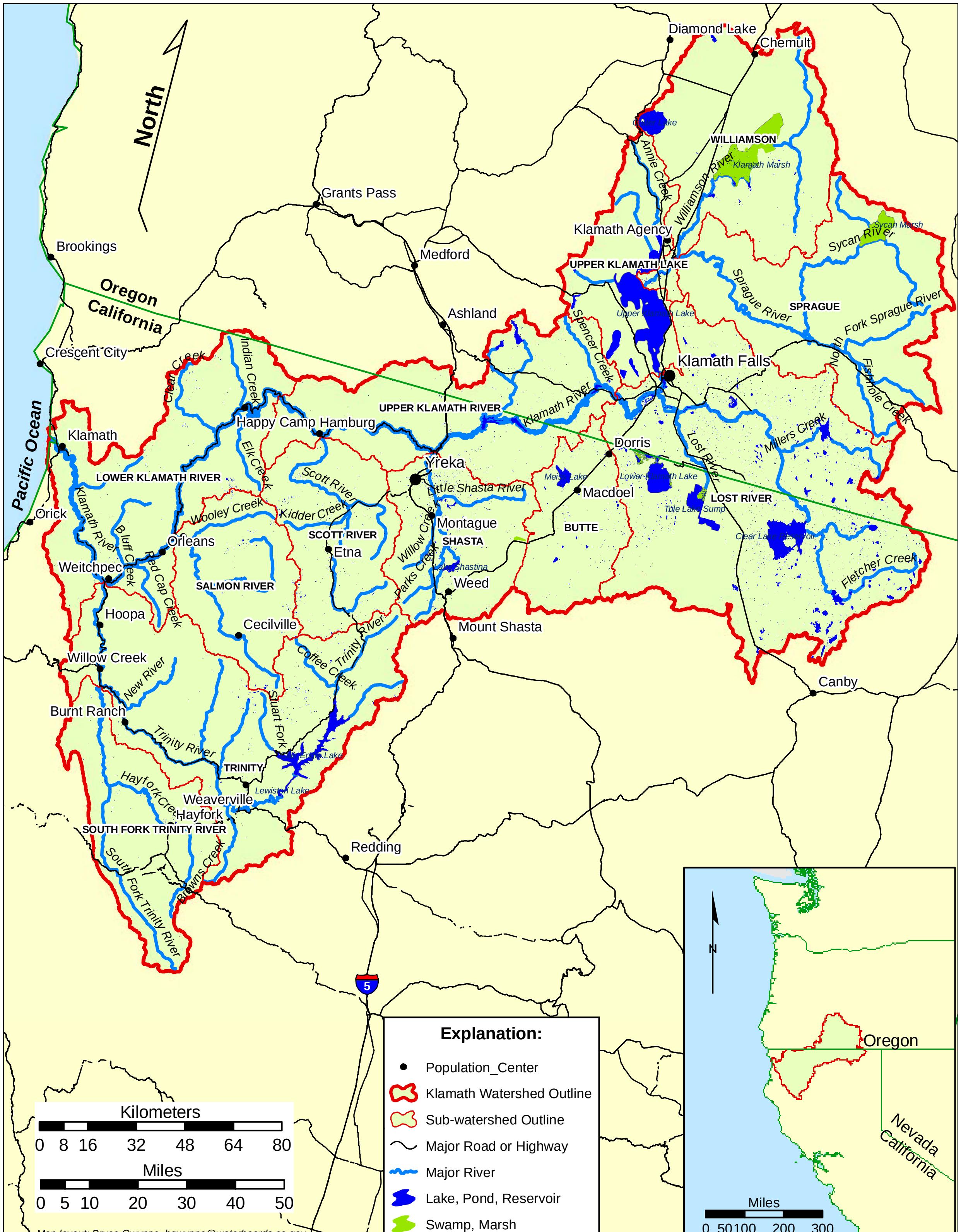

Figure 1-1: Klamath River Basin Showing Rivers, Lakes and Reservoirs, Population Centers, and Major Roads

A decline in the fisheries is one of several indicators of ecological distress in the basin. Congress passed Public Law 99-552 (Klamath Act) in 1986 to establish the Klamath River Basin Conservation Area Restoration Program with the intention of rebuilding the river's dwindling fish resources. Since that time several of the fish species endemic to the basin have been listed by federal and state agencies as threatened or endangered. Impairments to water quality have been identified as one of the factors contributing to the continued decline of native fish populations. This has led to water quality assessments by the States of Oregon and California and the listing of the Klamath River as impaired under section 303(d) of the federal Clean Water Act (CWA).

Table 1-1: Klamath River Water Quality Impairments in California

Hydrologic Area (HA)[2]	**CalWater Watershed**	**Pollutant/Stressor(s)**
Middle HA, Oregon to Iron Gate	10530000	Temperature Nutrients Organic enrichment/low dissolved oxygen
Middle HA, Copco 1 and 2 and Iron Gate Reservoirs	NA	Microcystin
Middle HA, Iron Gate Dam to Scott River	10530000	Temperature Nutrients Organic enrichment/low dissolved oxygen
Middle HA, Scott River to Trinity River	10500000	Temperature Nutrients Organic enrichment/low dissolved oxygen
Lower HA, Klamath Glen HSA, Trinity River to Pacific Ocean	10511000	Temperature Nutrients Organic enrichment/low dissolved oxygen Sedimentation/Siltation

The U.S. Environmental Protection Agency (USEPA) Region 9 has listed the portions of the Klamath River within its jurisdiction (from the CA/OR Stateline to the mouth) for impairments due to elevated water temperatures, elevated nutrients, and organic enrichment/low dissolved oxygen. In addition, the portion of the Klamath River watershed downstream of the Trinity River, partially within the Yurok Reservation, is listed for sedimentation/siltation impairment. Finally, in March 2008, the USEPA added the reach of the Klamath River that incorporates Copco 1 and 2 and Iron Gate Reservoirs to the 303(d) List for the blue-green algae toxin microcystin. Each of these impairments has an effect on ambient DO in the Klamath River mainstem. Table 1.1 summarizes the waterbody-pollutant combinations for the Klamath River in California as identified on the current (2006) section 303(d) List.

A consent decree entered into by the USEPA in March 1997 (*Pacific Coast Federation of Fisherman's Associations et al. v. EPA*) establishes the date by which TMDLs for seventeen northcoast California watersheds must be completed. The Klamath River TMDLs for the listed temperature and nutrient impairments were scheduled for

[2] Hydrologic Area (HA) is the terminology used in the CalWater watershed delineation system to identify a sub-unit of a watershed. Similarly, Hydrologic Sub Area (HSA) identifies a smaller hydrologic unit within a HA.

completion by 2007. Negotiations between USEPA and the plaintiffs resulted in an extension of that deadline to 2010.

1.2 Summary of the Proposed Action The action proposed in this Staff Report addresses the SSOs for DO on the Klamath mainstem, only. It does not affect any of the tributaries to the Klamath River.

Table 3-1 of the *Water Quality Control Plan for the North Coast Region* (Basin Plan) currently requires Klamath mainstem ambient water quality DO conditions as follows:

1) An instantaneous minimum DO upstream of the Iron Gate Dam of 7.0 mg/L. Half of the monthly mean DO values for the year must be 10.0 mg/L or greater.
2) An instantaneous minimum DO downstream of the Iron Gate Dam of 8.0 mg/L. Half of the monthly mean DO values for the year must also be 10.0 mg/L or greater.

The proposed action is an amendment to the Basin Plan to remove from Table 3-1 the instantaneous minimum and 50% lower limit numeric criteria for DO applicable as follows:

- In the Middle Klamath River HA, Klamath River above Iron Gate Dam including Iron Gate & Copco Reservoirs and Klamath River below Iron Gate Dam; and,
- In the Lower Klamath River HA, Klamath River.

In its place, language is to be inserted requiring that the DO objective for the Klamath River mainstem from the Oregon border to the Pacific Ocean is as depicted below. The percent DO saturation criteria are to be calculated as twelve (12) individual daily minima, one for each calendar month of the year using site salinity, site barometric pressure and natural receiving water temperatures.

Proposed Recalculated SSO for DO in the mainstem Klamath River
(To be applied from the Stateline to the Pacific Ocean except where there is Tribal jurisdiction).

From Stateline to Upper Hoopa Boundary

- 90% DO saturation based on natural receiving water temperatures from October 1 through March 31
- 85% DO saturation based on natural receiving water temperatures from April 1 through September 30

From Lower Hoopa Boundary to Turwar

- 85% DO saturation based on natural receiving water temperatures all year

Upper and Middle Estuary

- 80% DO saturation based on natural receiving water temperatures from August 1 through August 31

- 85% DO saturation based on natural receiving water temperatures from September 1 through July 31

Lower Estuary
For the protection of estuary habitat (EST), the Dissolved Oxygen content of the Lower Klamath Estuary shall not be depressed to levels adversely affecting beneficial uses as a result of controllable water quality factors.

1.3 History of the Proposed Basin Plan Amendment for DO
Regional Water Board staff has been assessing the need to revise the existing DO objectives for several years. In an August 2000 review of Russian River water quality objectives (focusing on DO, temperature, pH, oil and grease, and turbidity) for the protection of salmonid species prepared for the Sonoma County Water Agency, Regional Water Board staff found that the DO and water temperature objectives for the Russian River Basin, among others, did not afford adequate protection for species listed on the State and Federal Endangered Species Acts (CESA/ESA). In order to address this, Regional Water Board staff recommended developing numeric objectives specific to each salmonid life stage.

In 2005, staff distributed for public review a region wide proposal for the revision of both the temperature and DO objectives contained in the Basin Plan. Zabinsky and Azevedo (2005) proposed numeric temperatures objectives and updated numeric DO objectives for the protection of individual life stages of salmonids. A workshop on this subject was held before the Regional Water Board in April 2005.

Shortly thereafter, staff was diverted to the development of the Klamath Total Maximum Daily Loads (TMDL). As a result, the proposal to amend the Basin Plan's temperature and DO objectives was put on hold. As part of the Klamath TMDL, a series of models were developed to estimate water quality conditions, including temperature and DO, in the Klamath River mainstem under varying pollutant loading scenarios. Once the models were validated and calibrated, they were run to estimate natural conditions as the baseline.

One of the important findings of the TMDL natural conditions model run (T1BSR) is that DO fluctuates widely in the Klamath River mainstem due to such natural conditions as elevated summer temperatures, elevated nutrients emanating from the volcanic geology and organic-rich wetland soils of the upper basin, and elevated phytoplankton activity resulting from these natural conditions. As a result of the elevated phytoplankton activity, DO concentrations fluctuate both daily and seasonally. This fluctuation results in periodic noncompliance with the existing SSO for DO in the Klamath, particularly during the night time hours of the summer months. That is, the model demonstrates that under natural conditions, water quality in the mainstem of the Klamath River can not consistently meet the existing SSOs for DO. This is primarily due to the fact that the existing SSOs for DO are based on day time grab sample data and do not reflect the night time minima. This differs from the TMDL modeling which was calibrated and validated using 24 hour day.

After some evaluation, staff determined that the issues associated with the SSOs for DO in the Klamath River are also reflected in the SSOs for DO in the rest of the fifty-eight (58) waterbodies listed in Table 3-1 of the Basin Plan. For this reason, staff picked up the regionwide Basin Plan Amendment again, this time focusing just on DO. A CEQA scoping document was distributed and two scoping meetings held in the fall of 2008. A draft Staff Report was prepared and submitted for peer review. Peer review comments were received and responses drafted. Revisions to the regionwide proposal were prepared as a result of the peer review comments.

In the mean time, the need to establish accurate SSOs for DO in the mainstem of the Klamath River has become more pressing because of a court-ordered deadline for establishing the Klamath River TMDL by December 2010. By regulation, a TMDL must demonstrate that it will achieve applicable water quality objectives for it to be approvable. Staff has taken the concepts of the draft regionwide Basin Plan Amendment and applied them to the mainstem Klamath River as the means of establishing accurate SSOs for DO in the Klamath. This Staff Report documents the approach, including the model results which support this proposal.

After the adoption of recalculated SSOs for DO in the Klamath River, staff will finalize its proposal for amending DO objectives on a regionwide basis and bring it before the Regional Water Board for their consideration in the future.

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CHAPTER 2.
PHYSICAL SETTING OF THE KLAMATH RIVER BASIN

The purpose of this chapter is to establish the location and physical characteristics of the Klamath River basin. The Site Specific Objectives (SSO) for Dissolved Oxygen (DO), as developed in this Staff Report, are intended to apply to those portions of the Klamath River mainstem under the jurisdiction of the State of California: from the Oregon border to the Pacific Ocean, but excluding that portion near Saints Rest Bar which is under the independent jurisdiction of the Hoopa Valley Tribe and that portion downstream of the Trinity River through the estuary under the jurisdiction of the Yurok Tribe. Factors such as landuse, topography, geology, vegetation, climate, and hydrology affect the way in which DO dynamics are expressed in the Klamath River mainstem.

2.1 Population and Land Ownership

The population in the Klamath River basin was estimated in the 2000 US Census to be about 114,000 (United States Census Bureau [USCB] 2000). The largest population concentrations lie in the upper Klamath agricultural area, the Shasta River Valley, and Scott Valley. The largest population center is Klamath Falls in Oregon (19,462 people in 2000) followed by Yreka, California (7,290 people). The Klamath River basin can generally be characterized as a rural watershed with limited population-related water quality issues.

According to Natural Resources Conservation Service (NRCS) in a report published in 2004, 63% of the Klamath River watershed is in federal, state or tribal ownership; the remaining 37% of the basin in private ownership. While federal, state, and tribal land ownership surpasses private landownership in the California portion of the Klamath watershed, ownership is more evenly divided in Oregon.

Figure 2.1 shows, among other things, federal lands managed as National Forests, National Wildlife Refuges, and National Parks, in addition to lands administered by the Bureau of Land Management (BLM). The Hoopa Valley Tribe owns land, 12 miles by 12 miles, primarily in the Trinity River watershed but intersecting the Klamath River at Saints Rest Bar upstream of the confluence with the Trinity. The Yurok Tribes' land extends from 1 mile on each side of the Klamath River from the mouth upriver for a distance of 44 miles. The Karuk Tribe owns 800 acres of tribal trust land along the Klamath River between Orleans and Happy Camp, and in Yreka, California. The Quartz Valley Indian Reservation is located near Fort Jones and encompasses 174 acres along the Scott River. The Resighini Rancheria spans 228 acres along the south shore of the mouth of the Klamath River.

Forestland accounts for about 22% of the private lands in the basin, equally divided between California and Oregon, though the private timber activity in California occurs primarily in the lower Klamath basin (NRCS 2004). Cropland/pasture activities and rangeland activities account for 14% and 21%, respectively, of the private land use in the Klamath River watershed. Private cropland and pasture are concentrated in the upper Klamath watershed; but, private rangeland is more evenly divided throughout the basin

(NRCS 2004). Urban development, commercial and industrial lands, and residential lands account for less than 1% each of the landuse activities occurring on privately owned land in the Klamath River watershed. Urban and commercial/industrial development, such as it is, is concentrated in California while residential lands are concentrated in Oregon (NRCS 2004). Commercial landuse activities such as grazing, mining, and timber harvesting occur on Federal lands managed by the U.S. Forest Service and Bureau of Land Management, as well.

By area, the vast majority of streams and lakes present in the Klamath basin are in Oregon (93%). Only 7% of the area covered by water is made up of streams and lakes found in the California portion of the basin (NRCS 2004).

2.2 Topography, Geology and Soils

Topography in the Klamath River watershed varies between steep mountains and flat and rolling valley bottoms with little in between (Figure 2.2). Elevations range from 14,179 feet (4,322 meters) at the summit of Mount Shasta to sea level at the river mouth. The Klamath River watershed crosses four recognized geomorphic provinces, each of which is defined and shaped by its unique geologic history. From east (upstream) to west (downstream) these provinces are the Modoc Plateau, Cascade Range, Klamath Mountains, and Coast Ranges (Figure 2.3). These geomorphic provinces, defined by Oakshott (1978), are the result of the different structure and composition of the underlying rocks and different times of uplift and volcanism.

Headwaters of the Klamath gather in the Modoc Plateau, an area of geologically young lava flows (Pliocene and Pleistocene – less than fifteen million years) and flat valleys punctuated by volcanic cones. The rolling valley bottoms are at about 4000 to 5000 feet (1219 to 1524 meters) elevation and the volcanic cones rise a thousand feet higher. While drainage in this young landscape is through-flowing, many depressions contain shallow lakes, most of which have been augmented by dams. Although rainfall is low, the flat and rolling valley bottoms of rich volcanic and organic soils combine with abundance of water entering from higher surrounding country to create historically vast freshwater wetlands. Many of these wetlands have been converted to farmland. The volcanic soils are naturally rich in phosphorus, a nutrient of concern in the Klamath TMDLs and important to the DO dynamics in the basin. Similarly, the conversion of wetlands to farmland and other land uses has exposed the nutrient and organic rich soils to oxidation, resulting in the release to the water column of nitrogen and phosphorus previously stored in the soil and wetland vegetation (Snyder and Morace, 1997).

The transition between the Modoc Plateau and Cascade Range provinces is not sharp, so a line on a map is by necessity a bit arbitrary (Figures 2.3, 2.4). The Cascade Range province is a belt of mainly volcanic rocks that are younger than rocks of most of the Modoc Plateau and form higher relief. The Cascade Range is defined by a chain of active and potentially active volcanoes that stretches from Mount Lassen, east of Redding, northward through Oregon and Washington into Canada. The most prominent mountain in the Klamath region is Mount Shasta, a composite volcano that rises at the head of Shasta Valley, and which last erupted about 1786. Crater Lake, in the northeast, fills the collapsed crater of a volcano that erupted cataclysmically about 7,000 years ago.

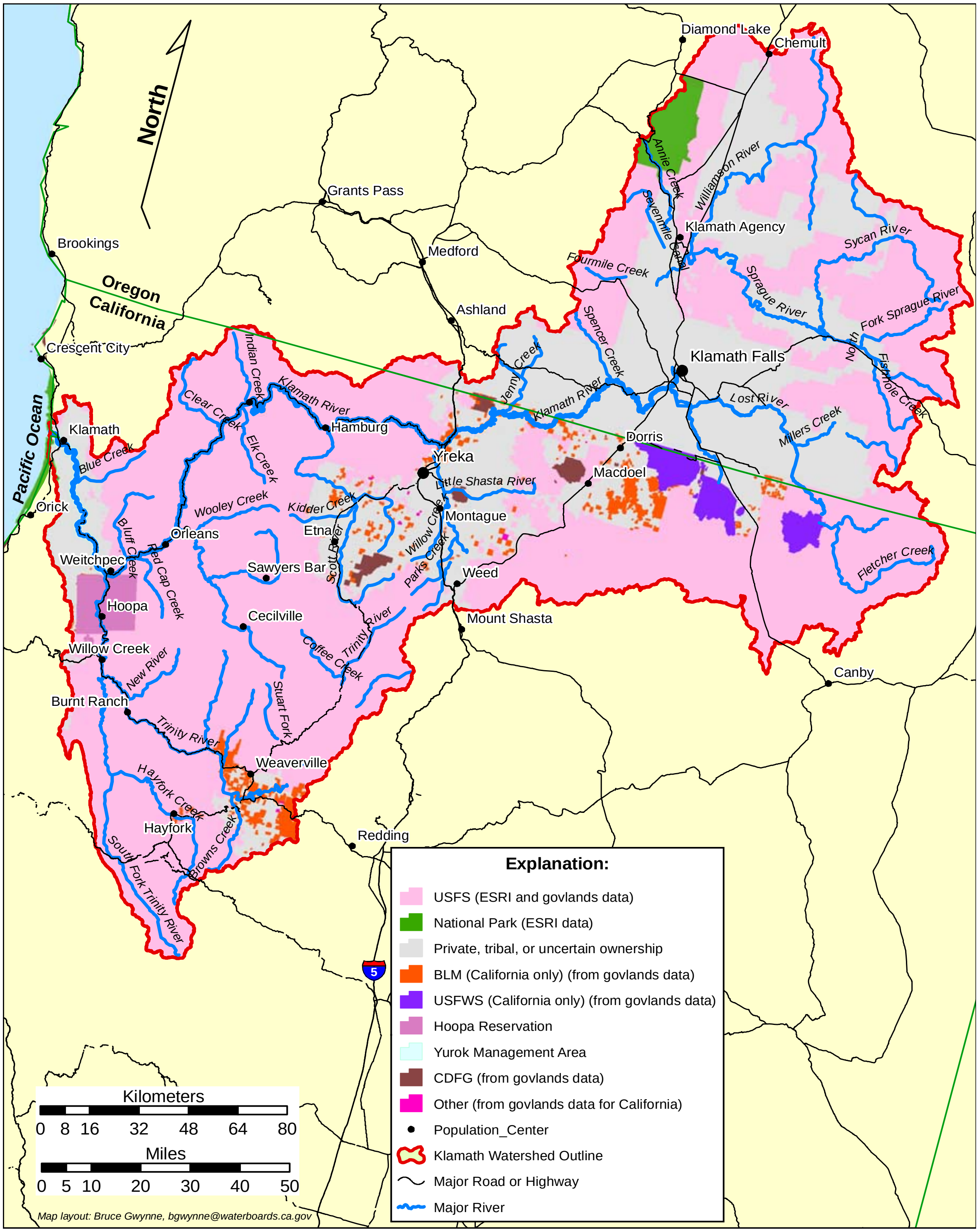

Figure 2.1: Land Ownership in the Klamath River Basin

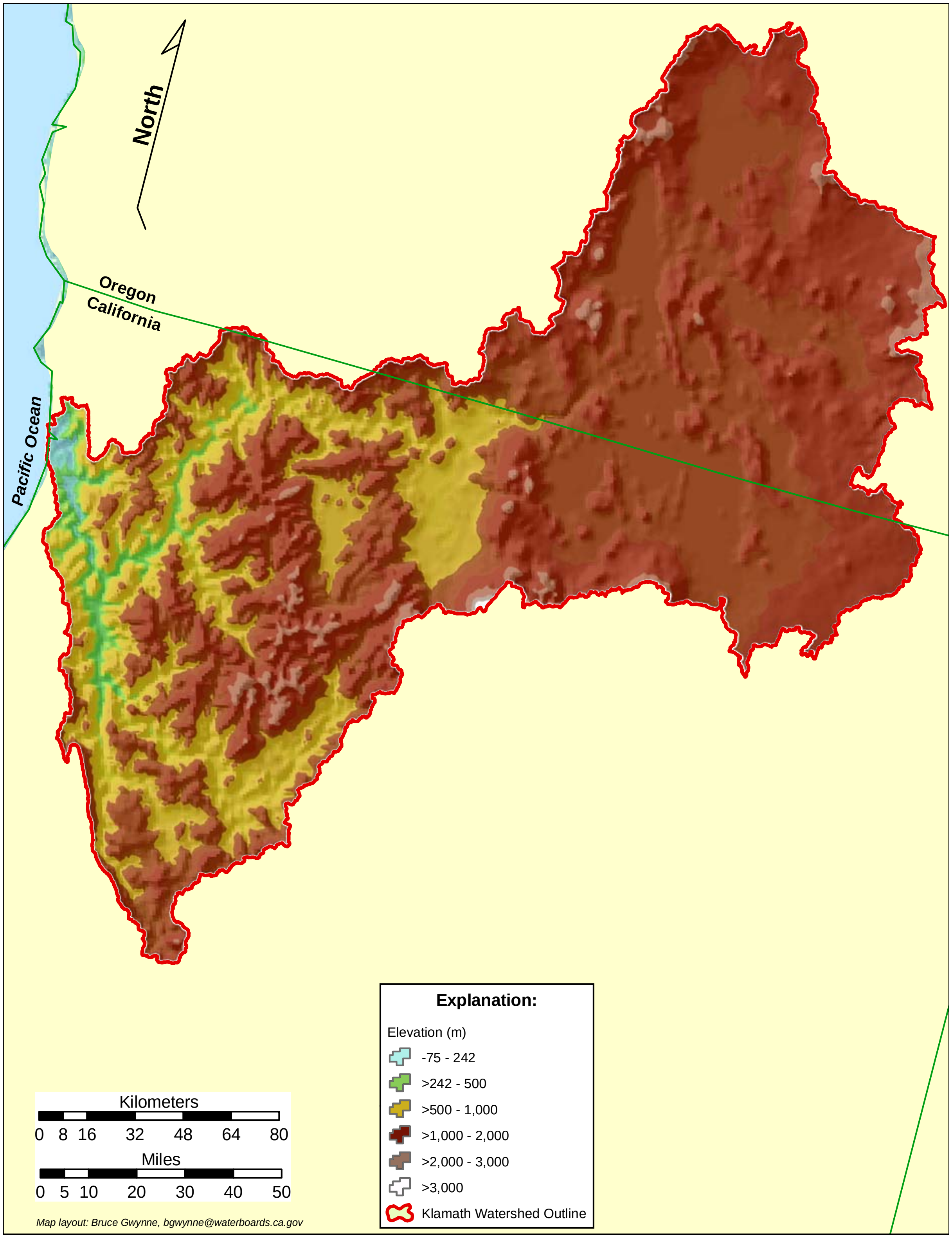

Figure 2.2: Land Elevation in the Klamath River Basin

Figure 2.3: Geomorphic Provinces in the Klamath River Basin - Source: Oakshott 1978

The border between the Cascade province and the Klamath Mountains province is spanned by Shasta Valley and covered by a unique deposit. Most of the floor of this valley is disrupted rolling topography of small hillocks and closed depressions. Crandell (1989) recognized this landscape as the deposits formed by a huge avalanche and debris flow, or series of such events, shed off the north flank of Mount Shasta more than 300,000 years ago.

The Klamath Mountains province is very steep and rugged for the most part, and in the Klamath River watershed consists of several irregularly oriented ranges – the Trinity Alps, Scott Bar Mountains, Siskiyou Mountains, and Marble Mountains. Shasta and Scott Valleys have broad flat valley bottoms that support agriculture, but other valleys are narrower and steeper and therefore less developed. Most of the land in the Klamath Mountains province is in federal ownership (Figure 2.1), and this rugged landscape lends itself more to timber harvest and cattle grazing than to crops.

The bedrock geology of the Klamath Mountains province is extremely varied and complex (Figure 2.4) and largely made up of ocean-floor igneous and sedimentary rocks of a large range in ages. Most of the igneous rocks in this province are dark colored mafic and ultramafic rocks of both intrusive and extrusive origin, most of which have been partly or wholly altered to serpentine and otherwise metamorphosed. Younger, light colored granitic rocks have been intruded in some places. Recent uplift has created a landscape of rapidly downcutting streams and steep slopes that are subject to rapid erosion and landsliding. The granitic rocks in particular weather to form loosely consolidated material that sloughs and ravels easily when disturbed.

The Coast Ranges province, the westernmost province (Figure 2.3), forms about 20 miles of the lower Klamath River valley and part of the west side of the valley of the lower Trinity River and South Fork Trinity River. These rivers have exploited the fault zone that forms the geologic boundary between the Klamath Mountains province and the Coast Ranges province. The Coast Ranges are steep, but are generally more rounded and not as high as the mountains of the Klamath Mountains province. Bedrock is the Franciscan Complex, which is structurally deformed and highly varied. The mix of sedimentary rocks includes sandstone, siltstone, shale, conglomerate, greywacke, and chert. Parts of the complex have been metamorphosed and include blueschist and greenschist as well as low grade mica schist. Some areas are mélange, which is geologic terrain that has been deformed and mixed by prolonged and complex tectonic movement, and lacks continuity of structure, rock type, or age.

The gradient profile of the Klamath River is anomalous for a large river in that it is generally low gradient in the headwaters in the Modoc Plateau and steeper farther downstream (Figure 2.2). This unusual gradient is largely the result of geologic uplift in the upstream portion of the river basin in recent geologic time. It is a defining characteristic of the Klamath watershed and strongly influences the nutrient and DO dynamics of the basin.

Figure 2.4: Geologic Map of the Klamath River Basin
Source: Modified from Schruben et al. (1997)

2.3 Vegetation

Vegetation in the Klamath River watershed varies greatly with elevation, precipitation, geology, and degree of disturbance. Figure 2.5 shows the major classifications of vegetation. Conifers dominate in the steep mountains and the higher elevations throughout the watershed and are the major land cover of the basin. Hardwood forest and shrubs are more abundant in the lower country within the Klamath Mountains and Coastal Range Provinces. Grass and brush land, as well as lands converted for agricultural purposes, are abundant in the low gradient landscapes associated with the Scott, Shasta, and Lost River valleys in California, as well as the Lost, Sprague, and Williamson River valleys in Oregon. Wetlands are found throughout Oregon, including around Upper Klamath Lake, as well as in the Lost River valley in California. The wetland habitat present in the Klamath River watershed today represents about 25% of what existed historically (http://www.fws.gov/klamathbasinrefuges/history.html retrieved October 26, 2009). As described above, much of the wetland land cover in the upper watershed has been converted to agricultural use over the last 150 years, significantly altering the natural processes by which organic matter and nutrients are stored and released downstream.

2.4 Climate

The great geographic extent and topographic relief of the Klamath River watershed combine to produce a wide variety of climate conditions (Figure 2.6). On average, the climate is characterized by dry summers with high daytime temperatures and wet winters with moderate to low temperatures. About three quarters of the annual precipitation falls between October and March, producing a snowpack in the higher mountain ranges that feeds streamflow in many lower areas through the summer. As major storms move in from the Pacific Ocean, the moisture-laden air rises over the coastal mountain ranges and condenses as rain and snow (California Department of Water Resources [CDWR] 1986). Further inland, in the valleys of major tributaries and over the lower terrain of the upper Klamath basin, a rain shadow effect is created, and less moisture falls (Figure 2.6).

Figure 2.7 provides a comparison of monthly precipitation values from Orleans, California in the mountainous country of the lower Klamath basin and Klamath Falls, Oregon in the broad valley of the upper Klamath basin as an illustration of rain shadow effect. The mean annual precipitation in the Klamath River watershed is about 32 inches (CDWR 1986); but, local averages range from more than 80 inches in the high elevations to 10 inches in the broad inland valleys (CDWR 1986; United States Forest Service [USFS] 1996).

In the 20th century the Klamath River watershed was characterized by a pattern of floods and droughts. This pattern is discussed by The Klamath River Basin Fisheries Task Force [KRBFTF] (1991, p. 2-3 to 2-7). During a drought in 1976-77, precipitation was only 20 percent of normal in the Scott River watershed and 40 percent of normal in the upper Klamath River basin. The largest floods occurred when relatively warm storm systems melted a pre-existing snow pack such as occurred in 1861, 1955, 1964, 1974 and 1997 (USFS 2000, p.3-3). Many areas of the Klamath River watershed, mostly in the middle third of the basin, are susceptible to these rain-on-snow events.

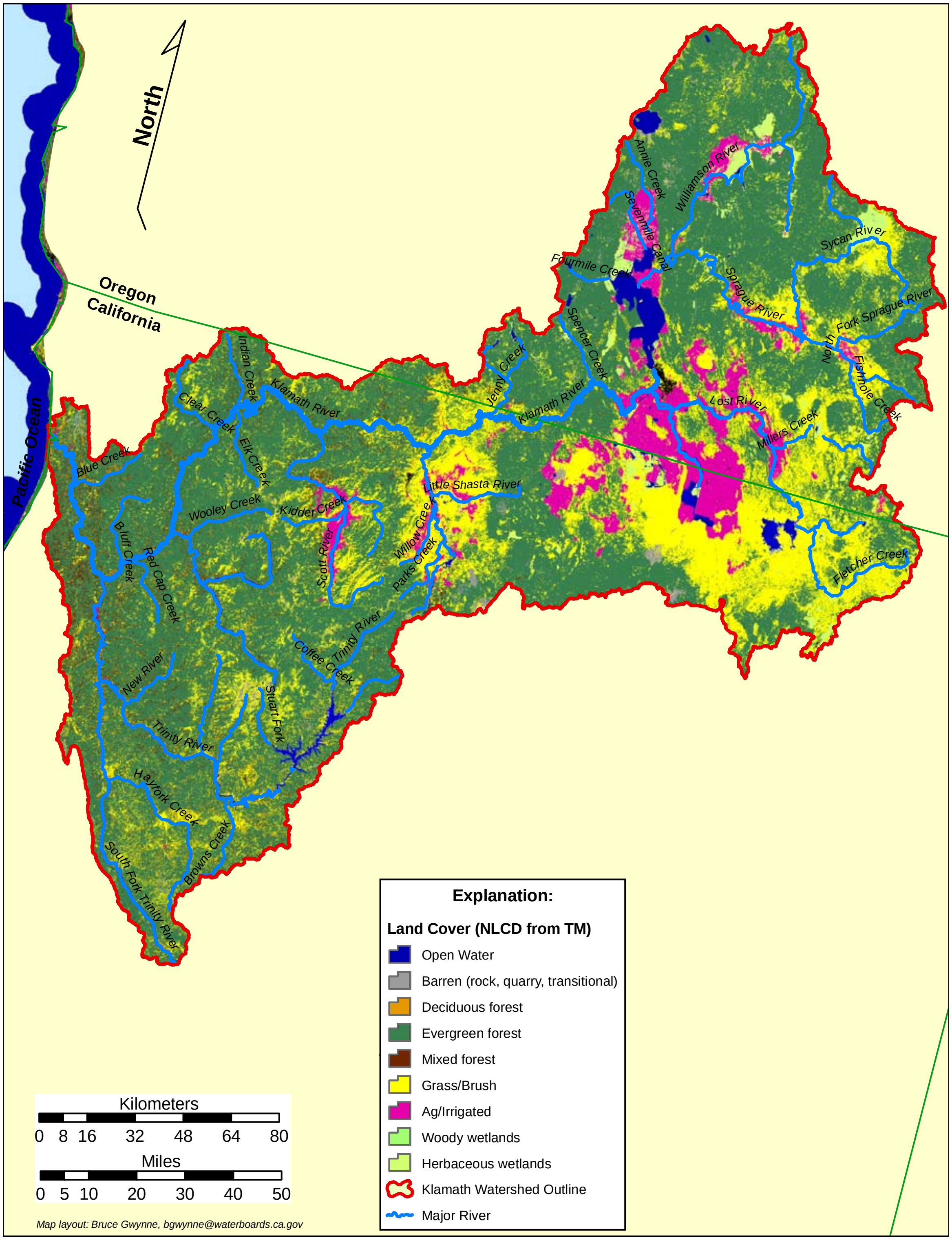

Figure 2.5: Vegetation and Land Cover of the Klamath River Basin, Thematic Mapper GIS database

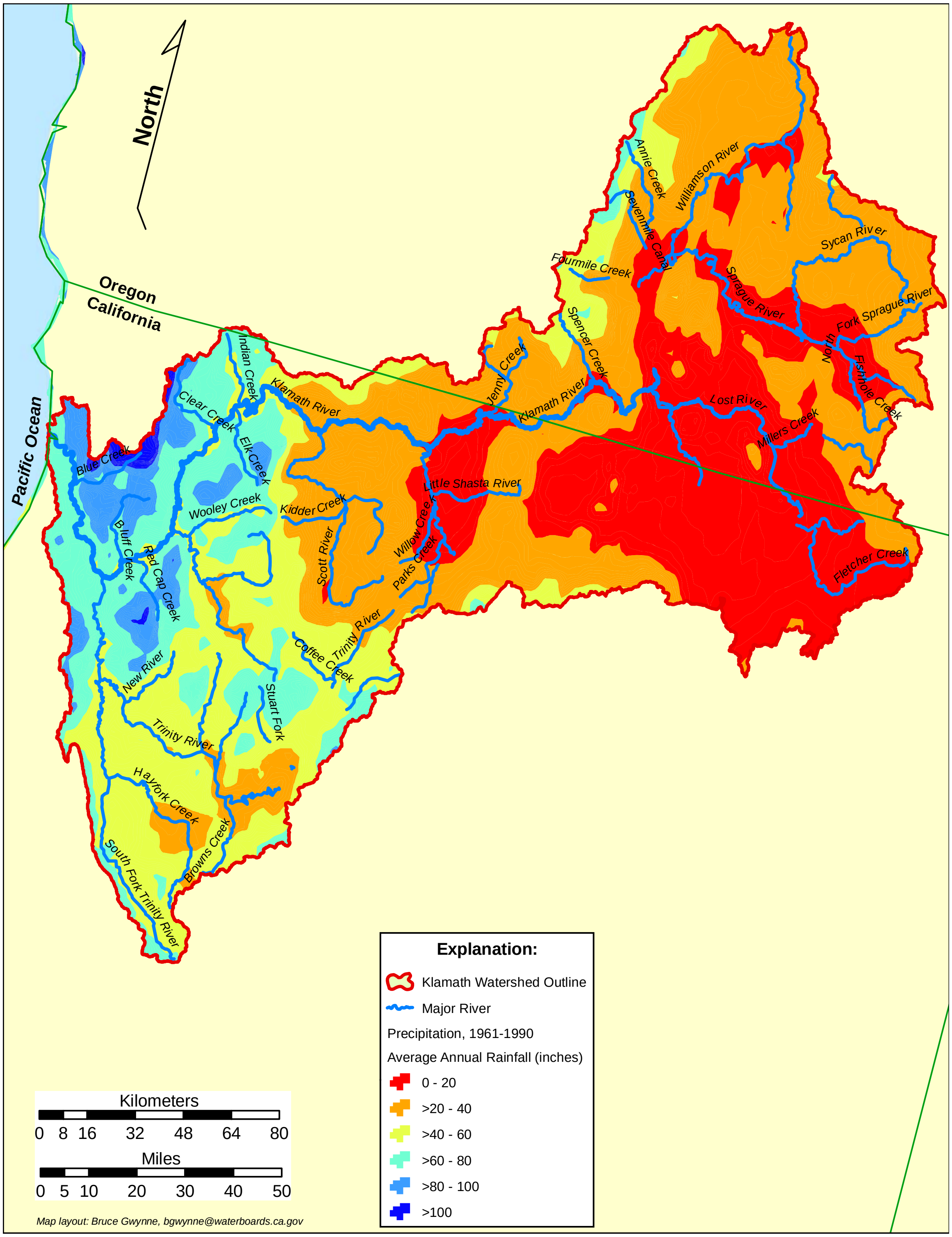

Figure 2.6: Average Annual Rainfall in the Klamath River Basin
Source: United States Department of Agriculture (USDA) Undated

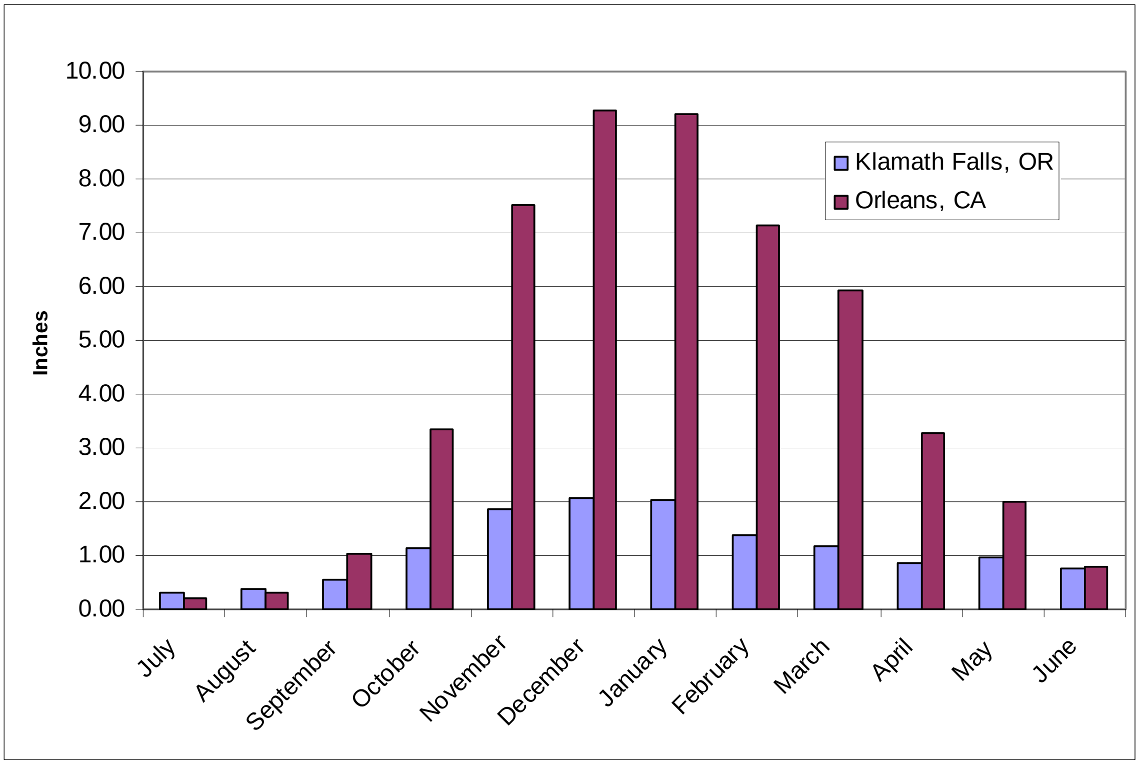

Figure 2.7: Average Monthly Precipitation, 1905-2003, in Klamath Falls, Oregon and Orleans, California
Source: California Data Exchange Center [CDEC] 2006; Oregon Climate Service [OCS] 2006

Klamath Basin air and water temperature data indicate that air and water temperatures have been steadily increasing since at least the 1960s. Bartholow (2005) analyzed air and water temperature records distributed throughout the Klamath basin and evaluated water temperatures simulated using a computer-based water temperature model. The results of Bartholow's analysis strongly suggest a trend of water temperature increases of approximately 0.5 ^{o}C per decade since the 1960s. As described in more detail in Chapter 4.0 of this Staff Report, water temperature is one of three factors controlling DO concentrations at saturation. DO concentrations at saturation are inversely proportional to water temperature. Thus, as water temperatures rise, the DO concentration at saturation decreases.

2.5 Hydrology

Drainage density in the Klamath River watershed is affected by infiltration capacity, tectonics, and underlying bedrock. Figure 2.8 shows dense drainage networks in the

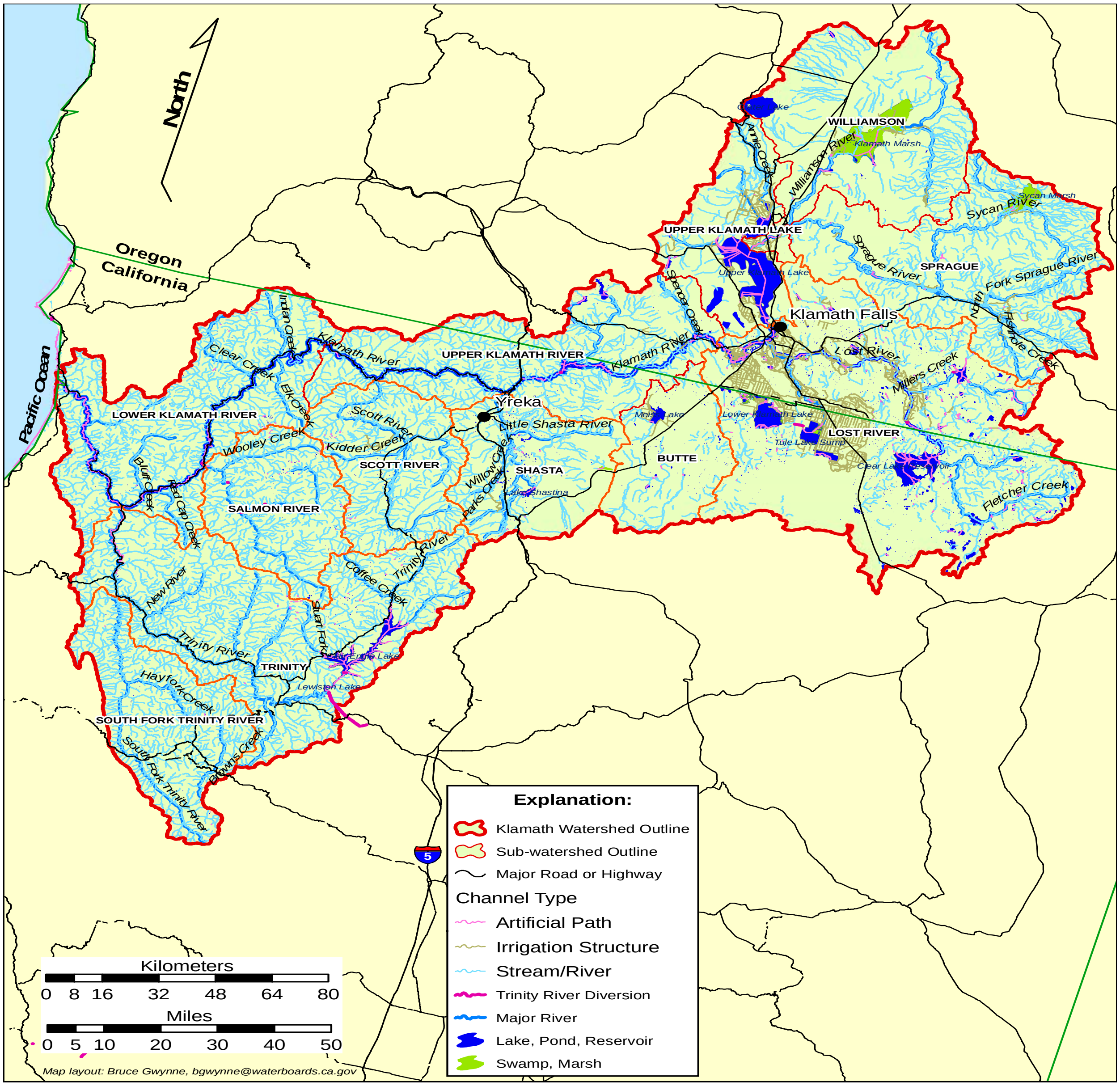

Figure 2.8: Map of Klamath River Basin Emphasizing Subbasins and Surface Drainage

steep, recently uplifted ranges to the west and in the volcanic mountains to the east. The lower, flatter country in the upper Klamath, in the region of Klamath Falls, has a much lower drainage density (though greater percent area covered by water) and is punctuated by lakes and wetlands associated with local tectonic subsidence.

Water yield in the Klamath basin varies by watershed setting. As illustrated in Figure 2.9, approximately half of the February flow measured in the lower watershed at the town site of Klamath, California is drained from that portion of the basin from Orleans, California to Klamath, California, representing about a third of the basin's area. Conversely, only 7% of the flow originates in the upper one third of the basin. This pattern is not as dramatic in the summer months when water yield is more generally proportional to drainage area. It is important to recognize that the data presented in

Figure 2.9 shows the pattern of flow associated with a history of consumptive use (e.g., Klamath Project in the upper basin) and altered flow timing (e.g., PacifiCorp's hydroelectricity generation). However, these factors do not affect the above observations with respect to winter flows.

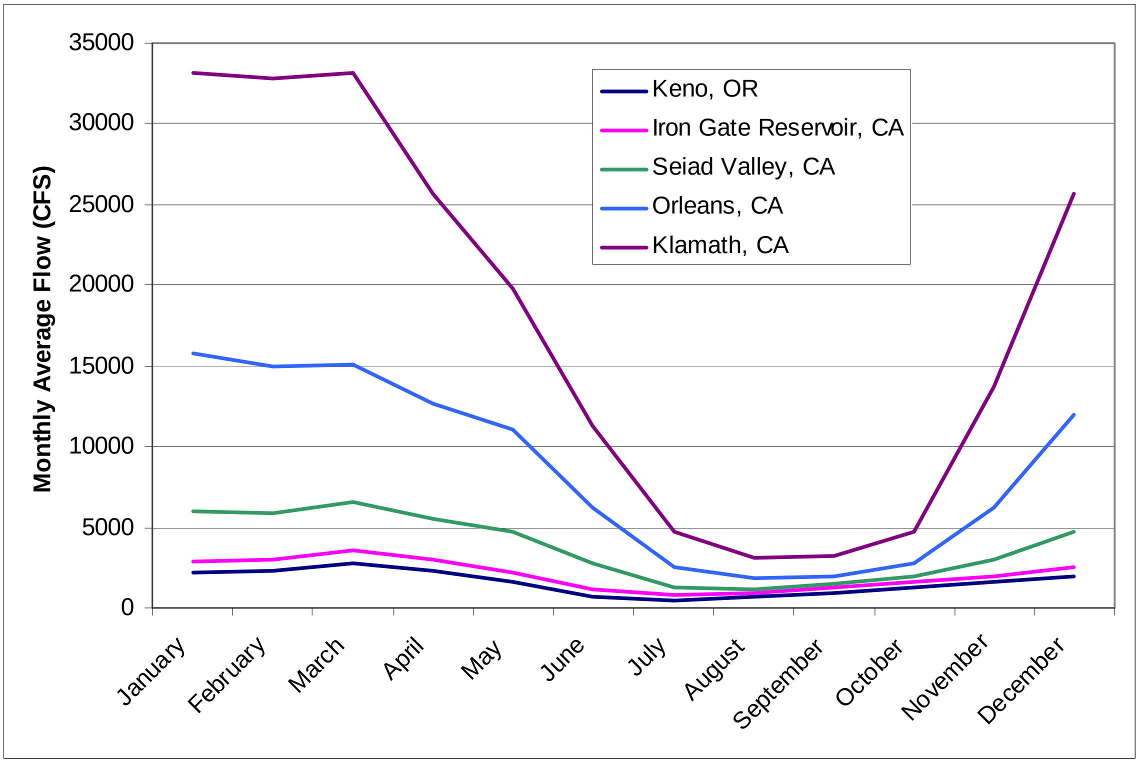

Figure 2.9: Monthly Average Flows at Five Klamath River Locations, Water Years 1963-2005
Source: United States Geological Survey [USGS] 2006

2.6 Summary

The Klamath River watershed has a number of unique physical characteristics which define the water quality dynamics of the basin. Most watersheds in the North Coast Region share a general topographic profile in which the headwaters flow down steep inner gorges, gather in second and third order streams of more moderate slope, and meander gently across a coastal plain before discharging to the Pacific Ocean. The Klamath River, on the other hand, gathers in the gently sloping wetlands and lakes of southeastern Oregon before leaving Upper Klamath Lake at Keno where the stream slope steepens through California and to the ocean. The soils of the upper basin are defined in large part by the volcanic geology of the southeastern part of Oregon and include naturally high levels of phosphorus which were historically stored in the wetland soils and vegetation of the upper basin. The periodic mobilization of excess organic matter and nutrients from Upper Klamath Lake to the free-flowing portion of the Klamath River created a zone of high productivity downstream which slowly dissipates as the stream channel steepens. This phenomenon has earned the Klamath River its nickname: "the River of Renewal."

The Klamath River watershed includes mountain ranges of higher elevation than most other watersheds in the North Coast Region. Many of the watersheds in the North Coast show a pattern of stream flow that closely mimics rainfall and can be quite flashy during and immediately after large storms. In the Klamath River; however, winter precipitation is stored as snow at the higher elevations. Thus, stream flow increases in the fall as a result of rainfall and is extended through the spring as the winter snows melt. (Though, rain-on-snow events can mobilize stored water quickly and catastrophically).

As is true of most other watersheds in the North Coast Region, the Klamath River is fundamentally a rural watershed, particularly within the boundaries of California. Thus, the water quality impacts associated with human activity in the Klamath River basin have little to do with point source discharges. In fact, point source discharges are prohibited in the California portion of the Klamath River watershed as is described in more detail in Chapter 5.0[1]. The much more significant cause of water quality impact in the Klamath River basin is the modification of *natural* water quality dynamics that has occurred due to human caused alterations of the landscape such as altered: flows and flow pattern; slope and stream channel stability; vegetation type, age, and density; and nutrient and organic matter availability, as examples.[2]

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1 The Regional Water Board has granted one exception to the prohibition against the point source discharge of waste to the Klamath River. The exception is granted to Iron Gate Hatchery, a fish rearing facility operated jointly by the Department of Fish and Game and PacifiCorp. They are issued a permit restricting the volume and quality of waste which can be discharged.

2 The effects of mining on the Klamath River are an exception to this general description, with large scale discharges of sediment resulting from hydraulic mining and toxics discharged from leach and tailings piles.

CHAPTER 3.
FISHES OF THE KLAMATH REGION

The proposed Site Specific Objectives (SSO) for dissolved oxygen (DO) in the mainstem Klamath River are designed to protect the beneficial uses of the mainstem. As such, the purpose of this chapter is to provide a review of the native fishes of the mainstem Klamath River that are at risk of extinction and identify their dissolved oxygen (DO) requirements. Staff focuses on the native fishes at risk of extinction because of their unique vulnerability. The Cold Freshwater Fishery (COLD) (i.e. salmonids) is identified as the most sensitive beneficial use of the Klamath River, the spawning and incubation of salmonids the most sensitive life stages.

The DO requirements of salmonids are identified in a series of review papers analyzing the relationship between DO and various fish health parameters as described in numerous laboratory and field studies. The review papers span 20 years, beginning with the 1986 DO guidance document published by the USEPA and including reviews conducted by the states of Oregon and Washington, as well as an in-house Regional Water Board review conducted by staff in 2005 (Carter 2005).

Water quality conditions in the mainstem Klamath River have been modeled as part of a Regional Water Board effort to establish Total Maximum Daily Loads (TMDLs) for dissolved oxygen, temperature, nutrients, and microcystin. The models indicate that under natural conditions, the Klamath River mainstem does not consistently produce the ideal DO conditions as defined by the laboratory and field studies of the last several decades. This has led staff to ponder the means by which salmonids have historically coped with less than ideal mainstem conditions. One well-accepted view is that they seek refuge in cool tributary streams and deep mainstem pools (thermal refugia). A listing of existing thermal refugia is also included in this chapter (Figure 3.2).

<u>Upper and Lower Klamath Subprovinces</u>
As described by Moyle (2002), the North Coast Region is divided into two zoogeographic provinces representing two distinct fauna: the Klamath Province and the North Coast Province. The Klamath Province is divided into 4 subprovinces, including the Upper and Lower Klamath through which the Klamath River flows.

Moyle (2002) describes the native fishes of the Upper Klamath Subprovince as primarily freshwater dispersants "most having their closet relatives in the Great Basin." A *freshwater dispersant* is a species that arrived in its present location from a freshwater route or has evolved in place from a distant saltwater ancestor (Moyle 2002). Freshwater dispersants in the Upper Klamath Subprovince arrived from the Great Basin during a time in geologic history when an ancestor of the Snake River, now draining through the Columbia River, previously flowed through the Klamath Region (Aalto et al. 1998 as cited by Moyle 2002). The native fishes of the Upper Klamath Subprovince include three species of sucker; three species of cyprinids (i.e., blue chub, Klamath tui chub, speckled dace); three species of sculpin; several species of salmonid (e.g., bull trout, rainbow trout, redband trout, coastal rainbow trout, and the now extinct Chinook salmon); and three species of lamprey (Moyle 2002). Of these, the Klamath River lamprey, Lost River sucker, shortnose sucker, and slender sculpin are at risk of extinction (Moyle 2002). The slender sculpin, however, only occurs in Klamath and Agency lakes in Oregon and is not discussed here.

The Lower Klamath Subprovince includes 21 native species of fish including: three species of lamprey, two species of sturgeon, one cyprinid (speckled dace), one sucker, two species of smelt, six species of salmonid (the pink salmon now extinct), one stickleback, four species of sculpin, and one flounder. Of these, the river lamprey, green sturgeon, eulachon, longfin smelt, chum salmon, coho salmon, and cutthroat trout are at risk of extinction (Moyle 2002).

What follows is a discussion of the individual life histories and DO requirements, to the degree that they are known, of the native fishes at risk of extinction in the Klamath River. Predictably, the DO requirements of salmonids are the most well understood and represent the largest part of the discussion. Because coldwater DO objectives have generally been developed based on the requirements of salmonids, the information below is intended to confirm that DO objectives developed to protect salmonids will protect the other fishes at risk, as well.

3.1 Salmonids

The present distribution and abundance of salmonids "has been strongly shaped by Pleistocene events. In northern and mountain areas, they followed the advance and retreat of continental glaciers, rapidly colonizing new streams and lakes" (Moyle 2002). Moyle (2002) asserts that salmonids thrive in dynamic environments. But, the water must be fairly cool (<22°C maximum) and well oxygenated (Moyle 2002). Moyle (2002) opines that because they have twice as much genetic material as most fishes, salmonids respond rapidly to evolutionary pressures.

Salmonids are anadromous fish, born in freshwater, migrating to the ocean where they feed and mature, and returning to their natal freshwater stream to reproduce. Salmonids typically die after spawning in fresh water, trout and steelhead being exceptions. Salmonid eggs are laid in a nest (i.e., redd) that the female digs in the gravel. The eggs are fertilized externally and the developing embryos covered with gravel as protection. After the yolk sac fry or alevin hatch, they remain in the interstices of the gravel until ready for emergence to the water column. Juvenile fish grow in freshwater until ready for outmigration to the ocean. They remain in the estuary where they develop osmoregulation facilities capable of life in the ocean. Once in the ocean they feed and grow before reaching sexual maturity. Some salmonids complete their sexual maturation in the freshwater of their natal stream. Others return to their natal stream ready to spawn.

Salmonid species differ in the timing of their life cycle stages, as well as the specific habitat niches they inhabit while in the freshwater environment. For example, spring-run Chinook enter a river system in the spring and hold over in cold water tributaries and deep pools until spawning in the fall. Fall-run Chinook enter a river system in the fall, immediately ready to spawn. However, both species wait until water flows increase and water temperatures decline in the fall before building redds and laying eggs. Other salmonid species arrive throughout the fall and winter for spawning. By June, the fry of all salmonid species have emerged from the gravel and begun their life in the water column. The length of time juvenile fish remain in freshwater before outmigrating to the ocean varies from several months to several years.

Endangered Species Act (ESA) listed salmonids may be present in some locations in the mainstem Klamath river during the entire year. At the Klamath River Fish Health (KRFH) Conference held in 2007, the participants in the "Panel Discussion on the Cultural, Economic, and Management Implications of Fish Disease in the Klamath River" described the Klamath River as historically being dominated by spring-run Chinook; but, population trends have shifted to favor fall-run Chinook. Carter and Kirk (2008) describe in some detail the causes of this shift and the reader is directed to Appendix 5 of the Klamath TMDLs Staff Report for a copy. Rebecca Quinones of the U.S. Fish and Wildlife Service reported at the 2007 KRFH Conference that the population of fall-run Chinook is looking stable; though, hatchery fish spawning is increasing. She also reported that spring-run Chinook are only found in the Salmon River and periodically in Beaver Creek. Coho populations have decreased by 90-95% from historical levels and populations are trending downwards in the Shasta River; though, returns to the Iron Gate Hatchery are increasing (Quinones, KRFH Conference, 2007).

3.1.1 Individual Species Descriptions

Coho Salmon

In California, coho salmon (*Oncorhynchus kisutch*) have a fairly strict 3 year life cycle with about half of its life spent in freshwater and the other half in the ocean (Moyle 2002). Coho adults migrate upstream for spawning after heavy fall or winter rains breach the sandbars of coastal streams allowing the fish to enter. Coho choose smaller coastal streams or the tributaries of larger coastal streams for spawning. They continue upstream when stream flows are rising or falling; though, not necessarily when the streams are in full flood (Moyle 2002). Redd locations generally are at the head of riffles, just below a pool, "where water changes from smooth to turbulent flow and there is abundant medium to small gravel" (Moyle 2002). Embryos hatch after 8-12 weeks of incubation, time being "inversely related to water temperature" (Moyle 2002).

After emergence, fry find quiet stream margins to feed and shelter before establishing territories. Nielsen (1992a and 1992b) as cited by Moyle 2002, documented a complicated division of territories amongst coho juveniles, including distinctions between those she called estuarine, margin, thalweg, and early pulse juveniles. All are as their name implies. "Early pulse juveniles show two pulses of growth, one in spring and one in autumn." (Moyle 2002)

The outmigration of juveniles begins between March and May. The triggers include: "rising or falling water levels, day length, water temperature, food densities, phase of the moon, and dissolved oxygen levels" (Moyle 2002). Migrants transform into silvery smolts often lingering for a period in the estuary while adjustments are made to their osmoregulatory system (Moyle 2002).

The National Marine Fisheries Service (NMFS) issued a biological opinion on the Klamath Project Operations dated May 31, 2002. In it, NMFS (2002) reports "adult and juvenile coho salmon are observed in tributaries and the main stem of the Klamath River." Coho populations are found in the Klamath River mainstem year round and in Klamath tributaries as listed in Table 3-1 below.

Table 3-1: From NMFS (2002) Biological Opinion on the Klamath Project Operations

Klamath River Tributaries in which coho populations are present	
Between Iron Gate Dam and Seiad Valley	
Bogus Creek	Empire Creek
Little Bogus Creek	Beaver Creek
Shasta River	Horse Creek
Humbug Creek	Scott River
Little Humbug Creek	
Between Seiad Valley and Orleans	
Seiad Creek	China Creek
Grider Creek	Fort Goff Creek
Indian Creek	Portuguese Creek
Elk Creek	Swillup Creek
East Fork Elk Creek	Independence Creek
Clear Creek	Ukonom Creek
Dillon Creek	Salmon River
Between Orleans and Klamath (mouth of the river)	
Camp Creek	Waukell Creek
Trinity River	McGarvey Creek
Turwar Creek	Tarup Creek
Blue Creek	Omagaar Creek
West Fork Blue Creek	Pularvasar Creek
Nickowitz Creek	Ah Pah Creek
One-Mile Creek	Bear Creek
Crescent City Fork	Little Sulfur Creek
Tectah Creek	Johnson Creek
Hunter Creek	Pecwan Creek
East Fork Hunter Creek	Roach Creek
Mynot Creek	Mettah Creek
Hoppaw Creek	Tully Creek
Saugep Creek	Pine Creek

Shaw et al. (1997) studied the life stage periodicities for Chinook, coho, and steelhead in the Klamath River basin from Iron Gate Dam to Seiad Creek. "USFS and USFWS personnel both agree that coho spawning does occur in the mainstem Klamath River (Shaw et al. 1997)." Though not measured, Shaw et al. (1997) believe that coho spawning occurs from November through January in the Klamath system, mostly within tributaries and quiet mainstem habitats. Emergence occurs from late February through April (Shaw et al. 1997). "Coho fry were observed outmigrating from tributaries from early March through late June (Shaw et al. 1997)." Shaw et al. (1997) believe that coho rear in the study area year round.

Coho are listed under the Endangered Species Act as a threatened species in the Southern Oregon/Northern California Coast Ecologically Significant Unit (ESU). The Klamath is listed under the Magnusen Stevens Fishery Conservation and Management Act as Essential Fish Habitat (EFH) for coho.

<u>Chinook Salmon</u>
In California, Chinook salmon (*Oncorhynchus tshawytscha*) are often described by the timing of their freshwater migration: fall-run, late fall-run, winter-run, and spring-run (Moyle 2002). Widely recognized runs in the North Coast Region include: Smith River fall and spring run, Klamath-Trinity fall run, Klamath-Trinity spring run, Klamath late fall run, Redwood Creek fall run, Little River fall run, Mad River fall run, Humboldt Bay tributary fall run, Eel River fall run, Bear River fall run, Mattole River fall run, and Garcia River fall run (Moyle 2002). As described by Moyle (2002), the Klamath-Trinity system has the largest diversity of Chinook salmon runs.

Stream-type Chinook are fish that migrate upstream before reaching sexual maturity, as well as juveniles that spend more than 1 year in freshwater before outmigrating (Moyle 2002). Ocean-type Chinook are fish that spawn immediately upon migrating upstream, as well as juveniles that spend less than 1 year in freshwater before outmigrating (Moyle 2002).

A fall-run Chinook is an ocean-type Chinook, entering the big rivers of the Klamath and North Coast Provinces in the late summer and early fall, and spawning in the lowland reaches within a few days to weeks of arrival (Moyle 2002). Juveniles emerge from the gravel in spring and move downstream within a few months to rear in the mainstem or estuary before going out to sea (Moyle 2002).

A spring-run Chinook is a stream-type Chinook, entering the Smith, Klamath or Eel River in the spring or early summer, going as far upstream as it can, and holding in deep, cold pools until spawning in the early fall (Moyle 2002). The juveniles rear for 3-15 months depending on flow conditions (Moyle 2002). Spring-run Chinook in the Klamath River are considerably less abundant than fall-run Chinook because of the presence of dams, blocking much of their historical mid-elevation habitat (Moyle 2002). Shaw et al. (1997) reports that spring-run Chinook migrate up the Klamath River mainstem beginning in June, tailing off in the Trinity River by mid-September. They hold over until the fall when they spawn primarily in the tributaries. Historically, spring-run Chinook returned to the Iron Gate Hatchery throughout July and August. But, whether or not spring-run Chinook ever spawned in the mainstem is unknown.

Shaw et al. (1997) report that fall-run Chinook enter the Klamath in September with peak migration occurring in October; though, historically they entered as early as August. "Spawning in the mainstem Klamath begins during the second week of October, peaks during the last week of October and declines by the end of November (Shaw et al. 1997)." Fall-run Chinook spawn in the lower reaches of tributaries and in the mainstem Klamath River, although less than 33% spawn in the mainstem (Carter and Kirk 2008).

Juveniles emerge from early February through the end of April, depending on water temperatures. Peak juvenile emigration from the tributaries occurs in mid-March. "Juveniles may emigrate directly to the estuary or remain in the mainstem and emigrate as yearlings (Shaw et al. 1997)."

The Klamath River is listed under the Magnusen Stevens Fishery Conservation Management Act as essential fish habitat for Chinook salmon.

Chum Salmon

In California, small runs of chum salmon were historically present in streams from the Sacramento River north (Moyle 2002). Today, small runs of chum salmon continue in the Smith, Klamath and Trinity Rivers. Hamilton et al. (2005) reports that chum salmon were historically present in the Klamath River basin well below Iron Gate Dam. Chum salmon are generally ocean-type salmon, spending little time in freshwater, and most of that often in the estuary. Chum salmon enter freshwater in the late fall with optimal spawning temperatures of 7.2-12.8 °C and oxygen levels greater than 80% saturation (Moyle 2002). NRC (2004) reports that chum in the Klamath basin are at the southern-most end of their existing range.

Cutthroat Trout

In California, coastal cutthroat trout live in the coastal drainages from the Eel River north (Moyle 2002). Coastal cutthroat trout are more strongly tied to fresh water than most anadromous fishes, leaving freshwater only in the summer months, if at all, and returning to overwinter in freshwater (Moyle 2002). They live primarily in small, low-gradient coastal streams and estuaries where temperatures are cool (<18 °C), well-shaded, and there is abundant cover (Moyle 2002). They especially avoid waters with DO <5 mg/L (Moyle 2002). Embryo survival can be reduced to less than 10% with DO levels lower than 6.9 mg/L (Moyle 2002).

Cutthroat trout migrate upstream in August-October following the first substantial rainfall (Moyle 2002). Cutthroat trout have a prolonged spawning period, lasting as long as September through April (Moyle 2002). Embryos hatch after 6-7 weeks of incubation and alevin remain in the gravel for an additional 1-2 weeks (Moyle 2002), emerging from March to June (Moyle 2002). Juveniles grow in the stream 1-3 years before going to sea (NRC 2004). They spawn 2-4 times. In the Klamath River basin, they occur primarily in the smaller tributaries to the main stem within about 22 miles of the estuary (NRC 2004).

Voight and Gale (1998) "found juvenile and/or adult coastal cutthroat in 13 of the 19 tributaries downstream of and including Johnsons Creek in the lower Klamath River." In several of the tributaries where they were found, cutthroat dominated the electrofishing catch. Voight and Gale (1998) suggest cutthroat trout maybe more abundant in headwater streams than historically because they have become resident above migration barriers. Gale et al. (1998) report large numbers of adult cutthroat in Blue Creek where they seek refuge from inhospitable conditions in the mainstem.

3.1.2 DO requirements of salmonid species

Regional Board staff has relied primarily on four surveys of the scientific literature associated with the DO requirements of salmonids. The first is USEPA's guidance on the development of DO criteria (USEPA 1986). The second is a review conducted by members of the Dissolved Oxygen Technical Advisory Committee (DOTAC) and staff of the Oregon Department of Environmental Quality and published in 1995 (Oregon 1995). The third is a review conducted by staff of the Washington State Department of Ecology and published in 2002 (Washington 2002). And, the fourth is an in-house literature survey conducted by Katharine Carter, peer reviewed, and published in 2005 (Carter 2005). The following discussion is derived primarily from these literature surveys. For a discussion of the original literature from which these conclusions were drawn, the reader is directed to the four above mentioned surveys.

DO criteria for salmonids are generally divided into two categories: those designed to protect early life stages and those designed to protect other life stages. The early life stages of salmonids face specific environmental issues not otherwise confronting other life stages of salmonids, namely relative immobility and life within the intergravel environment. As such, the DO criteria designed to protect the early life stages take into account the inability of embryos to find refuge from inhospitable DO conditions and the difficulty with which fry and alevin avoid inhospitable intergravel DO conditions. They also take into account the reduction in DO concentration that occurs as water from the water column passes through the intergravel environment.

<u>3.1.2.1 Intergravel Dissolved Oxygen (IGDO) Requirements of Early Life Stages of Salmonids</u>

Intergravel dissolved oxygen (IGDO) is the result of a balance between the rate of respiration among gravel dwelling organisms and the rate of oxygen supply. The rate of oxygen supply, in turn, is dependent on the rate of water percolation and convection, as well as oxygen diffusion (USEPA 1986). IGDO has been correlated to embryo survival in some studies, as has apparent velocity and temperature (USEPA 1986, Oregon 1995, Washington 2002). However, the influence of these parameters, one on the others, can not always be separated (Oregon 1995, Washington 2002). A clear relationship between IGDO and alevin growth and development, however, is observable (USEPA 1986, Oregon 1995). Researchers hypothesize that smaller alevin and alevin that hatch later, as a result of depressed IGDO, may be 1) less successful in their competition for food and space as fry and 2) more susceptible to predation (USEPA 1986, Oregon 1995).

USEPA (1986) concludes that the DO requirements of the early life stages of salmonids (i.e., embryo-to-fry emergence from the gravels) are not appreciably different from adult salmonids. In short, a daily minimum of 6.0 mg/L and an average (weekly or monthly) of 8.0 mg/L DO is sufficient to protect the early life stages of salmonids while they reside in the intergravel environment (USEPA 1986). Washington (2002) notes that alevin selectively prefer oxygen concentrations from 8-10 mg/L and will move through the gravel interstices to find favorable DO conditions. Above 7.8 mg/L DO, there may be no size and survival benefit (Washington 2002).

The outstanding question is how to predict from water column DO measurements, the DO available in the intergravel environment. IGDO can be expected to vary widely within redds and between redds (USEPA 1986, Oregon 1995). Yet, USEPA (1986) assumes an average 3 mg/L DO difference between the water column and intergravel environment based on two studies in which the minimum IGDOs were an average of 3 mg/L less than the DO of the overlying water. Early life stage DO requirements as measured in the water column, then, should be 9.0 mg/L as a daily minimum (i.e., 6.0 mg/L + 3.0 mg/L) and 11.0 mg/L as an average (i.e., 8.0 mg/L + 3.0 mg/L). These criteria are intended to apply to unimpaired settings, only. Locations in which sedimentation, elevated temperatures, or reduced flows are complicating factors, the difference between the overlying water and intergravel environment may be substantially more (Oregon 1995).

For comparison, data collected from two streams in Oregon showed IGDO consistently higher than 8.0 mg/L with the IGDO typically less than 1.0 mg/L below surface water measurements (Oregon 1995). In these streams, the observed surface measures fell below 9.0 mg/L and 11.0 mg/L and yet the intergravel data indicated no measureable impairment (Oregon 1995). A 3.0 mg/L difference between water column DO and IGDO, therefore, may sometimes be overly protective and/or unattainable. Washington (2002) identifies from studies a range of 0.5 to 7.2 mg/L difference in DO from the water column to the intergravel environment; but, suggests that 1-3 mg/L difference is the "typical" range and should be used in setting water quality criteria.

Oregon (1995) recommends that in impaired streams, monitoring protocol should be to collect test and control samples, either from paired watersheds; upstream and downstream of a site; or before and after an activity. Reduction in sedimentation through cessation of activity or stream restoration is correlated to improvement in IGDO, either through improvement in apparent velocity and/or reduction in sediment oxygen demand (Oregon 1995).

<u>3.1.2.2 DO Requirements of Other Life Stages of Salmonids</u>

Once fry emerge from the gravels, they enter the water column where they will reside throughout the rest of their freshwater tenure. As young-of-year, salmonids must put on weight, compete for food, and find shelter from predators and adverse environmental conditions. At issue is the effect of DO on swimming performance; growth; avoidance behavior; and synergistic relationship with toxics, temperature, and disease.

<u>Swimming Performance</u>

Laboratory studies demonstrate that any reduction from saturation in DO concentrations can result in reduced swimming performance (USEPA 1986, Oregon 1995, Washington 2002). Salmonids conserve their energy when DO is depressed and remain more active when DO is fully saturated. While the importance of top swimming performance to the health and survivability of salmonids has not been established, it is hypothesized that it is important during spawning and to avoid predators (USEPA 1986, Washington 2002, Carter 2005). With these exceptions, USEPA (1985) concludes that "the moderate levels of swimming activity required by salmonids are apparently little affected by concentrations of dissolved oxygen that are otherwise acceptable for growth and reproduction." Oregon (1995) suggests that reduction in swimming speed may act as a surrogate measure of the effect of chronic stress, a phenomena that influences natural populations, but is not directly measurable.

Growth

Researchers hypothesize that food conversion efficiency is influenced by a number of factors, including DO concentration. Constant exposure studies indicate that when food resources are abundant and temperatures are warm but not lethal, there is a significant correlation between salmonid growth and DO concentration (USEPA 1986, Oregon 1995); though the statistical significance is less universal amongst the studies evaluated for DO concentrations in the range of 5-8 mg/L (USEPA 1986, Washington 2002). Washington (2002) reports a loss of growth when DO concentrations fluctuate from high (>10.0 mg/L) to low concentrations (<5.3 mg/L). Oregon (1995) reports better growth for fish exposed to intermittently low concentrations as compared to those exposed to continuously low concentrations.

In the natural environment, where food resources, temperatures and DO concentrations vary episodically, one expects growth rates less robust than those of fish held under constant, ideal, laboratory conditions. Still, USEPA (1986) concludes that "the attainment of critical size is vital to the smolting of anadromous salmonids and may be important for all salmonids if size-related transition to feeding on larger and more diverse food groups is an advantage." USEPA's (1986) survey of the literature indicates: 1) no reduction in the growth rates of salmonids at temperatures ranging from 12-18 °C and DO ≥8 mg/L, and 2) <10% reduction in growth in the same temperature range and with DO ≥ 6mg/L. Washington (2002) concludes that growth rates may become independent of DO concentrations well below saturation when food availability is low, particularly when temperatures are cool. Washington (2002) notes a general trend for growth rates, even in highly fed salmonids in warm waters, to commonly be indistinguishable from controls at concentrations above 8 mg/L. USEPA (1986) recommends a DO concentration of 8.0 mg/L to ensure no production impairment of other life stages of salmonids and 6.0 mg/L to ensure only slight production impairment. Washington (2002) observes that the highest levels of protection against growth effects are demonstrated under DO conditions ranging from 7.9 to 9 mg/L.

Avoidance Behavior

Juvenile salmonids have the ability to detect areas of substandard DO and avoid them (USEPA 1986, Oregon 1995, Washington 2002, Carter 2005). This is an ability that apparently refines as fry grow and age (Oregon 1995). Even alevin will position themselves in the gravel interstices to avoid DO in the range of 4.5-7 mg/L, showing a selective preference for waters in the range of 8-10 mg/L DO (Washington 2002). Within the water column, studies indicate an avoidance behavior that is triggered by DO conditions below 5-6 mg/L (USEPA 1986, Washington 2002); though, the early avoidance studies for coho typically only tested up to 6 mg/L DO (Oregon 1995). "Later tests conducted at concentrations of 7 mg/L indicated no (coho) avoidance; however, the test temperatures were much cooler which, if reactions are similar to those observed for Chinook juveniles, would be expected to reduce avoidance (Oregon 1995)."

Synergistic Relationships

Salmonids may be exposed to any number of toxicants and/or disease organisms during their time in freshwater, depending on the watershed and the associated anthropogenic activities. Oregon (1995) reports evidence that DO concentrations below saturation act to increase the response of fish to toxicants. Oregon (1995) describes the mechanisms by which adverse actions of a toxicant might be increased by low DO:

1. Increased ventilation of the gill associated with low DO can increase uptake of waterborne toxics;
2. Any toxic which damages the gill epithelium and decreases efficiency of oxygen uptake can thereby increase sensitivity to low DO; and
3. A number of toxics such as pentachlorophenol increase oxygen consumption due to interference with oxidative phosphorylation.

Washington (2002) concludes that maintaining high (>8.5 mg/L) oxygen levels provides added protection from the effects of several very common pollutants.

Washington (2002) also notes the synergistic effects of temperature on the toxicity of pollutants. For several salmonid species, the resistance to lack of oxygen decreases with increasing temperature (Oregon 1995). This is combined with the physical fact that as temperatures rise, the DO concentration at saturation decreases such that less DO is available to aquatic biota in warm water than in cold water. These combined phenomena indicate the importance of cold water refugia, to the success of many salmonids, particularly when summer temperatures otherwise approach levels of concern. Cold water refugia such as deep mainstem pools and tributary streams have the benefit of providing the cool temperatures necessary to many species of salmonids; but also provide DO concentrations at saturation greater than those in the warmer mainstem channel. Without access to cold water refugia, salmonids are confronted with an accelerated metabolism (driven by warmer temperatures) and a reduced ability to swim and feed (driven by lower DO).

In order to identify the locations of known thermal refugia in the Klamath River basin, Regional Water Board staff solicited information from fisheries biologists working in the Klamath through a formal request in April 2009. Based on the information staff received, as well as review of the available reports on the topic, staff compiled a list of the known thermal refugia in the Klamath River basin in California (Table 3-2). The listed tributaries provide thermal refugia at their confluence with the Klamath River mainstem. Maps showing the locations of these creeks in the Klamath River basin are provide in Appendix B. The implementation plan for the Klamath River TMDL and SSO for DO includes a provision to restrict discharges within a buffer zone associated with known thermal refugia (see Chapter 6 of the Klamath TMDL Staff Report).

Table 3-2: Tributaries to the Klamath River Known to Provide Thermal Refugia In and Around Their Confluence.

Tributaries		
Aikens Creek	Halverson Creek	Pine Creek
Aubrey Creek	Hopkins Creek	Portuguese Creek
Barkhouse Creek	Horse Creek	Red Cap Creek
Beaver Creek	Humbug Creek	Reynolds Creek
Blue Creek	Hunter Creek	Roach Creek
Bluff Creek	Ikes Creek	Rock Creek
Bogus Creek	Independence Creek	Rogers Creek
Boise Creek	Indian Creek	Rosaleno Creek
Boulder Creek[1]	Irving Creek	Sandy Bar Creek
Cade Creek	Kelsey Creek[1]	Salt Creek
Camp Creek	King Creek	Seiad Creek
Canyon Creek[1]	Kohl Creek	Slate Creek
Cappell Creek	Kuntz Creek	Stanshaw Creek
Cheenitch Creek	Ladds Creek	Swillup Creek
China Creek	Little Horse Creek	Ten Eyck Creek
Clear Creek	Little Humbug Creek	Thompson Creek
Coon Creek	Little Grider Creek	Thomas Creek
Crawford Creek (Humboldt Co.)	Lumgrey Creek	Ti Creek
Crawford Creek (Siskiyou Co.)	McGarvey Creek	Titus Creek
Dillon Creek	Mill Creek	Tom Martin Creek
Doggett Creek	Miners Creek	Trinity River
Dona Creek	McKinney Creek	Tully Creek
Donahue Flat Creek	Nantucket Creek	Ukonom Creek
Elk Creek	Negro Creek	Ullathorne Creek
Elliot Creek	Oak Flat Creek	Walker Creek
Empire Creek	O'Neil Creek	West Grider Creek
Fort Goff Creek	Pecwan Creek	Whitmore Creek
Grider Creek	Pearch Creek	Wilson Creek

[1] Scott River tributary

Poor water quality conditions have been at least partially responsible for a number of documented fish kills in the Klamath River mainstem downstream of Iron Gate Dam through to the estuary from 1994 to 2004. Juvenile fish kills are thought to be fairly common in the mainstem; but, they often go undetected. Low DO was identified as a contributing stressor in the juvenile fish kills documented in 1997, 1998, and 2000. It was also identified as a contributing stressor in the adult fish kill of 1997.

The adult fish kill of 2002 killed a recorded 33,000 adult salmonids. The majority of the dead fish examined were infected with the fish diseases *Ichthyophthiriasis* (Ich) and Columnaris, which was identified as the principal cause of death (CDFG 2004, USFWS 2003). Subsequent study has identified other diseases affecting salmonid populations in the Klamath River.

Ceratomyxa shasta (*C. shasta*) is thought to be indigenous to the Klamath River, and is the primary fish health issue in the Klamath River (Bartholomew et al. 2007). The lifecycle of *C. shasta* is complex because the parasite changes form and the lifecycle involves two hosts, a freshwater polychaete (worm) and a salmonid. Two of the factors associated with the presence of *C. shasta* appear to be the presence and abundance of the polychaete in the Klamath River (Bartholomew and Bjork 2007).

There may be a linkage between the proliferation of *C. shasta* in the mainstem Klamath River, elevated nutrient concentrations, and subsequent increases in the diurnal fluctuation of DO. Elevated nutrient concentrations result in increased periphyton and increased suspended algae and blue-green algal growth in the river, which have been identified as prime habitat for the polychaete. Increased habitat leads to an increased abundance of the polychaete, which in turn leads to a high infectious spore load in the river. This results in a high probability that adult and juvenile salmonids migrating and rearing in the river will be infected by *C. shasta*. *C. shasta* is commonly found in salmonid streams. But, large scale outbreaks of disease are rarely observed unless, as shown in the Figure 3-1, there is an increase in both parasite spores and environmental stressors, including low DO. Oregon (1995) reports that generalized stress causes increased releases of cortisol in salmonids which suppresses immune function and disease resistance, as appears to have been happening in the Klamath River.

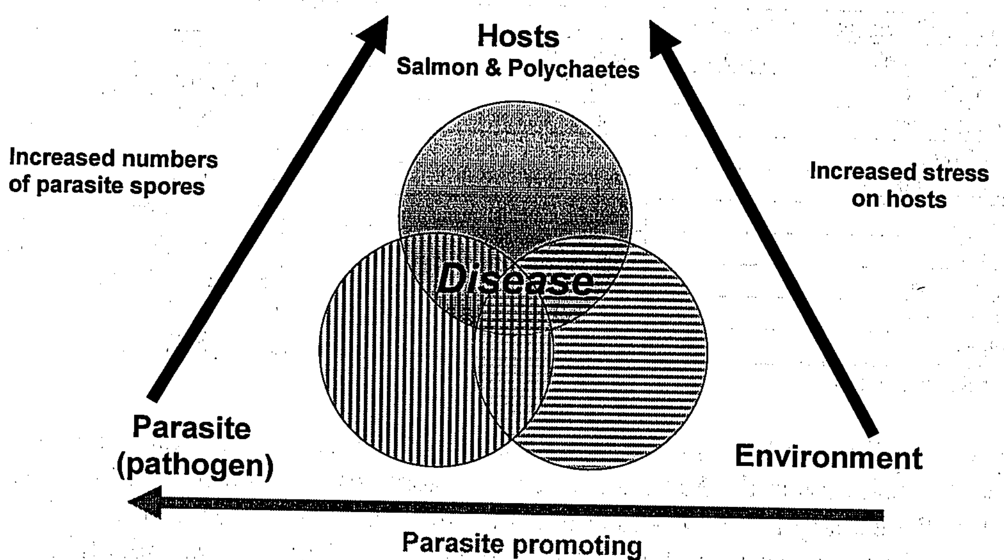

Figure 3-1: Severity of *Ceratomyxosis* in Klamath River suggests a shift in the host/parasite balance towards *C. shasta*
Source: Bartholomew personal communication 2008

<u>3.1.2.3 Summary of Salmonid DO Requirements</u>
USEPA (1986), Oregon (1995) and Washington (2002) each provide technical recommendations for appropriate DO criteria for the protection of salmonids. Table 3-3 represents USEPA's (1986) recommendations derived from it's synthesis of scientific studies but primarily relying on 1) growth data and 2) information on temperature, disease, and pollutant stresses (USEPA 1986). USEPA (1986) proposes national coldwater criteria for the protection of early life stages of 9.5 mg/L DO in the water column as a 7-day mean and 8.0 mg/L DO in the water column as 1-day minimum. For

other life stages, USEPA (1986) recommends 6.5 mg/L DO as a 30-day mean, 5.0 mg/L DO as a 7-day mean minimum, and 4.0 mg/L DO as a 1-day minimum.

However, "if slight production impairment or a small but undefinable risk of moderate production impairment is unacceptable, then continuous exposure conditions should use the "no production impairment values" as means and the "slight production impairment values" as minima (USEPA 1986)." The Klamath River is a system in which even slight production impairment is unacceptable because of the threatened and endangered status of several of the basin's native fish species. For a river such as the Klamath, then, USEPA (1986) would recommend (see Table 3-3) for early life stages 11 mg/L DO in the water column as a 7- or 30-day mean (8 mg/L IGDO) and 9.0 mg/L DO in the water column as a 1-day minimum (6.0 IGDO). For other life stages, USEPA (1986) would recommend 8.0 mg/L as a 7- or 30-day mean and 6.0 mg/L as a 1-day minimum.

Table 3-3 from USEPA (1986) Ambient Water Quality Criteria for Dissolved Oxygen

	No Production Impairment (mg/L)	**Slight Production Impairment** (mg/L)	**Moderate Production Impairment** (mg/L)	**Severe Production Impairment** (mg/L)	**Limit to Avoid Acute Mortality** (mg/L)
Salmonid Waters-- Embryo and larval stages	11* (8)	9* (6)	8* (5)	7* (4)	6* (3)
Salmonid Waters--Other life stages	8	6	5	4	3
Nonsalmonid Waters— Early life stages	6.5	5.5	5	4.5	4
Nonsalmonid Waters— Other life Stages	6	5	4	3.5	3
Invertebrates	8	5			4

* These are mean water column concentrations recommended to achieve the required intergravel DO concentrations shown in parentheses. The recommended water column concentrations are based on the assumption that there is a 3 mg/L difference between water column and intergravel DO, on average.

USEPA (1986) also considers waterbodies in which natural conditions produce DO in noncompliance with the given criteria. USEPA (1986) recommends that "if natural conditions alone create dissolved oxygen concentrations less than 110 percent of the applicable criteria means or minima or both, the minimum acceptable concentration is 90 percent of the natural concentration (USEPA 1986)." The Klamath River is a productive river which under natural conditions produces DO in noncompliance with the recommended criteria (see Chapter 6.0 of this Staff Report). As such, USEPA's (1986) guidelines suggest that 90% of the natural DO concentrations will provide adequate protection of the beneficial uses.

Oregon (1995) also includes several recommendations with respect to DO criteria suitable to protect salmonids. The Oregon Department of Environmental Quality assembled a Dissolved Oxygen Technical Advisory Committee (DOTAC) for the purpose of reviewing the existing standards, reviewing the current state of the scientific literature associated with the DO requirements of salmonids and other aquatic species, and developing findings and recommendations. The DOTAC was chaired by Dr. Gary Chapman of the USEPA who also authored the USEPA's 1986 guidance on ambient water quality criteria for DO. The DOTAC conducted its review of Oregon standards from 1992-1994. Their findings and recommendations were published in 1995. The DOTAC found that:

1. "The "natural" conditions in some streams will cause dissolved oxygen levels to fall below the numerical criteria, especially the conservative 90-95 percent criteria when interpreted as absolute minimums.
2. Saturation criteria may result in inadequate protection at high temperatures and greater than necessary criteria at low temperatures, often inversely related to the needs of the resource. Because of the high level of protection warranted for salmonid spawning, concentration and saturation criteria would be similar for this use.
3. Current criteria recognize that situations will occur where the achievement of dissolved oxygen standards will not be possible due to naturally occurring conditions or due to human activities which are beyond regulatory control. In these cases, the background conditions become the criteria and no further degradation is permitted. Other states, such as Washington, provide an allowance on the order of 0.20 mg/L for further degradation under similar conditions.
4. 10% of the reference sites and 24% of the Regional Environmental Monitoring and Assessment Program (REMAP) sites in the coast range would violate a 90% saturation criterion, even though they meet a no measureable impact to cold-water fish criteria of 8.0 mg/L.

The DOTAC and staff at the Oregon Department of Environmental Quality jointly reviewed scientific literature related to DO criteria. They reviewed literature associated with salmonid physiology, early life stages and intergravel DO, relationship between intergravel DO and solids, natural range and variation in intergravel DO, swimming performance, fish growth, oxygen cycles, supersaturation; avoidance and behavioral changes; toxics and disease; water temperature; field studies; estuarine criteria; and relationship between pH, CO_2, and DO. From this review, the DOTAC recommended that:

1. Criteria should be related to the biological resources that are to be protected.
2. There should be consistency between the criteria for different river basins.
3. Critical compliance issues related to temperature and dissolved oxygen need to be analyzed. The State needs to manage its aquatic resources much more broadly than by single parameter or by point-source pollution control.
4. Concentration criteria should be used rather than percent of saturation for other life stages of cold-water biological resources, with the exception of supersaturation criteria. The criterion for early life stages of cold-water fish could be equally well presented as a percent saturation.
5. Statistical criteria with associated duration period should be used.

6. Statistical criteria should be applied only when adequate data are available.
7. The early life stages criteria for salmonid protection should apply during the latter stages of incubation of embryos and fry, until after fry emerge from the gravels. The protective criteria need only apply to areas of salmonid spawning.
8. The state should establish intergravel dissolved oxygen criteria for protection of the early life stages of salmonids. For unimpaired watersheds, the expected loss of an average of 3.0 mg/L DO from surface to the gravels provides the method for determining minimum surface-water concentrations. The assumption of a 3.0 mg/L loss between surface and intergravel environments may underestimate the loss that occurs in highly impacted spawning areas.
9. The importance of nutrient and sediment runoff and removal of the riparian canopy as major cause of DO depletion in streams and lakes should be recognized.
10. The impact of stream flows on temperature changes and therefore on DO should be recognized.

In 2002, the State of Washington published the findings and recommendations resulting from its review of the State's DO criteria and the current scientific literature. It notes that any depression of oxygen from saturation will produce some reduction in the performance of fish (Washington 2002). It also notes that statistically significant changes to growth, swimming speed, etc. do not occur until oxygen levels are depressed to levels that are sometimes well below the saturation value (Washington 2002).

Table 3-4 captures the technical recommendations of USEPA (1985), Oregon (1995), and Washington (2002) with respect to DO criteria suitable for the protection of salmonids and other aquatic life.

3.2 Lamprey

Lamprey are a jawless fish from the family *Petromyzontidae* that generally feed on the blood and body fluids that they extract with their sucker-like mouth from live fish (Moyle 2002). This "predatory" phase of the Pacific lamprey is spent in the ocean, except for those species that are landlocked (Moyle 2002).

Pacific lamprey spawning usually begins in early March and lasts through late June (Moyle 2002). There are variations to this schedule. And, in the larger rivers (Klamath, Trinity, and Eel) there may be both spring and fall runs, similar to salmon (Moyle 2002).

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Table 3-4: Recommendations of USEPA (1986), Oregon (1995), and Washington (2002)

	USEPA (1986)—mg/L		Oregon (1995)—mg/L		Washington (2002)—mg/L	
Incubation through emergence[1]	≥11	7- or 30-day mean	≥11[2]	7-day mean	≥9.0-11.5[34]	30- to 90-day average of daily minima
	≥9	1-day minimum	No comment			
	≥8 IGDO	7- or 30-day mean	No comment			
	≥6 IGDO	1-day minimum	≥6 IGDO	1-day minimum		
Growth of Juvenile Fish	≥8	7- or 30-day mean	≥8[5]	30-day mean	≥8.0-8.5	30-day daily minimum
	≥6	1-day minimum	No comment		≥5.0-6.0	1-day minimum
Swimming Performance	No comment		No comment		≥8.0-9.0	1-day minimum
Avoidance	No comment		No comment		≥5.0-6.0	1-day minimum
Acute Lethality	No comment		No comment		≥4.6	7- to 30-day average of daily minima
	No comment		No comment		≥3.0	1-day minimum
Macro-Invertebrates	≥8	7- or 30-day mean	No comment		No comment	
	≥5	1-day minimum	No comment		≥8.5-9.0[6]	1-day minimum or average
					≥7.5-8.0[7]	1-day minimum or average
					≥5.5-6.0[8]	1-day minimum or average
Synergistic Effect Protection	≥8	7- or 30-day mean	No comment		No comment	
	No comment				≥8.5	1-day average
	6	1-day minimum			No comment	
To ensure no risk	No comment		No change from natural		No comment	

1 Applies only during the period of incubation through emergence and only in those locations in which spawning occurs.

2 If conditions of altitude and natural temperature preclude achievement of 11 mg/L, then 95% saturation applies.

3 No measureable change when waters are above 11°C (weekly average) during incubation.

4 Applies throughout the period from spawning through emergence and assumes 1-3 mg/L will be lost between the water column and the incubating eggs.

5 If conditions of altitude and natural temperature preclude achievement of 8 mg/L, then 90% saturation applies.

6 To be applied in mountainous headwater streams

7 To be applied to mid-elevation streams, lakes, and non-salmonid water

8 To be applied to low-elevation streams, lakes and non-salmonid water

Adult lamprey migrate from the ocean to freshwater where a male and female build a nest together in the gravel (Moyle 2002). After the eggs are laid and fertilized, embryos develop and hatch in about 19 days at 15 °C (Moyle 2002). The ammocoetes are washed downstream to a muddy or sand-bottomed backwater where they burrow in the sediment, tail down (Moyle 2002). They remain in the sediment as filter feeders while they undergo a metamorphosis to become adult lamprey (Moyle 2002). Metamorphosis takes from 5-7 years (Moyle 2002).

There is some evidence of temperature requirements of lamprey. But, little information is available regarding dissolved oxygen requirements, though ammocoete development is impaired under very low DO concentrations (Goodman 2008). Of primary concern to lamprey conservation are activities that may directly disturb ammocoetes, result in sedimentation of quiescent stream reaches, or cause localized dewatering (USFWS 2007a). Data on optimal DO conditions for lamprey are not available; however, DO conditions suitable to support salmonids are believed to be adequate for lamprey, as well (Goodman 2008).

3.3 Sucker

The Lost River sucker (*Catostomus luxatus*) and shortnose sucker (*Chasmistes brevirostris*) are two native fish species of the upper Klamath basin. Both sucker species are endangered and belong to a "part of a group of suckers that are large, long-lived, late-maturing, and live in lakes and reservoirs but spawn primarily in streams; collectively, they are commonly referred to as lake suckers" (NRC 2004). Lake suckers differ from most other suckers in having terminal or subterminal mouths that open more forward than down, an apparent adaptation for feeding on zooplankton rather than suctioning food from the substrate (Scoppettone and Vinyard 1991 as cited by NRC 2004). Historically, Lost River suckers and shortnose suckers occurred in the Lost River and upper Klamath River and their tributaries, especially Tule Lake, Upper Klamath Lake, Lower Klamath Lake, Sheepy Lake, and their tributaries (Moyle 2002 as cited by NRC 2004).

The adult suckers reach sexual maturity between years 4 and 6 for the shortnose sucker (USFWS 2007c) and 5 and 14 for the Lost River sucker (USFWS 2007b). They spawn in river riffle and run habitat from February through May in gravel and cobble substrate with moderate flows and depths less than 4 feet (USFWS 2007b and 2007c). Sucker larvae move out of the gravel soon after hatching and generally drift downstream to the lake environment where they disperse in the near shore areas (Cooperman and Markle 2004 as cited by USFWS 2007a; USFWS 2007b). Larval habitat is best described as shallow, nearshore, and vegetated in both rivers and lakes, except Clear Lake and Gerber Reservoir which lack vegetation (NRC 2004). Adult suckers select water depths of 3-15 feet, their strongest preference appears to be for 5-11 feet (NRC 2004). Adult Lost River suckers have been aged to 43 years while shortnose suckers have been aged to 33 years (NRC 2004). The lake suckers spawn numerous times over their life time producing millions of eggs, a life history strategy necessary due to the high natural mortality of the young fish and the low natural mortality of the older adult fish (NRC 2004).

With respect to water quality, Woodhouse et al. (2004) synthesized several studies in the Lost River basin to determine appropriate thresholds for Lost River and shortnose suckers. They were unable to identify appropriate criteria for the protection of suckers; but, did identify acute lethality thresholds, as follows:

- DO < 2.3 mg/L (based on LC_{50} in shortnose sucker larvae);
- pH > 9.5 (based on critical maxima in shortnose sucker adults);
- Water temperature < 30.3 °C (based on LC50 in shortnose sucker juveniles);
- Un-ionized ammonia < 0.48 mg/L (based on LC_{50} in Lost River sucker larvae and shortnose sucker juveniles).

Comparing to the lethality thresholds for salmonids as described by USEPA (1986), Oregon (1995), Washington (2002), staff concludes that DO conditions suitable for the protection of salmonids will adequately protect suckers, as well.

3.4 Green Sturgeon

The green sturgeon (*Acipsenser medirostris Ayres*) is a long-lived anadromous fish that spends most of its time in ocean waters with feeding forays to bays and estuaries (NMFS 2009). Both adults and juveniles are benthic feeders eating shrimp, mollusks, amphipods and small fish (Moyle 2002). The green sturgeon migrates into freshwater systems to spawn. In the North Coast Region, green sturgeon are primarily found in the Klamath and Trinity rivers; though, they will occasionally be seen in the Eel River which once supported a spawning run (Moyle 2002).

Green Sturgeon in the Klamath River system are likely to be part of the Northern Distinct Population Segment (DPS) which is a Federal ESA species of concern, commonly referred to as a candidate species. Adults of the Southern DPS may also enter the river, particularly the estuary to forage; and, they are listed as a threatened species under the Federal ESA. Green sturgeon enter the Klamath River system between February and late July with a spawning period of March to July and a peak from mid-March to mid-June (Moyle 2002). They spawn in deep, fast water where eggs are broadcast and externally fertilized (Moyle 2002). Juveniles remain in freshwater for up to 3 years before migrating to the ocean. Water quality requirements for the green sturgeon are unknown; but, a small amount of silt will prevent the eggs from clumping together and thus reduce viability (Moyle 2002).

Gulf of Mexico sturgeon were found in locations in the Suwannee River estuary ranging from 6.0 to 9.8 mg/L DO with an average of 7.5 mg/L DO (Harris et al. 2005). Eggs were found in areas of the Suwannee River with DO exceeding 5.0 mg/L (Sulak and Clugston 1998). Campbell and Goodman (2004) exposed juvenile shortnose sturgeon, an Atlantic species, to varying laboratory conditions and derived LC50s ranging from 2.2-3.1 mg/L DO depending on the accompanying salinity, temperature, and age of the fish. Younger fish were more sensitive to low DO than older fish.

NMFS 2009 lists as threats to California's green sturgeon:

- ✓ Insufficient freshwater flow rates in spawning areas,
- ✓ Contaminants (e.g., pesticides),

- ✓ Bycatch of green sturgeon in fisheries,
- ✓ Potential poaching (e.g., for caviar),
- ✓ Entrainment by water projects,
- ✓ Influence of exotic species,
- ✓ Small population size,
- ✓ Impassable barriers, and
- ✓ Elevated water temperatures.

DO is not specifically identified as a limiting factor. But, elevated temperatures and decreased flows have the potential to affect DO concentrations. Green sturgeon have an advantage over salmonids with respect to DO and spawning in their choice of deep, fast water as spawning habitat. The DO conditions of this habitat niche are likely superior to that of more shallow, slow moving water. Staff concludes that DO requirements designed to protect salmonids will reasonably protect sturgeon, as well, even though their spawning and incubation period extends past that of salmonids.

3.5 Smelt

The eulachon (*Thaleichthys pacificus*) and longfin smelt (*Spirinchus thaleichthys*) are both in the smelt family *Osmeridae* and are anadromous fish. Within the North Coast Region, the eulachon has been found historically in the Klamath River, as well as in the Mad River, Redwood Creek, and the Smith River while the longfin smelt has been found in Humboldt Bay, the Eel River estuary, the Klamath River estuary, and the Russian River estuary (Moyle 2002). They (eulachon) have been proposed by the National Marine Fisheries Service (NMFS) to be listed as threatened under the Federal ESA and are considered a species of concern.

The eulachon is the largest species of the smelt family (Moyle 2002). It is a very oily fish, also sometimes called the candlefish because of its historic use when dried to be burned as a candle. It is an anadromous fish, spending most of its life at sea and then spawning in the lower reaches of coastal rivers (Moyle 2002). Eulachon return to freshwater between December and May in their third year and their migration appears to be timed with river temperatures between 4-8 °C (Moyle 2002). Migrating fish seldom travel farther than 7.5 miles (12 km) up river, the fish keeping to the river bottom and shallow river edges (Moyle 2002). Spawning occurs where temperatures are between 4-10 °C, velocities are moderate, and substrate consists of pea-sized gravel or gravel mixed with sand, wood or other debris (Moyle 2002). Fertilization is external with females producing an average of 25,000 eggs (Moyle 2002). Eggs have two membranes, the outer one of which ruptures when the egg hits the channel bottom. This allows the sticky edges to adhere to the substrate where the larvae will hatch in 2-3 weeks. The larvae are quickly washed out to sea (Moyle 2002).

Moyle (2002) states "given the extended ocean life phase of eulachon and the apparently sporadic nature of their abundance in recent years, it is likely that oceanic conditions may be important determinants of the size of spawning runs." He continues "eulachon are sensitive to a number of environmental factors and their recent decline in California streams may be the result of changes in water quality or spawning habitat in the lower reaches of rivers" (Moyle 2002).

Longfin smelt have a wide salinity and temperature range, reflecting their ability to occupy various estuarine niches depending on the time of year and life cycle stage (Moyle 2002). They spawn in freshwater over sandy or gravel substrates, rocks and aquatic plants as early as November and up through the month of June (Moyle 2002). Embryos hatch in 40 days at temperatures of 7 °C, the newly hatched larvae drift quickly down to the estuary (Moyle 2002). Larvae metamorphose into juveniles after 30-60 days from hatching, depending on the temperature (Moyle 2002). Most adult longfin smelt die after spawning (Moyle 2002).

Pientka and Parrish (2002) found that in a comparison of habitat use by Atlantic salmon and rainbow smelt, the two occupied similar thermal habitat. But, Atlantic salmon generally chose habitat with higher DO concentrations. Staff concludes that DO objectives designed to protect salmonids will be protective of smelt, as well.

3.6 Summary

In summary, there are a number of native fish species of the Klamath Province that are at risk of extinction, including species of: salmonids, lamprey, sucker, sturgeon, and smelt. These fishes occupy a variety of freshwater and estuarine habitats, some of them overlapping with other native species. The life cycles vary considerably with some species spending a majority of their lives in freshwater and others in the ocean. Yet, the information staff has been able to gather on the DO and/or other water quality requirements of each of the species of interest suggests that DO objectives designed to protect salmonids likely will protect the other native species, as well, even for those species with extended larval stages such as the lamprey. This brief assessment is intended only to confirm that the general bias towards salmonids in the establishing of water quality objectives is, at least for DO, warranted.

A summary of various DO recommendations for salmonids is given in Table 3-4 above. From these recommendations, it is determined that Klamath River fishes, including those at risk of extinction, would ideally enjoy the following DO conditions, including:

Early Life Stages: **9.0-11.5 mg/L** as a 7- or 30-day mean or 30- to 90-day average of daily minima to protect eggs and alevin from growth effects, assuming a 1-3 mg/L decrease in DO from the water column to the intergravel environment.

6.0 mg/L IGDO as a 1-day minimum to protect eggs and alevin from acute lethality and growth effects.

Other Life Stages: **8.0 mg/L** as a 7- or 30-day mean to protect against acute lethality and growth effects.
6.0 mg/L as a 1-day minimum to protect against growth effects, avoidance behavior, acute lethality, and synergistic effects. According to research conducted by Washington (2002), this criterion does not appear to protect optimum swimming performance or macroinvertebrate health (except in low elevation streams). USEPA (1986) concludes that optimum swimming performance is only required in short bursts. Moderate swimming performance is protected by criterion that protects growth and is adequate for the protection of the species. USEPA (1986) also acknowledges that some macroinvertebrates are more DO sensitive than fish; but suggests that 6 mg/L as a 1-day minimum is adequate to protect a reasonably diverse macroinvertebrate assemblage, particularly since DO sensitive species seek high flow environments so as to optimize their DO exposure.

CHAPTER 4.
GENERAL DISCUSSION OF DISSOLVED OXYGEN

The purpose of this chapter is to provide a general discussion of dissolved oxygen (DO), including a discussion of what it is, why it is important, and what factors influence its concentration

Dissolved Oxygen (DO) provides an excellent measure of general aquatic health. It is one of the primary water quality factors that define the habitability of a given aquatic system. Yet, it varies considerably both temporally and spatially in the natural environment. Thus, to interpret DO data, one must know something about the factors influencing its concentration and the expected pattern and range of its variation to be able to discern any deviation from background conditions and/or any critical impact. A general discussion of these issues follows.

4.1 What is Dissolved Oxygen?

Dissolved oxygen, most often measured in mg/L, is the amount of oxygen gas present in a volume of water. Water has a limited capacity to hold oxygen gas in solution. This capacity is defined by a mathematical relationship among the temperature, atmospheric pressure, and salinity at a given site. When water has reached its capacity to hold oxygen gas in solution it is said to be *saturated.* When it exceeds its capacity, it is said to be *supersaturated.* And, when it does not reach its capacity, it is said to be *sub-saturated.*

4.2 Why is Dissolved Oxygen important?

Oxygen is necessary for the respiration of aerobic organisms. Because water has a limited capacity to hold oxygen gas in solution, aquatic organisms have evolved specialized structures or methods of extracting from water the limited amount of oxygen gas that is present in it. These structures or methods generally rely on the partial pressure differential between oxygen in the water column and oxygen in the blood (or the equivalent oxygen receptor). Gills, as an example, are designed to allow the passive diffusion of oxygen from water across the gill membrane to the arterial system.

A healthy riverine system is generally one in which the DO concentration is at or approaches full saturation and is maintained by diffusion (Allan 1995). Under these conditions, aerobic organisms can extract from the water column the oxygen necessary to ensure basic metabolic success (e.g., growth, general health, and reproduction) leading to a greater likelihood of population success. Further, a riverine system approaching DO saturation is better able to support a wide and diverse array of life forms than one which does not.

As the concentration of DO in water is reduced to levels significantly less than saturation, the oxygen partial pressure gradient between the water column and blood (or equivalent oxygen receptor) is reduced and the ability of the gill structure (or equivalent oxygen receptor) to acquire the necessary oxygen for respiration is impaired. This can lead to chronic effects, such as reduced growth, increased susceptibility to disease, reduced reproductive success, or loss of habitat through avoidance. It can also lead to acute effects, such as asphyxiation and death. The term *hypoxia* (meaning "low oxygen") refers to the water quality condition in which the dissolved oxygen present in water is insufficient to provide the oxygen requirements of aerobic organisms. Water devoid of oxygen is known as *anoxic*.

4.3 What are the factors influencing the concentration of Dissolved Oxygen?

The concentration of DO in an aquatic environment is controlled by many interrelated variables, including stream temperature, salinity, atmospheric pressure, turbulence, respiration, photosynthesis, and biological and chemical oxygen demanding reactions. To simplify, these factors can be divided two categories: 1) those that define the capacity of the water to hold DO (DO saturation) and 2) those that affect the percent of that capacity which is actually utilized (% DO saturation).

4.3.1 DO saturation

DO saturation is defined by the mathematical relationship among three variables: atmospheric pressure, temperature, and salinity. Variation in DO saturation is proportional with variation in atmospheric pressure and is inversely proportional with variation in temperature and salinity. Thus, as atmospheric pressure increases so does the concentration of DO at saturation. Because atmospheric pressure decreases as elevation increases, DO at saturation is inversely proportional with elevation. At any one elevation, DO at saturation also will vary based on the presence of low or high pressure storm systems.

As water temperature and/or salinity increase, the concentration of DO at saturation decreases. Water temperature varies depending on numerous factors including: latitude, climate, season, presence of springs, shade, and volume of warm water inputs, as examples. Salinity primarily varies based on the degree of oceanic influence.

One of the primary routes by which oxygen dissolves in water is through the diffusion of oxygen across the air-water interface. Atmospheric oxygen exerts a pressure at the air-water interface allowing for the diffusion of oxygen across the boundary until the partial pressure of atmospheric oxygen equals the partial pressure of oxygen in water. The pressure exerted on the air-water interface by oxygen dissolved in water is defined not only by the concentration of oxygen in water, but by the temperature of the water, as well. For example, O_2 molecules become excited and exert a greater partial pressure on the air-water interface when warm then they do when cool. Thus, the warming of a waterbody serves to slow or even reverse the diffusion of oxygen from the air to the water column.

With respect to salinity, one can visualize water as including H_2O molecules and the spaces between them. The spaces between the H_2O molecules allow for various other molecules to be dissolved in water. If the spaces between the H_2O molecules are filled with molecules such as salts, then the number of spaces available for oxygen is reduced. Salinity is a measure of salts and is generally used to define the gradient between freshwater, brackish water, and saltwater systems. An aquatic system with a high salinity (e.g., the ocean) will naturally have a lower DO concentration at saturation than will a freshwater system with little or no salinity.

Staff has calculated and graphed DO at 100% saturation for individual elevations based on a standard pressure of 760 mm Hg (Figure 4-1). These are theoretical DO concentration values based solely on salinity (i.e., freshwater), atmospheric pressure and temperature and represent the physics associated with holding oxygen in a dissolved state in an aqueous solution. Figure 4-1 does not represent DO concentrations as altered by water quality conditions such as turbulence, aerobic decomposition, photosynthesis, etc. For a given elevation and temperature, Figure 4-1 illustrates the maximum DO concentrations physically possible under conditions of equilibrium.

Figure 4-1: Theoretical DO at 100% Saturation (produced by Rich Fadness of the Regional Water Board)

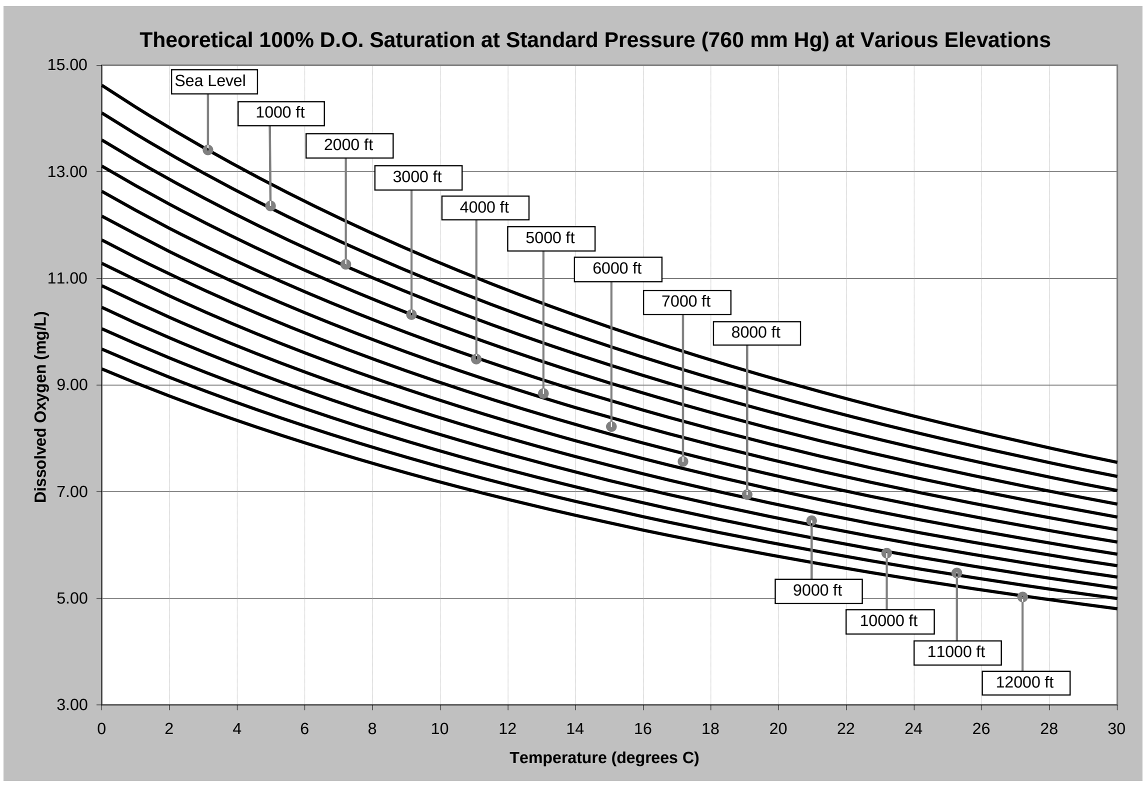


Figure 4-1 illustrates the decline in the ability of water to hold oxygen in solution that occurs as a result of increasing temperatures. For example, at 1,000 feet elevation, DO concentrations range from approximately 14.0 to 7.2 mg/L as temperatures increase from 0 to 30°C. Figure 4-1 also illustrates at a given temperature, an increase in the ability of water to hold oxygen in solution that occurs as water moves from a higher elevation to a lower elevation. For example, at 16°C, DO concentrations range from approximately 6.2 to 10.0 mg/L as water flows from 12,000 feet elevation to sea level. For a given elevation and temperature, Figure 4-1 provides an estimate of the ability of water to hold oxygen in solution (i.e., DO concentration) when in a state of equilibrium. For example, at 3,000 feet elevation, when water temperatures reach 22°C, DO is approximately 7.9 mg/L at 100% saturation.

4.3.2 Percent Saturation

In the natural environment, there are several other factors at play besides the effects of atmospheric pressure, temperature, and salinity. For example, photosynthesis, turbulence, respiration, organic decomposition, and oxygen demanding biological and chemical reactions also effect the concentration of DO in an aquatic system. These factors do not control the capacity of an aquatic system to hold oxygen in solution (DO saturation). Instead, they affect the percentage of the capacity that is actually utilized (percent saturation).

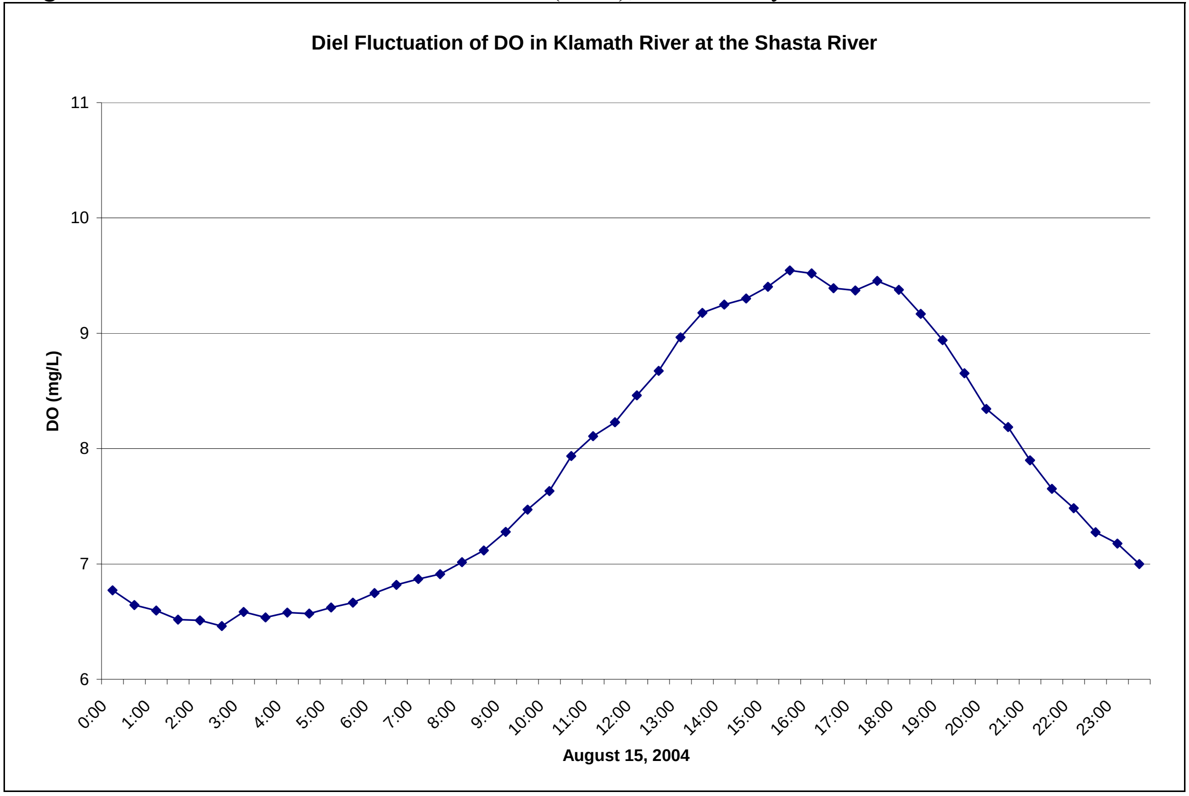
The *photosynthesis* of aquatic plants, algae, and cyanobacteria has a profound effect on the oxygen content of water. Photosynthetic organisms use carbon dioxide to convert the energy contained in sunlight into carbohydrates and oxygen. Aquatic photosynthetic organisms release their oxygen (a waste product) to the water column, temporarily increasing the DO concentration of the water. Areas in which the substrate, light, nutrients and temperature favor the growth of aquatic photosynthetic organisms may see large increases in DO during the late afternoon when the effects of photosynthesis have accumulated through the day. Such areas may be naturally present in an aquatic system (e.g., wetlands; lakes; and slow moving, shallow river reaches) or promoted by anthropogenic activities (e.g., nutrient enrichment, shade removal, reduction in flow, or reduction in water depth through sediment deposition).

The contribution of oxygen to the water column as a result of photosynthesis occurs only during the daylight hours when photosynthesis is active. This source of oxygen is not present during the night when in the absence of sunlight photosynthesis does not occur. The result is a notable cyclical DO pattern where DO is low in the pre-dawn hours, increases slowly during the morning, reaches a peak prior to sunset, and then declines through the night. This is called a *diel* cycle. A typical DO diel cycle results in daily minimum DO concentrations in the pre-dawn hours.

Figure 4-2 depicts the DO diel curve that results from 24-hour DO data collected on August 15, 2004 in the Klamath River at its confluence with the Shasta River. On that day, DO dropped below 7 mg/L sometime prior to 1am and didn't exceed 8 mg/L until 12 noon. The DO concentration peaked at approximately 9.5 mg/L by 3:30pm. These data do not represent natural conditions. But, they do represent the typical shape of a diel DO curve, specifically showing lower DO concentrations at night followed by higher DO concentrations during the day as photosynthesis is active.

The term *turbulence* refers to a physical process in which the air-water interface is disturbed. Turbulence serves to increase the transfer of oxygen across the air-water interface by increasing the surface area of the interface either at the surface of the water or in the form of bubbles of air entrained within the water column (e.g., as occurs at waterfalls or through mechanical mixing). Turbulence can serve to either decrease or increase the transfer of oxygen to the water column depending on whether the water is supersaturated or sub-saturated and whether or not air is entrained in the water column.

Figure 4-2: 24-hour DO data in mid-summer (2004), collected by US Fish and Wildlife Service



The *respiration* of aquatic organisms requires oxygen for the process of converting carbohydrates into energy for growth and reproduction. It also results in the release of carbon dioxide as a waste product. The oxygen fueling the respiration of aquatic organisms comes from the water column and as described above is extracted using specialized structures or methods (e.g., gills

The *decomposition* of organic matter in the aquatic environment is a complex process involving numerous organisms and chemical reactions. Biological oxygen demand is a measure of the pressure exerted on dissolved oxygen supplies by the biological decomposition of organic molecules. Numerous species of micro-organisms are involved in the process of biological decomposition.

Chemical oxygen demand is a measure of the pressure exerted on dissolved oxygen supplies by the chemical oxidation of organic molecules. Some of the reactions are initiated by biological activity. The chemical reactions typically at play in an aquatic environment include: carbonaceous deoxygenation, nitrogenous deoxygenation, nitrification, and methantrophy.

The percentage of the capacity of water to hold oxygen in solution is reported as *percent saturation*. In any given system, it is the unique and fluctuating combination of oxygen sources (e.g., photosynthesis and turbulence) and oxygen sinks (e.g., respiration, biological oxygen demand, and chemical oxygen demand) that define the percent saturation. For example, the infusion of dissolved oxygen into the water column via photosynthesis or turbulence can result in the temporary supersaturation of water (i.e., DO concentrations in excess of that described by 100% saturation). These conditions subside either during the night when photosynthesis is no longer active or downstream as water moves out of the influence of waterfalls or rapids.

In the reverse, respiration and decomposition can remove oxygen from the water column resulting in the temporary sub-saturation of water (i.e., DO concentrations less than those described by 100% saturation). These conditions also subside on the spatial and temporal scale. But, the subsidence might occur seasonally, rather than daily. In highly eutrophic systems, the decomposition of organic matter can result in the temporary removal of oxygen from the water column. The loss of oxygen from an aquatic system can result in the temporary loss of all aerobic organisms, such as observed in fish kills.

Figure 4-3: Theoretical DO at 85% (produced by Rich Fadness of the Regional Water Board)

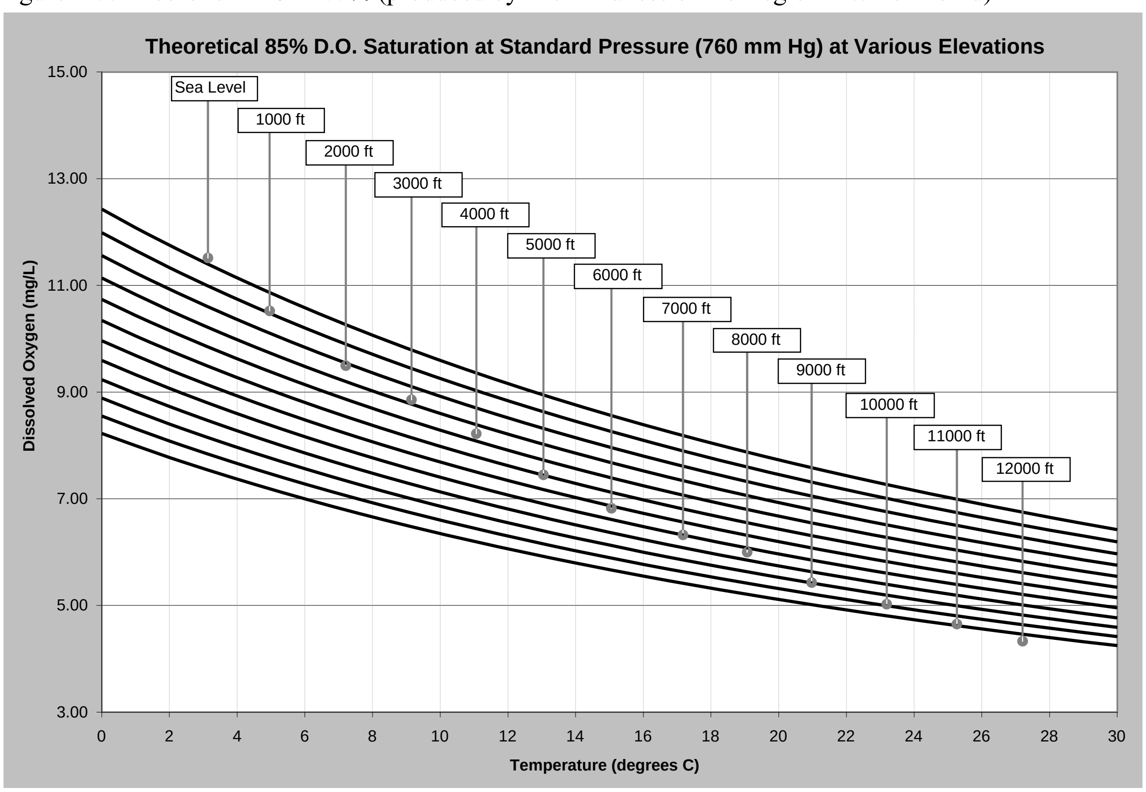


Figure 4-3 represents the theoretical concentration of DO at 85% saturation at various elevations and temperatures. As described in Chapter 7.0 of this Staff Report, staff estimates that 85% saturation is the minimum percent saturation occurring in a healthy, free-flowing stream with moderate nutrient and organic loading.

By comparing Figures 4-1 and 4-3, one can estimate at any given temperature and elevation, the difference in DO concentration at equilibrium versus that influenced by moderate decomposition and respiration, generally estimated to occur at DO saturations no less than 85%. For example, at 3000 feet elevation and 20°C, a DO concentration under equilibrium (100% saturation) decreases from 8.1 mg/L to 6.9 mg/L due to only moderate decomposition and respiration (85%). In a river with a daily minimum DO requirement of 7.0 mg/L, the only way to achieve compliance at 3000 feet or higher is to ensure that temperatures never reach 20°C or natural organic matter and nutrient loading is curtailed.

4.4 Summary

In summary, DO is the amount of oxygen gas present in a volume of water. DO is the source of oxygen used by aquatic aerobic organisms and is thus a critical indicator of aquatic ecosystem health**.** The concentration of DO in a given aquatic system is defined by the capacity of that system to hold oxygen in solution and the percent of that capacity that is utilized. An aquatic system that is saturated with DO is at equilibrium as defined by the effects of barometric pressure, temperature, and salinity. Variation in saturation occurs as a result of the influences of oxygen sources (e.g., photosynthesis and turbulences) and oxygen sinks (e.g. respiration, decomposition, and biological and chemical oxygen demanding processes). A healthy, free-flowing aquatic system maintains DO concentrations close to full saturation (100%), generally no less than 85%.

CHAPTER 5.
EXISTING WATER QUALITY OBJECTIVES
FOR DISSOLVED OXYGEN IN THE KLAMATH RIVER

In this chapter, staff describes the existing Site Specific Objectives (SSO) for Dissolved Oxygen (DO) in the Klamath River mainstem and presents its assessment of their continued appropriateness.

The Regional Water Board adopted the *Water Quality Control Plan for the North Coast Region* (Basin Plan) in which it established the region's water quality standards, including the standards that apply to the portion of the Klamath River basin that falls under the jurisdiction of the State of California. The Basin Plan has been approved by the State Water Board and by USEPA and is in full force and effect.

5.1 Beneficial Uses

Chapter 2 of the Basin Plan identifies 28 beneficial uses of water within the North Coast region. The following beneficial uses have been designated as existing uses of the Klamath River mainstem (Basin Plan, Table 2-1):

- MUN—Municipal and domestic supply
- AGR—Agricultural supply
- IND—Industrial service supply
- PRO—Industrial process supply
- GWR—Groundwater recharge
- FRSH—Freshwater replenishment
- NAV—Navigation
- POW—Hydropower generation
- REC1—Water contact recreation
- REC2—Non-contact water recreation
- COMM—Commercial and sport fishing
- WARM—Warm freshwater habitat
- COLD—Cold freshwater habitat
- WILD—Wildlife habitat
- RARE—Rare, threatened, or endangered species
- MAR—Marine habitat
- MIGR—Migration of aquatic organisms
- SPWN—Spawning, reproduction, and/or early development
- SHELL—Shellfish harvesting
- EST—Estuarine habitat
- AQUA— Aquaculture
- CUL—Native American Culture

The beneficial uses of most importance to the discussion of DO in the Klamath River mainstem are those related to human consumption/contact and aquatic life, including: municipal and domestic supply; water contact recreation; commercial and sport fishing; warm freshwater habitat; cold freshwater habitat; wildlife habitat; rare, threatened and endangered species; marine habitat; migration of aquatic organisms; spawning, reproduction, and/or early development; shellfish harvesting; estuarine habitat; aquaculture; and Native American culture.

The rare, threatened and endangered cold water aquatic species (RARE, SPWN beneficial uses) of the Klamath River mainstem are identified as the most sensitive of the beneficial uses, thereby requiring the greatest dissolved oxygen to ensure their protection. The spawning, incubation and emergence life stage of these species is identified as the most sensitive life stage

5.2 Water Quality Objectives

The water quality objectives for DO are given in the Basin Plan in two parts. The first part is given as *life cycle DO requirements*, designed to protect individual beneficial uses, including: WARM, MAR, SAL[1], COLD and SPWN. The *life cycle DO requirements* were first adopted in 1975 and are given as daily minima. They do not include weekly or monthly average limits by which to prevent chronic effects of DO stress. These objectives apply to all waterbodies in the North Coast Region *except* those listed in Table 3-1 of the Basin Plan.

The second part of the water quality objectives for DO is given in Table 3-1 of the Basin Plan. These are Site Specific Objectives (SSO) designed to protect the background conditions of individual waterbodies based on the statistical analysis of monthly grab sample data collected in the 1950s and 1960s. From these analyses, daily minima and annual means were established for individually named waterbodies, including fifty-eight (58) separate entries. The Klamath River mainstem is included in Table 3-1 of the Basin Plan with two SSOs for DO: a) 7.0 mg/L as an instantaneous minimum for that portion of the mainstem from the Oregon-California state line to Iron Gate Dam and b) 8.0 mg/L as an instantaneous minimum from Iron Gate Dam to the estuary. Fifty percent of the monthly means must be greater than or equal to 10.0 mg/L DO throughout the length of the Klamath mainstem under California's jurisdiction. The *life cycle DO requirements,* as described above, do not apply in the Klamath River basin.

The framework of the Basin Plan is based on the logic that protection of water quality in the North Coast region is best provided by prohibiting the point source discharge of waste. Some exceptions to this framework are included in the Basin Plan for the Lost River at all times and for the Mad, Eel, and Russian Rivers from October 1 through May 14. In all other streams and all other times of the year, the point source discharge of waste is prohibited, except as stipulated in the Thermal Plan, the Ocean Plan, and the action plans and policies contained in the Point Source Measures section of the Basin Plan. In the Klamath River, a single exception has been granted, under the Hatcheries Policy, to the Iron Gate Fish Hatchery, owned by PacifiCorp and operated by the Department of Fish and Game.

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[1] SAL is not a beneficial use identified in the Klamath River.

5.3 Background Conditions

In concept, the DO objectives included in Table 3-1 of the Basin Plan compliment the general framework of the Basin Plan by requiring that background water quality conditions for DO be maintained for all the waterbodies named in Table 3-1, including the Klamath River mainstem. The question that has arisen in recent years is whether or not the SSOs for DO in Table 3-1 truly represent background conditions. Staff has sought to answer this question by assessing two lines of inquiry:

1. Were the landuse activities in the Klamath River basin prior to the 1950s significant with respect to DO?
2. Do the existing SSOs for DO in the Klamath River mainstem represent the true DO minima under background conditions?

5.3.1 Relationship of landuse activities to background DO conditions

Commercial scale mining and logging operations began in areas throughout California, including the North Coast Region in the mid-to-late 1800s spurred by the gold rush of that era. This was followed by dam building and agricultural enterprises, as well as urban development. By the 1950s and 1960s, areas of the North Coast Region were undergoing their second wave of timber cutting, this time with the use of tractors and other heavy ground-based equipment which left a significant foot print on the landscape and downstream watercourses. Though the point source discharge of waste from urban development has been very localized in the North Coast Region, other direct effects on water quality from stream channel modification, road building, dam building, and gravel mining, as examples, have been felt in the North Coast Region for over a century. Further, the indirect effects of nonpoint source pollution emanating from agricultural runoff, wetland reclamation, sedimentation, water diversions, and the like have also been felt in the North Coast for over a century.

The National Research Council, in its assessment of the causes of decline in salmonid populations in the Klamath River watershed, describes the history of land use as the primary factor affecting the decline in the fisheries (NRC 2004). In summary they conclude that

> "The watershed has been drastically altered by human activities. The anadromous fishes have been in decline since the 19th century, when dams, mining, and logging severely altered many important streams and shut off access to the upper basin. The declines continued through the 20th century with the development of intensive agriculture and its accompanying dams, diversion, and warm water." (NRC 2004)

The *Long Range Plan for the Klamath River Basin Conservation Area Fishery Restoration Program* (KRBFTF 1991) provides an excellent description of the history of the land management activities in the Klamath River basin and the reader is referred to it for a good overview. The Natural Research Council's *Endangered and Threatened Fishes in the Klamath River Basin: Causes of Decline and Strategies for Recovery* also includes a description of the basin's history.

5.3.1.1 Fur Trapping

NRC (2004) describes the era of fur trapping in the Klamath Basin during the 1820s as relatively peaceful. Yet, "in an attempt to discourage Americans from laying claim to the region, Hudson Bay Company's written policy was to trap fur-bearing animals from streams south of the Columbia River to extinction (NRC 2004)." Ultimately, the loss of beaver resulted in the degradation of their dams and the draining of the wetlands that had built up behind them. As these wetlands filled in, they became fertile meadows upon which ranching latter thrived (Elmore and Beschta 1987 as cited by NRC 2004). Staff does not hypothesize any direct link between fur trapping and DO conditions. But, staff believes that the failure of beaver dams, conversion of wetlands to meadows, and use of meadows for grazing has had an effect on DO conditions, as described below.

5.3.1.2 Mining

Mining activities historically prominent in the Klamath River basin include hydraulic mining and suction dredging for gold; lode mining for gold, copper, and chromite; and, gravel mining. Water quality concerns related to mining include water diversions, increased sediment loading, channel alteration, habitat alteration and destruction, acid mine drainage, and turbidity. The water quality impacts associated with mining operations can be enormous, depending on the size of the operation and the sensitivity of the associated stream. NRC (2004) reports that "mining in the 19th century was particularly destructive of fish habitat along the lower Klamath basin."

KRBFTF (1991) reports the beginning of exploratory mining by John Scott and his party at Scott Bar in 1850. The towns of Happy Camp, Orleans, Somes Bar, Sawyers Bar, Hamburg, Callahan, Yreka, and Scott Bar owe their origins to the gold mining boom of the 1800s (KRBFTF 1991). "While hydraulic mining was outlawed by the state in the late 1880s for the rivers near Sacramento, the Klamath River was not regulated. Gold production reached a peak in 1894 (KRBFTF 1991)."

Gold mining in the Klamath River basin boomed again in the 1930s, particularly in the Salmon and Scott Rivers, this time using large dredges to rework old tailing dumps and other auriferous gravels (KRBFTF 1991). Stream surveys conducted during this era determined that pools and spawning gravels were filled in with silt and macroinvertebrate production down stream of mining operations was severely impacted (KRBFTF 1991).

> "Many other problems were also noted: increased poaching in the small, clear streams where spawners were forced to congregate; reduced streamflows due to mining diversions into ditches; loss of juvenile salmonids in unscreened mining ditches; and habitat blockage by permanent and temporary diversion dams (KRBFTF 1991)."

Mining in the Klamath, like elsewhere in California, brought with it other subsidiary effects, including population growth, building, timber harvesting, food production, water withdrawl, and fishing, to name a few. Many of these activities also have effects on water quality, including DO conditions as described below.

The information in KRBFTF (1991) regarding the history of gravel mining is fairly vague, particularly with respect to activities prior to 1972. But, KRBFTF (1991) does make the point that "commercial operations are primarily scattered in accessible tributaries near towns." It may be that larger scale gravel activities did not come into operation until the development of Interstate 5 to the east and Highway 101 through Redwood National Park to the west later in the 1970s and 1980s, respectively.

Staff believes it likely that mining activities of the late 19th and early 20th centuries altered DO conditions in select locations as follows:

- Decreased water column DO by decreasing channel depths through increased sediment delivery from increased streambank and hillslope instability and instream modifications.
- Decreased intergravel DO by increasing fines intrusion through increased streambank and hillslope instability and instream modifications.
- Decreased water column and intergravel DO by increasing sediment organic loading and decomposition.

5.3.1.3 Timber Harvest

Timber harvest activities include felling, limbing, and yarding trees, as well as transporting the logs to facilities for milling into lumber. With respect to water quality, the primary issues of concern include:

1. Timber harvest and road building activities in the stream channel which can result in an alteration of stream channel form, loss of hydrologic function, loss of aquatic habitat, increase in sediment loading, increase in organic loading, and the development of migration barriers.
2. Timber harvest and road building activities in the riparian zone which can result in a loss of shade, loss of sources of large woody debris, destabilization of the stream bank, an increase in sediment loading, an increase in organic loading, and an increase in the intensity of stormwater runoff events.
3. Timber harvest and road building activities on the hillslope which can decrease hillslope stability, increase sediment delivery, increase organic loading, decrease rates of transpiration, and increase the intensity of stormwater runoff events.
4. Road building activities which can result in an increase in hillslope instability, increase in stream network density, decrease in soil absorptive capacity, increase in stormwater runoff events, and the development of barriers to surface flow and access to upstream habitat.

NRC (2004) reports that commercial timber operations began in the Klamath basin in 1863 when the U.S. Army constructed a sawmill. In 1881, the Klamath Commercial Company was established to harvest both timber and fish at the mouth of the Klamath River (KRBFTF 1991). "The arrival of the railroad in 1887 near Yreka helped develop the markets for timber in the upper Klamath area (KRBFTF 1991)." Hard wood was shipped to Crescent City for reshipment to San Francisco; and, other mills were built on Hunter Creek near the estuary and Klamathon near what is now Iron Gate Dam (KRBFTF 1991)." Until the development of roads later in the 20th century, logs were "dropped into the Klamath River and floated to the mouth to be made into ocean-going rafts (KRBFTF 1991)."

"Peak lumber production occurred in 1941, when 22 lumber mills processed a total of 808.6 million board feet within the upper basin (NRC 2004)." In the lower Klamath, "timber harvesting began in the 1850s…commensurate with the growth in mining…(and) reached a peak in the 1950s (Sommerstram et al. 1990 as cited by NRC 2004). By 1955, sports fisherman complained that log rafting in the lower Klamath River was destroying the fishery and required regulation (KRBFTF 1991). The California State Assembly's Interim Committee on Fish and Game held a field trip in August of 1955 and observed "small creeks and streams tributary to the Klamath completely obliterated by earth moved into the stream bed from a 'cat' roadway and in other cases by being choked with logging debris (KRBFTF 1991)."

KRBFTF (1991) reports in 1953 that due to its rugged terrain, the southwest half of the Klamath River Basin had not yet been substantially logged. By the mid-1960s, road building allowed greater access to the Scott and Salmon river regions (KRBFTF 1991). "The Hog Fire of 1977 burned 56,000 acres in that subbasin (Salmon River) with an estimated 450 million board feet being salvage logged over the ensuing five years (KRBFTF 1991)." NRC (2004) reports that as logging and fire suppression have generally altered the forest composition of the basin, "the risk of intense fires has increased substantially. Such fires can contribute damaging amounts of sediments and nutrients to streams and rivers."

Staff believes it likely that the timber harvest activities of the early 20th century altered DO conditions in select locations as follows:

- Decreased water column DO by increasing solar radiation through the removal of riparian shade trees;
- Decreased water column DO by decreasing channel depths through increased sediment delivery from increased streambank and hillslope instability.
- Decreased water column DO by increasing organic debris loading and oxygen consumption through decomposition.
- Decreased intergravel DO by increasing fines intrusion through increased streambank and hillslope instability.

5.3.1.4 Agriculture

Agricultural activities in the Klamath River basin include both irrigated agricultural and grazing activities. The Natural Resources Conservation Service (NRCS) has mapped the land use and land cover within the Klamath River basin (NRCS 2004). In California, agricultural activity is shown primarily in the Lost River basin, the Butte River basin, the Shasta River basin, and the Scott River Valley. Considerable additional agricultural activity occurs in Oregon in the Lost River basin, around Upper Klamath Lake, in the Sprague River Valley, and in the Williamson River basin.

Forage crops are the primary agricultural crops served by the Klamath Project, an irrigation project of the US Bureau of Reclamation. But, cereals, field crops, fruits, nuts, and vegetables are also grown in the Upper Klamath Basin (Stene 1994). Irrigated agriculture began in the Upper Klamath Basin in 1882 with the construction of an irrigation ditch connecting the Link River to present day Klamath Falls (Stene 1994). A discussion of water and power projects follows (Section 5.3.1.4). By 1953, approximately 26% of Modoc and Siskiyou counties in California and Klamath County in Oregon was in agricultural production (USBR 1953). Of this, more than half the crop land was irrigated, nearly tripling that which was irrigated 50 years prior (USBR 1953).

KRBFTF (1991) reports that the droughts of the 1860s and heavy grazing pressure reduced the range of native perennial grasses in Siskiyou County, replacing them with annual grasses and forbs. The new grasses and forbs produced less duff than the native grasses, thereby allowing more rapid runoff and surface erosion, as well as greater peak flows in streams (KRBFTF 1991). Grazing caused greater soil compaction which further exacerbated the problem (KRBFTF 1991). NRC (2004) reports that "cattle increased in abundance during the 1870s and 1880s until by the late 1880s overgrazing became a political and ecological issue. "Government inspectors…recommended that the only solution was to provide more grass by draining wetlands and planting them with hay so that there would be less competition for a dwindling resources (NRC 2004). NRC (2004) concludes that the effects of grazing in the watershed "were probably profound but are impossible to quantify."

Agricultural issues of concern to DO include: application and runoff of nutrients, alterations in stream flow and flow timing from water impoundment and/or withdrawl, alteration of riparian vegetation and streambank stability, conversion of wetlands and reduction in nutrient sequestration, increased sedimentation due to channel destabilization and reduction in flows.

5.3.1.5 Water and Power Projects

There exist in the Klamath River basin numerous dams and diversions associated with power generation and irrigation. The histories of many of these are well documented and the effects on water yield quantified. The effects of withdrawals and diversions granted under riparian rights and groundwater withdrawals, however, are not well understood. Beginning around 1850, small dams and diversion ditches were built on smaller tributaries for use in mining and irrigation. Starting out small and temporary in nature, some became more fixed as established use persisted. As early as 1930, these more permanent diversion structures were creating barriers to fish migration (KRBFTF 1991). Among the mining dams, some were left in place after cessation of mining, creating additional barriers (KRBFTF 1991).

Beginning in the 1890s, hydroelectric power facilities were installed, first on the Shasta River, then on the Link River. California Oregon Power Company (COPCO) built Copco Number 1 Dam and Copco Number 2 Dam between 1917 and 1925. These comprise the first major hydroelectric facilities built on the mainstem of the Klamath River (KRBFTF 1991).

Prohibitions on the construction of any obstructions in the Klamath River downstream from the mouth of the Shasta River were enacted as a result of Proposition 11 passed in a statewide election of 1924 (KRBFTF 1991). This effectively ended the prospective efforts to build major hydroelectric and diversion projects in the Klamath River below the mouth of the Shasta River; though no such protections were afforded the flows above the confluence with the Shasta. In 1958, J.C. Boyle (Big Bend) Dam began operations just upstream of the California state line.

In 1962 Iron Gate Dam was built below Copco 1 and 2 at river mile 190. From this point to the ocean the river is protected as free flowing under the National Wild and Scenic Rivers System. Iron Gate Dam was originally built to attenuate flow variations caused by the operations of Copco 1 and 2 Dams. These dams were originally run as peak demand generation facilities but are now used in other ways.

Most of the Klamath River water is used in the Klamath River basin, including the use of water for crop and pasture irrigation within the Williamson River, Sprague River, Lost River, Shasta River, Scott River, and South Fork Trinity River. Facilities built to support consumptive uses in California include the U.S. Bureau of Reclamation Klamath Project (construction began in 1906, first water delivered in 1907) and Lake Shastina (created by the construction of Dwinnell Dam on the Shasta River in 1928). A total of 240,412 acres of irrigable lands, including 235,667 acres of farmland, and 4,745 acres of residential, commercial, and industrial lands, are served by Klamath Project infrastructure.

In addition to in-basin use; however, there are also diversions out of the basin maintained for agriculture and power generation: The Lewiston and Trinity Dams were completed in 1964 on the Trinity River to enable a significant transfer of flow out of the Klamath-Trinity watershed and into the Sacramento River system. An additional, smaller, out-of-basin diversion occurs from the upper tributaries in the Jenny Creek watershed in Oregon and into the Rogue River watershed in Oregon.

The pattern of water use is nearly the opposite of the pattern in drainage density and water yield. That is, the majority of the diversions in the basin are upstream of Seiad Valley where the least amount of the water is produced. As demonstrated by Figure 5.1, some of the effects of this pattern of water use are to:

- Move the timing of the peak spring flows from mid-April to mid-March;
- Make steeper the decline in the spring hydrograph, thus reducing flows by roughly 30-45% in June and July and 20-25% in May and August;
- Lower the minimum summer flows; and
- Move the timing of the minimum summer flow from mid-September to mid-August.

The estimated unimpaired flows represented in Figure 5.1 illustrate the magnitude and pattern of flows that would be expected with natural flows in the Scott and Shasta Rivers and without diversions upstream of Keno, Oregon. This unimpaired data; however, should be viewed with caution because the estimated unimpaired flows are based on the estimated median monthly unimpaired flows at Keno, as reported by the United States Bureau of Reclamation [USBR] (2005), whereas the estimated natural Scott and Shasta

River flows are reported by the USGS (2006) as monthly means. Although the two types of data sets use different metrics, the data are useful for general comparison purposes.

Altering the shape of the hydrograph through anthropogenic manipulation simultaneously alters the seasonal pattern of DO availability. For example, lower flows from April to September likely result in lower DO concentrations by increasing the rate at which the river heats during the summer months, thereby reducing the concentration of DO at saturation. Further, the warm and slow moving conditions behind the dams promote the excess growth of algae which simultaneously promotes wider fluctuations in DO, including much lower night concentrations than occur naturally.

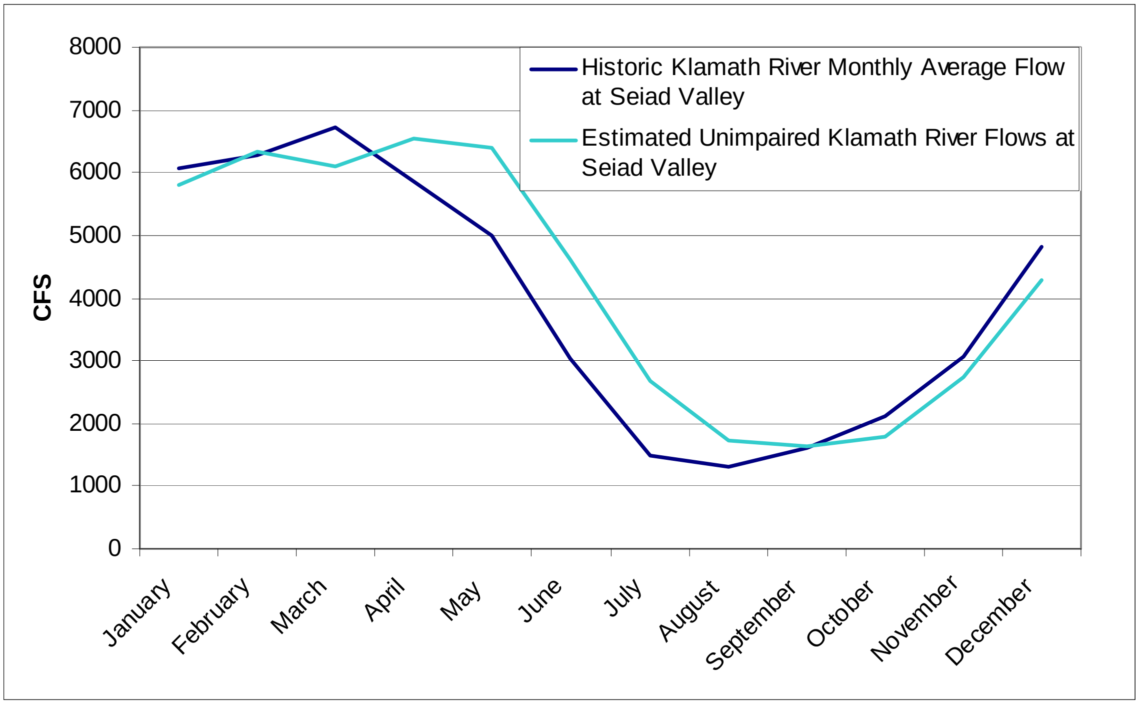

Figure 5.1: Estimated Unimpaired Klamath River Flows at Seiad Valley, California, and Historic Monthly Average Klamath River Flow at Seiad Valley, California; Water Years 1952-2004
Source: United States Bureau of Reclamation [USBR] 2005; USGS 2006

<u>5.3.1.6 Conceptual Model for DO</u>The USEPA's CADDIS (Causal Analysis/Diagnostic Decision Information System) has produced a conceptual model for dissolved oxygen depicting the potential linkages between and among various environmental and anthropogenic factors.

As depicted in Figure 5-2, the causal pathways potentially resulting in DO impairment include: 1) channel alteration; 2) land cover alteration; 3) water impoundment; and, 4) chemical, organic matter, and nutrient loading. Increased stream temperatures, increased ionic strength, and/or increased sediment loading are interacting stressors that can further exacerbate DO impairment. The biotic responses of concern include changes in behavior, increased mortality, impairment of invertebrate assemblages, impairment of fish assemblages, and other biological impairments. Increased susceptibility to disease, decreased growth, and decreased fecundity are also biotic responses of concern, though not specifically indicated in this model.

The following is USEPA's written explanation of the conceptual model:

> "Certain human activities, such as agricultural, residential, and industrial practices, can contribute to DO depletion (or, less frequently, DO supersaturation), and subsequent biological impairment. These practices may directly introduce chemical contaminants, organic loading, and nutrients to streams, via point and non-point sources such as wastewater treatment plant effluents, fertilizers, animal wastes, landfills, and septic systems. Increases in these substances can increase chemical and biochemical oxygen demand, most notably due to increased respiration of plants and especially microbes.
>
> Physical alteration of the stream channel, through impoundments or channel alterations, can contribute to low DO concentrations in several ways. For example, an impoundment downstream of a location will slow water velocities and increase water depths, which will tend to reduce turbulence and lower incorporation of oxygen into the water column via aeration, as well as reduce diffusion of oxygen from the atmosphere. Channel incision also reduces oxygen diffusion due to decreases in surface-to-volume ratio with increasing stream depth. An impoundment upstream of a location (upper far right of figure 4-4) may reduce DO levels if downstream water releases come from deeper, oxygen-depleted waters of the reservoir (i.e., if they are hypolimnetic), but may increase DO levels if discharges are highly turbulent; whether DO levels increase or decrease will depend on impoundment size and type of release.
>
> Land cover alterations also may reduce stream DO levels by altering in-stream physical characteristics. For example, decreases in riparian vegetation often associated with these activities can reduce large woody debris inputs to the channel, reducing turbulence and aeration; homogenization of stream substrates can have similar effects. In addition these alterations may increase delivery of chemical contaminants, organic material, and nutrients to streams with surface runoff.
>
> In addition to these processes discussed above, DO concentrations are closely linked to several other stressors…Nutrient enrichment stimulates oxygen-generating (photosynthesis) and oxygen-depleting (respiration) processes. DO levels also are affected by water temperature, ionic strength, and dissolved solids; oxygen solubility decreases as these parameters increase, reducing the amount of available DO in the water. Increased bedded sediment can decrease interstitial flow, reducing oxygen availability for sediment-dwelling organisms, and decreases in water velocity can lower oxygen delivery rates.
>
> DO concentrations directly impact abiotic and biotic stream environments. Low DO…affects the oxidation and reduction (redox) reactions which determine the

bioavailability of many inorganic compounds, as well as biologically important materials such as nitrogen and sulfur. For example, lower redox potential (↓ Eh) may decrease the release of precipitated metals, which actually may benefit organisms by reducing bioavailability; however, it also may increase the release of precipitated phosphates, encouraging the proliferation of nitrogen-fixing cyanobacteria and potentially altering food resources for fish and invertebrate assemblages.

The most direct effect of low DO is respiratory distress in biota, which may be exacerbated by relatively rapid fluctuations in available DO. During periods of low DO, some species may increase movement to enhance ventilation across gill structures, attempt to gulp air from the surface, or gather around photosynthesizing plants. Respiratory stress can cause low DO-sensitive taxa [e.g., EPT taxa, or Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddis flies), and salmonid fishes] to decrease; often these taxa are considered indicators of good water quality. Decreases in low DO-sensitive life stages also are potential indicators. Conversely, more tolerant organisms (e.g., cyprinids, amphipods, and chironomids with hemoglobin) and life stages may increase. Increased populations of plant-breathers (e.g., insects that can obtain air from plants, such as certain beetle larvae) and air-breathers (e.g., insects that can carry air bubbles with them underwater) also may be observed. If DO depletion is significant enough, widespread fish kills may occur.

Although biological impairments related to DO usually result from insufficient DO levels, too much DO, or supersaturation, also may pose a problem in certain situations. This supersaturation may result from extremely high levels of oxygen-generating photosynthesis, or from extremely high turbulence and aeration downstream of impoundments. Ultimately, these rapid or large increases in DO may affect organisms by contributing to stressful fluctuations in DO levels, altering redox potentials and bioavailability of potentially toxic substances (e.g., metals), or leading to gas bubble disease (a condition indicated by gas bubbles forming under skin and around eyes) (CADDIS 2007)."

With respect to the kind of activities generally found in the North Coast Region, the conceptual model highlights the importance of evaluating and controlling anthropogenic inputs of chemicals, nutrients, and organic rich wastes. But, it also highlights the importance of evaluating and managing such disturbances as:

- ✓ Anthropogenic alteration to the natural pattern and range of flows, including stormwater management, groundwater protection, and control of water impoundment and withdrawal;
- ✓ Anthropogenic sources of erosion and sediment delivery;
- ✓ Anthropogenic loss of channel forming materials (e.g., large woody debris);
- ✓ Alteration of the stream channel, such as through gravel mining;
- ✓ Disturbance to wetlands, the flood plain and riparian zone;
- ✓ Anthropogenic sources of nutrients, organic matter, warm water and their delivery to a waterbody, including the discharge of agricultural return flows; and,

- ✓ Threat of loss or alteration (e.g., reduction in flow or increase in temperature) of cold water springs.

Many of these listed disturbances have been impacting the DO conditions of the Klamath River for many decades.

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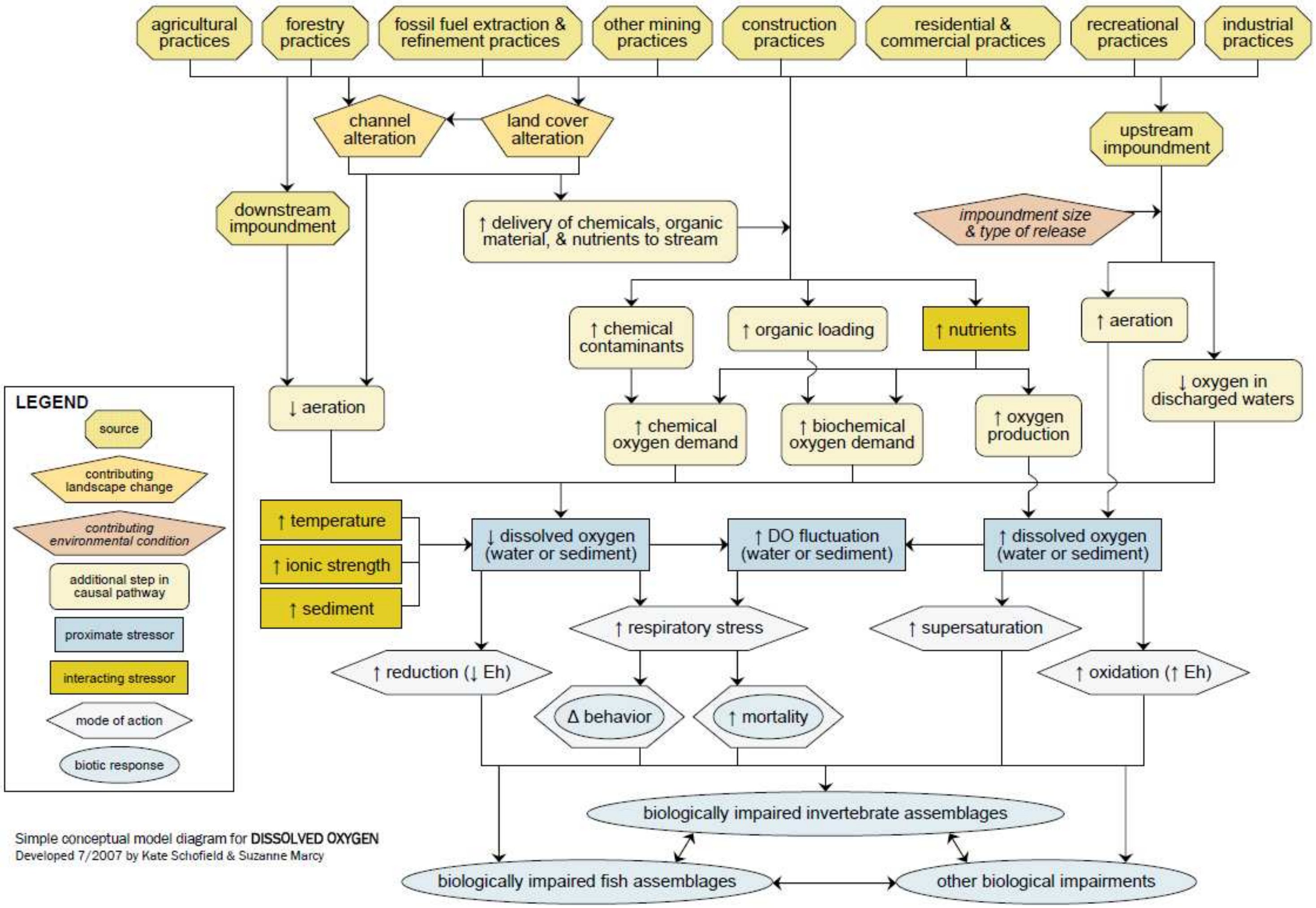
Figure 5-2 CADDIS Conceptual Model for DO



5.3.1.7 Summary

USEPA's CADDIS generic conceptual model depicts the effects on DO expected from activities such as agriculture, forestry, and mining. Effects include channel alteration, watershed land cover alteration, riparian land cover alteration, and impoundments, flow alteration, and discharges of sediment and nutrients. These can lead to a decrease in water velocity, decrease in turbulence, increase in substrate homogenization, increase in organic loading, and increase in nutrients. Secondary results can include an increase in DO fluctuation, decreases in water column and intergravel DO, and decreases in interstitial flow.

A review of the landuse history of the Klamath River basin indicates that numerous, large scale alterations to the landscape from the 1850s through the 1950s have dramatically changed the aquatic ecology. Such landscape alterations are at least partially responsible for the loss and threatened loss of aquatic species in the basin, as described by NRC (2004). Landuse activities such as mining, timber harvest, agriculture, and the development of water and power have had profound effects on water quality, including:

1. Loss of wetland habitat, including nutrient sequestration and flow moderation;
2. Reduction in summer flows and altering of the pattern of flows;
3. Acceleration of surface erosion and increase in peak flows;
4. Elevation of summer water temperatures;
5. Reduction in channel integrity
6. Increase in algae production

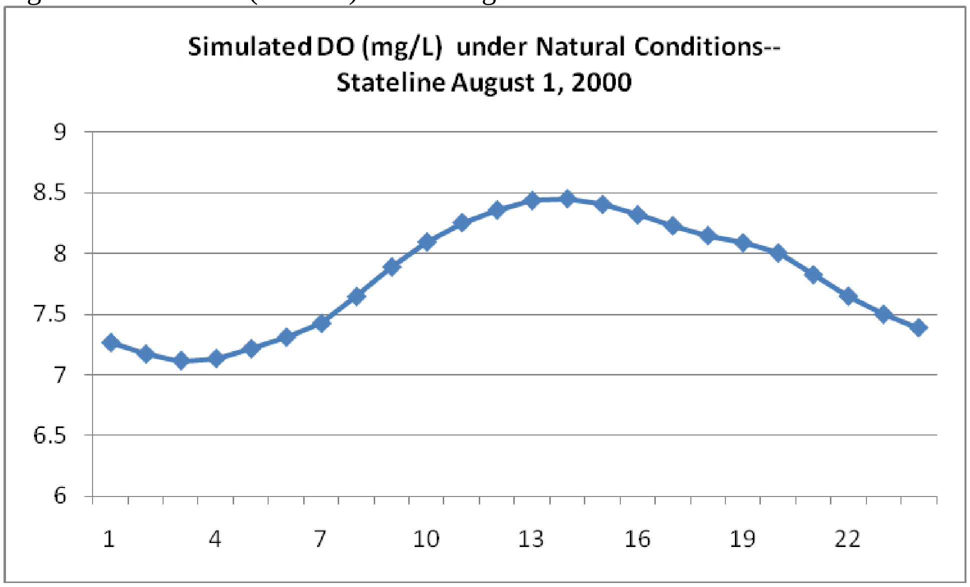
Staff concludes that the landuse history of the Klamath River basin is such that DO conditions in the basin have undoubtedly been altered as a result of them. DO data collected during the 1950s and 1960s most certainly reflect the alteration in water quality resulting from 100 years of landscape manipulation.

5.3.2 Existing SSOs for DO and diel DO fluctuation

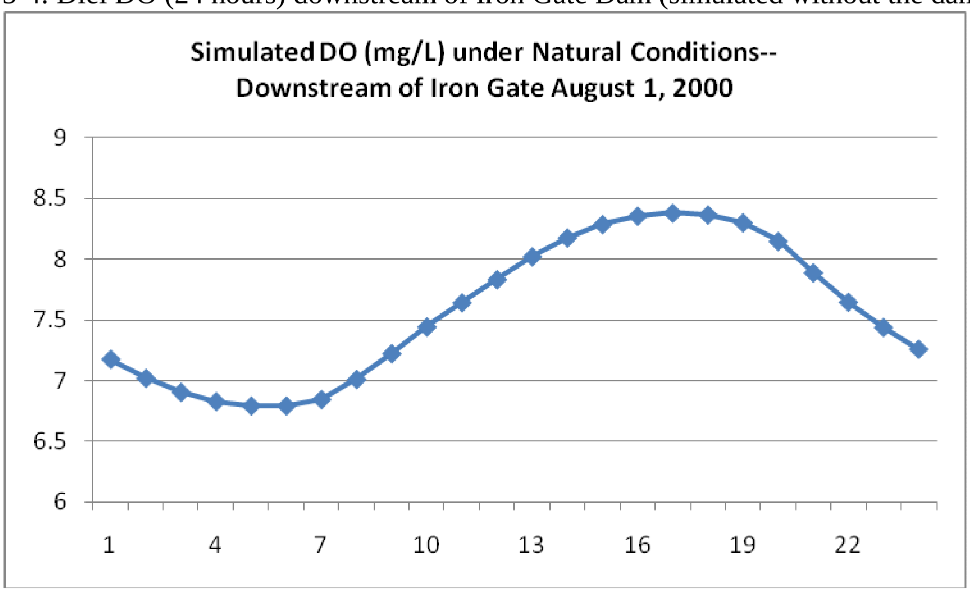
The existing SSOs for DO are contained in Table 3-1 of the Basin Plan and are designed to reflect background conditions as measured in the 1950s and 1960s. The data used to establish these background conditions were collected by a range of partners including federal, state, and local agencies. The Department of Water Resources published the data in annual bulletins beginning with data from 1951. Generally, the data are monthly grab samples that were collected during day light hours and analyzed in the field using the Winkler titration method. The sampling of this period represented an enormous effort, providing results with great statistical power. But, in addition to being collected during a period in which land uses affected water quality, the data were also limited by the fact that they only represented day time conditions.

As discussed in Chapter 4.0 of this Staff Report, the photosynthesis of aquatic plants, algae, and cyanobacteria has a profound effect on the pattern and range of diel DO fluctuation. Photosynthesis has the effect of increasing DO concentrations over the course of the day as plants actively respire oxygen. After reaching a peak in the late afternoon, DO concentrations then decrease through the night until hitting a low in the hours of the early morning. This pattern is apparent in Klamath River as shown in Figures 5-3 and 5-4. These figures depict a simulation of diel DO concentrations

Figure 5-3: Diel DO (24 hour) at the Oregon-California Stateline



5-4: Diel DO (24 hours) downstream of Iron Gate Dam (simulated without the dams)



under natural conditions at the Oregon-California stateline and downstream of Iron Gate Dam (though simulated without the dam) during the summer. The phosphorus-rich volcanic geology and organic matter and nutrients produced and stored in the wetlands of the upper basin naturally feed episodic algae blooms downstream in the Klamath River mainstem leading to diel fluctuations in DO, particularly during the summer months. These natural conditions originate in the reaches downstream of Upper Klamath Lake in Oregon. Under natural conditions, they dissipate slowly as the river heads downslope. Under existing conditions, though, the fluctuation of DO is exacerbated and perpetuated further downstream by impoundments, agricultural return flows, water diversions, reduction in stream bank stability, reduction in stream side shade, and increase in sediment delivery—conditions which were present when the SSOs for DO were first established.

The SSOs for DO contained in Table 3-1 of the Basin Plan are given as absolute minima (7.0 mg/L upstream of Iron Gate Dam and 8.0 mg/L downstream of Iron Gate Dam) and an annual mean of the monthly means (10 mg/L). Because the absolute minima are developed from grab sample data collected during normal working hours in the 1950s and 1960s, they capture only a moment in time and only from a portion of the diel curve. In particular, the actual minimum concentration, typically observed in the early morning hours, is not represented in the dataset from which the existing SSOs for DO were developed. Further, the dataset from which the existing SSOs for DO were developed includes measurements representing supersatured DO conditions which periodically occur during the late afternoon as a result of elevated photosynthetic activity.

With the development of the existing SSOs for DO in 1975, compliance with the SSOs has been measured by collecting grab samples during normal working hours and performing a Winkler titration in the field. As such, compliance monitoring compared reasonably well to the existing daily minimum SSOs. At issue; however, is how to use the existing SSOs when compliance data is collected using a Hydrolab DataSonde data logger (DataSonde).

A DataSonde measures the current resulting from the electrochemical reduction of oxygen diffusing through a selective membrane (HACH 2008a). It is capable of collecting and storing data at intervals (every 15 minutes, for example) over several days. Thus, one is able to record the entire diel DO curve at a given location, identifying, among other things, the actual daily minimum. The existing SSOs for DO do not lend themselves for comparison to 24 hour DO datasets of this kind. Summers and Engle (1993), as cited by Kamer and Stein (2003), found that single, daytime instantaneous measures of DO detected hypoxia[2] only 20% of the time that it was known to occur based on 31 days of continuous sampling in the Gulf of Mexico. While this statistic is unlikely to apply to freshwater streams in the North Coast, it nonetheless illustrates the point that minimum objectives based on data collected during the day can not reasonably represent true daily minimums which are more typically experienced at night.

DataSondes are now widely used in the Klamath Basin for monitoring. The DataSondes sometimes suffer from calibration drift and biofouling of the membrane when the device is deployed for multiple days. Quality assurance procedures are critical to ensuring accurate data collection. The availability of Luminescent Dissolved Oxygen technology may reduce the issues of biofouling; however, the use of this new technology is not yet widespread. But, it is expected to replace the earlier membrane-based probes in the coming year (Fadness 2008). Luminescent Dissolved Oxygen technology has a thicker membrane than its predecessor and is thus less susceptible to biofouling. It is also reported to have the ability to hold a calibration without drift (HACH 2008b). Data can be collected with this device at intervals over a 7-day period (or longer), thus allowing for assessment not only of the daily minimum, but daily and weekly

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[2] Hypoxia means "low oxygen." In estuaries, lakes, and coastal waters low oxygen usually means a concentration of less than 2 parts per million. In many cases hypoxic waters do not have enough oxygen to support fish and other aquatic animals.

averages, as well. In all other regards, the data collected by Luminescent Dissolved Oxygen technology is comparable to that collected by datasondes (Fadness 2009).

5.4 *Rationale for Revising the SSOs for DO in the Klamath River Mainstem*

Staff has reviewed the existing SSOs for DO in the Klamath River mainstem. The following is a summary of our findings:

1. The SSOs for DO in the Klamath River mainstem are based on a statistical analysis of data collected during the 1950s and 1960s. The background conditions of the Klamath River mainstem codified by Table 3-1 of the Basin Plan are not natural conditions, but conditions modified by decades of mining, timber harvesting, agricultural irrigation and return flows, wetland conversion and other landscape alterations, hydroelectric power operations, dams, and other water withdrawls, as examples.
2. The SSOs for DO in the Klamath River mainstem are based on day time grab samples and thereby do not include the daily minima DO conditions typically expected in the pre-dawn hours of the night.
3. Continuous monitoring data collected by DataSondes are predominantly being used in the Klamath River mainstem to collect DO data and include both day time and night time DO data; this data can not be reasonably compared to the existing SSOs for DO.

Staff concludes that the SSOs for DO in the Klamath River mainstem must be updated to: a) accurately depict daily minima conditions and b) deliberately define background conditions. As they are currently set, the SSOs for DO in the Klamath River mainstem are outdated with respect to the monitoring tools currently available. And, they erroneously establish as background, conditions which very likely reflect significant anthropogenic influence. More accurate and protective SSOs for DO would reflect the actual daily minima expected during the early morning hours and would be based on natural background conditions.

CHAPTER 6.
New Site Specific Information

The Klamath River watershed has been the subject of ecological study for many years, including water quality evaluations. Most recently, the Regional Water Board has been engaged in a project to define the total maximum daily load (TMDL) of pollutants that can be discharged into the Klamath River mainstem and still meet water quality objectives. The Regional Water Board has listed the portions of the Klamath River from the Oregon-California state line to the Pacific Ocean for impairments due to elevated water temperatures, elevated nutrients, and organic enrichment/low dissolved oxygen. Further, the portion of the Klamath River watershed downstream of the Trinity River is listed for sedimentation/siltation impairment. Finally, in March 2008, the U.S. Environmental Protection Agency (USEPA) added the reach of the Klamath River that incorporates Copco 1 and 2 and Iron Gate Reservoirs to the 303(d) List for the blue-green algae toxin microcystin. Table 1.1 summarizes the waterbody-pollutant combinations for the Klamath River in California as identified on the current (2006) section 303(d) List.

Work on the Klamath River TMDLs has resulted in the development of new information regarding water quality conditions in the Klamath River mainstem. Two assessments of interest to the evaluation of the existing SSOs for DO are:

1. Assessment of the range of DO concentrations possible under 100% and 85% saturation. As described in Chapter 4.0, this assessment looks at the physical characteristics of the basin with respect to the ability of the water to hold DO in solution.
2. Assessment of DO under natural water quality conditions as simulated by a series of computer models developed to calculate the TMDLs for the Klamath River mainstem.

The discussion in Chapter 5.0 seeks to demonstrate that the existing SSOs for DO do not achieve the intended goal of establishing as the water quality objective, background conditions in the mainstem. The discussion here in Chapter 6.0 seeks to demonstrate that the existing DO objectives as contained in Table 3-1 of the Basin Plan are unachievable even under natural water quality conditions and therefore require recalculation. The computer simulation of natural water quality conditions provides model output suitable for the recalculation. The model and its output are described below. Alternative methods of recalculating the SSOs for DO are presented in Chapter 7.0.

6.1 *Assessment of 85% and 100% Saturation in the Klamath River Mainstem*

The Klamath River mainstem flows approximately 209 miles from the Oregon-California state line to the Pacific Ocean at Requa, CA. It has a maximum river elevation of 2,885 feet and summer water temperatures that exceed 23 ºC under natural conditions.

Figure 6-1: Range of DO Concentrations at 100% Saturation in the Klamath River Mainstem

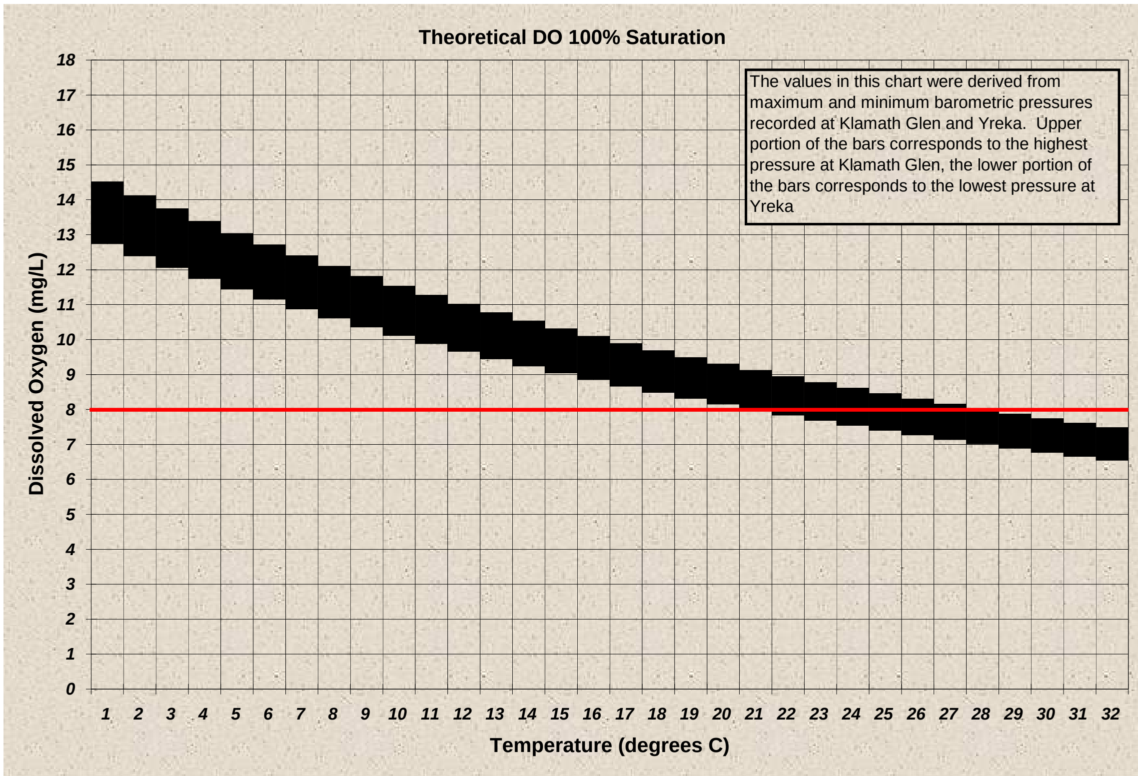
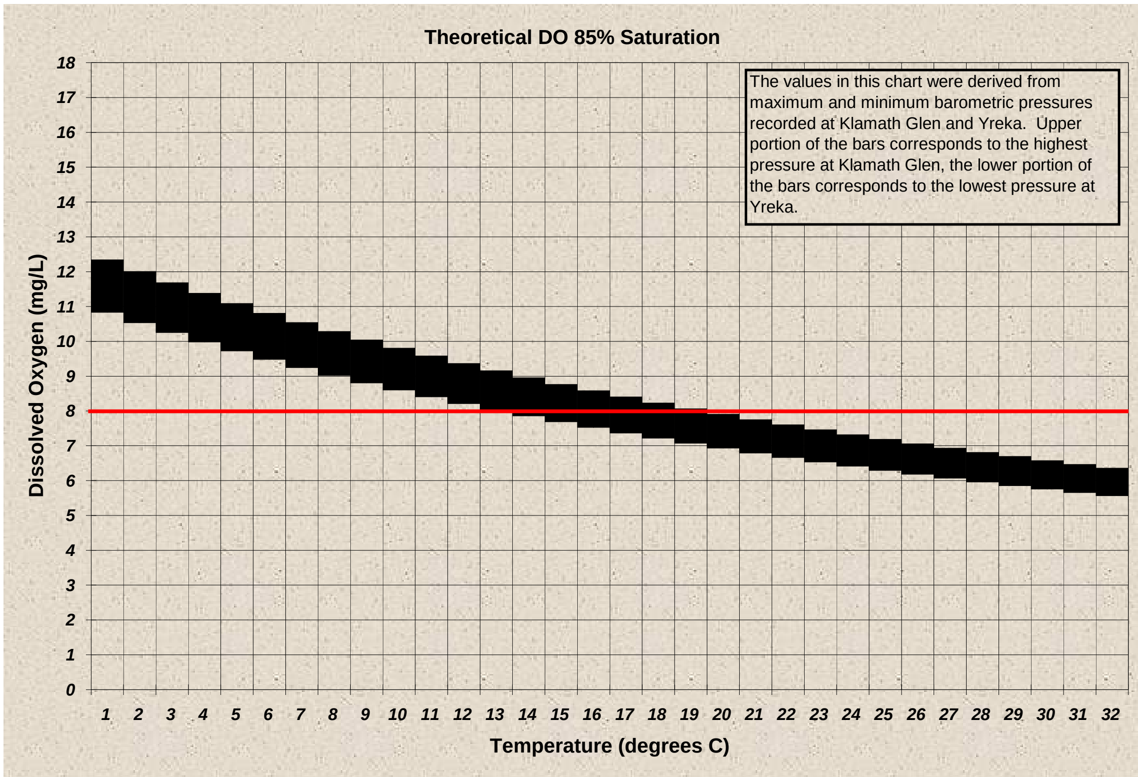


Figure 6-1 depicts the range of DO concentrations at 100% saturation estimated in the Klamath River mainstem at various temperatures. The range is defined by the elevations at two weather stations in the watershed: Yreka, CA (2,648 feet) and Klamath Glen, CA (56 feet). Both stations are within that portion of the Klamath River watershed downstream of Iron Gate Dam in which the existing SSO for DO is 8 mg/L. Figure 6.1 shows the DO concentrations that are theoretically possible when conditions of temperature, barometric pressure and salinity are in equilibrium. The figure demonstrates that during the hottest summer days, when temperatures exceed 21°C, DO concentrations can not physically meet the existing SSO for DO of 8 mg/L at all locations. This is in the absence of other moderating influences such as photosynthesis, turbulence, respiration, decomposition, and chemical oxygen demand.

Figure 6-2 presents the range of DO concentrations at various temperatures when DO saturation is at 85%. The 85% saturation figure is chosen because it represents a reasonable range of variation from equilibrium that occurs in healthy, free-flowing streams, considering the effects of photosynthesis, turbulence, respiration, decomposition, and chemical oxygen demand. In addition, the computer models used to simulate natural water quality conditions (described in detail in Section 6.2.1 and the TMDL Staff Report) also indicate that in the Klamath River mainstem, natural DO conditions maintain a minimum of 85% saturation. At 85% saturation, then, Figure 6.2 illustrates that during even modestly warm days, when temperatures exceed 14 °C, the water column can not physically hold oxygen in solution at concentrations sufficient to meet the existing SSOs for DO of 8 mg/L at all locations.

Figure 6-2: Range of DO Concentrations at 85% Saturation in the Klamath River Mainstem



This assessment provides a basic framework for understanding the range of DO conditions that can physically occur in the Klamath River mainstem. Figures 6-1 and 6-2 do not provide a basis for recalculating SSOs for DO in the Klamath River mainstem. But, they provide further evidence that the existing SSOs for DO are unattainable at all locations at all times, even under the best possible natural conditions (i.e., 100% DO saturation) and certainly when considering the natural variation that occurs due to photosynthesis, turbulence, respiration, decomposition, and chemical oxygen demand (i.e., 85% DO saturation).

6.2 Assessment of Simulated Natural DO Conditions in the Klamath River Mainstem

Tetra Tech, Inc., under contract to USEPA and with assistance from Regional Water Board staff, and staffs at the Oregon Department of Environmental Quality (ODEQ), and USEPA Regions 9 and 10, has developed a tool for estimating the natural water quality conditions in the Klamath River mainstem. It is with this tool that Regional Water Board staff has unequivocally determined that the existing SSOs for DO are unattainable even under natural conditions and thereby must be recalculated. It is also with this tool that Regional Board staff has recalculated the SSOs for DO. The alternatives by which the

SSOs for DO can be recalculated are presented in Chapter 7.0. In this chapter, staff describes the tool and its results.

6.2.1 Description of the Model

To support TMDL development for the Klamath River system, the need for an integrated receiving water hydrodynamic and water quality modeling system was identified. A model for the Klamath River had already been developed by PacifiCorp to support studies for the Federal Energy Regulatory Commission hydropower relicensing process (PacifiCorp 2005) when this project commenced. The version of the model available in 2004 is hereafter referred to as the *PacifiCorp Model*. The Regional Water Board, ODEQ, and USEPA determined that this existing *PacifiCorp Model* would provide the optimal basis, after making some enhancements, for TMDL model development. The *PacifiCorp Model* used hydrodynamic and water quality models with a proven track record in the environmental arena and had already been reviewed by stakeholders in the Klamath River watershed. Additionally, it allowed direct comparison to ODEQ, Regional Water Board and tribal water quality criteria.

The original *PacifiCorp Model* consisted of Resource Management Associates (RMA) RMA-2 and RMA-11 models and the U.S. Army Corps of Engineers' CE-QUAL-W2 model. The RMA-2 and RMA-11 models were applied to riverine segments including Link River, Keno Dam to J.C. Boyle Reservoir, Bypass/Full Flow Reach, and Iron Gate Dam to Turwar (See Figures 6-3 and 6-4). RMA-2 simulates hydrodynamics while RMA-11 represents water quality processes. The CE-QUAL-W2 model was applied to reservoir segments including Lake Ewauna-Keno Dam, J.C. Boyle Reservoir, Copco Reservoir, and Iron Gate Reservoir (see Figure 6-3). CE-QUAL-W2 is a two-dimensional, longitudinal/vertical (laterally averaged), hydrodynamic and water quality model (Cole et al. 2003). For the purposes of TMDL development, enhancements to the RMA/CE-QUAL-W2 portions of the *PacifiCorp model* were made in the following areas: BOD/organic matter (OM) unification, algae representation in Lake Ewauna, Monod-type continuous Sediment Oxygen Demand (SOD) and OM decay, pH simulation in RMA, OM-dependent light extinction simulation in RMA, re-aeration formulations, and dynamic OM partitioning. The Klamath TMDL staff report and appendices provide more detail on this subject.

Since the estuarine portion of the Klamath River (Turwar to the Pacific Ocean) was not included in the original *PacifiCorp Model*, it was updated to include an estuarine model. USEPA's Environmental Fluid Dynamics Code (EFDC), which is a 3-D hydrodynamic and water quality model, was selected to model the complex estuarine environment. The hydrodynamics and water quality within the estuary are spatially and temporally variable and are greatly influenced by time of year, river flow, tidal cycle, and location of the estuary mouth (which changes due to sand bar movement). Additionally, transect temperature and salinity data in the lower estuary show significant lateral variability, as does DO to a lesser extent.

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EFDC is capable of predicting hydrodynamics, nutrient cycles, DO, temperature, and other parameters and processes pertinent to the TMDL development effort for the estuarine section. It is capable of representing the highly variable flow and water quality conditions within years and between years for the estuary. As with RMA-2, RMA-11, and CE-QUAL-W2, EFDC has a proven record in the environmental arena and model results can be directly compared to ODEQ, Regional Water Board and tribal water quality criteria. It is an USEPA-endorsed and supported model and available freely in the public domain.

Table 6-1: Models applied to each Klamath River and estuary segment

Modeling Segment #	Modeling Segment	Segment Type	Model(s)	Dimensions
1	Link River	River	RMA-2/RMA-11	1-D
2	Lake Ewauna-Keno Dam	Reservoir	CE-QUAL-W2	2-D
3	Keno Dam to J.C. Boyle Reservoir	River	RMA-2/RMA-11	1-D
4	J.C. Boyle Reservoir	Reservoir	CE-QUAL-W2	2-D
5	Bypass/Full Flow Reach	River	RMA-2/RMA-11	1-D
6	Copco Reservoir	Reservoir	CE-QUAL-W2	2-D
7	Iron Gate Reservoir	Reservoir	CE-QUAL-W2	2-D
8	Iron Gate Dam to Turwar	River	RMA-2/RMA-11	1-D
9	Turwar to Pacific Ocean	Estuary	EFDC	3-D

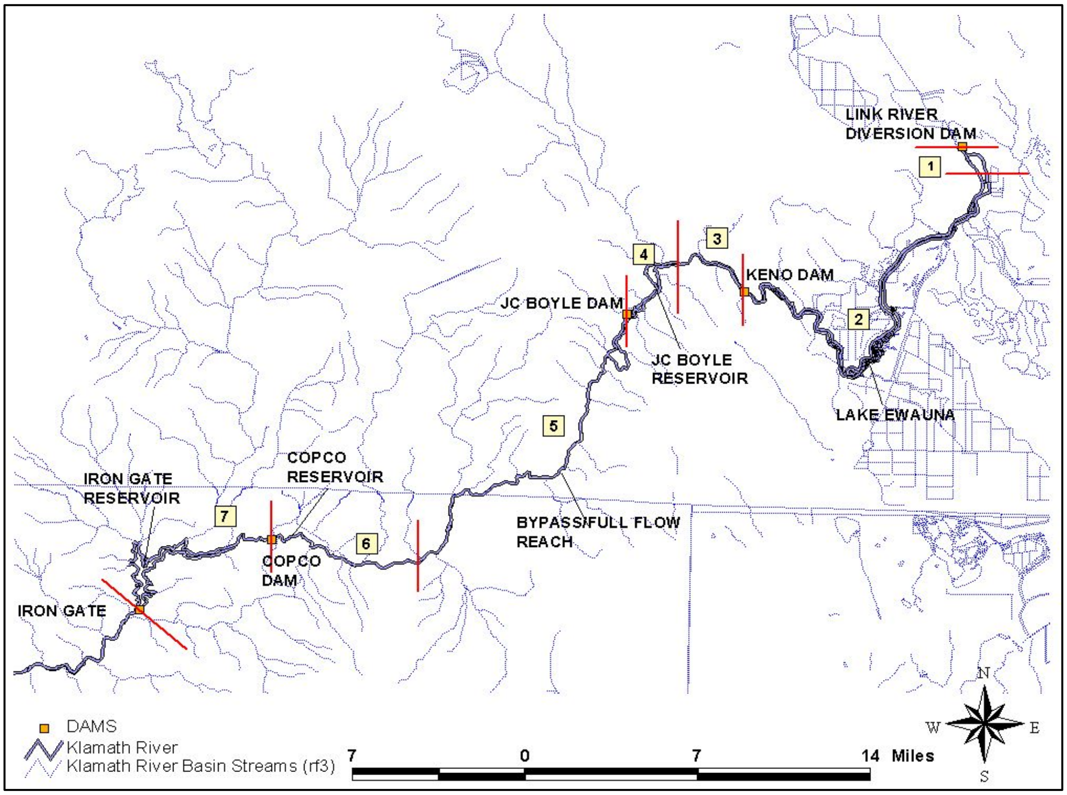
The combination of the *PacifiCorp Model* (RMA and CE-QUAL-W2), with enhancements, and the EFDC model for the estuary resulted in the *Klamath TMDL Model* used for TMDL development. Table 6-1 identifies the modeling elements applied to each river segment. Within each reservoir segment, the model further divides the segment into layers 0.61 to 1.0 meter in depth and 37 to 714 meters in length. Within each river segment, the model further divides the segment into nodes of 75 to 300 meters in length (assumed to be homogeneous in the vertical direction). These nine segments are depicted graphically in Figures 6-3 and 6-4. Linkages between the different modeling segments are made by transferring time-variable flow and water quality from one model to the next (e.g., output from the Link River model became input for the Lake Ewauna-Keno Dam model).

To run the *Klamath TMDL model*, external forcing factors known as boundary conditions must be specified for the system. These forcing factors are a critical component in the modeling process and have direct implications on the quality of the model's predictions; and include: upstream inflow boundary conditions, tributary inflow boundary conditions, withdrawal boundary conditions, downstream boundary conditions, and surface boundary conditions.

As summarized above, the upstream boundary condition is replicated from the downstream boundary condition produced by the model in the segment above. The surface boundary conditions are determine by meteorological or atmospheric conditions and include air temperature, dew point temperature, wind speed, wind direction, and cloud cover. Data obtained from the U.S. Bureau of Reclamation's (USBR) AgriMet

Station (KFLO) near Klamath Falls were used to represent the boundary conditions from J.C. Boyle Dam to Seiad Valley. Data from Brazie Ranch meteorological station represent the surface boundary conditions from Seiad Valley to Turwar. The weather data from Hoopa and Somes Bay were used to represent the meteorological boundary conditions for those areas. Data from the Arcata Eureka Airport were applied to the estuarine portion of the Klamath River (Turwar to the Pacific Ocean). In addition, tributary and withdrawal boundary conditions are also modeled, including: major springs, tributary streams, stormwater outfall, point source discharges, irrigation withdrawals, agricultural return flows, etc.

Figure 6-3: Model segments in Oregon and Northern California

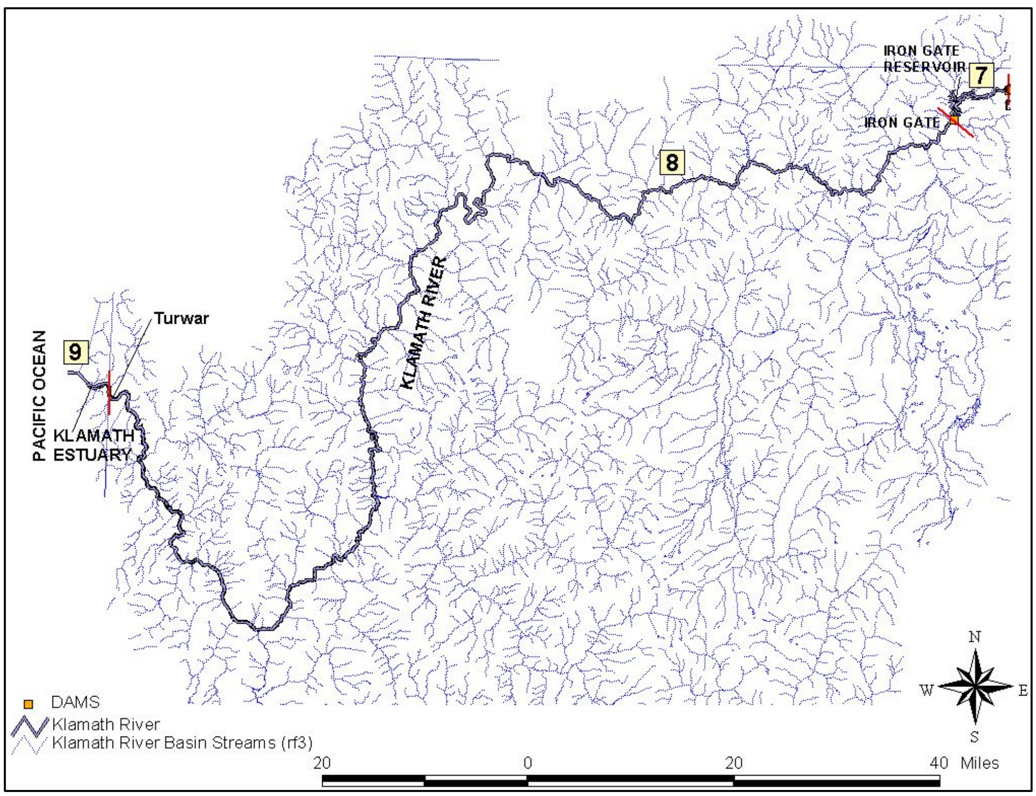


The model was calibrated and validated to known water quality conditions in the Klamath River mainstem. It was then run to simulate natural water quality conditions (referred to as the Natural Conditions *Klamath TMDL model run* and identified in model documentation as T1BSR) and calculate appropriate TMDLs for the listed parameters. These became the basis for the draft TMDL Staff Report and draft DO Staff Report submitted for public review with the comment period ending in September 2009.

Prior to the Regional Water Board's release of the Public Review Draft TMDL Staff Report, the development team initiated various peer reviews related to the *Klamath TMDL model*. In 2005, peer reviews of the *Klamath TMDL model* were completed by Dr. Scott Wells (developer of CE-QUAL-W2 model), Portland State University; Brown

& Caldwell (under contract to the City of Klamath Falls, Oregon); and the U.S. Bureau of Reclamation (Technical Services Center – Environmental Applications and Research Group, Denver). Peer review materials were also sent to Dr. Michael Deas of Watercourse Engineering, Inc. as developer of the *PacifiCorp Model* and technical consultant to PacifiCorp; but, neither Dr. Deas nor PacifiCorp submitted comments at that time. Between 2005 and 2007 the TMDL development team and Tetra Tech, Inc. had informal consultation with Dr. Deas, on behalf of PacifiCorp, regarding the *Klamath TMDL model*. Then, in accordance with Section 57004 of the California Heath and Safety Code, in 2009 the Regional Water Board's draft Staff Report was reviewed by four external scientific peer reviewers. The model has been developed and refined through a process of expert consultation, calibration, validation, and peer review. Finally, the TMDL Staff Report, including details regarding model development were released for public review during two comment periods beginning in June 2009 and

Figure 6-4: Model segments in California



December 2009. These rounds of peer and public review have resulted in additional refinements to the model. The results discussed below reflect the most recent model refinements (November 5, 2009), including refinements to barometric pressure made as a result of consultation with representatives of the Hoopa Valley Tribe (and others). Those refinements are represented for the reach of the Klamath River from Iron Gate Dam to

Turwar and are based on a run of the model (T1BSR) for that reach conducted February 2, 2010.

6.2.2 Description of Mainstem Reaches in California
The Klamath River mainstem is divided into three reaches for the purposes of evaluation and modeling. Reach 1 includes that portion of the mainstem from the Stateline to Iron Gate Dam. Iron Gate Dam represents the upper limit of anadromy in the mainstem. Reach 2 includes that portion of the mainstem from Iron Gate Dam to Turwar, downstream of the Klamath's confluence with the Trinity River. And, the third reach encompasses the whole estuary from Turwar to the Pacific Ocean.

6.2.2.1 Stateline to Iron Gate Dam (Reach 1)
The region from the Oregon-California border to Iron Gate Dam currently includes both Copco and Iron Gate dams; though prior to 1917 it was free flowing. The *Klamath TMDL model* evaluates this reach of the river in three model segments: 1) Segment 5 (Bypass/Full Flow Reach), Segment 6 (Copco Reservoir), and Segment 7 (Iron Gate Reservoir); though, Segment 5 originates in Oregon before crossing into California.

The T1BSR run of the *Klamath TMDL model* configures the Klamath River mainstem as a free flowing river from it's headwaters at Upper Klamath Lake (UKL) to the Pacific Ocean. As such, in the Stateline to Iron Gate Dam reach, both Segments 6 and 7 are modified to eliminate the dams. The water quality boundary conditions are defined by the UKL TMDLs at the headwaters and at the Lost River and Klamath Straits Drain, elimination of all point sources, and natural or TMDL conditions for all other tributaries. There are 3 springs in Segment 5 which are estimated to flow at 75 cubic feet per second (cfs).

6.2.2.2 Iron Gate Dam to Turwar (Reach 2)
The mainstem Klamath River from Iron Gate Dam to Turwar is a free flowing river. It is represented in the *Klamath TMDL model* by a single segment (Segment 8) and includes twenty-three tributaries. Five of the tributaries are actively gauged: Shasta River, Scott River, Salmon River, Indian Creek and Trinity River. The remaining minor tributaries are represented in the *Klamath TMDL model* as daily accretion/depletions. Water quality constituent concentrations in the tributaries for all parameters except DO are based on U.S. Fish and Wildlife Service, U.S. Bureau of Reclamation, and USEPA data. Temperature data is based on USGS-estimated temperatures for 2002. According to Tetra Tech (2009), the USGS study showed that there is no significant inter-year variation in the predicted in-stream temperature.

DO in the tributaries is estimated based on percent saturation and natural temperatures as follows: 1) 100% saturation in minor tributaries and the Trinity River and 2) 95% saturation in the Shasta, Scott and Salmon rivers.

6.2.2.3 Klamath River Estuary
The Klamath River Estuary is the lower most reach of the river and flows from Turwar to the Pacific Ocean. This reach is established as Segment 9 in the *Klamath TMDL model*.

For Segment 9, the EFDC model was used (Tetra Tech 2009), allowing for three dimensional water quality predictions. The model was calibrated using data collected in 2004 and including chlorophyll *a,* DO, PO_4, NH_4, and NO_2/NO_3. The model reproduces the observed diel fluctuation of DO in both the surface and bottom water. Since the model and observed data both show very low algae concentrations in the estuary, significant diel fluctuations of DO do not occur as a result of phytoplankton. Periphyton biomass, however, is predicted at high levels in the shallow regions of the estuary. This is likely a key contributor to diel DO fluctuation. The T1BSR run of the *Klamath TMDL model* generates simulated data for the Upper, Middle and Lower Estuary. With respect to DO, the Upper and Middle Estuary act like freshwater reaches. The Lower Estuary, however, does not.

6.2.3 Natural Watershed Characteristics

The Klamath River TMDL models were applied to characterize natural baseline water quality conditions of the Klamath River. To estimate natural conditions, several characteristics of the Klamath River watershed had to be considered, including the natural nutrient loading, limited buffering capacity, and elevated summer temperatures.

6.2.3.1 Nutrient Loading

The underlying geology in much of the Upper Klamath basin is of volcanic origin. Soils derived from this rock type are naturally high in phosphorus (Walker 2001). Through natural erosion and leaching processes these soils contribute a high background phosphorous load to Upper Klamath basin waters. In a nutrient loading study conducted by Rykbost and Charlton (2001), monitoring of several natural artesian springs in the upper Klamath basin were characterized by high levels of nitrogen and phosphorus, demonstrating the high natural background loading of nutrients. Upper Klamath Lake has long been noted for its eutrophic condition and demonstrated presence of high levels of organic matter (algae), including nitrogen fixing blue-green algae (Kann and Walker 2001). This nutrient and organic-matter rich Upper Klamath Lake water is the headwaters source of the Klamath River.

Within the Klamath Mountains Province of the mid- and lower-Klamath River, the underlying geology is not volcanic, and therefore does not tend to have the high levels of nitrogen and phosphorus characteristic of the Upper Klamath basin. Consequently, the tributaries that drain to the Klamath River within this province have considerably lower nutrient concentrations. As a result, the quality of the Klamath River generally improves as it flows from the Upper Klamath basin to the Pacific Ocean.

6.2.3.2 Buffering Capacity

Alkalinity is a measure of the ability of water to neutralize acids. In the natural environment, alkalinity comes primarily from the dissolution of carbonate rocks. Carbonate rock sources are rare in much of the Klamath basin due to its volcanic origin. As a result, the Klamath River has a relatively low alkalinity (<100 mg/L). The low alkalinity provides for a weak buffering capacity of Klamath River water. Photosynthetic activity removes carbon dioxide in the water (in the form of carbonic acid) which increases the water pH. Natural alkalinity serves as a buffer to minimize the photosynthetically induced increase in pH. In low alkalinity waters such as the Klamath River, this buffering capacity is frequently exceeded and high pH values are observed during daytime hours when photosynthesis is occurring. The large daily variation of pH observed in the Klamath River is caused by photosynthetic activity in the low alkalinity water.

6.2.3.3 Summer Temperatures
Further exacerbating the effect of the naturally productive and weakly buffered system is the presence of regionally high ambient summer air temperatures, and the resulting high heat load to the shallow and predominantly un-shaded Upper Klamath Lake. These naturally warm waters are the source of the Klamath River. In addition, the east-west aspect of much of the Klamath River also makes it prone to heating, even within the steep gorges of some reaches of the river.

6.2.3.4 Summary
In summary, the high ambient air temperatures, coupled with the high levels of biological productivity and respiration that is enhanced by the high levels of biostimulatory nutrients, yield large volumes of organic matter, seasonally high water temperatures, daily low dissolved oxygen, and high pH levels. All of these water quality conditions can be extremely stressful to many forms of aquatic life. These natural background nutrient, heat, and organic matter loads to the Klamath River underscore the very limited capacity of the river to assimilate anthropogenic pollutant sources.

6.2.4 Natural Baseline Conditions (T1BSR) Model Configuration
The natural baseline conditions scenario (T1BSR) of the *Klamath TMDL model* run simulates the Klamath River from Upper Klamath Lake to the Pacific Ocean in the absence of all dams and uses a different configuration than for the current conditions scenario. For example, the entire length of the river from Upper Klamath Lake to just upstream of the estuary is simulated using the riverine RMA model. No CE-QUAL-W2 modeling segments are included since the natural configuration includes no impoundments.

The Upper Klamath Lake (UKL) boundary is the starting point for the *Klamath TMDL model*. The UKL boundary condition for the model is derived from the Upper Klamath Lake TMDL (ODEQ 2002) which has been adopted by the State of Oregon and approved by USEPA. The median concentrations for water quality constituents and existing temperature are applied at the outlet and based on 1995 Upper Klamath Lake model output. Flow from Upper Klamath Lake is set at existing conditions, in order to maintain consistency with the existing conditions modeling scenario. Without this consistency, the TMDL team would not have been able to compare the existing conditions scenario to the natural background conditions scenario, impeding their ability to establish appropriate TMDLs for the pollutants of concern.

The flow balance for the current conditions model (when dams are present) and the reservoir operations limit the ability of the model to represent natural flows. It should be noted however, that results for two model runs: one that uses current conditions flows from Upper Klamath Lake and one that uses estimated flows from a natural regime (USBR 2005), were compared and not found to be substantially different.

Permitted point sources are removed from the model (i.e., both flow and water quality contributions were removed). The Lost River Diversion Channel (LRDC) and Klamath Straits Drain (KSD) are represented using current conditions flow however, their water quality and temperature are set to be the same as the Upper Klamath Lake (TMDL compliant water quality conditions). Current flow is again used to maintain consistency with the current conditions scenario in order to calculate pollutant load reductions, and associated TMDL load allocations, necessary to meet water quality standards. For major springs and tributaries to the Klamath River in California, natural and TMDL conditions are represented, depending on the tributary.

In summary, the key components of the natural conditions baseline scenario are:

- Representation of the river with no dams;
- The Upper Klamath Lake (UKL) boundary condition based on existing UKL TMDL compliant conditions;
- Absence of all point sources;
- LRDC and KSD represented using current conditions flow, but water quality set equal to UKL TMDL compliant conditions; and
- California major springs and tributaries flow and water quality conditions set at estimated natural and existing TMDL compliant conditions.

The model simulation was run for the year 2000.

6.2.4.1 Barometric Pressure

As described in Chapter 4.0, barometric pressure plays an important role in determining the concentration of DO that a body of water is capable of holding in solution. The model was originally configured using barometric pressure data at three locations. Data from KFLO near Klamath Falls was used to define the barometric pressure from J.C. Boyle Dam to Seiad Valley. Data from Brazie Ranch was used to define the barometric pressure from Seiad Valley to Turwar and, data from the Arcata Eureka Airport was used to define the barometric pressure in the estuary. These data provide an accurate depiction of barometric pressure for those locations on the river closest to the stations from which the data were collected. However, the accuracy is reduced at locations as one moves farther from the station of origin. In addition, there is a large jump in estimated barometric pressure between locations where a switch is made from one dataset to the next. This results in inaccuracies in the associated estimates of DO at the downstream location.

To resolve this problem, Tetra Tech, Inc. with guidance from Regional Water Board staff and as a result of consultation with representatives of the Hoopa Valley Tribe (and others), corrected the barometric pressure data as collected at the given meteorological stations. The barometric pressure data was refined to reflect elevations at the locations downstream of Iron Gate Dam to Turwar, correcting for elevation at each modeling node. A single barometric pressure was applied to all locations above Iron Gate Dam. A single barometric pressure was also applied to all locations in the estuary, downstream of Turwar..

There still is to be expected a minor artifact relating to the barometric pressure jumps, particularly at the first location represented by an elevation correction. But, the node dependent barometric pressure assignment in Reach 2 serves to smooth out any jumps considerably. As a result of the correction to barometric pressure, new data simulating DO under natural conditions was made available February 2, 2010 and is reflected in this updated Staff Report.

6.2.4.2 Percent Saturation

Percent DO saturation is one of the surface boundary conditions requiring assignment for individual tributaries throughout the watershed. Regional Water Board staff evaluated historic data and applied best professional judgment to make the following percent saturation assignments:

1. For minor tributaries, 100% saturation
2. For the Shasta, Scott and Salmon Rivers, 95% saturation
3. For the Trinity River, 100% saturation

These are the percent saturation assignments made in the most recent (December 2009) run of the *Klamath TMDL model*. They vary only slightly from previous runs of the model.

6.2.5 Discussion of Modeled DO Results

The results of T1BSR, the natural conditions baseline model run of the *Klamath TMDL model*, simulate DO concentrations and saturation values at selected nodes for every hour of the modeled year. Staff presents the modeling results in a number of different ways. First, staff presents the daily minimum and monthly average DO concentrations resulting from the T1BSR natural conditions model run. Second, staff compares these model outputs to the existing SSOs for DO. Third, staff compares the T1BSR model output to the life stage requirements of salmonids as presented in Chapter 3.0. Finally, staff evaluates percent saturation model output.

6.2.5.1 DO Output for the T1BSR Natural Conditions Model Run

Monthly data output for several stations down the length of the Klamath River mainstem from Stateline to the lower estuary have been developed.

These data indicate that in the Klamath River mainstem, when considering *24-hour* data, the *natural background* baseline DO concentrations are as follows:

Upstream of Iron Gate Dam	6.9 mg/L as a daily minimum
	9.4 mg/L as an annual median of the monthly means
Downstream of Iron Gate Dam	6.9 mg/L as a daily minimum
	9.4 mg/L as an annual median of the monthly means
Bottom of the Lower Estuary	7.0 as a daily minimum
	8.8 mg/L as an annual median of the monthly means

6.2.5.2 Comparison of Natural Conditions to Existing SSOs for DO

As described in Chapter 5.0, the existing SSOs for DO were developed with the intention of establishing background conditions as the water quality objective, keeping in mind the prohibition against point source discharge in the basin. By comparing the simulated natural conditions with the existing SSOs for DO, staff is able to determine how well the existing SSOs for DO represent background conditions, as intended. With respect to this comparison, Table 6-2 illustrates a number of important points.

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Table 6.2: Minimum DO Concentrations in the Klamath River Mainstem based on T1BSR run of the *Klamath TMDL model*

Location	Jan mg/L	Feb mg/L	Mar mg/L	Apr mg/L	May mg/L	Jun mg/L	Jul mg/L	Aug mg/L	Sep mg/L	Oct mg/L	Nov mg/L	Dec mg/L	Min mg/L	Median mg/L	Max mg/L
Stateline	10.9	10.1	9.2	8.7	8.1	7.3	7.3	7.2	7.8	8.4	10.3	11.3	7.2	8.5	11.3
DS Copco Dam	11.1	10.2	9.2	8.7	8.0	7.3	7.1	7.1	7.9	8.5	10.4	11.3	7.1	8.6	11.3
US Iron Gate Dam	11.2	10.3	9.2	8.6	7.9	7.2	7.0	6.9	7.8	8.4	10.5	11.3	6.9	8.5	11.3
Upstream of Iron Gate Dam Reach	**10.9**	**10.1**	**9.2**	**8.6**	**7.9**	**7.2**	**7.0**	**6.9**	**7.8**	**8.4**	**10.3**	**11.3**	**6.9**	**8.5**	**11.3**
DS Iron Gate Dam	11.2	10.3	9.2	8.6	7.9	7.2	7.0	6.9	7.8	8.4	10.5	11.6	6.9	8.5	11.6
US Shasta	11.3	10.4	9.2	8.6	7.9	7.2	7.2	7.2	8.0	8.6	10.5	11.7	7.2	8.6	11.7
DS Shasta	11.4	10.5	9.3	8.7	8.1	7.4	7.3	7.3	8.2	8.7	10.5	11.6	7.3	8.7	11.6
US Scott	11.6	10.7	9.6	9.0	8.2	7.6	7.3	7.3	8.2	8.7	10.6	11.7	7.3	8.9	11.7
DS Scott	11.5	10.7	9.8	9.2	8.5	7.8	7.4	7.3	8.2	8.7	10.6	11.6	7.3	9.0	11.6
Seiad	11.7	10.9	10.0	9.4	8.6	7.8	7.3	7.3	8.1	8.6	10.7	11.7	7.3	9.0	11.7
US Indian Creek	12.1	11.2	10.3	9.7	8.7	7.8	7.4	7.3	8.2	8.7	10.9	11.9	7.3	9.2	12.1
DS Indian Creek	12.0	11.2	10.3	9.8	8.8	7.9	7.5	7.4	8.2	8.8	10.9	11.9	7.4	9.3	12.0
US Salmon	12.1	11.6	10.8	10.3	9.2	8.2	7.7	7.7	8.3	8.9	11.1	12.1	7.7	9.8	12.1
DS Salmon	12.1	11.5	10.8	10.2	9.2	8.2	7.8	7.7	8.3	8.9	11.0	12.0	7.7	9.7	12.1
Hoopa	12.0	11.5	10.8	10.2	9.2	8.3	7.7	7.6	8.3	9.0	11.0	11.9	7.6	9.7	12.0
US Trinity	12.0	11.5	10.8	10.2	9.2	8.2	7.7	7.6	8.3	8.9	11.0	11.9	7.6	9.7	12.0
DS Trinity	12.0	11.6	10.9	10.4	9.5	8.5	8.0	7.8	8.4	9.1	10.9	11.8	7.8	10.0	12.0
Youngsbar	11.9	11.6	10.9	10.4	9.5	8.5	8.0	7.8	8.4	9.1	10.9	11.8	7.8	10.0	11.9
Turwar	11.8	11.5	10.7	10.3	9.3	8.0	7.7	7.5	8.3	9.0	10.8	11.6	7.5	9.8	11.8
Downstream of Iron Gate Dam Reach	**11.2**	**10.3**	**9.2**	**8.6**	**7.9**	**7.2**	**7.0**	**6.9**	**7.8**	**8.4**	**10.5**	**11.6**	**6.9**	**8.5**	**11.6**
Upper Estuary	11.7	11.3	10.6	10.1	9.2	7.9	7.6	7.5	7.9	8.7	10.7	11.5	7.5	9.7	11.7
Middle Estuary - Top	11.7	11.3	10.7	10.2	9.3	8.0	7.7	7.6	8.0	8.7	10.6	11.4	7.6	9.7	11.7
Middle Estuary - Bottom	11.7	11.3	10.7	10.2	9.3	8.0	7.7	7.6	8.0	8.7	10.6	11.4	7.6	9.7	11.7
Upper and Middle Estuary Reach	**11.7**	**11.3**	**10.6**	**10.1**	**9.2**	**7.9**	**7.6**	**7.5**	**7.9**	**8.7**	**10.6**	**11.4**	**7.5**	**9.7**	**11.7**
Lower Estuary - Top	8.1	11.1	10.5	9.9	9.0	7.8	7.6	7.8	7.9	8.3	9.7	10.1	7.6	8.7	11.1
Lower Estuary - Bottom	8.0	8.5	8.7	8.4	8.1	7.6	7.5	7.3	7.0	7.2	7.9	8.0	7.0	7.9	8.7
Lower Estuary Reach	**8.0**	**8.5**	**8.7**	**8.4**	**8.1**	**7.6**	**7.5**	**7.3**	**7.0**	**7.2**	**7.9**	**8.0**	**7.0**	**7.9**	**8.7**

Table 6.3: Monthly Mean DO Concentrations in the Klamath River Mainstem based on the T1BSR run of the *Klamath TMDL model*

Location	Jan mg/L	Feb mg/L	Mar mg/L	Apr mg/L	May mg/L	Jun mg/L	Jul mg/L	Aug mg/L	Sep mg/L	Oct mg/L	Nov mg/L	Dec mg/L	Min mg/L	Max mg/L	Median mg/L
Stateline	11.5	10.5	9.7	9.1	8.8	8.2	8.0	8.0	8.7	9.6	11.4	11.9	8.0	11.9	9.4
DS Copco Dam	11.7	10.7	9.8	9.3	8.8	8.2	8.1	8.1	8.8	9.7	11.6	12.0	8.1	12.0	9.5
US Iron Gate Dam	11.7	10.7	9.9	9.3	8.8	8.2	8.1	8.1	8.8	9.7	11.6	12.0	8.1	12.0	9.5
Upstream of Iron Gate Dam Reach	**11.5**	**10.5**	**9.7**	**9.1**	**8.8**	**8.2**	**8.0**	**8.0**	**8.7**	**9.6**	**11.4**	**11.9**	**8.0**	**11.9**	**9.4**
DS Iron Gate Dam	11.7	10.7	9.8	9.3	8.8	8.2	8.1	8.1	8.8	9.7	11.7	12.0	8.1	12.0	9.5
US Shasta	11.8	10.8	9.9	9.4	8.8	8.3	8.0	8.1	8.8	9.8	11.8	12.2	8.0	12.2	9.6
DS Shasta	11.8	10.8	10.0	9.5	8.9	8.4	8.1	8.1	8.9	9.9	11.7	12.1	8.1	12.1	9.7
US Scott	12.0	11.1	10.2	9.8	9.0	8.5	8.0	8.1	8.8	9.9	11.9	12.3	8.0	12.3	9.9
DS Scott	11.9	11.0	10.3	9.9	9.1	8.6	8.1	8.1	8.9	9.9	11.9	12.2	8.1	12.2	9.9
Seiad	12.1	11.3	10.6	10.1	9.3	8.7	8.2	8.2	8.9	10.1	12.1	12.5	8.2	12.5	10.1
US Indian Creek	12.4	11.7	11.0	10.4	9.5	8.8	8.4	8.3	8.9	10.1	12.2	12.6	8.3	12.6	10.2
DS Indian Creek	12.4	11.7	11.0	10.5	9.6	8.9	8.4	8.3	9.0	10.1	12.2	12.6	8.3	12.6	10.3
US Salmon	12.7	12.0	11.5	10.8	10.0	9.1	8.6	8.5	9.1	10.3	12.3	12.7	8.5	12.7	10.6
DS Salmon	12.5	11.9	11.4	10.8	10.0	9.1	8.6	8.5	9.1	10.3	12.2	12.6	8.5	12.6	10.5
Hoopa	12.4	11.9	11.5	10.8	10.0	9.2	8.6	8.5	9.1	10.3	12.0	12.4	8.5	12.4	10.5
US Trinity	12.4	11.9	11.5	10.8	10.0	9.2	8.6	8.5	9.1	10.3	12.0	12.4	8.5	12.4	10.5
DS Trinity	12.3	11.9	11.5	10.8	10.2	9.3	8.8	8.6	9.2	10.3	11.9	12.3	8.6	12.3	10.6
Youngsbar	12.3	11.8	11.5	10.8	10.1	9.3	8.7	8.6	9.1	10.2	11.8	12.2	8.6	12.2	10.5
Turwar	12.2	11.7	11.4	10.7	10.0	9.1	8.7	8.5	9.0	10.1	11.7	12.1	8.5	12.1	10.4
Downstream of Iron Gate Dam Reach	**11.7**	**10.7**	**9.9**	**9.3**	**8.8**	**8.2**	**8.0**	**8.0**	**8.8**	**9.7**	**11.6**	**12.0**	**8.0**	**12.0**	**9.5**
Upper Estuary	12.0	11.6	11.3	10.6	9.9	9.1	8.8	8.8	9.4	10.3	11.7	12.0	8.8	12.0	10.4
Middle Estuary - Top	12.0	11.6	11.3	10.6	9.9	9.1	8.8	8.8	9.4	10.2	11.6	12.0	8.8	12.0	10.4
Middle Estuary - Bottom	12.0	11.6	11.3	10.6	9.9	9.1	8.8	8.8	9.4	10.2	11.6	12.0	8.8	12.0	10.4
Upper and Middle Estuary Reach	**12.0**	**11.6**	**11.3**	**10.6**	**9.9**	**9.1**	**8.8**	**8.8**	**9.4**	**10.2**	**11.6**	**12.0**	**8.8**	**12.0**	**10.4**
Lower Estuary - Top	11.8	11.5	11.2	10.4	9.8	9.1	9.0	9.2	9.5	9.7	10.5	11.1	9.0	11.8	10.1
Lower Estuary - Bottom	10.8	10.9	10.9	9.7	9.1	8.7	8.8	8.8	8.6	8.3	8.4	8.7	8.3	10.9	8.8
Lower Estuary Reach	**10.8**	**10.9**	**10.9**	**9.7**	**9.1**	**8.7**	**8.8**	**8.8**	**8.6**	**8.3**	**8.4**	**8.7**	**8.3**	**10.9**	**8.8**

As shown in Tables 6-2 and 6.3, neither the existing daily minimum nor the monthly mean requirements as contained in Table 3-1 of the Basin Plan reasonably represent that which is achievable under natural conditions as simulated by the T1BSR run of the *Klamath TMDL model*. There are a number of locations where the simulated DO concentrations meet neither the daily minimum requirement (7.0 mg/L above Iron Gate Dam and 8.0 mg/L below Iron Gate Dam) nor the monthly mean requirement (10.0 mg/L) and the months of violation range from May to September for the daily minima and March to October for the monthly mean. Violations of the daily minima occur from Iron Gate Dam to the Pacific Ocean. Violations of the monthly mean requirement occurs from the Stateline to Seiad and in the lower estuary.

The lower estuary does not meet the daily minimum requirement for 4 months of the year at the surface and 6 months of the year at depth. The monthly mean criteria is met at the surface 50% of the year as required. But , it is only met 25% of the year at depth. As shown even more dramatically in Section 6.2.5.4, the lower estuary, with its tidal influence, presents a special case with respect to DO and deserves separate consideration and treatment. Chapter 7.0 (Alternatives) offers some suggestions to address the unique DO conditions present in the lower estuary.

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Table 6-4: T1BSR Model Results as compared to Existing SSOs for DO

Location	**Existing SSO for DO –min. (mg/L)**	**Existing SSO for DO-- 50% monthly means (mg/L)**	**Simulated min. (mg/L)**	**No. of Months. Exceeding min.**	**% of simulated monthly means greater than 10 mg/L**
Stateline	≥7.0	≥10.0	7.2	0	33
DS Copco Dam	≥7.0	≥10.0	7.1	0	33
US Iron Gate Dam	≥7.0	≥10.0	6.9	1	33
DS Iron Gate Dam	≥8.0	≥10.0	6.9	5	33
US Shasta	≥8.0	≥10.0	7.2	4	33
DS Shasta	≥8.0	≥10.0	7.3	3	42
US Scott	≥8.0	≥10.0	7.3	3	42
DS Scott	≥8.0	≥10.0	7.3	3	42
Seiad	≥8.0	≥10.0	7.3	3	58
US Indian	≥8.0	≥10.0	7.3	3	58
DS Indian	≥8.0	≥10.0	7.4	3	58
US Salmon	≥8.0	≥10.0	7.7	2	58
DS Salmon	≥8.0	≥10.0	7.7	2	58
Hoopa	≥8.0	≥10.0	7.6	2	50
US Trinity	≥8.0	≥10.0	7.6	2	50
DS Trinity	≥8.0	≥10.0	7.8	1	67
Youngsbar	≥8.0	≥10.0	7.8	2	67
Turwar	≥8.0	≥10.0	7.5	2	67
Upper Estuary	≥8.0	≥10.0	7.5	4	58
Top Middle Estuary	≥8.0	≥10.0	7.6	2	58
Bottom Middle Estuary	≥8.0	≥10.0	7.6	2	58
Top Lower Estuary	≥8.0	≥10.0	7.6	4	50
Bottom Lower Estuary	≥8.0	≥10.0	7.0	6	25

Shading indicates those locations which under natural water quality conditions are in noncompliance with the existing SSOs for DO.

6.2.5.3 Comparison of Natural Conditions to Salmonid Life Stage Requirements

A fundamental element of recalculating appropriate SSOs for DO in the mainstem Klamath is determining the degree to which beneficial uses are protected given the natural biochemical processes of the Klamath River (under natural conditions). As described in Chapter 3.0, salmonid cold water habitat, including spawning habitat, is identified as the most sensitive beneficial uses of the Klamath River with respect to DO and stands as a surrogate for the other beneficial uses for which DO is important. Chapter 3.0 identifies the DO concentrations demonstrated by laboratory studies as necessary to ensure little to no population impairment. Staff have compared the DO output from the T1BSR (natural conditions) run of the *Klamath TMDL model* to these life cycle requirements as well as National DO Criteria.

Of the range of DO conditions identified in Chapter 3.0 appropriate for the protection of salmonids, staff has chosen for comparison purposes daily minima and monthly averages that reflect USEPA (1986) guidance on DO criteria development to ensure "no production impairment" or "slight production impairment". Specifically, staff has taken heed of USEPA's (1986) recommendation that

> "if slight production impairment or a small but indefinable risk of moderate production impairment is unacceptable, then continuous exposure conditions should use the no production impairment values as means and the slight production impairment values as minima."

This approach results in DO criteria for the protection of salmonid life stages as follows:

- 6.0 mg/L as a daily minimum to protect other life stages,
- 8.0 mg/L as a 30-day average to protect other life stages,
- 9.0 mg/L as a daily minimum to protect early life stages, assuming a 3 mg/L difference between the intergravel DO and water column DO, and
- 11.0 mg/L as a 30-day average to protect early life stages, assuming a 3 mg/L difference between the intergravel DO and water column DO.

In addition, staff began its assessment by presuming that the period in which salmonids spawn in the Klamath River, including early development and fry emergence, is the same as the period identified for the Trinity River: September 15 through June 4.

A comparison of these criteria to Tables 6.2 and 6.3 illustrate several important phenomena. With respect to the daily variation in DO, the T1BSR natural conditions modeled results show that DO at all locations in the mainstem, including the estuary, are consistently above 6.0 mg/L. This suggests that under natural conditions, the mainstem provides adequate daily DO conditions to protect other (non-embryo, non-larval) life stages against growth effects, avoidance behavior, acute lethality, and synergistic effects. This is critical because the mainstem Klamath provides the corridor through which adult fish migrate upstream to high quality spawning habitat and juveniles migrate downstream to the estuary and ocean. In addition, the mainstem Klamath provides rearing habitat for numerous species of salmonids and other fishes.

The T1BSR natural condition modeled results also show that daily DO conditions in the mainstem do not consistently meet a 9.0 mg/L daily minimum requirement designed to protect early (embryo and larval) life stages during the spawning season (presumed to be September 15 through June 4). A 9.0 mg/L DO requirement is only met from November 1 through March 31. National criteria, as described in USEPA (1986), however, require a daily minimum of 8.0 mg/L as protection of early life stages. The *Klamath TMDL model* (Table 6.2) indicates consistent compliance with 8.0 mg/L as a daily minimum from October 1 through April 30 and compliance at most locations from September 1 through May 31.

With respect to the 30-day average requirements, The T1BSR natural conditions run of the *Klamath TMDL model* (Table 6.3) indicates consistent compliance with an 8.0 mg/L as a 30-day average throughout the mainstem Klamath and throughout the year. As above, this suggests that under natural conditions, the mainstem provides adequate monthly average DO conditions to protect other (non-embryo, non-larval) life stages against growth effects, avoidance behavior, acute lethality, and synergistic effects. This is critical because the mainstem Klamath provides the corridor through which adult fish migrate upstream to high quality spawning habitat and juveniles migrate downstream to the estuary and ocean. In addition, the mainstem Klamath provides rearing habitat for numerous species of salmonids and other fishes.

DO under natural conditions as estimated by the *Klamath TMDL model* and depicted in Table 6.3 does not meet an 11 mg/L monthly average during the spawning and incubation period, except from about November through January. The National criterion for the protection of early life stages is a 7-day mean of 9.5 mg/L. If raised to 10.0 mg/L and applied as a 30-day mean, then the *Klamath TMDL model* (Table 6.3) indicates consistent compliance with early life stage criteria from November through February and from October through April with a some exceptions above the Scott River.

It is possible that the weekly average SPWN-related metric as derived by using USEPA (1986) for no production impairment may overstate the DO requirements of salmonids in the Klamath River. For example, it may be that less than 3 mg/L DO is lost between the water column and intergravel environment in the mainstem Klamath, such that no production impairment in the intergravel environment is assured by water column DO concentrations less than 11.0 mg/L as a monthly average. Future monitoring efforts should investigate the relationship between water column DO concentrations and intergravel DO concentrations in the mainstem Klamath and important spawning tributaries.

Further, Chapter 3.0 highlights the spawning and incubation periodicity of salmonids in the Klamath River, to the degree they are known. Shaw et al. (1997) reports that coho spawning occurs from November through January with emergence occurring from late February through April. They also report that spring-run Chinook migrate up the Klamath River beginning in June and hold over until the fall to spawn, primarily in the tributaries (Shaw et al. 1997). For fall-run Chinook "spawning in the mainstem Klamath begins during the second week of October, peaks during the last week of October and declines by the end of November (Shaw et al. 1997)." Juveniles emerge from early February through the end of April (Shaw et al. 1997). Chum salmon are said to be at the southern end of their historic range and are rare in the Klamath River, historically present primarily in the estuary (Hamilton et al. 2005). No Klamath-specific spawning and incubation periodicity information was identified for cutthroat trout. However, their preference for smaller tributaries was noted.

Though not definitive, these observations coupled with the results of T1BSR natural conditions model run suggest that the spawning and incubation period for salmonids in the mainstem Klamath is primarily from October through April.

Staff believe that under natural conditions, when the upper watershed was open to migration and tributaries were free of excess sediment and other migration barriers, the mainstem may have provided only secondary spawning habitat, the primary spawning and incubation occurring in conjunction with cold springs and in high quality tributary streams. In support of this, NRC (2004) reports that coho salmon, spring-run Chinook salmon and summer steelhead in particular depended heavily on tributaries to complete their life cycles and sustain their populations. The *Klamath TMDL model* indicates that under natural conditions, daily minimum and monthly mean DO concentrations ensure no production impairment and no more than slight production impairment, respectively, of other (non-embryo and non-larval) life stages of salmonid. It also indicates that under natural conditions, daily minimum and monthly mean DO concentrations essentially meet National criteria for the protection of all early (embryo and larval) life stages if the primary spawning and incubation season in the mainstem Klamath River is understood to occur from about October 1 through April 30.

6.2.5.4 <u>Percent Saturation under Natural Conditions</u>
The *Klamath TMDL model* was used to produce an estimate of percent saturation at each location in the Klamath River mainstem as a corollary to the concentration estimates. Tetra Tech, Inc. has compiled the monthly percent saturation values for each of the stations and they are included in Table 6-5.

As described in Section 6.2.4.1, the *Klamath TMDL model* has been adjusted to account for differences in elevation at specific locations as compared to the meteorological stations from which barometric pressure data was collected. The elevations used to calculate percent saturation at each of the locations are given in Figure 6.5. For those locations from the Stateline to Iron Gate Dam and from Turwar to the Pacific Ocean, barometric pressure is not corrected for elevation (e.g. 909.83 millibars from Stateline to Iron Gate Dam and 1012.60 millibars from Turwar through the estuary). As a result, there may be a small artifact of the modeling process represented in the DO data associated with the locations within each of these reaches where the elevation is different from that of the associated weather station. But, from Iron Gate Dam to Turwar, the barometric pressure has been adjusted for elevation at every modeling node. This has resulted in a far smoother depiction of DO conditions throughout this reach. By adjusting barometric pressure at more locations throughout the mainstem than was the case in previous model runs, jumps in barometric pressure have been significantly minimized.

Figure 6.5:Barometric Pressure as assigned at individual nodes within the Klamath River mainstem from Iron Gate Dam to Turwar in the January 2010 T1BSR run (new pressure assignment) of the *Klamath TMDL Model*

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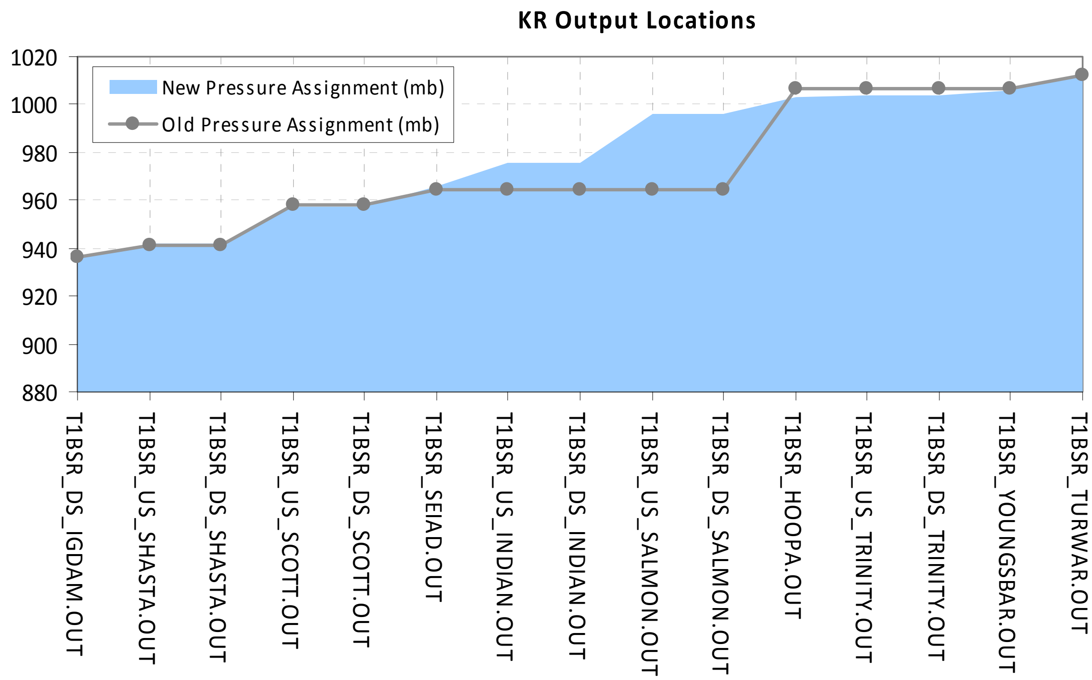

Table 6.5 presents the monthly minimum percent saturation values estimated by the T1BSR run of the *Klamath TMDL model* to occur at specific locations. It also presents the annual minimum percent DO saturation, as well as the minimum to occur in the Klamath River mainstem, overall. (The mainstem minima exclude the data associated with the Klamath River estuary.) The T1BSR model run estimates that under natural conditions, the minimum percent DO saturation in the mainstem Klamath River is 86%. It estimates that the minima range from 86% to 98% depending on the location; and, that the lowest percent DO saturation occurs during the months of July and August.

Figure 6.6 depicts the monthly minimum percent DO saturation within the mainstem over the course of the year. With the exception of the lower estuary, the graph shows a relatively smooth pattern of change in saturation in which saturation is at its lowest during the summer months, rises in the fall and winter and then decreases again in the spring. The T1BSR data output for percent DO saturation demonstrates even more clearly than the DO concentration data output, the need to consider the lower estuary separately from the freshwater-dominated portion of the river.

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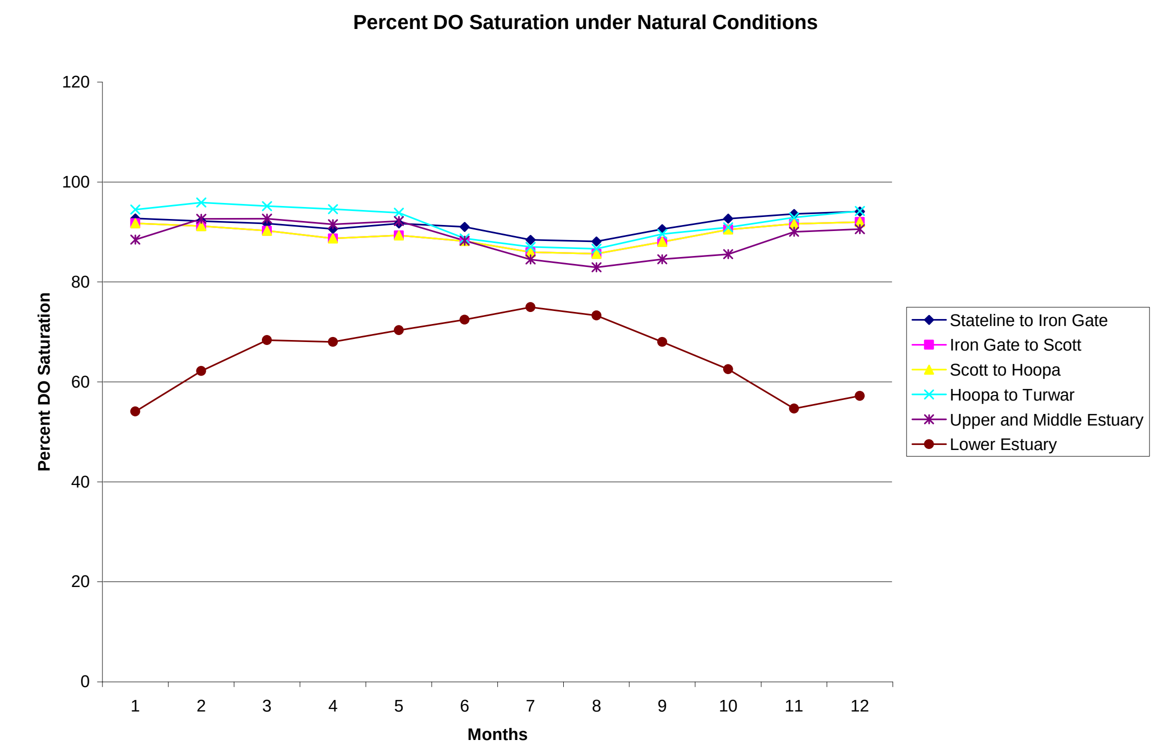
Table 6.5: Minimum Percent DO Saturation at Locations throughout the Klamath River Mainstem under Natural Conditions (T1BSR Model Run)

Min. % saturation under natural conditions (T1BSR) at each location	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
Stateline	93	92	92	91	92	91	90	90	91	93	94	94	**90**
DS Copco Dam	94	93	92	91	92	91	91	90	91	93	94	95	**90**
US Iron Gate Dam	94	94	93	91	92	91	88	88	91	93	94	95	**88**
DS Iron Gate Dam	92	91	90	89	89	88	86	86	88	90	92	92	**86**
US Shasta	92	91	90	89	89	88	88	89	90	91	93	93	**88**
DS Shasta	92	92	91	90	90	89	89	90	91	92	93	94	**89**
US Scott	93	92	92	92	92	90	90	90	92	93	94	93	**90**
DS Scott	93	93	93	93	93	92	91	91	92	93	94	94	**91**
Seiad	95	95	94	94	95	92	90	90	93	94	95	95	**90**
US Indian Creek	96	96	96	96	96	92	90	90	93	94	96	96	**90**
DS Indian Creek	97	97	96	96	96	93	90	91	93	94	96	97	**90**
US Salmon	97	98	97	97	97	94	92	92	93	95	96	97	**92**
DS Salmon	97	97	97	97	96	94	92	92	94	95	96	97	**92**
Hoopa	96	97	96	96	95	92	89	89	91	93	95	96	**89**
US Trinity	96	97	96	96	95	92	89	88	91	92	95	96	**88**
DS Trinity	97	98	98	97	97	95	92	91	92	94	96	97	**91**
Youngsbar	97	98	97	97	96	94	91	90	91	93	95	96	**90**
Turwar	94	96	95	95	94	89	87	87	90	91	93	94	**87**
STATELINE TO TURWAR	**92**	**91**	**90**	**89**	**89**	**88**	**86**	**86**	**88**	**90**	**92**	**93**	**86**
Upper Estuary	93	93	93	92	92	88	85	84	85	88	92	92	**84**
Middle Estuary Surface	93	93	93	92	93	89	86	83	85	86	90	91	**83**
Middle Estuary Subsurface	93	93	93	92	93	89	86	83	85	86	90	91	**83**
Lower Estuary Surface	82	90	91	89	90	86	83	78	75	72	71	73	**71**
Lower Estuary Subsurface	54	62	68	68	70	72	75	73	68	63	55	57	**54**

Figure 6.6: Fluctuation in percent DO saturation under natural conditions (T1BSR simulation) in individual reaches from the Stateline to the estuary.



6.3 Summary of Findings

Water has a limited ability to hold oxygen in solution that is defined by barometric pressure, temperature, and salinity. An assessment of the theoretical DO concentrations at 100% and 85% saturation indicate that water in the Klamath River is unable as a result of these simple physical properties to consistently meet the existing SSOs for DO. The *Klamath TMDL model* simulates, among other things, water quality conditions in the Klamath River mainstem under natural conditions, including DO concentration and percent DO saturation. It indicates that the daily minimum DO values above Iron Gate Dam and below Iron Gate Dam are less than the existing SSO for DO. Similarly, the annual median of monthly means is less than the existing SSO for DO, as well. . In short, the *Klamath TMDL model* demonstrates that even under natural conditions, water quality in the mainstem Klamath River is of insufficient quality to consistently attain the existing SSOs for DO.

A closer assessment of the DO output from the natural conditions run of the *Klamath TMDL model* indicates the following:

- The lower estuary experiences DO fluctuations that are dissimilar from the fluctuation that occurs elsewhere in the mainstem.
- The period in which DO concentrations meet the "no production impairment" or "slight production impairment" requirements of salmonid embryos and alevin (as defined by USEPA 1986) is from October through April.

- Under natural conditions, the transfer of DO from the water column to the intergravel environment is likely to be more efficient than estimated by USEPA (1986). If this is the case than water column DO concentrations less than 11.0 mg/L as a monthly average may sufficiently ensure intergravel DO concentrations of 8.0 mg/L DO as a monthly average to ensure “no production impairment” of salmonid embryos and alevin.
- The protection of salmonid refugia may be an important companion to the recalculation of the SSOs for DO in the Klamath River mainstem.
- Under natural conditions, the daily minimum DO upstream of the Lower Estuary is 6.9 mg/L. The annual median of monthly means is 9.4 mg/L. In the lower estuary, the daily minimum is 7.0 mg/L and the annual median of the monthly means in 8.8 mg/L.
- Under natural conditions, the Klamath River (excluding the estuary) maintains a minimum DO saturation greater than or equal to 86% at all times.

CHAPTER 7.
ALTERNATIVES ANALYSIS AND PROPOSED RECALCULATION OF THE SSOs FOR DO IN THE KLAMATH RIVER MAINSTEM

In this chapter, staff analyzes the new information presented in Chapter 6.0 and discusses the alternatives for recalculating the SSOs for DO in the Klamath River mainstem. As a result of the assessment of the existing SSOs for DO, staff has determined that the four main goals of the recalculation are to:

1. Represent an improved understanding of *natural background* conditions,
2. Accommodate updated monitoring techniques that allow for 24-hour DO sampling,
3. Be protective of identified beneficial uses, and
4. Represent physically achievable DO conditions.

The alternatives presented are 1) no change, 2) recalculated SSOs based on simulated DO concentrations under natural conditions, or 3) recalculated SSOs based on simulated percent DO saturation under natural conditions. Staff has not developed an alternative based on salmonid life cycle DO requirements. This is because, as shown in Chapter 6.0, the *Klamath TMDL model* indicates that DO under natural conditions does not consistently meet criteria designed to ensure no production impairment. Recovery of threatened and endangered species requires protection against further production impairment.

Staff uses the simulations resulting from the T1BSR run of the *Klamath TMDL model* because it offers the best estimate, to date, of DO under natural conditions. A description of the model and the natural conditions run are given in Chapter 6.0. T1BSR simulates DO in the mainstem considering conditions of barometric pressure, salinity, natural temperatures, and diel fluctuation. Staff believes that the T1BSR run of the *Klamath TMDL model* represents a more accurate and protective basis for establishing background DO objectives than the day time data collected in the 1950s and 1960s which was used to establish the existing SSOs for DO. This is because the T1BSR model run simulates conditions in the absence of anthropogenic influence (e.g., without dams), incorporates 24-hour data, and is directly comparable to data collected by datasondes, as well as grab samples.

Of importance is the observation in Chapter 6.0 that DO conditions in the lower Klamath estuary are different enough from conditions in the mainstem to warrant separate treatment. The existing SSOs for DO are given as two separate criteria: those that apply above Iron Gate Dam and those that apply below Iron Gate Dam. As a consequence, the criteria established for locations below Iron Gate Dam are applied to the estuary without consideration of the unique hydrological, ecological, and water quality (e.g., salinity concentrations) conditions present in the estuary.

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USEPA (1986) guidance says:

> "Where natural conditions alone create dissolved oxygen concentrations less than 110 percent of the applicable criteria means or m inima or both, the m inimum acceptable concentration is 90 percent of the natural concentration."

Based on this guidance, staff has assessed various means by which DO objectives based on natural concentrations could be developed. The proposed recalculation of the SSOs for DO in the mainstem Klamath River are designed to protect salmonids and other aquatic resources by ensuring that DO in the mainstem Klamath River is consistent with natural background conditions.

7.1 Alternative 1- No Change of the Criteria

Alternative 1 proposes to make no changes to the existing SSOs for DO in the Klamath River mainstem, except to add a footnote making clear that the objectives represent background conditions during daylight hours and can not reasonably be compared to data collected during the night. In this way, the potential for inaccuracies resulting from comparison of 24-hour data collected by DataSondes to the SSOs for DO is reduced. It leaves unaddressed however, the fact that the SSOs for DO represent background conditions as measured during the 1950s and 1960s after over 100 years of widespread anthropogenic influence on water quality. It also leaves unaddressed the fact that during the summer months, the SSOs for DO downstream of Iron Gate Dam are frequently unachievable due to conditions of barometric pressure and natural temperatures. Further, it does not address the unique conditions found in the lower estuary.

7.2 Alternative 2- DO Concentration Limits

Alternative 2 is to replace the SSOs for DO now existing in Table 3-1 of the Basin Plan with new concentration limits that are more precisely based on natural background DO conditions and can be compared to 24-hour data as have been more commonly collected in the last few years. The Alternative 2 DO concentration limits are intended to be the 24-hour equivalent replacement of the existing SSOs which were designed to be compared to day time samples, only. This means that the data set used to recalculate the SSOs includes the nighttime DO low, thereby resulting in true daily minima. This alternative is divided into Alternative 2a and 2b to allow for two differing ways of configuring the reaches within the mainstem.

Tables 6.2 and 6.3 presents the simulated minimum and monthly mean DO data resulting from the T1BSR run of the *Klamath TMDL model*. These simulated data are the basis for the Alternative 2 proposal.

USEPA's (1986) recommendation to derive water quality objectives as 90% of natural background accommodates naturally occurring inter-annual variation. For example, the T1BSR run of the *Klamath TMDL model* provides hourly estimates of natural DO concentration for every day of a given year. It provides a data record which is orders of magnitude greater than the one used to establish the original SSOs for DO in the Klamath mainstem. Yet, it is based on the climatic conditions of a single test year. Inter-annual variability in DO concentration due to variation in climatic conditions is predicted. As such, establishing water quality objectives as 90% of natural conditions is appropriate. With this correction, the potential for confusing natural variation for anthropogenic influence is reduced. Thus, in accordance with USEPA (1986), staff proposes for Alternative 2 criteria that are 90% of the natural concentrations estimated in the Klamath River mainstem.

7.2.1 Alternative 2a - DO Concentration with Existing Reach Configuration

Alternative 2a is to replicate the format of the existing SSOs for DO (adding new criteria for the estuary), but replace the numeric criteria with the simulated data resulting from the T1BSR run of the *Klamath TMDL model,* corrected with a 90% factor as recommended by USEPA (1986). Table 6.3 depicts the minimum monthly DO concentrations from the Stateline through the Lower Estuary.

7.2.1.1 Stateline to Iron Gate Dam

The minimum DO concentration from Stateline to Iron Gate Dam is 6.9 mg/L with an annual median of the monthly means of 9.4 mg/L. Staff recommends adding a monthly mean to better monitor for chronic DO impairment. The minimum monthly mean for this reach is 8.0 mg/L.

The DO concentrations under natural conditions are multiplied by 90% (0.90) to derive the following proposed concentration-based SSOs for DO in the Klamath River mainstem from the Stateline to Iron Gate Dam.

- 6.2 mg/L minimum
- 7.2 mg/L monthly mean
- 8.5 mg/L annual median of monthly means

7.2.1.2 Iron Gate Dam to Turwar

The minimum DO concentration from Iron Gate Dam to Turwar is 6.9 mg/L with an annual median of the monthly means of 9.5 mg/L. Staff recommends adding a monthly mean to better monitor for chronic DO impairment. The minimum monthly mean for this reach is 8.0 mg/L.

The DO concentrations under natural conditions are multiplied by 90% (0.90) to derive the following proposed concentration-based SSOs for DO in the Klamath River mainstem from Iron Gate Dam to Turwar, excluding the reach under the jurisdiction of the Hoopa Valley Indian Tribe.

- 6.2 mg/L minimum
- 7.2 mg/L monthly mean
- 8.6 mg/L annual median of monthly means

7.2.1.3 Upper and Middle Estuary

For the Upper and Middle Estuary, the DO is fairly uniform from the top of the water column to the bottom. The minimum DO concentration in this reach is 7.5 mg/L while the annual median of monthly means is 10.4 mg/L. As above, staff recommends adding a monthly mean to better monitor for chronic DO impairment. The minimum monthly mean for this reach is 8.8 mg/L.

The concentrations under natural conditions are multiplied by 90% (0.90) to derive the following proposed concentration based SSOs for DO in the upper and middle Klamath River estuary.

- 6.8 mg/L minimum
- 7.9 mg/L monthly mean
- 9.4 mg/L annual median of monthly means

7.2.1.4 Lower Estuary

The Basin Plan lists over 30 rivers and creeks as providing estuarine habitat (EST) in the North Coast Region, including the Klamath River. At present however, the Basin Plan does not include water quality objectives specifically designed to protect the EST beneficial use. In part this is because estuarine water quality data is fairly sparse and extensive estuarine studies rare.

The estuarine portion of the Klamath River is relatively short in relation to the watershed, though the length of the estuary varies seasonally with salt water intrusion achieving its greatest length during low flow when brackish water extends a couple of miles upriver (NRC 2004). NRC (2004) reports that the tidal amplitudes in the estuary vary up to 2 m.

The T1BSR run of the *Klamath TMDL model* provides some insight into the DO conditions in the Lower Klamath Estuary. Tables 6.2 and 6.3 provide simulated minimum and mean DO concentrations at the top and bottom of the water column. Of note is the fact that DO remains fairly constant at the bottom of the water column, fluctuating under natural conditions by only 1 mg/L from 7.0 to 8.0 mg/L. This is likely a function of the relatively constant water quality characteristics of salt water which, heavier than fresh water, forms a wedge at the bottom of the estuary. At the surface, on the other hand, DO fluctuates more widely (7.6 to 11.1 mg/L). This is likely a function of freshwater which forms a wedge at the surface of the estuary and varies in temperature, nutrients, and other water quality characteristics.

Estuarine DO conditions vary daily, seasonally, and annually. The degree and pattern of variation in the Lower Klamath Estuary is not yet very well understood. Without further study, staff does not believe the simulated estuarine data is sufficient to establish SSOs for this reach.

As an alternative, staff proposes the development of a narrative objective that identifies the water quality protection goals for this reach. Staff further proposes that as part of its Triennial Review of the Basin Plan, the Regional Water Board consider the development of numeric water quality standards for North Coast estuaries, including the Lower Klamath Estuary.

Under this alternative, staff proposes the following narrative objective:

"For the protection of estuarine habitat (EST), the dissolved oxygen content of the lower Klamath estuary shall not be depressed to levels adversely affecting beneficial uses as a result of controllable water quality factors."

7.2.1.5 Summary of Alternative 2a

Table 7.1- Alternative 2a

	Minimum (mg/L)	**Monthly Mean (mg/L)**	**Annual Median of Monthly Means (mg/L)**
Stateline to Iron Gate Dam	6.2	7.2	8.5
Iron Gate Dam to Turwar	6.2	7.2	8.6
Upper and Middle Estuary	6.8	7.9	9.4
Lower Estuary (Reach 4)	For the protection of estuarine habitat (EST), the dissolved oxygen content of lower Klamath estuary shall not be depressed to levels adversely affecting beneficial uses as a result of controllable water quality factors.		

7.2.2 Alternative 2b - DO Concentration with Reconfiguration of Reaches

The simulated DO concentration data resulting from the T1BSR run of the *Klamath TMDL model* suggests a configuration of reaches that differs from that used with the existing SSOs for DO. For example, Table 6.2 shows minimum DO concentrations under natural conditions from the Stateline to the Shasta River ranging from 6.9 to 7.2. From the Shasta to the Trinity River, the natural DO concentrations range from 7.2 to 7.4 mg/L. From the Trinity River to the Lower Estuary, the natural DO concentrations range from 7.5 to 7.7 mg/L. If the river is divided in this way, the ranges of minimum values are reduced in each reach ensuring that the daily minimum objective more closely mimics the natural conditions throughout the reach.

7.2.2.1 Stateline to Shasta River

The daily minimum for this reach is given in Table 6.2 as 6.9 mg/L. The monthly mean is given in Table 6.3 as 8.0 mg/L and the annual median of monthly means is given as 9.4 mg/L. Applying a 90% correction factor, the resulting criteria are as follows:

- 6.2 mg/L minimum
- 7.2 mg/L monthly mean
- 8.5 mg/L annual median of monthly means

7.2.2.2 Shasta River to Trinity River

The daily minimum for this reach is given in Table 6.2 as 7.3mg/L. The monthly mean is given in Table 6.3 as 8.0 mg/L and the annual median of monthly means is given as 9.9 mg/L. Applying a 90% correction factor, the resulting criteria are as follows:

- 6.6 mg/L minimum
- 7.2 mg/L monthly mean
- 8.9 mg/L annual median of monthly means

7.2.2.3 Trinity River to Lower Estuary

The daily minimum for this reach is given in Table 6.2 as 7.5 mg/L. The monthly mean is given in Table 6.3 as 8.5 mg/L and the annual median of monthly means is given as 10.4 mg/L. Applying a 90% correction factor, the resulting criteria are as follows:

- 6.8 mg/L minimum
- 7.7 mg/L monthly mean
- 9.4 mg/L annual median of monthly means

7.2.2.4 Lower Estuary

As with Alternative 2a, staff recommends a narrative objective describing the water quality protection goals for the lower estuary.

7.2.2.5 Summary of Alternative 2b

Table 7.2: Alternative 2b

	Minimum (mg/L)	**Monthly Mean (mg/L)**	**Annual Median of Monthly Means (mg/L)**
Stateline to Shasta	6.2	7.2	8.5
Shasta to Trinity	6.6	7.2	8.9
Trinity to Lower Estuary	6.8	7.7	9.4
Lower Estuary (Reach 4)	For the protection of estuarine habitat (EST), the dissolved oxygen content of the lower Klamath estuary shall not be depressed to levels adversely affecting beneficial uses as a result of controllable water quality factors.		

7.3 Alternative 3 - Percent DO Saturation

An alternative to recalculating the SSOs as concentration based objectives is to establish the objectives based on percent saturation. DO in healthy streams and rivers approaches saturation, fluctuating slightly due to the natural processes associated with photosynthesis and decomposition (Deas and Orlob 1999). The range of fluctuation in saturation in such a system is generally defined as 80-100% (Hauer and Hill 2007; SFBRWQCB 2007; Moyle 2008).

There are numerous regions, states and countries that utilize percent saturation as a water quality criterion for DO. For example, the San Francisco Bay Regional Water Quality Control Board (Region 2) requires that the median DO concentration for any three consecutive months not be less than 80% of the DO content at saturation (SFBRWQCB 2007). It further states that in areas unaffected by waste discharges, a level of about 85% of oxygen saturation exists (SFBRWQCB 2007). The Central Coast Regional Quality Control Board (Region 3) requires that median values not fall below 85% saturation as a result of controllable water quality conditions (CCRWQCB 1994). The Central Valley Regional Water Quality Control Board (Region 5) requires that for those surface water bodies outside the legal boundaries of the Delta, the monthly median of the mean daily DO concentration shall not fall below 85% of saturation in the main water mass (CVRWQCB 2007). It further requires that for water bodies unable to meet concentration-based DO objectives due to natural conditions, DO must be maintained at or above 95% of saturation (CVWQCB 2007). Finally, the Santa Ana Regional Water Quality Control Board (Region 8) requires that waste discharges shall not cause the median DO concentration to fall below 85% of saturation (SARRWQCB 2008).

The State of Oregon applies a 90% saturation criterion in those COLD waterbodies unable to meet concentration-based limits due to conditions of barometric pressure, altitude and temperature, and 95% saturation in SPWN waterbodies under the same conditions. The Hoopa Valley Tribe has proposed a 90% saturation criterion under natural receiving water temperatures in those COLD and SPWN waterbodies unable to meet concentration-based limits due to natural conditions. The National Rivers Authority of England requires DO in their RE1 waterbodies (very high quality, suitable for all fisheries) to be at or above 80% of saturation (NRA 1994).

One of the appealing aspects of percent saturation as a DO criterion is that it establishes a relationship between DO and temperature so that as temperatures decline in the winter, DO concentrations naturally increase even if percent saturation remains the same. This natural pattern of DO fluctuation—rising through the fall, reaching a peak in the winter, and declining in the spring—follows the same pattern as required of salmonids and other aquatic organisms (see Chapter 3.0). This natural pattern of DO concentration and DO life cycle requirements is better represented by a percent saturation criterion than a static minimum concentration limit.

The T1BSR run of the *Klamath TMDL model* produces simulated percent saturation data as presented in Table 6.5. The model calculates percent saturation based on estimates of natural temperatures, salinity, and barometric pressure as adjusted by elevation at locations throughout the mainstem. With the exception of the Hoopa proposal, the percent saturation criteria as described above are applied based on *actual* temperature. As a result, the DO concentrations associated with the criteria adjust based on changes in temperature, including anthropogenically influenced changes such as loss of riparian canopy or decrease in flow to water diversions.

A Technical Advisory Committee (TAC), chaired by Dr. Gary Chapman the author of USEPA's guidance on water quality criteria development for DO (USEPA 1986), was established to review the State of Oregon's water quality criteria for DO. In its' review (Oregon 1995), the TAC made the following observation.

> "Saturation criteria may result in inadequate protection at high temperatures and greater than necessary criteria at low temperatures, often inversely related to the needs of the resource. Because of the high level of protection warranted for salmonid spawning, concentration and saturation criteria would be similar for this use."

To overcome the problem of under protection at high temperatures, staff recommend that a percent DO saturation criterion be calculated based on estimates of *natural* water temperatures rather than existing water temperatures as is more widely done. By this method, the DO concentrations resulting from a calculation of percent saturation will reflect *natural* background conditions rather than allow for anthropogenic influences on temperature, particularly injurious during otherwise warm summer months. Further, by calculating the DO concentration associated with a given percent DO saturation criteria as based on natural temperatures, the criteria easily can be adjusted to accommodate improvements in the estimate of natural temperatures, including consideration of the effects of climate change, as necessary.

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Table 7.3- Percentage of time in which a Percent Saturation Criterion of 90% DO Saturation is not met under Natural Conditions (T1BSR)

90% Saturation	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Stateline	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
DS_COPCO DAM	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
DS_IGDAM	0%	0%	0%	9%	1%	8%	23%	27%	7%	0%	0%	0%
US_SHASTA	0%	0%	0%	5%	1%	7%	6%	1%	0%	0%	0%	0%
DS_SHASTA	0%	0%	0%	1%	0%	2%	1%	0%	0%	0%	0%	0%
US_SCOTT	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
DS_SCOTT	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
SEIAD	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
US_INDIAN	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
DS_INDIAN	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
US_SALMON	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
DS_SALMON	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
HOOPA	0%	0%	0%	0%	0%	0%	2%	6%	0%	0%	0%	0%
US_TRINITY	0%	0%	0%	0%	0%	0%	3%	6%	0%	0%	0%	0%
DS_TRINITY	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
YOUNGSBAR	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
TURWAR	0%	0%	0%	0%	0%	1%	21%	20%	1%	0%	0%	0%
Upper Estuary	0%	0%	0%	0%	0%	5%	21%	34%	30%	8%	0%	0%
Middle Estuary - Top	0%	0%	0%	0%	0%	3%	15%	34%	34%	18%	0%	0%
Middle Estuary - Bottom	0%	0%	0%	0%	0%	3%	15%	35%	35%	19%	0%	0%
Lower Estuary - Top	21%	0%	0%	0%	1%	17%	29%	51%	57%	90%	100%	91%
Lower Estuary - Bottom	40%	28%	22%	49%	63%	70%	65%	66%	84%	100%	100%	98%

Lightly shaded cells are months and locations at which a 90% saturation criterion is always met under natural conditions. Dark shaded cells are months and locations at which a 90% saturation criterion is violated no more than 1% of the time. Unshaded cells are months and locations at which a 90% saturation criterion is violated under natural conditions.

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As described above, USEPA (1986) recommends with respect to concentration based objectives, applying a 10% correction factor when deriving objectives from estimates of natural DO concentrations. Staff has considered whether or not a similar correction factor should be applied when deriving objectives from estimates of natural DO percent saturation. As an example, 90% of an 85% DO saturation criterion is 77% (85*0.9).

DO objectives must protect beneficial uses and, if derived from estimates of natural conditions should be established in such a way as to accommodate natural, inter-annual variation. Staff does not believe a criterion less than 80% would adequately protect the beneficial uses. Indeed, establishing a percent saturation criteria for an entire reach or for the entire year, necessarily allows for some flexibility at some locations during some times of the year. To better identify a protective yet implementable and appropriate program, staff has reviewed compliance statistics for assumed percent DO saturation criteria of 95, 90, and 85%.

None of the locations in the Klamath River mainstem achieve a 95% DO saturation criteria for the whole year while all of the locations achieve an 85% DO saturation criteria, except the Upper and Middle Estuary during the month of August. In question, then, is whether or not there are reaches or seasons in which a 90% DO saturation criteria might be appropriate.

Table 7.3 presents the compliance statistics for an assumed percent DO saturation criterion of 90%. Dark shaded cells indicate noncompliance with a 90% DO saturation criterion less than 1% of the time, under natural conditions. Light shaded cells indicate full compliance with a 90% DO saturation criterion. From Table 7.3 staff makes the following observations.

- From the Stateline to Shasta, a 90% criterion is met under natural conditions from October to March.
- From upstream of the Scott River to Hoopa, a 90% criterion is met under natural conditions for the entire year.
- From Hoopa through the Turwar, a 90% criterion is met under natural conditions from October through May. A 90% criterion is estimated to be violated 1% of the time during the month of September based on a daily minimum of 89.53% DO saturation which occurs during 6 one-hour increments during this period.

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Table 7.4: Minimum DO Concentrations Resulting from Alternative 3 Percent DO Saturation Criteria

DO Concentrations (mg/L)	Jan	Feb	March	April	May	June	July	August	Sept	Oct	Nov	Dec
Stateline to Scott River—90% October 1 through March 31 and 85% April 1 through September 30												
Stateline	10.4	9.6	8.5	7.6	7.0	6.3	6.3	6.4	6.9	7.8	9.5	10.6
Downstream Copco Dam	10.4	9.6	8.5	7.6	6.9	6.3	6.3	6.4	6.9	7.8	9.5	10.6
Downstream Iron Gate Dam	10.8	9.9	8.8	7.8	7.1	6.5	6.5	6.5	7.1	8.1	9.7	10.9
Upstream Shasta River	10.8	10.0	8.9	7.9	7.1	6.6	6.4	6.4	7.1	7.9	9.6	10.8
Downstream Shasta River	10.8	10.1	9.0	7.9	7.2	6.7	6.5	6.5	7.2	8.0	9.7	10.9
Upstream Scott River	10.9	10.2	9.1	8.1	7.2	6.7	6.4	6.5	7.1	7.9	9.8	10.9
Scott River to Hoopa—90% all year												
Downstream Scott River	10.8	10.2	9.3	8.7	7.9	7.3	6.9	6.9	7.6	8.0	9.8	10.9
Seiad Valley	10.9	10.2	9.3	8.8	7.8	7.2	6.9	6.9	7.5	7.9	9.9	10.9
Upstream Indian Creek	11.0	10.3	9.4	8.9	8.0	7.3	7.0	7.0	7.5	7.9	9.9	10.8
Downstream Indian Creek	11.0	10.3	9.5	9.0	8.1	7.4	7.0	7.0	7.6	8.0	9.9	10.8
Upstream Salmon River	11.2	10.6	9.8	9.3	8.4	7.5	7.2	7.2	7.7	8.2	10.0	11.0
Downstream Salmon River	11.1	10.6	9.9	9.4	8.5	7.6	7.2	7.2	7.7	8.2	10.0	10.9
Hoopa to Turwar—90% September 1 through May 31 and 85% June 1 through August 31												
Hoopa	11.0	10.6	10.0	9.5	8.5	7.2	7.0	6.9	7.8	8.3	10.1	11.0
Upstream Trinity River	11.0	10.6	10.0	9.5	8.5	7.2	7.0	6.9	7.8	8.3	10.0	11.0
Downstream Trinity River	10.9	10.6	9.9	9.5	8.6	7.4	7.1	7.0	7.9	8.4	10.0	10.9
Youngsbar	10.9	10.6	9.9	9.5	8.7	7.4	7.1	7.0	7.9	8.4	10.0	10.9
Turwar	10.9	10.5	9.9	9.5	8.6	7.2	6.9	6.8	7.6	8.1	9.8	10.8
Upper and Middle Estuary- 90% November 1 through May 31, 85% September 1 through October 31 and June 1 through July 31, 80% August 1 through August 31												
Upper Estuary	10.9	10.6	10.1	9.5	8.6	7.3	7.1	6.7	7.6	8.0	10.0	10.7
Middle Estuary	10.9	10.6	10.1	9.6	8.6	7.3	7.2	6.8	7.8	8.2	10.1	10.8
Lower Estuary—Narrative Objective												

The goal in choosing the appropriate set of percent DO saturation criteria for the mainstem Klamath River is to provide maximum protection of the beneficial uses, particularly the rare, threatened, and endangered aquatic species. Simultaneously, criteria must be implementable and reasonably accommodate natural inter-annual variation and other uncontrollable influences.

To accomplish these goals, then, Alternative 3 is presented in Table 7.5. The proposal is based on the simulation of *natural* background DO data (T1BSR) and accommodates 24-hour DO datasets. It also reflects the improvement in DO conditions that naturally occurs during the spawning season from late fall through early spring. Finally, it is intended as a means of balancing the need to establish maximum resource protection and simultaneously ensure that the objectives reasonably accommodate inter-annual variation.

Table 7.5 Alternative 3 Summary

Location	**Percent DO Saturation based on natural receiving water temperatures**	**Time period**
Stateline to Scott River	90%	October 1 through March 31
	85%	April 1 through September 30
Scott River to Hoopa	90%	Year round
Hoopa to Turwar	90%	September 1 through May 31
	85%	June 1 through August 31
Upper and Middle Estuary	80%	August 1 through August 31
	85%	September 1 through October 31 and June 1 through July 31
	90%	November 1 through May 31
Lower Estuary	For the protection of estuarine habitat (EST), the dissolved oxygen content of the Lower Klamath Estuary shall not be depressed to levels adversely affecting beneficial uses as a result of controllable water quality factors.	

Alternative 3 is implemented by calculating the corresponding DO concentration resulting from a given percent DO saturation using site-specific barometric pressure, site-specific salinity, and an estimate of site-specific natural temperatures as derived from the T1BSR run of the *Klamath TMDL model.* Staff envision the future possibility that new data may be developed or the modeling tool improved in such a way as to improve the estimate of natural receiving water temperatures. In this case, an opportunity for public review should be offered and use of improved or updated estimates of natural receiving water temperatures first reviewed and approved by the Executive Officer.

For the purpose of this assessment, site-specific natural temperatures are estimated by the *Klamath TMDL model*. Table 7.4 presents the minimum monthly DO concentrations resulting from Alternative 3 as calculated by the *Klamath TMDL model.*

7.4 Comparison of Alternatives

To identify the most protective and appropriate alternative, staff has had to develop a means of comparing Alternatives 1, 2a, 2b, and 3. This is made difficult by the fact that

Alternative 1 (No Change) is based on daytime DO samples while Alternatives 2a, 2b, and 3 are based on 24-hour simulated data. Because of the diel pattern of DO fluctuation, with daily minima generally occurring during the night, Alternative 1 is not reasonably compared to the other alternatives.

Further, as described in Chapter 4.0, Alternative 1 is not consistently achievable, particularly during the summer months at higher elevations when temperatures exceed 16 ºC and at lower elevations when temperatures exceed 22 ºC (see Figure 7.1). This is due simply to conditions of barometric pressure and temperature and the effect these parameters have on the ability of water to hold oxygen in solution (see Chapter 4). A review of Table 6.2 further indicates that under natural conditions from June to September, the daily minimum DO concentration is less than 8.0 mg/L at many locations. During the months of July and August the daily minimum DO *throughout* the mainstem ranges from 6.9 to 7.9 m/L, never reaching 8.0 mg/L.

Tetra Tech has calculated the DO concentrations resulting from Alternatives 2a, 2b, and 3 when using simulated data generated for the hours of 9am to 5pm, only—excluding the nighttime simulations. By this means, Alternatives 1, 2a, 2b, and 3 can be directly compared to one another. This comparison is necessary to determine which of the alternatives offers the greatest overall water quality protection, particularly with respect to the life cycle requirements of sensitive salmonid species. One must keep in mind that Table 7.6 is for comparison purposes, only. With respect to Alternatives 2a, 2b, and 3, it does not represent the actual proposed criteria. In addition, with respect to Alternative 1, the 8.0 mg/L DO required downstream of Iron Gate Dam is unachievable at higher elevations during the month of June and throughout the mainstem during the months of July and August.

For ease of presentation, Table 7.6 does not include all listed sampling locations. A subset of locations has been chosen as representative of the conditions found throughout the mainstem. These locations include: Stateline, downstream of Iron Gate Dam, downstream of the Scott River, downstream of the Trinity River, and the Middle Estuary.

In Table 7.6 the Alternative 1 objective of 8.0 mg/L DO downstream of Iron Gate Dam is crossed out for some of the summer months because they have been demonstrated to be unachievable solely due to the effects of barometric pressure and natural temperatures. The resulting comparison of the 4 alternatives strongly recommends Alternative 3 as the most protective alternative, overall. Table 7.6 demonstrates that during the summer, Alternative 1 requires higher DO concentrations than do Alternatives 2a, 2b, and 3 during some months at some locations with DO concentrations ranging from 0.1 to 0.7 mg/L higher and on one occasion, 0.9 mg/L higher. Table 7.6 also demonstrates, however, that the protection offered by Alternative 3 during the salmonid spawning and incubation period is far superior to that offered by any of the other alternatives. For this reason, staff recommends the adoption of Alternative 3 as the recalcualtion of the SSOs for DO in the Klamath River.

Alternative 3 offers one additional benefit over the other alternatives. DO saturation is based on the relationship of barometric pressure, temperature, and salinity. As such, a percent saturation criteria inherently incorporates temperature, a closely related water quality parameter. Alternative 3 uniquely calls for the implementation of the percent DO saturation criteria using estimates of *natural* temperature, rather than existing temperatures as is more common. Using natural temperatures as the basis for calculating the DO concentrations associated with the given percent DO saturation criteria ensures that the resulting concentrations more closely mimic natural DO conditions than would

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Table 7.6 Comparison of Alternatives 1, 2a, 2b, and 3, DO Minimum Concentration Values for the Hours of 9am to 5pm																				
	Stateline (mg/L)				**Downstream Iron Gate Dam (mg/L)**				**Downstream Scott River (mg/L)**				**Downstream Trinity River (mg/)**				**Middle Estuary (mg/L)**			
Alt	**1**	**2a**	**2b**	**3**	**1**	**2a**	**2b**	**3**	**1**	**2a**	**2b**	**3**	**1**	**2a**	**2b**	**3**	**1**	**2a**	**2b**	**3**
Jan	7.0	6.2	6.2	10.4	8.0	6.2	6.2	10.8	8.0	6.2	6.6	10.8	8.0	6.2	6.8	10.9	8.0	6.8	6.8	10.9
Feb	7.0	6.2	6.2	9.6	8.0	6.2	6.2	9.9	8.0	6.2	6.6	10.2	8.0	6.2	6.8	10.6	8.0	6.8	6.8	10.6
Mar	7.0	6.2	6.2	8.5	8.0	6.2	6.2	8.8	8.0	6.2	6.6	9.3	8.0	6.2	6.8	9.9	8.0	6.8	6.8	10.1
Apr	7.0	6.2	6.2	7.6	8.0	6.2	6.2	7.3	8.0	6.2	6.6	8.7	8.0	6.2	6.8	9.5	8.0	6.8	6.8	9.6
May	7.0	6.2	6.2	7.0	~~8.0~~	6.2	6.2	7.1	8.0	6.2	6.6	7.9	8.0	6.2	6.8	8.6	8.0	6.8	6.8	8.6
Jun	7.0	6.2	6.2	6.3	~~8.0~~	6.2	6.2	6.5	~~8.0~~	6.2	6.6	7.3	8.0	6.2	6.8	7.4	8.0	6.8	6.8	7.3
Jul	7.0	6.2	6.2	6.3	~~8.0~~	6.2	6.2	6.5	~~8.0~~	6.2	6.6	6.9	8.0	6.2	6.8	7.1	~~8.0~~	6.8	6.8	7.2
Aug	7.0	6.2	6.2	6.4	~~8.0~~	6.2	6.2	6.5	~~8.0~~	6.2	6.6	6.9	~~8.0~~	6.2	6.8	7.0	~~8.0~~	6.8	6.8	6.8
Sep	7.0	6.2	6.2	6.9	~~8.0~~	6.2	6.2	7.1	8.0	6.2	6.6	7.6	8.0	6.2	6.8	7.9	8.0	6.8	6.8	7.8
Oct	7.0	6.2	6.2	7.8	8.0	6.2	6.2	8.1	8.0	6.2	6.6	8.0	8.0	6.2	6.8	8.4	8.0	6.8	6.8	8.2
Nov	7.0	6.2	6.2	9.5	8.0	6.2	6.2	9.7	8.0	6.2	6.6	9.8	8.0	6.2	6.8	10.0	8.0	6.8	6.8	10.1
Dec	7.0	6.2	6.2	10.6	8.0	6.2	6.2	10.9	8.0	6.2	6.6	10.9	8.0	6.2	6.8	10.9	8.0	6.8	6.8	10.8

occur using existing temperatures, in most cases. Further, using an estimate of natural temperatures as the basis for calculating DO concentration allows for consideration of the effects of climate change. If convincing data is developed which confirms a rise in natural temperatures due to the effects of climate change, then consideration can be given to adjusting the estimate of natural temperatures upon which the percent saturation criteria are based. Staff do not intend to pre-judge whether or not a rise in natural temperature due to climate change will be considered natural but, only mean to acknowledge the flexibility of this approach, as compared to others, for dealing with the effects of climate change. For example, if the percent saturation criteria were applied based on existing temperatures, no specific consideration would be given to climate change and all increase in natural temperature would automatically adjust the DO objective without executive or public review.

7.5 Proposed Alternative

Staff proposes the adoption of Site Specific Objectives (SSOs) for the Klamath River mainstem, to replace the existing SSOs for DO in Table 3-1 of the Basin Plan, as given in Table 7.5. Staff further proposes that the *Klamath TMDL model* as described in the Klamath TMDL Staff Report be used to determine natural receiving water temperatures with which to calculate the DO concentrations associated with the given percent saturation criteria. Finally, staff propose that a clause be included in the Basin Plan that allows for the re-evaluation of natural temperatures as new data or modeling improvements become available, but only after public review and if the Executive Officer finds that re-evaluation is warranted. It must be understood that the proposed alternative will be applied to the maximum extent allowed by law. To the extent that the State lacks jurisdiction, the proposed SSO is extended as a recommendation to the applicable regulatory authority. Proposed Basin Plan Amendment language is presented in Appendix A of this Staff Report.

CHAPTER 8.
REGULATORY REQUIREMENTS

The protection of water quality in the State of California is guided by the Porter-Cologne Water Quality Control Act as amended. Section 13000 states that

> "The Legislature finds and declares that the people of the state have a primary interest in the conservation, control and utilization of the water resources of the state, and that the quality of all the waters of the state shall be protected for use and enjoyment by the people of the state."

To this end, nine Regional Water Quality Control Boards were established and each created water quality control plans with which to regulate water quality within their respective regions. The first comprehensive water quality control plans were approved for the North Coast Region in 1975, including a the Klamath Basin Plan for all waters draining to the Pacific Ocean from the mouth of the Klamath River north to the Oregon border and a separate North Coast Basin Plan for those waters draining to the Pacific Ocean south to San Antonio Creek at the Sonoma-Marin County boundary. The Water Quality Control Plan for the North Coast Region (Basin Plan), combining the Klamath and North Coast Basin Plans into one document, was approved in 1988. A triennial review of the Basin Plan is required, resulting in periodic updates and alterations.

As part of the 2007 Triennial Review, the Regional Board directed staff to develop revised water quality objectives (objectives) for dissolved oxygen (DO). To this end, a draft Staff Report has been developed, resulting from CEQA scoping and scientific peer review. Staff intends to bring a final report and proposed Basin Plan Amendment to the Regional Board for their consideration in late 2010. This Staff Report has been developed to support a proposed amendment of the site-specific DO objectives to the Klamath River mainstem, only.

Chapter 5.0 describes the existing Klamath River Site Specific Objectives (SSO) for DO currently contained in Table 3-1 of the Basin Plan. In this chapter, staff concludes that the existing SSOs for DO in the Klamath are established at levels too high to represent actual daily minima. This is because they are based on data collected during day light hours only. In fact, they are higher than is physically possible at all locations and during all times of the year, based on conditions of barometric pressure, temperature, and salinity. Staff also concludes that the human activities in the basin prior to and including the 1950s and 1960s were such that the pattern and range of DO in the basin was very likely altered from natural conditions. In particular, the presence of dams in the upper basin likely perpetuates downstream the effects of natural organic and nutrient loading from Upper Klamath Lake which would otherwise have been assimilated in the reaches above Iron Gate Dam.

Chapter 6.0 describes the new information available as a result of the Klamath TMDLs being developed to assess and control impairments due to elevated nutrients, temperatures, and organic enrichment/low DO. As described in Chapter 6.0 of this Staff

Report, a general assessment of DO saturation, based on the range of barometric pressures and temperatures observed in the basin indicates that at summer temperatures, the existing 8.0 mg/L DO requirement downstream of Iron Gate Dam is physically impossible to achieve. This is the case for an assumed 100% DO saturation and even more pronounced at an assumed 85% DO saturation, as is expected in a healthy, free-flowing river with moderate levels of organic and nutrient loading.

The *Klamath TMDL models* simulate, among other things, hourly DO conditions throughout the length of the mainstem Klamath River. The T1BSR run of the *Klamath TMDL models* unequivocally demonstrate that during the summer months, in various reaches of the mainstem, DO conditions do not meet the existing DO objectives under natural conditions. This is an indication that the existing DO objectives are ill-suited for comparison to data collected using modern tools for sampling and data analysis. In the 1950s and 1960s, day time samples were collected as grab samples and analyzed in the field as were compliance samples. Compliance samples can now be collected with datasonde data probes, however, which allow for 24 hours of sampling. These compliance data can not usefully be compared to the existing day time DO objectives.

Chapter 7.0 describes several alternatives for recalculating the SSOs for DO in the Klamath River mainstem. The alternatives include: 1) No Action, 2) recalculation of existing SSOs using simulated concentration data produced by the T1BSR run of the *Klamath TMDL models*, and 3) recalculation of existing SSOs using simulated percent saturation data produced by the T1BSR run of the *Klamath TMDL models.* Staff recommends the adoption of Alternative 3, creating a new approach to DO compliance by applying a percent DO saturation criteria based on an estimate of natural temperatures. By applying a percent DO saturation requirement based on natural temperatures, the objective reflects natural DO conditions in the basin. Using percent DO saturation (based on natural temperatures) as the metric ensures that it is physically possible to achieve, unlike a static DO concentration requirement that may not be achievable at some elevations and/or at some temperatures. And, not only does a percent DO saturation requirement (based on natural temperatures) ensure a given minimum DO condition, it also ensures a normal pattern of DO fluctuation, including elevated DO in the winter when salmonid eggs are incubating.

Chapter 8.0 provides an assessment of the proposed alternative to confirm that it meets the following requirements:

1. Section 13241 of Porter-Cologne Water Quality Act
2. State and Federal antidegradation requirements
3. Protection of the Hoopa Valley Tribal Waters downstream of California waters.

In addition, Chapter 8.0 provides a discussion of how the proposed alternative is to be applied in the reservoir portions of the Klamath River mainstem. This later part is described in detail in the Klamath TMDL Staff Report.

8.1 Section 13241 of Porter Cologne Water Quality Act

Section 13241 of the Porter Cologne Water Quality Act requires that each regional board establish water quality objectives to ensure the reasonable protection of beneficial uses and the prevention of nuisance, recognizing that it may be possible for the quality of water to be changed to some degree without unreasonably affecting beneficial uses. Section 13241 lists the following factors for consideration:

a. Past, present and probable future beneficial uses of water;
b. Environmental characteristics of the hydrographic unit under consideration, including the quality of water available thereto;
c. Water quality conditions that could reasonably be achieved through the coordinated control of all factors which affect water quality in the area;
d. Economic considerations;
e. The need for developing housing within the region; and,
f. The need to develop and use recycled water.

8.1.1 Past, Present, and Probable Future Beneficial Uses of Water

The past, present and probable future beneficial uses of Klamath River water are listed in Section 2 of the Basin Plan and summarized in Chapter 5.0 of this Staff Report. The mainstem Klamath River is listed as providing benefit for both human uses (e.g. MUN, AGR, IND, PRO, NAV, POW, REC1, REC2, COMM, SHELL, AQUA, and CUL) and environmental uses (e.g., GWR, FRSH, WARM, COLD, WILD, RARE, MAR, MIGR, SPWN, and EST). With respect to DO, the most sensitive beneficial uses are those associated with salmonids threatened with extinction.

Staff considered the needs of past, present and probable future beneficial uses of water in the following ways. First, staff determined the beneficial use most sensitive to DO conditions so as to ensure a conservative approach to the protection of beneficial uses. As above, staff determined that the spawning and incubation of salmonids forms the most sensitive of the mainstem Klamath uses.

Second, staff identified the DO requirements of all fish species at risk in the Klamath River mainstem; focusing on those of salmonids. Chapter 3.0 describes the DO requirements of the fish species evaluated.

Third, staff compared simulated natural DO conditions to the requirements of salmonids and determined that under natural conditions the Klamath River has never consistently provided ideal DO conditions, particularly during hot summer months. The *Klamath TMDL model* is a tool developed over the course of many years by an interdisciplinary and intergovernmental team of representatives of two States and two USEPA regions, including their consultant. The tool has been calibrated, validated, peer reviewed (multiple times), and reviewed by the public. It is this tool that staff has relied on to determine natural DO conditions under a scenario absent anthropogenic influences. Staff is confident that the *Klamath TMDL model* provides simulated data of sufficient quality to reasonably represent natural conditions in the Klamath River. (See Tetra Tech 2009, Appendix 6 of the Klamath TMDL Staff Report for a more detailed discussion of this topic).

Fourth, to ensure the best possible DO regime, for the benefit of threatened and endangered salmonids, staff proposed the adoption of DO objectives based on *natural conditions*. Specifically, staff proposed the adoption of percent DO saturation objectives based on natural temperatures as the method by which to establish natural DO conditions. This approach ensures that not only reasonable minimum DO conditions are maintained, but the natural seasonal pattern of DO fluctuation is also maintained. This is important to the protection of salmonids because spawning and incubation requires DO concentrations higher than other life cycle stages. And, these uses occur during the late fall, winter, and early spring when DO naturally increases with decreasing temperatures. The proposed SSO for DO incorporates the spawning and incubation DO needs of salmonids by applying a metric that more accurately depicts the natural seasonal pattern and ensures its preservation.

Fifth, in Chapter 6.0 staff determined that ideal salmonid DO conditions (i.e., "no production impairment" as defined by USEPA 1986) have never been consistently met, even under natural conditions. To determine how salmonids once thrived in the Klamath River basin, despite periodically moderate DO, staff further evaluated the spawning habits of salmonids. Staff determined that salmonids do indeed spawn in the mainstem; but, by far the largest majority of salmonids make more use of tributaries for spawning, particularly the large tributaries such as the Trinity, Salmon, Scott and Shasta rivers. Further, salmonids historically made considerable use of the tributaries of the upper basin which are now blocked from use by a series of dams, Iron Gate Dam being the first encountered.

These facts have led staff to develop two hypotheses. One hypothesis is built upon the fact that incubating salmonid embryos and alevin require a greater concentration of DO in the water column than do other life stages. This is because they reside in the gravels which, depending on the degree of sedimentation, sediment oxygen demand, and other factors, may receive only a percentage of the DO contained in the water column. Thus, to meet their DO needs for growth and development in the intergravel environment, DO in the water column must be higher. USEPA (1986) argues that DO in the water column must be 3 mg/L higher than that required in the intergravel environment to protect incubating salmonids. Others argue that the factor more accurately ranges from 1-6 mg/L. Still others argue that the factor difference between the water column and intergravel environment is best determined on a site-by-site basis.

Using USEPA (1986) guidance, staff compared the DO needs of incubating salmonids to simulated DO conditions during the spawning and incubating season and determined that a daily minimum of 9.0 mg/L was reasonably met under natural conditions; but, a weekly average of 11.0 mg/L was not. Staff hypothesizes that under natural conditions, sedimentation, especially during the late fall through early spring, may not historically have posed a significant problem in the mainstem Klamath. As such, the transfer of oxygen from the water column to the intergravel environment may have been relatively efficient. Unfortunately, neither historic nor current intergravel DO data exists for the Klamath River mainstem with which to assess the validity of this hypothesis. For the protection of the beneficial uses of intergravel waters, however, the Basin Plan includes several narrative objectives associated with the settling of suspended material, including sediment. For example, the Basin Plan requires that "Waters shall not contain suspended material in concentrations that cause nuisance or adversely affect beneficial uses." The Basin Plan also requires that "Water shall not contain substances in concentrations that result in deposition of material that causes nuisance or adversely affect beneficial uses." In addition, it reads "The suspended sediment load and suspended sediment discharge rate of surface waters shall not be altered in such a manner as to cause nuisance or adversely affect beneficial uses." Thus, whatever the validity of staff's hypothesis regarding historic mainstem sedimentation, the Basin Plan provides adequate current protection.

With respect to staff's second hypothesis, there appears to be general agreement that the tributaries to the Klamath River have played a critical role in the historic success of salmonids in the Klamath River basin (NRC 2004). Staff hypothesize that the loss of access to tributaries upstream of Iron Gate Dam, as well as the degradation of water quality and habitat in tributaries downstream of Iron Gate Dam have severely impacted the ability of salmonid populations to rebound from other assaults such as overfishing, disease, drought, water withdrawals, water impoundment, and loss of mainstem habitat, to name a few. The tributaries have offered refuge.

In addition to the TMDLs for the Klamath River, of which this Staff Report is a part, the Regional Board and/or USEPA has also adopted TMDLs for several of the main tributaries to the Klamath River, including: the Lower Lost River, Shasta River, Scott River, Salmon River, Trinity River, and South Fork Trinity River. The implementation of these TMDLs will result in the improvement of tributary water quality conditions so as to better support the salmonid populations that make use of them. In the mean time, however, staff believes that known, existing salmonid refugia should be afforded special protection as a way of more immediately providing for the needs of these threatened and endangered species. To that end, Chapter 6.0 of the Klamath TMDL Staff Report describes the plan to implement the Klamath TMDL and SSOs for DO in the Klamath River. The implementation plan includes the proposed protection measures in and around known thermal refugia. The known refugia are named and mapped.

Finally, staff have conducted an environmental analysis of the likely impacts associated with the potential means by which landowners/dischargers in the Klamath River watershed will achieve compliance with the plan for implementing the Klamath River TMDLs and the recalculated SSOs for DO. This analysis was conducted in compliance with the requirements of CEQA and are included as Chapter 9 of the Klamath TMDL Staff Report of which this staff report is a part. The CEQA analysis is incorporated as a part of the DO Staff Report by reference. The CEQA analysis considers the beneficial uses of the Klamath River in the context of determining whether or not any significant environmental impacts are likely.

In summary, staff has considered the past, present and probable future beneficial uses of the Klamath River mainstem by proposing SSOs for DO designed to protect the most sensitive of the listed beneficial uses-- salmonids. The proposed SSOs for DO protect salmonids by protecting not the anthropogenically altered DO conditions in the basin, but the natural DO conditions. The proposed SSOs for DO do this by approximating natural DO conditions through the application of percent DO saturation criteria based on natural temperatures. This is a unique approach to the use of percent DO saturation criteria that serves to better associate the protection of DO conditions with the protection of temperature conditions. Further, to ensure immediate protection of salmonids, staff also proposes—as described in the Klamath TMDL Staff Report of which this is a part—the adoption of protective measures in known thermal refugia. This further cements the relationship between DO and temperature.

8.1.2 Environmental characteristics of the hydrographic unit

Section 13241 of the Porter Cologne Act requires when developing water quality objectives that the Regional Board consider the environmental characteristics of the hydrographic unit under consideration, including the quality of water available thereto. This Staff Report describes the site specific assessment that is the basis for the proposed alternative for the recalculation of the SSOs for DO in the mainstem Klamath. Chapter 2.0 describes the physical setting of the Klamath River basin. Chapter 3.0 describes the fishes of the Klamath region. Chapter 4.0 provides a general discussion of DO. Chapter 5.0 describes the existing water quality objectives for DO in the Klamath River. Chapter 6.0 describes new site specific environmental data and information associated with the Klamath River basin. This includes the development and implementation of the *Klamath TMDL model* which assesses on an hourly basis the effects of various input parameters at thousands of points throughout the river from Upper Klamath Lake in Oregon to the Pacific Ocean. Further, this Staff Report is a companion to the Klamath TMDL Staff Report, an even more thorough and detailed analysis of the environmental characteristics of the Klamath River basin and its water quality.

Staff believes the environmental characteristics of the Klamath River hydrographic unit have been thoroughly and completely considered and form the foundation for the proposed action. In addition, staff believes that the analysis of the environmental characteristics of the Klamath River basin as represented by this Staff Report and the Klamath TMDL Staff Report is significantly broader and deeper than that represented by the existing SSOs for DO in the mainstem Klamath River. This is due to an improvement in monitoring and analytical tools which allows to staff to better represent the diel and seasonal cycling of DO and to better simulate alternate conditions, such as natural conditions.

8.1.3 Water quality conditions that could reasonably be achieved through the coordinated control of all factors which affect water quality in the area;

Section 13241 of the Porter Cologne Act requires when developing water quality objectives that the Regional Board consider the water quality conditions that could reasonably be achieved through the coordinated control of all factors which affect water quality in the area. This Staff Report and the associated Klamath TMDL Staff Report describe the relationships among several related parameters and propose a coordinated approach to their control.

This Staff Report considers the relationship between DO and water temperature as well as DO and sedimentation. It also considers the relationship between DO impairment and protection of refugia. The proposed SSO for DO in the mainstem Klamath River relates DO and temperature by establishing a percent DO saturation criteria that is calculated based on an estimate of natural temperatures. This is a unique approach to the application of percent DO saturation as a water quality objective which is otherwise more often calculated based on existing temperatures. But, staff proposes the use of percent saturation based on natural temperatures as a technique for estimating natural DO conditions because the simulation of natural temperatures is viewed as a much easier task than the simulation of DO conditions (Tetra Tech 2009). Further, DO concentration varies inversely to fluctuations in temperature and thus must be viewed together to ensure an accurate understanding of the water quality dynamics and appropriate implementation measures.

In addition, this Staff Report describes the importance of thermal refugia to the success of salmonids in the Klamath River basin. Thermal refugia, particularly in the tributary streams, provides a place for salmonids, otherwise stressed by mainstem water quality conditions, to find respite from environmental stress, including stress due to low DO conditions. As a companion to the proposed recalculation of the SSOs for DO in the mainstem Klamath River, staff has also proposed the adoption of protective measures in thermal refugia, including known mapped refugia. More discussion of this is included in the Klamath TMDL Staff Report, Chapter 6.0.

The Klamath TMDL Staff Report addresses several other related parameters, assesses the degree of water quality impairment, proposes point and nonpoint source load reductions, and a plan for implementing the reductions. The pollutants of concern include: temperature, dissolved oxygen, nutrient and microcystin.

Chapter 6.0 of the Klamath River TMDL Staff Report describes a plan for the implementation of measures necessary to control the discharge of pollutants responsible for temperature, DO, nutrient and microcystin impairment. The implementation plan contained in the Klamath River TMDL Staff Report is incorporated by reference into this Staff Report and includes the actions staff believes are necessary to control DO impairment.

Finally, the Basin Plan already contains several other numeric and narrative objectives which are applied to the protection of water quality in coordination with one another. Most notable with respect to salmonids and the issues associated with water quality in the Klamath River are the objectives designed to protect against harmful suspended material, settleable material, biostimulatory substances, sediment, turbidity, bacteria, temperature, toxicity, and pesticides.

Staff believes a thorough and complete assessment of the related parameters of concern to DO conditions in the mainstem Klamath River has been conducted and described in this Staff Report. More detail is provided in the Klamath River TMDL Staff Report, of which this Staff Report is a part. Staff further believes that the implementation plan contained in Chapter 6.0 of the Klamath River TMDL Staff Report describes all the actions necessary to ensure achievement of the proposed DO objective and control of the other related parameters.

8.1.4 Economic considerations

Section 13421 of the Porter Cologne Act requires when developing water quality objectives that the Regional Board consider economic factors. Chapters 6, 9 and 10 of the Klamath TMDL Staff Report consider two proposed actions: adoption of a Basin Plan Amendment to incorporate the Klamath TMDLs and adoption of a Basin Plan Amendment to update the SSOs for DO for the mainstem Klamath River. As such, Chapters 6, 9 and 10 of the Klamath TMDL Staff Report are incorporated here by reference.

Chapter 6 of the Klamath TMDL Staff Report describes the policies; including a waste discharge prohibition staff believes are necessary to implement the proposed TMDL load allocations and recalculated SSOs for DO. Chapter 9 of the Klamath TMDL Staff Report presents the California Environmental Quality Act (CEQA) analysis, including an analysis of the potential means by which landowners and land managers may comply with the load allocations, recalculated SSOs for DO, and proposed policies and prohibitions. Chapter 10 of the Klamath TMDL Staff Report presents an analysis of the costs associated with the potential means of compliance.

Chapter 10 of the Klamath TMDL Staff Report, incorporated here by reference, highlights the potential costs associated with each of the potential means of compliance but does not present a total cost. A total cost was deemed impossible to calculate because of the unknown condition of much of the landscape within the Klamath River watershed. Many of the potential compliance measures are measures that may be required by other regulatory programs, as well. And, many of the potential compliance measures are measures typically identified in TMDLs for the control of sediment, temperature, nutrients and DO. Many of these measures are earmarked by state and federal grant programs for full or partial government funding.

The identification of the potential compliance measures necessary for PacifiCorp to achieve compliance with the SSOs for DO and TMDLs were identified in work conducted by PacifiCorp, including their own pricing of these measures. In some instances, PacifiCorp has through other negotiations made obligations with respect to the funding of these measures and/or their testing.

As such, staff concludes that the costs associated with the implementation of the SSOs for DO are reasonable when compared with the water quality benefits that will ensue and generally represent the costs associated with good land stewardship.

8.1.4.1 <u>Point Source Discharges</u>

The Basin Plan prohibits the point source discharge of waste to the Klamath River except as stipulated by the Thermal Plan, the Ocean Plan, and the action plans and policies contained in the Point Source Measures section of the Basin Plan. Under the "Policy on the Regulation of Fish Hatcheries, Fish Rearing Facilities, and Aquaculture Operations" (Hatchery Policy), an exception to this prohibition has been granted to the California Department of Fish and Game and PacifiCorp for the operation of the Iron Gate Hatchery. The Hatchery Policy recognizes the potential for beneficial uses to be enhanced by the operation of fish hatcheries.

The Hatchery Policy allows for discharge from a fish hatchery as long as the discharge does not adversely impact beneficial uses, does not include wastes generated from cleaning activities, and does not include detectable levels of disease treatment and control chemicals. A permit can be issued depending on the characteristics of the discharge, and in the case of the Iron Gate Hatchery is issued as NPDES Permit No. CA0006688. The Iron Gate Hatchery is the only permitted point source discharge to the Klamath River within the boundaries of State of California.

NPDES Permit No. CA0006688 was last issued in 2000 and is overdue for renewal. Issuance of a renewed permit has been delayed to ensure that a new permit is compliant with the Hatcheries Policy and includes the discharge limitations necessary to comply with the Klamath River TMDLs and recalculated SSOs for DO. The Iron Gate Hatchery currently treats water released from the fish production ponds in a set of two settling ponds which discharge directly to the Klamath River below Iron Gate Dam and immediately below Bogus Creek. The current permit is designed to achieve an ambient DO of 7.0 mg/L as a daily minimum. The proposed recalculated SSOs for DO at that location range from 6.3 mg/L during the summer to 10.6 mg/L during the winter. Monitoring data for 2008 indicates upstream and downstream ambient DO conditions as shown in Table 8.1

These data indicate that the Iron Gate Hatchery discharge may be responsible for a reduction in ambient DO during the months of February, May, August, and September as shown by a lower DO downstream of the discharge as compared to that measured upstream of the discharge. On the other hand, the Iron Gate Hatchery discharge may be responsible for an increase in ambient DO during the months of January, March, April, and June as shown by a higher DO downstream of the discharge as compared to that measured upstream of the discharge. Ambient Klamath River water upstream and downstream of Iron Gate Dam, as shown by 2008 monitoring data, does not meet proposed SSOs for DO during the months of October through January. Downstream DO conditions do not meet proposed SSOs for DO during the month of September, as well.

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Table 8.1: DO Monitoring Results Upstream and Downstream of the Iron Gate Hatchery Discharge for the Year of 2008.

2008	Proposed SSO for DO Downstream of Iron Gate Dam (mg/L)	Klamath River Upstream of Iron Gate Hatchery (mg/L)	Klamath River Downstream of Iron Gate Hatchery (mg/L)
January	10.8	9.2	9.5
February	9.9	11.4	10.8
March	8.8	12.8	13.0
April	7.8	13.2	15.3
May	7.1	10.55	8.72
June	6.5	10.96	11.14
July	6.5	9.47	9.44
August	6.5	7.36	6.65
September	7.1	7.6	6.34
October	8.1	6.15	6.3
November	9.7	6.0	6.11
December	10.9	6.01	6.23

Light grey shaded cells indicate upstream ambient waters that do not meet proposed SSOs for DO. Dark grey shaded cells indicate downstream ambient waters that do not meet proposed SSOs for DO.

Staff has evaluated the monitoring data of only one year (e.g., 2008). Renewal of the NPDES permit will require a thorough analysis of the monitoring data from additional years. From this one dataset, however, it appears that some additional treatment may be necessary to achieve compliance during the month of September. It also appears that an evaluation of the role of Iron Gate Dam on the ambient DO conditions downstream during the months of October through January is warranted, including consideration of the effects of water withdrawals by the Hatchery from the nutrient-rich waters of the reservoir's hypolimnion.

As described in Chapter 10 of the Klamath TMDL Staff Report, the California Department of Fish and Game and PacifiCorps will have to conduct an engineering study to determine what additional treatment will be necessary to meet new permit limits designed to attain TMDL allocations and recalculated SSOs for DO. Until that time, any estimate of the cost of compliance would be unreasonably speculative. PacifiCorps, however, has signed an agreement by which it will provide funding to the Hatchery, perhaps including some portion of the cost of treatment upgrade.

8.1.4.2 <u>Nonpoint Source Discharges</u>

The nonpoint source discharges of concern to the Klamath TMDLs and proposed SSOs for DO include:

- Modifications to water quality resulting from the Klamath Hydroelectric Project
- Road construction and maintenance activities
- Grazing
- Irrigated agriculture
- Timber harvest activities

The economic analysis (Chapter 10 of the Klamath TMDL staff repot) considers the costs associated with each of these activities. It also considers the costs associated with the proposed prohibition against discharge in the vicinity of thermal refugia. Finally, it highlights several public funding sources, as well as funding associated with other similar programs such as the Recovery Strategy for Coho Salmon. Staff believes Chapter 10 of the Klamath TMDL Staff Report presents information sufficient to satisfy the requirements of Section 13421 of the Porter Cologne Act.

8.1.5 Housing

Section 13421 of the Porter Cologne Act requires when developing water quality objectives that the need for developing housing within the region be considered. The population in the Klamath River basin was estimated in the 2000 US Census to be about 114,000 (United States Census Bureau [USCB] 2000). The largest population concentrations lie in the upper Klamath agricultural area, the Shasta River Valley, and Scott Valley. The largest population center is Klamath Falls in Oregon (19,462 people in 2000) followed by Yreka, California (7,290 people). The Klamath River basin can generally be characterized as a rural watershed with limited population-related water quality issues.

More than two thirds of the Klamath River watershed is in federal ownership. The largest blocks of private ownership are agricultural areas in the upper Klamath watershed and agricultural and timber properties in the Shasta and Scott Valleys and adjacent areas of the mainstem. Also, much of the Klamath River Valley near the mouth of the river is privately owned.

The Hoopa Valley Tribe owns land, 12 miles by 12 miles, primarily in the Trinity River watershed but intersecting the Klamath River at Saints Rest Bar upstream of the confluence with the Trinity. The Yurok Reservation's lands extend from 1 mile on each side from the mouth of the Klamath River and upriver for a distance of 44 miles. The Karuk Tribe owns 800 acres of tribal trust land along the Klamath River between Orleans and Happy Camp, and in Yreka, California. The Quartz Valley Indian Reservation is located near Fort Jones and encompasses 174 acres along the Scott River. The Resighini Rancheria spans 228 acres along the south shore of the mouth of the Klamath River. The Klamath River basin is primarily a rural river basin.

Population growth and the need for housing are of limited concern in the Klamath River basin. As described in Chapter 9 of the Klamath TMDL Staff Report (CEQA Analysis) none of the actions required by the adoption of the Klamath TMDL or the recalculated SSOs for DO on the mainstem Klamath River will result in displacement of existing housing or the need for additional development.

In any event, the recalculation of the SSOs for DO in the mainstem Klamath does not impact the ability of entities to develop land in the basin for housing, if necessary. With the existing prohibition against the discharge of waste in the Klamath River, any discharge of organic or nutrient waste, such as point source domestic wastewater, must be discharged to land. Staff believes it has thoroughly considered the issue of housing in the development of the recalculated SSOs for DO in the mainstem Klamath River.

8.1.6 Recycled water

Section 13421 of the Porter Cologne Act requires when developing water quality objectives consideration of the need to develop and use recycled water. The existing prohibition against the discharge of waste to the Klamath River ensures as the baseline that any development be predicated on the development first of recycled water as a means of reducing the amount of land necessary for the treatment of discharged waste. With respect to the recalculation of the SSOs for DO specifically, one of the primary producers of organic and nutrient rich discharge to the Klamath River comes from agricultural activities. Chapters 6 and 9 of the Klamath TMDL Staff Report (Implementation Plan and CEQA Analysis, respectively) describe the required and likely actions necessary for the agricultural community to comply with the TMDL and recalculated SSOs for DO. These actions include development and use of recycled water, particularly the reuse of irrigation return flows to reduce water quality impacts.

Staff believes it has thoroughly considered the issue of recycled water in the development of the recalculated SSOs for DO in the mainstem Klamath River.

8.2 State and Federal Antidegradation Requirements

There are two applicable antidegradation policies pertinent to water quality in the North Coast Region – a state policy and a federal policy. The state antidegradation policy is titled the *Statement of Policy with Respect to Maintaining High Quality Waters in California* and is commonly known as "Resolution 68-16." The federal antidegradation policy is found at 40 CFR section 131.12. Both policies are incorporated in the Basin Plan for the North Coast Region.

8.2.1 State Antidegradation Resolution 68-16

While requiring the continued maintenance of existing high quality waters, Resolution 68-16 provides conditions under which a change in water quality is allowable. A change must:

- Be consistent with maximum benefit to the people of the state;
- Not unreasonably affect present and anticipated beneficial uses of water; and
- Not result in water quality less than that prescribed in water quality control plans or policies.

Table 7.6 provides a comparison of the daytime values associated with the three alternatives evaluated in the recalculation of the SSOs for DO. Alternative 1 is to leave the existing SSOs for DO as they are, including a footnote indicating their applicability during the daytime, only. Alternative 3—the proposed alternative—is to calculate natural DO concentrations based on given percent DO saturation criteria and estimates of natural temperature. In the comparison of criteria, one sees that the existing SSOs for DO provide a more protective DO concentration value during the summer months. But, for many of these months, the given concentration is unattainable simply due to conditions of barometric pressure, temperature and salinity and are therefore inappropriate. During the fall, winter, and spring, however, Alternative 3 provides significantly greater protection and this during the spawning and incubation period of the basin's most sensitive beneficial use. It is on this basis that Alternative 3 is proposed.

Staff argues the proposed recalculation of the SSOs for DO in the mainstem Klamath River provide greater protection to the beneficial uses than the existing SSOs for DO. Because of the ambiguous nature of the analysis during the summer months, however, staff believes it important to consider the three issues presented by Resolution 68-16 with respect to any change in water quality.

1). Staff believes that protecting the rare and threatened salmonids of the Klamath River is of maximum benefit to the people of the state. This is because of the inherent value of protection species from extinction. It is also because of the value of restoring a fishery which once supported an important cultural and commercial fishing use. As one of the State's largest salmon fisheries, impacts to the Klamath fisheries have State wide impacts.

2) Staff believes this action does not unreasonably affect the present and anticipated beneficial uses of water; in fact, it serves to better protect the beneficial uses of water.

3) Staff believes the water quality resulting from this action is greater than that prescribed in the existing water quality control plan, particularly in the fall, winter and spring when the most sensitive beneficial use requires greater DO conditions.

8.2.2 Federal Antidegradation Policy

The federal antidegradation policy is found at 40 CFR Section 131.12. The federal policy must be addressed whenever it is proposed to relax a standard (beneficial use or water quality objective) for surface water. As described above, staff believes that the recalculation of the existing SSOs for DO does not result in a relaxed standard but, in fact, results in an improved standard providing greater protection of beneficial uses, particularly the spawning and incubation of salmonids—the most sensitive beneficial use. During the summer months when the existing SSOs for DO are represented as higher than those associated with the proposed recalculated SSOs, many of these values are unattainable due simply to conditions of barometric pressure, natural temperature, and salinity. As such, they are inappropriate for use during that period. The proposed SSOs for DO, on the other hand, represent conditions that are achievable year round under natural conditions and represent the highest DO conditions physically possible for the mainstem.

8.3 Hoopa Valley Tribe's Water Quality Objectives for DO

The Hoopa Valley Tribe has a water quality control plan, approved by USEPA and implemented by the Tribe. With respect to DO, the <u>Water Quality Control Plan for the Hoopa Valley Indian Reservation</u> (Hoopa 2008) requires the following in the mainstem Klamath:

> *Water Column Dissolved Oxygen* –Klamath River D.O. criteria based on the designated use COLD (year-round), the 7-day moving average of the daily minimum D.O. in the water column shall not drop below **8.0 mg/L**, whereas SPWN (whenever spawning occurs, has occurred in the past or has potential to occur), the 7-day moving average of daily minimum D.O. in the water column shall not drop below **11.0 mg/L**. If dissolved oxygen standards are not achievable due to natural conditions, then the COLD and SPAWN standard shall instead be dissolved oxygen concentrations equivalent to 90% saturation under natural receiving water temperatures.

If water quality monitoring indicates that dissolved oxygen levels are below the criteria listed, then an investigation of impact will be conducted.

Inter-gravel Dissolved Oxygen-- Klamath River D.O. criteria that are based on the designated use SPWN (whenever spawning occurs, has occurred in the past or has potential to occur), where the 7- day moving average of the daily minimum D.O. in the inter□gravel water shall not drop below **8.0 mg/L**. If dissolved oxygen standards are not achievable due to natural conditions, then the COLD and SPAWN standard shall instead be dissolved oxygen concentrations equivalent to 90% saturation under natural receiving water temperatures.

USEPA approved Hoopa (2008) with one exception; it did not approve the use of the 90% saturation criteria until the Hoopa Valley Tribe could develop a method for determining if natural conditions prevent the attainment of the approved concentration based criteria. For the purposes of this report, staff compares the proposed recalculation of the SSOs for DO in the California portion of the Klamath mainstem to both the concentration limits and the percent DO saturation limits. This is because, while the concentration limits are the approved limits associated with the Hoopa (2008), Regional Water Board staff have participated in the development of the *Klamath TMDL models,* a tool with which to assess DO under natural conditions.

Based on conversations with representatives of the Hoopa Valley Tribe (and others), staff directed Tetra Tech to rerun the *Klamath TMDL model* for that portion of the river from Iron Gate Dam to Turwar to improve the way in which barometric pressure was represented. This was undertaken to improve the DO model output in the reach just above and including the Hoopa Valley Tribe Reservation and thereby improve the potential for the Hoopa Valley Tribe to adopt the *Klamath TMDL model* as it's own tool for establishing natural conditions. Further, it allowed staff to propose a SSO for DO in the reach up to the California-Hoopa boundary which is consistent with the Hoopa objective.

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8.3.1 Life cycle-based DO objectives

Figure 8-1: T1BSR modeled daily DO concentrations at Hoopa-California boundary

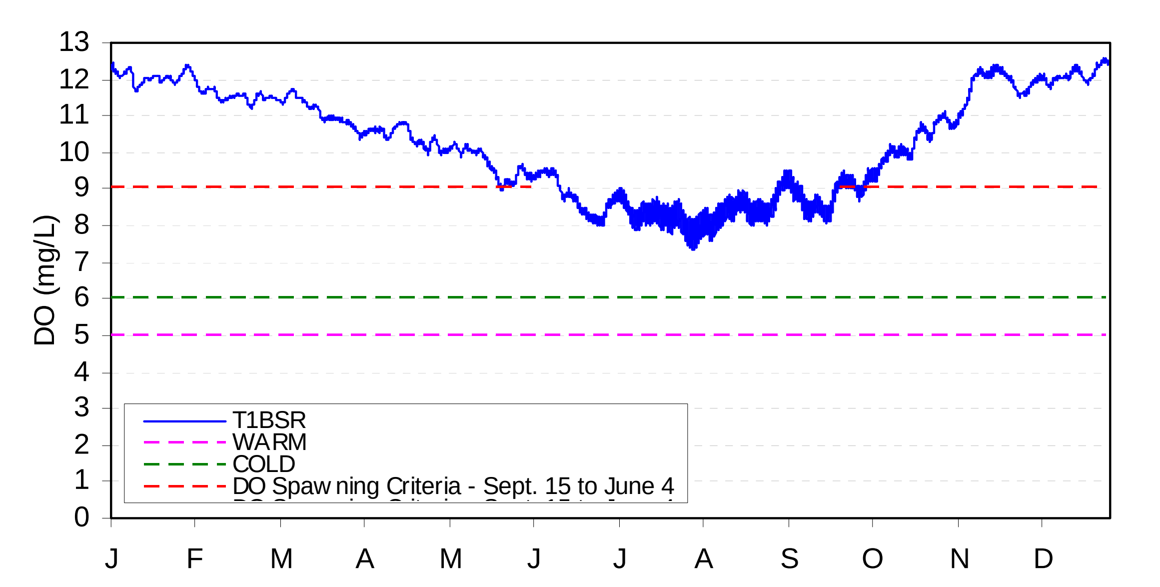

Figure 8-1 depicts simulated daily minimum DO concentrations at the Hoopa-California border. A line drawn at the 8.0 mg/L mark indicates that except from about July through mid-August, the daily minima are otherwise above 8.0 mg/L under natural conditions. As such a moving 7-day average of the daily minima is also above 8.0 mg/L. During the period from July through mid-August, the daily minima drop to a low of about 7.3 mg/L in late July making it possible that under natural conditions a 7-day moving average of the daily minima from late July through mid-August may not meet an 8.0 mg/L objective.

With respect to spawning and incubation requirements, a line drawn at 11.0 mg/L on Figure 8-1 indicates that from early November through mid-March, the daily minima under natural conditions are greater than 11.0 mg/L ensuring that the 7-day average of the daily minima is also above 11.0 mg/L. Under natural conditions from mid-March to June, however, the daily minima drop steadily from 11.0 mg/L to about 9.0 mg/L ensuring that the moving 7-day average of the daily minima fall short of 11.0 mg/L for at least some portion of this period. Similarly, under natural conditions from mid-September through October, the daily minima rise steadily from 9.0 mg/L to 11.0 mg/L ensuring that the moving 7-day average of the daily minima fall short of 11.0 mg/L for some portion of this period, as well.

Hoopa (2008) requires the application of objectives designed to protect SPWN during the period and in those locations in which spawning actually occurs, has occurred in the past, or has the potential to occur. Though not specifically mentioned in the definition of beneficial uses, SPWN is intended to apply not only to spawning but incubation, as well. The period of SPWN, as estimated in the Trinity River is from September 15 through June 4. The T1BSR (natural conditions) run of the *Klamath TMDL model* indicates that

DO conditions favor spawning and incubation [as based on Regional Water Board staff's reading of USEPA (1986)] from about October through April. In either case, ambient water quality under natural conditions does not achieve the life cycle objectives for SPWN for several weeks to months of the year.

This analysis demonstrates that ambient water quality conditions are unable to achieve the SPWN objectives as contained in Hoopa (2008) within the California-Hoopa boundary.

8.3.2 Percent saturation

The *Klamath TMDL model* provides an excellent, validated, calibrated, and peer-reviewed tool with which to demonstrate that under natural conditions DO life cycle objectives as defined by Hoopa (2008) are unachievable. It was the lack of such a tool in 2007 that prevented USEPA from approving the 90% saturation element of Hoopa (2008). With the current availability of the *Klamath TMDL model* the Hoopa Valley Tribe can consider applying the 90% DO saturation criteria (under natural receiving water temperatures) as is contained in its water quality control plan.

- For the reach of the Klamath from the Scott River to the California-Hoopa boundary, the recalculated SSOs for DO call for a 90% DO saturation criteria (based on natural temperatures) year round. This is supported by the T1BSR run of the *Klamath TMDL model* and is identical to the percent saturation criteria contained in the Hoopa Basin Plan. At a monitoring location on Hoopa land, the T1BSR (natural conditions) run of the *Klamath TMDL model* indicates a minimum percent DO saturation for every month of the year as listed below. In only two months does the minimum percent DO saturation fall below 90% under natural conditions; and then achieves a minimum 89% DO saturation. The rate of violation of the 90% DO saturation objective is 2% during the month of July (based on 14 one-hour excursions during the month) and 6% during the month of August (based on 44 one-hour excursions during the month).
    - January 96%
    - February 97%
    - March 96%
    - April 96%
    - May 95%
    - June 92%
    - July 89%
    - August 89%
    - September 91%
    - October 93%
    - November 95%
    - December 96%

Regional Water Board staff concludes that the proposed SSOs for DO in the reach from the Scott River to the Hoopa boundary are consistent with the Hoopa percent DO saturation objective. Staff also conclude that the *Klamath TMDL model,* as improved by consultation with representatives of the Hoopa Valley Tribe (and others), provides a reasonable tool by which to establish natural conditions in that portion of the Klamath River on the Hoopa Valley Tribe Reservation. When applying the *Klamath TMDL model* as the tool by which to establish natural DO conditions, the State's proposed 90% DO saturation objective (based on natural receiving water temperatures) for that reach from the Scott River to the Hoopa-California boundary achieves the Hoopa's 90% DO saturation objective and is consistent with these downstream requirements.

8.4 Application of Recalculated SSOs for DO in Impounded Reaches

The mainstem Klamath River is impounded behind dams in several places above the Shasta River confluence. Behind the dams, the biochemical interactions associated with nutrient and organic loading differ from those in the free-flowing portions of the river. The proposed recalculated SSOs for DO do not speak to these differences because the Klamath TMDL addresses the issue by requiring that the DO objectives be applied across a depth and width of the reservoirs that is equivalent to the depth and width of the river as it would exist without the impoundments. Further, the DO objective is to be applied in a zone that overlaps with a zone in which the temperature objectives apply, ensuring that a lens of water of sufficient quality to support beneficial uses exists within the reservoirs.

8.5 Summary

Staff conclude that the proposed Site Specific Dissolved Oxygen Objectives for the Klamath River in California meet all the regulatory requirements associated with the adoption of a basin plan amendment, including Section 13241 of Porter Cologne Water Quality Act, federal and state antidegradation requirements, and the downstream water quality requirements of the Hoopa Valley Tribe.

CHAPTER 9.
PUBLIC PARTICIPATION

Chapter 1 describes the history of the effort to revise Dissolved Oxygen objectives in the existing Basin Plan. In the fall of 2008, staff released a CEQA scoping document for public review and presented the concept for DO objective revision at two scoping meetings: one in the southern part of the Region (Santa Rosa) and the other in the northern portion (Weaverville). A peer review draft was produced and submitted for formal peer review in the spring of 2009. The project was modified to focus only on the mainstem Klamath River and a public review draft was released as an appendix to the Klamath TMDL Staff Report in June 2008. This Staff Report (Appendix 1 of the Klamath TMDL Staff Report,) was presented for public review beginning on December 23, 2009. Public comments were received by February 9, 2010 and are incorporated into this March 2010 draft, as appropriate. This March 2010 draft also reflects consultation with representatives of the Hoopa Valley Tribe (and others) regarding the means by which barometric pressure was represented in the *Klamath TMDL model* for that portion of the river from Iron Gate Dam to Turwar. The *Klamath TMDL model* was updated for this portion and rerun on February 2, 2010, the resulting revised DO data incorporated into this Staff Report. A proposed Basin Plan Amendment, based on the findings of this Staff Report, will go before the Regional Water Board in March 2010 in a public hearing regarding its adoption.

Chapter 11 of the Klamath TMDL Staff Report describes in detail the public participation process with respect to the Klamath TMDL. During 2009, public meetings addressing the Klamath TMDL have also addressed the development of the SSOs for DO.

CHAPTER 10.
IMPLEMENTATION PLAN

Chapter 6 of the Klamath TMDL Staff Report includes implementation measures necessary to achieve the proposed recalculated SSOs for DO in the mainstem Klamath River. Chapter 6 of the Klamath TMDL Staff Report is incorporated into this Staff Report by reference.

CHAPTER 11.
ECONOMICS

Chapter 10 of the Klamath TMDL Staff Report assesses the economics associated with implementation of the Klamath TMDL and SSOs for DO. Chapter 10 of the Klamath TMDL Staff Report is incorporated into this staff report by reference.

CHAPTER 12.
CALIFORNIA ENVIRONMENTAL QUALITY ACT (CEQA)

Chapter 9 of the Klamath TMDL Staff Report assesses the environmental impacts associated with implementation of the Klamath TMDL and SSOs for DO as required under the California Environmental Quality Act (CEQA). Chapter 9 of the Klamath TMDL Staff Report is incorporated into this staff report by reference.

CHAPTER 13.
MONITORING

Chapter 7 of the Klamath TMDL Staff Report describes a monitoring plan for the assessment of ambient water quality conditions and compliance with the Klamath TMDL and SSOs for DO. Chapter 7 of the Klamath TMDL Staff Report is incorporated into this staff report by reference.

REFERENCES

Aalto, K.R., W.D. Sharp, and P.R. Renne. 1998. ^{40}Ar/^{39}Ar dating of detrital micas from Oligocene-Pleistocene sandstones of the Olympic Peninsula, Klamath Mountains, and northern California coast ranges: province and pelodrainage patterns. Can. J. earth Sci. 35:735-745.

Allan, David J. 1995. *Stream Ecology: Structure and function of running waters*. New York. Chapman & Hall.

Bartholow, J. 2005. Recent water temperature trends in the lower Klamath River, California. North American Journal of Fisheries Management. 25: 152-162.

Bartholomew, J., S.D. Atkinson, S.L. Hallett, C.M. Zielinski, and J.S. Foott. 2007. Distribution and abundance of the Salmonid parasite *Parvicapsula minibicornis* (Myxozoa) in the Klamath River basin (Oregon-California, USA). Diseases of Aquatic Organisms. 78:137-146.

Bartholomew, J. and S.J. Bjork. 2007. Establishing baseline information for assessment of flow management alternatives for mitigating effects of myxozoan pathogens in the Klamath River. California Energy Commission, PIER Energy Related Environmental Research. CEC-500-2007-089. Commission Contract No. 500-01-044. Corvallis, OR.

California Department of Fish and Game (CDFG). 2004. *September 2002 Klamath River Fish-Kill: Final Analysis of Contributing Factors and Impacts*. Northern California-North Coast Region. 173pp.

California Department of Water Resources (CDWR). 1986. *Shasta/Klamath Rivers Water Quality Study*. 26 pp. Accessed August 25, 2006. Available at: http://www.krisweb.com/biblio/klamath_cadwr_clawsonetal_1986.pdf#search=%22%20%22shasta%2Fklamath%20rivers%20water%20quality%22%22.

Campbell, J.G. and L.R. Goodman. 2004. Acute sensitivity of juvenile shortnose sturgeon to low dissolved oxygen concentrations. Transactions of the American Fisheries Society. 133:772-776.

Carter, Katharine. 2005. *The effects of dissolved oxygen on steelhead trout, coho salmon, and Chinook salmon biology and function by life stage*. Prepared as staff to the California Regional Water Quality Control Board, North Coast Region. Santa Rosa, CA.

Carter, K. and S. Kirk. 2008. *Fish and fishery resources of the Klamath River basin*. Prepared as staff to the California Regional Water Quality Control Board, North Coast Region and the Oregon Department of Environmental Quality, respectively. In: Staff report for the Klamath river total maximum daily loads (TMDLs) addressing temperature, dissolved oxygen, nutrient, and microcystin impairments in California, the proposed site-specific dissolved oxygen objectives for the Klamath River in California and the Klamath River and Lost River implementation plans – Appendix 5. December 2009.

Causal Analytic/Diagnostic Decision Information System (CADDIS). 2007. Conceptual Model Library: Dissolved Oxygen. Accessed March 2, 2009. Available at: <http://cfpub.epa.gov/caddis/detailedCM.cfm?modelId=21&section=181&step=0&parent_section=29>.

Central Coast Region Water Quality Control Board. 1994. *Central Coast Region Water Quality Control Plan (Region 3)*. San Luis Obispo, CA. Available at: http://www.waterboards.ca.gov/centralcoast/publications_forms/publications/basin_plan/index.shtml.

Central Valley Region Water Quality Control Board. 2007. *Central Valley Region Water Quality Control Plan (Region 5)*. Sacramento, CA. Available at: http://www.waterboards.ca.gov/centralvalley/water_issues/basin_plans/index.shtml.

Cole, T.M. and S.A. Wells. 2003. CE-QUAL-W2: A two-dimensional, laterally averaged, Hydrodynamic and Water Quality Model. Version 3.1. Instruction Report EL-03-1. US Army Engineering and Research Development Center. Vicksburg, MS.

Cooperman, M. and D.F. Markle. 2004. Abundance, size, and feeding success of larval shortnose and Lost River suckers from different habitats of the littoral zone of Upper Klamath Lake. Environmental Biology of Fishes 71:365-377.

Crandell, D.R. 1989. Gigantic debris avalanche of Pleistocene age from ancestral Mount Shasta volcano, California, and debris-avalanche hazard zonation. United States Geological Survey Bulletin 1861. 32 pp.

Davies, Tudor. 1997. “Establishing Site Specific Aquatic Life Criteria Equal to Natural Background.” A memorandum from the USEPA Director of the Office of Science and Technology dated November 5, 1997. Washington D.C

Deas, M. L. and G. T. Orlob. 1999. *Klamath River Modeling Project. Project #96-HP-01. Assessment of alternatives for flow and water quality control in the Klamath River below Iron Gate Dam.* University of California Davis Center for Environmental and Water Resources Engineering. Report No. 99-04. 379 pp. Available at: <http://www.krisweb.com/biblio/biblio_klamath.htm>.

Elmore, Wayne and Robert L. Beschta. 1987. Riparian Areas: Perceptions in Management. *Rangelands.* Vol. 9, No. 6. pp. 260-265.

Fadness, Rich. 2008. Personal communication between Rich Fadness and Alydda Mangelsdorf of the North Coast Regional Water Quality Control Board on June 2, 2008.

Fadness, Rich. 2009. Personal communication between Rich Fadness and Alydda Mangelsdorf of the North Coast Regional Water Quality Control Board on January 28, 2009.

Gale, D.B., T.R. Hayden, L.S. Harris, and H.N. Voight. 1998. *Assessment of anadromous fish stocks in Blue Creek, lower Klamath River, California, 1994-1996.* Yurok Tribal Fisheries Program, Habitat Assessment and Biological Monitoring Division Technical Report No. 4, Klamath, California.

Goodman, Damon. Personal communication via telephone between Damon Goodman of the US Fish and Wildlife Service in Arcata, CA and Alydda Mangelsdorf of the North Coast Regional Water Quality Control Board on November 13, 2008.

HACH Environmental. 2008a. Products, Water Quality Sensors: Dissolved Oxygen. Accessed May 20, 2008. Available at: <http://www.hydrolab.com/beta/products/d_oxygen.asp>.

HACH Environmental. 2008b. Products, Water Quality Sensors: LDO. Accessed May 21, 2008. Available at: <http://www.hydrolab.com/products/ldo_sensor.asp>.

Hamilton, John. B., Gary L. Curtis, Scott M. Snedaker, and David K. White. 2005. Distribution of anadromous fishes in the upper Klamath River watershed prior to hydropower dams- a synthesis of the historical evidence. American Fisheries Society, vol. 30 no. 4. 20p. Available at: http://www.klamathriver.org/Documents/Distribution-of-Anadromous-Fishes.pdf

Harris, J. E., D. C. Parkyn, and D.J. Murie. 2005. Distribution of Gulf of Mexico sturgeon in relation to benthic invertebrate prey resources and environmental parameters in the Suwannee River Estuary, Florida. Transactions of the American Fisheries Society 134:975-990.

Hauer, F.R. and W.R. Hill. 1996. Temperature, Light, and Oxygen. *IN:* F.R. Hauer and G.A. Lamberti eds. *Methods in Stream Ecology*. Academic Press. San Diego, CA. p. 103-117.

Hoopa Valley Tribe (Hoopa). 2008. *Water Quality Control Plan Hoopa Valley Indian Reservation (as amended February 14, 2008).* Hoopa, CA. 100p. Available at: http://www.hoopa-nsn.gov/documents/WQCP.pdf

Kamer, Krista and Eric Stein. 2003. Dissolved Oxygen Concentration as a Potential Indicator of Water Quality in Newport Bay: A Review of Scientific Research, Historical Data, and Criteria Development. Technical Report 411 of the Southern California Coastal Water Research Project (SCCWRP) prepared for the Santa Ana Regional Water Quality Control Board.

Kann, J. and W. Walker. 1999. *Nutrient and hydrological loading to Upper Klamath Lake, Oregon, 1991–1998*. Prepared for the Klamath Tribes Natural Resources Department and the Bureau of Reclamation. Klamath Falls, Oregon. 48 p. plus appendices.

Klamath River Basin Fisheries Task Force (KRBFTF). 1991. *Long Range Plan for the Klamath River Basin Conservation Area Fishery Restoration Program*. Assistance from William M. Kier Associates. 403pp.

Moyle, Peter. 2002. *Inland Fishes of California*. Berkeley. University of California Press.

Moyle, Peter. 2008. Personal communication from Dr. Peter Moyle of UC Davis via email to Alydda Mangelsdorf of the North Coast Regional Water Control Board on 2008.

National Marine Fisheries Service (NMFS). 2002. *Biological Opinion: Klamath Project Operations.* Available at: http://swr.nmfs.noaa.gov/psd/klamath/KpopBO2002finalMay31.PDF

National Marine Fisheries Service (NFMS). 2009. *NOAA Office of Protected Resources: Green Sturgeon (Acipenser medirostris)*. Accessed January 26, 2009. Available at <http://www.nmfs.noaa.gov/pr/species/fish/greensturgeon.htm>.

National Research Council (NRC). 2004. *Endangered and Threatened Fishes in the Klamath River Basin: Causes of Decline and Strategies for Recovery*. National Academies Press. Washington, D.C. pp. 397.

National Rivers Authority. 1994. *Water Quality Objectives: Procedures Used by the National Rivers Authority for the Purpose of the Surface Waters (River Ecosystem) (Classification) Regulations 1994*. Water Quality Planning Department. Bristol, England.

Natural Resources Conservation Service (NRCS). 2004. *Work Plan for Adaptive Management: Klamath River Basin*, Oregon & California. 16pp.

Nielsen, J.L. 1992a. Microhabitat specific foraging behavior, diet, and growth of juvenile coho salmon. Trans. Am. Fish. Soc. 121:617-634.

Nielsen, J.L. 1992b. The role of cold-pool refuge in the freshwater fish assemblage in northern California rivers. Pages 79-88 in H.M. Kerner, ed. Proceedings of the symposium on biodiversity of northwestern California. Davis: Univ. Califor. Wildland Resources Center Rpt. 29.

North Coast Regional Water Quality Control Board. 2006. *Staff Report for the Action Plan for the Shasta River Watershed Temperature and Dissolved Oxygen Total Maximum Daily Loads*. Santa Rosa, CA.

Oakshott, G.B. 1978. New York, NY. McGraw Hill, Inc.

Oregon Department of Environmental Quality (ODEQ). 1995. *Dissolved Oxygen: 1992-1994 Water quality standards review. Final Issue Paper.* 166pp. Available online at: http://www.fishlib.org/Bibliographic/waterquality.html. Website accessed on August 20, 2004.

PacifiCorp. 2005. *Klamath River Water Quality Model Implementation, Calibration, and Validation*. Klamath Hydroelectric Project (FERC Project No. 2082). Response to November 10, 2005 FERC AIR GN-2. December.

Pientka, B. and D.L. Parrish. 2002. Habitat selection of predator and prey: Atlantic salmon and rainbow smelt overlap, based on temperature and dissolved oxygen. Transactions of the American Fisheries Society 131:1180-1193.

Quinones, KRFH Conference. 2007. Notes from the Klamath River Fish Health Conference, Jan. 31 - Feb. 1, 2007: Trends and Abundance of Salmon Populations.

Rykbost, K.A. and B.A. Charlton. (2001). *Nutrient loading of surface waters in the Upper Klamath Basin: Agricultural and natural sources*. Corvallis, Oregon. Agricultural Experiment Station, Oregon State University. Accessed May 21, 2007. Available at: <http://klamathwaterlib.oit.edu/u?/kwl,391>.

San Francisco Bay Regional Water Quality Control Board. 2007. *San Francisco Bay Basin (Region 2) Water Quality Control Plan (Basin Plan)*. Oakland, CA. Available at: http://www.waterboards.ca.gov/sanfranciscobay/basin_planning.shtml.

Santa Ana River Regional Water Quality Control Board. 2008. *Santa Ana River Region Water Quality Control Plan (Region 8)*. Riverside, CA. Available at: http://www.waterboards.ca.gov/santaana/water_issues/programs/basin_plan/index.shtml.

Schruben, P.G., R.E., Arndt, and W.J. Bawiec. 1997. Geology of the conterminous United States at 1:2,500,000 scale – a digital representation of the 1974 P.B. King and H.M. Beikman map. United States Geological Survey Digital Data Series 11, Release 2. Accessed January 11, 2007. Available at: http://pubs.usgs.gov/dds/dds11/

Scoppettone, G.G. and G.L. Vinyard. 1991. Life history and management of four endangered lacustrine suckers. Pp. 359-377 in Battle Against Extinction: Native Fish

Management in the American West, W.L. Minckley and J.E. Deason, eds. Tucson, AZ: University of Arizona Press.

Shaw, T.A., C. Jackson, D. Nehler, and M. Marshall. 1997. *Klamath River (Iron Gate Dam to Seiad Creek) life stage periodicities for Chinook, coho, and steelhead*. Prepared as staff to the Department of the Interior, US Fish and Wildlife Service, Coastal California Fish and Wildlife Office, Arcata, Ca.

Snyder D. T. and J. L Morace. 1997. *Nitrogen and phosphorus loading from drained wetlands adjacent to Upper Klamath Lake and Agency Lakes, Oregon*. U.S. Geologic Survey. Water-Resources Investigations Report. 97-4059. 69 pp.

Sommarstrom, S., K. Kellogg, and J. Kellogg. 1990. Scott River Watershed Granitic Sediment Study. Prepared for the Siskiyou Resource Conservation District with funding under Cooperative Agreement 14-160-001-89506 from the U.S. Fish and Wildlife Service.

Stene, Eric A. 1994. *The Klamath Project (seventh draft)*. Bureau of Reclamation History Program. Denver, CO. Available at: http://www.usbr.gov/dataweb/html/klamathh.html

Sulak, K.J. and J.P. Clugston. 1998. Early life history stages of gulf sturgeon in the Suwannee River, Florida. Transactions of the American Fisheries Society 127: 758-771.

Summers, J.K. and V.D. Engle. 1993. Evaluation of sampling strategies to characterize dissolved oxygen conditions in northern Gulf of Mexico estuaries. Environmental Monitoring and Assessment. 24:219-229.

Tetra Tech, Inc. 2009. *Klamath River Model for TMDL Development (Fourth Revision).* Prepared for USEPA Region 9, USEPA Region 10, North Coast Regional Water Quality Control Board, and Oregon Department of Environmental Quality. Fairfax, VA. 57p. Available at: http://www.waterboards.ca.gov/northcoast/water_issues/programs/tmdls/klamath_river/091223/Appendix/Appendix%206_KlamathRiver_ModelingReport.pdf

US Bureau of Reclamation (USBR). 1953. *Reclamation Accomplishments 1905-1953: Klamath Project, Oregon-California*. Division of Operation and Maintenance, Repayment Branch.

US Bureau of Reclamation (USBR). 2005. *Natural Flow of the Upper Klamath River - Phase 1, Natural Inflow to, Natural Losses from, and Natural Outfall of Upper Klamath Lake to the Link River and the Klamath River at Keno*. 115 pp. Available at: http://www.usbr.gov/mp/kbao/docs/undepleted_klam_fnl_rpt.pdf.

United States Census Bureau (USCB). 2000. Your Gateway to Census 2000. American Fact Finder and State and County Quick Facts. Accessed January 5, 2007. Available at: http://www.census.gov/main/www/cen2000.html.

US Department of Agriculture (USDA). Undated. Processed Annual Precipitation. Vector dataset provides derived average annual precipitation according to a model using point precipitation and elevation data for the 30-year period of 1961-1990. USDA, National Cartography & Geospatial Center.

US Environmental Protection Agency (USEPA). 1986. *Ambient Water Quality Criteria for Dissolved Oxygen*. Office of Research and Development, Environmental Research Laboratories, Duluth, MN.and Narragansett, RI.EPA 440/5-86-003.

US Fish and Wildlife Service (USFWS). 2003. *Klamath River Fish Die-off, September 2002, Causative Factors of Mortality*. Arcata Fish and Wildlife office. Arcata, CA. Report Number AFWO-F-02-03. 115pp.

US Fish and Wildlife Service (USFWS). 2007a. *Pacific Lamprey Conservation Initiative*. Accessed January 29, 2009. Available at http://www.fws.gov/pacific/fisheries/sp_habcon/lamprey/index.html.

US Fish and Wildlife Service (USFWS). 2007b. *Lost River Sucker (Deltistes luxatus) 5-Year Review: Summary and Evaluation*. Klamath Falls Fish and Wildlife Office. Klamath Falls, OR.

US Fish and Wildlife Service (USFWS). 2007c. *Shortnose Sucker (Chasmistes brevirostris) 5-Year Review: Summary and Evaluation*. Klamath Falls Fish and Wildlife Office. Klamath Falls, OR.

US Forest Service (USFS). 1996. *Clear Creek Watershed Analysis*. Happy Camp Ranger District. Klamath National Forest.

US Forest Service (USFS). 2000. *Lower Scott Ecosystem Analysis. Klamath National Forest*. Scott River Ranger District. United States Department of Agriculture, Pacific Southwest Region.

US Geological Survey (USGS). 2006. USGS Surface-Water Data for California. Accessed August 1, 2006. Available at: <http://waterdata.usgs.gov/ca/nwis/sw>.

Voight. H.N. and D.B. Gale. 1998. *Distribution of fish species in tributaries of the lower Klamath River: An interim report, FY 1996*. Yurok Tribal Fisheries Program, Habitat Assessment and Biological Monitoring Division, Technical Report No. 3.

Walker, W.W. 2001. *Development of a phosphorus TMDL for Upper Klamath Lake, Oregon.* Oregon Department of Environmental Quality. March 7, 2001.

Washington State Department of Ecology (WDOE). 2002. *Evaluating criteria for the protection of freshwater aquatic life in Washington's surface water quality standards: Dissolved oxygen. Draft discussion paper and literature summary*. Publication Number 00-10-071. 90pp.

Woodhouse, C., W. Hobson, C. Wilder. 2004. *California Regional Water Quality Control Board, North Coast Region, Upper Lost River and Clear Lake Reservoir Watershed, Total Maximum Daily Load Analysis, Water Temperature and Nutrients*. North Coast Regional Water Quality Control Board. Santa Rosa, CA.

Zabinsky, Ben and Rick Azevedo. 2005 *Preliminary draft staff report for the consideration of an amendment to water quality control plan for the North Coast Region revising the existing instream water quality objectives for water temperature and dissolved oxygen concentrations*. North Coast Regional Water Quality Control Board. Santa Rosa, CA. 101p.

Appendix 2

Nutrient Numeric Endpoint Analysis for the Klamath River, CA

Prepared for:

U.S. EPA Region IX

and

North Coast Regional Water Quality Control Board

Prepared by:

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November 18, 2008

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1 Introduction: The California NNE Approach

The Klamath River in California is listed as impaired for temperature, nutrients, and low DO/organic enrichment. The North Coast Regional Board is developing TMDLs in collaboration with Oregon and USEPA to address these impairments. For TMDL development, Tetra Tech is applying a set of linked simulation models consisting of CE-QUAL-W2 (for reservoirs) and RMA (for free-flowing reaches). The TMDL runs have primarily addressed numeric criteria for DO and temperature.

Tetra Tech, under contract to EPA Region IX and the California State Water Resources Control Board also developed an approach for calculating nutrient numeric endpoints (NNE) for use in California Water Quality Programs (Tetra Tech, 2006). The "Technical Approach to Develop Nutrient Numeric Endpoints for California," referred to as the California NNE approach, is a risk-based approach in which targets are developed for response variables (or secondary indicators) such as algal density. These response targets can then be converted to site-specific nutrient targets through use of modeling tools.

The California NNE approach recognizes that there is no clear scientific consensus on precise levels of nutrient concentrations or response variables that result in impairment of a designated use. To address this problem, waterbodies are classified in three categories, termed Beneficial Use Risk Categories (BURCs). BURC I waterbodies are not expected to exhibit impairment due to nutrients, while BURC III waterbodies have a high probability of impairment due to nutrients. BURC II waterbodies are in an intermediate range, where additional information and analysis may be needed to determine if a use is supported, threatened, or impaired. Tetra Tech (2006) lists consensus targets for response indicators defining the boundaries between BURC I/II and BURC II/III.

Tetra Tech (2006) also documents a set of relatively simple but effective spreadsheet tools for application in lake/reservoir or riverine systems to assist in evaluating the translation between response indicators and nutrient concentrations or loads.

One important use of the NNE is for setting initial nutrient endpoints for waterbodies requiring nutrient TMDLs. Tetra Tech (2007), under contract with USEPA, conducted a case study of potential NNE endpoints on the Klamath River. That study, "Nutrient Numeric Endpoints for TMDL Development: Klamath River Case Study", addressed only periphyton in the riverine portion of the watershed and used water quality data for 2000-2003, coupled with periphyton observations from 2004. Since that time, significantly more data have become available, and corrections have been made to earlier data. At the request of the North Coast Regional Water Quality Control Board, USEPA has funded this follow-on study. The two major purposes are (1) to extend the NNE analysis to the two reservoirs (Iron Gate and Copco) on the California portion of the Klamath system, and (2) to update the stream periphyton analysis to reflect more recent and corrected data.

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2 Iron Gate and Copco Reservoirs

2.1 Uses and Impairments

Beneficial uses of Copco and Iron Gate reservoirs are defined in the Water Quality Control Plan (NCRWQCB, 2007) and are summarized in Table 1. Both existing and potential uses are protected. Uses related to the protection of endangered salmonid fish species (COLD, RARE, MIGR, SPWN) are of particular interest to many stakeholders in the Klamath River system.

Table 1. Beneficial Uses of Copco and Iron Gate Reservoirs

Code	Use	Copco	Iron Gate
MUN	Municipal and Domestic Supply	E	P
AGR	Agricultural Supply	E	P
IND	Industrial Service Supply	E	P
PRO	Industrial Process Supply	P	P
FRSH	Freshwater Replenishment	E	E
NAV	Navigation	E	E
POW	Hydropower Generation	E	E
REC1	Water Contact Recreation	E	E
REC2	Non-Contact Water Recreation	E	E
COMM	Commercial and Sport Fishing	E	E
WARM	Warm Freshwater Habitat	E	E
COLD	Cold Freshwater Habitat	E	E
WILD	Wildlife Habitat	E	E
RARE	Rare, Threatened, or Endangered Species	E	E
MIGR	Migration of Aquatic Organisms	E	E
SPWN	Spawning, Reproduction, and/or Early Development	E	E
SHELL	Shellfish Harvesting	NA	E
AQUA	Aquaculture	E	E

Notes: E – Existing Use; P – Potential Use; NA – Use not applicable.

California's 2006 Section 303(d) list identified the Klamath River hydrologic unit from the Oregon border to Iron Gate (including both Iron Gate and Copco reservoirs) as impaired due to nutrients, organic enrichment/low dissolved oxygen, and temperature.

By letter of 13 March 2008, Alexis Strauss, Director, Water Division, USEPA Region IX determined that, in addition to this listing, "one Klamath River segment is impaired due to the presence of elevated concentrations of microcystin toxins, specifically the Oregon to Iron Gate segment which includes the Copco and Iron Gate reservoirs." EPA's decision came in response to a suit filed by the Klamath

Riverkeeper on 30 July 2007 (*Klamath Riverkeeper v. USEPA,* Docket No. C 07-3908 (SBA) (N.D. Cal.)). Microcystins are a class of toxic chemicals produced by some strains of the cyanobacteria *Microcystis aeruginosa* that are released into waters when cyanobacterial cells die or cell membranes degrade. These chemicals are a human health risk, capable of inducing skin rashes, sore throat, oral blistering, nausea, gastroenteritis, fever, and liver toxicity (USEPA Region IX, 2008). Microcystin toxins have also been shown to produce effects on animals including acute livestock poisoning and tumor production in fish guts and liver. Microcystin can thus potentially impair a number of beneficial uses of a waterbody. While California has not established numeric water quality objectives for microcystin toxins, EPA based its decision on observations that exceed the World Health Organization guidelines for moderate probability of adverse health effects of microcystin concentrations above 20 µg/L in recreational waters (WHO, 2003), resulting in impairment of the REC-1 beneficial use and the narrative toxicity objective for Iron Gate and Copco reservoirs.

2.2 POTENTIAL NNE TARGETS

Nutrient concentrations in Iron Gate and Copco reservoirs, along with associated physical conditions, are associated with the formation of summer algal blooms, including the formation of extensive blooms of the cyanobacteria *Microcystis aeruginosa*. Algal blooms in the Klamath reservoirs potentially impact designated beneficial uses in a number of ways, including the following linkages between algal growth and beneficial use impairment:

1. The presence of visible algal blooms can directly impact contact and non-contact recreational uses (REC1, REC2) by creating unaesthetic conditions and unpleasant conditions for contact recreation. This is foremost a function of the total algal biomass present during blooms, but a given biomass of cyanobacteria that form visible scums or mats may present a greater problem than a comparable biomass of planktonic algae.
2. Microcystin toxins, produced by blooms of *Microcystis aeruginosa*, have been determined by EPA to cause impairment in the reservoirs. The beneficial uses threatened by elevated microcystin levels include MUN, AGR, REC1, REC2, COMM, WARM, COLD, WILD, RARE, MIGR, SPWN, AQUA and SHELL.
3. Excess algal growth disrupts the dissolved oxygen (DO) balance, leading to super-saturation during daylight periods of high productivity, and depletion of DO during nighttime respiration and as a result of the decay of dead biomass in the water column. Excess productivity typically results in an increase in organic matter loading to the bottom (hypolimnetic) waters of a reservoir, resulting in rapid DO depletion during stratified conditions. In addition, there can be a self-reinforcing feedback loop, as oxygen depletion at the sediment-water interface can promote the release of phosphorus and ammonium from the sediment, which in turn can support additional algal growth. High algal densities can also disrupt pH, as CO_2 is consumed during the day (at depths with sufficient light for photosynthesis) and released during nighttime respiration. Algal-induced changes to the DO balance can thus impair REC1, REC2, COMM, WARM, COLD, WILD, RARE, SPWN, and AQUA beneficial uses.
4. Excess algal growth results in an increase in the export of organic matter from the reservoirs, which in turn can exert an oxygen demand and potentially impair the DO balance and associated beneficial uses in the stretches of the Klamath River downstream from the reservoirs. On the other hand, algal uptake and settling may reduce the transport of inorganic nutrients downstream during the growing season, potentially mitigating impacts in the reaches below the reservoirs.
5. Conditions that lead to dominance by cyanobacteria in the plankton community can have adverse effects on the fishery (other than direct toxicity), as cyanobacteria generally support a much less rich population of planktonic invertebrates, which in turn support forage and juvenile game fish

populations. This potentially affects REC2, COMM, WARM, COLD, WILD, RARE, and SPWN uses.

Of these five impact linkages, the current TMDL effort, driven by the Consent Decree schedule, focuses on numbers 3 and 4, specifically addressing the need to meet DO (as well as temperature) numeric criteria. For these impacts, the target is already established in the numeric water quality criteria.

The required reductions in nutrient and organic matter loads to meet DO criteria will also reduce impacts associated with the other three impact linkages, but are not developed to specifically address these issues. These three risk hypotheses involve narrative, rather than numeric criteria. The Basin Plan contains the following statements of objectives relevant to nutrients in the Klamath:

> ***Biostimulatory Substances***
>
> *Waters shall not contain biostimulatory substances in concentrations that promote aquatic growths to the extent that such growths cause nuisance or adversely affect beneficial uses.*
>
> ***Toxicity***
>
> *All waters shall be maintained free of toxic substances in concentrations that are toxic to, or that produce detrimental physiological responses in human, plant, animal, or aquatic life. Compliance with this objective will be determined by use of indicator organisms, analyses of species diversity, population density, growth anomalies, bioassays of appropriate duration, or other appropriate methods as specified by the Regional Water Board.*

EPA, in establishing the 303(d) listing for microcystin toxins, cites WHO guidance on microcystin targets. However, the scientific understanding does not seem to be sufficiently advanced to translate microcystin levels into quantitative target levels of *Microcystis* biomass or biovolume. As stated in the 2008 EPA staff report

> "WHO used a number of studies to estimate an approximate microcystin concentration that would be expected from a given cell density of *Microcystis aeruginosa*. However, WHO acknowledges that the cyanobacterial cell density may not be a reliable proxy for microcystin toxin concentrations, because different cyanobacterial strains may be present and their genetic capacity may not produce toxins. In fact, some blooms of *Microcystis aeruginosa* may produce little to no microcystin toxins… For Section 303(d) purposes, EPA considered the cyanobacterial cell density results as part of our assessment but we did not rely on this ancillary information as definitive evidence of corresponding ambient concentrations of microcystin toxins."

Further, quantitative prediction of *Microcystis* cell density as a function of nutrient loading is exceedingly difficult, as it involves a combination of the total potential algal growth supported by nutrient loads, the factors that may promote cyanobacterial dominance within the planktonic algal community, and the factors that may enable *Microcystis* to out-compete other cyanobacteria. To achieve narrative standards and protect beneficial uses, linkage (1) requires an appropriate limit on total algal biomass, linkage (5) requires control of cyanobacterial dominance within blooms, and linkage (2) requires control of toxin-producing strains of *Microcystis* within cyanobacterial blooms. Notably, the risks associated with impact linkages (2) and (5) would also be controlled if the general risk of algal blooms was reduced.

Proposed nutrient numeric endpoints developed for the draft CA NNE framework are expressed as two numbers: the boundary between BURC I/II, indicating a concentration below which impacts are unlikely, and the boundary between BURC II/III, indicating a concentration above which impacts are likely. Table 3-2 in Tetra Tech (2006) recommended algal density targets for summer average chlorophyll *a*. These proposed targets were selected by Regional and State Board staff, based on input from Tetra Tech, at the State Water Board Nutrient Numeric Training Workshop held on May 18-19, 2005 in Sacramento, CA, as shown in Table 2.

Table 2. Proposed CA NNE Planktonic Algal Biomass Targets in Lakes and Reservoirs (as µg/L chlorophyll *a* expressed as a summer mean)

Risk Category Boundary	Beneficial Use				
	COLD	WARM	REC1	REC2	MUN
I/II	5	10	10	10	5
II/III	10	25	20	25	10

The most restrictive recommendations are for the COLD and MUN beneficial uses, both of which apply to Copco and Iron Gate reservoirs. Therefore, the BURC II/III boundary of 10 µg/L summer average chlorophyll *a* provides one potential target for managing these reservoirs. It should be noted, however, that the CA NNE targets are still in draft form, and have not been adopted by the State Board or incorporated into the North Coast Water Quality Control Plan at this time.

The CA NNE document (Tetra Tech, 2006) also considered cyanobacterial density as a potential target, but did not propose specific BURC boundary values. One potential target for cyanobacteria would be to reduce the frequency of cyanobacterial dominance. For example, British Columbia states that waters classified for primary recreation and aquatic life uses should have planktonic populations consisting of less than 50 percent of cyanobacterial cells by volume (MELP, 1992). Volumetric predictions are difficult with simple models, and Downing et al. (2001) instead recommend a target of less than 50 percent of total algal biomass for cyanobacteria. Their work demonstrated that there is typically a rapid phase change between low cyanobacteria densities (less than 20 percent of biomass) to cyanobacterial dominance (> 80 percent of biomass) as nutrient concentrations and total phytoplankton biomass increase. Cyanobacterial dominance is also conveniently expressed using the BG index (BGI), where BGI = ln(%BG/(100 - %BG)), in which %BG is the cyanobacterial biomass expressed as a percentage of the total algal biomass (Trimbee and Prepas, 1987). The 50 percent breakpoint is equivalent to BGI = 0, while values greater than zero indicate increasing cyanobacterial dominance. Downing et al. also found that the risk of greater than 50% cyanobacteria in individual lakes increased proportionately with the BGI.

Downing et al. also undertook regression analysis for prediction of BGI, using data from 99 lakes around the world. Contrary to expectation, they found that TN/TP ratio was not a good predictor of BGI (R^2=26%). The best predictors were phytoplankton biomass, total chlorophyll *a*, and total nitrogen, with R^2 value of 42-43 percent. Total phosphorus was also a better predictor of BGI than TN/TP (R^2 = 34%). The authors argue that "the most potentially useful of these relationships is that with total P, because total P predicts phytoplankton biomass…and discriminates incisively the lakes dominated by Cyanobacteria…," although the correlation coefficient is decreased by a few outliers and a nonlinear asymptote. The equations for predicting BGI from TN and TP are given as follows:

$$BGI = -10.0 + 3.03 \log_{10} TN$$

$$BGI = -4.16 + 1.88 \log_{10} TP$$

In sum, management of Iron Gate and Copco reservoirs to achieve designated beneficial uses appears to require some or all of the following: controls on total algal biomass, the percent of cyanobacteria within total algal biomass, and the dominance of *Microcystis* within the cyanobacterial population.

2.3 APPLICATION OF NNE SCOPING TOOLS

The NNE BATHTUB scoping tool was applied to Copco and Iron Gate reservoirs for the two years of 2002 and 2005, selected because these are the years for which extensive monitoring data are available.

After documenting a reasonable agreement with observations, the tool was then applied to the 2000 TMDL model year.

2.3.1 BATHTUB Tool

In support of the CA NNE approach, Tetra Tech developed a spreadsheet application of the U.S. Army Corps of Engineers BATHTUB model (Walker, 1996) to establish screening level nutrient loading targets for lakes and reservoirs by estimating algal response to nutrient loading. BATHTUB is a steady-state model that calculates nutrient concentrations, chlorophyll *a* concentrations (or algal densities), turbidity, and hypolimnetic oxygen depletion based on nutrient loadings, hydrology, lake morphometry, and internal nutrient cycling processes. It explicitly addresses conditions in run-of-river, and short residence time reservoirs. BATHTUB uses a steady-state mass balance model approach that estimates the distribution of external and internal nutrient loads between the water column, outflows, and sediments. External loads can be specified from various sources including stream inflows, nonpoint source runoff, atmospheric deposition, groundwater inflows, and point sources. Internal nutrient loads from cycling processes may include sediment release and macrophyte decomposition. Since BATHTUB is a steady-state model, it focuses on long-term average conditions rather than day-to-day or seasonal variations in water quality. Algal concentrations are predicted for the summer growing season when water quality problems are most severe. Annual differences in water quality, or differences resulting from different loading or hydrologic conditions (e.g., wet vs. dry years), can be evaluated by running the model separately for each scenario.

BATHTUB first calculates steady-state phosphorus and nitrogen balances based on nutrient loads, nutrient sedimentation, and transport processes (lake flushing, transport between segments). Several options are provided to allow first-order, second-order, and other loss rate formulations for nutrient sedimentation that have been proposed from various nutrient loading models in the literature. The resulting nutrient levels are then used in a series of empirical relationships to calculate chlorophyll *a*, oxygen depletion, and turbidity. Phytoplankton concentrations are estimated from mechanistically based steady-state relationships that include processes such as photosynthesis, settling, respiration, grazing mortality, and flushing. Both nitrogen and phosphorus can be considered as limiting nutrients, at the option of the user. Several options are also provided to account for variations in nutrient availability for phytoplankton growth based on the nutrient speciation in the inflows. The empirical relationships used in BATHTUB were derived from field data from many different lakes, including those in EPA's National Eutrophication Survey and lakes operated by the Army Corps of Engineers. Default values are provided for most of the model parameters based on extensive statistical analyses of these data.

It is important to emphasize that the model is a simple screening tool for prediction of average conditions, and that more informative results can be obtained from more detailed, calibrated models. However, BATHTUB's ease of use makes it ideal for rapid evaluation of potential nutrient-algal interactions.

2.3.2 Data Assembly

BATHTUB application to Copco and Iron Gate reservoirs addressed conditions observed near the dams, representing each reservoir as a single longitudinal segment with a stratified water column. Relatively intensive monitoring data for the two reservoirs exists for 2002 and 2005. These data, along with an analysis of mass balances, are presented in Kann and Asarian (2005), and Kann and Asarian (2007). Due to very short residence times in the winter high-flow season, summer algal concentrations in these reservoirs are most strongly affected by loading in and shortly prior to the growing season, consistent with the recommendations of Walker (1996). Flows and loads were therefore calculated for April to September in 2002 and May to September in 2005 (data are not available for April 2005), based on the results calculated by Kann and Asarian, as shown in Table 3.

Table 3. Flow and Nutrient Data for BATHTUB Application

	Copco		Iron Gate	
	2002 (Apr-Sep)	2005 (May-Sep)	2002 (Apr-Sep)	2005 (May-Sep)
Inflow (hm^3)	434	379	532	402
TP Load (kg)	119,380	59,000	122,300	53,700
TN Load (kg)	480,710	545,100	511,500	421,400
TIP Load (kg)	71,489	35,331	79,925	35,094
TIN Load (kg)	182,031	206,414	130,586	107,583
Summer TP (mg/L)	0.24	0.15	0.19	0.13
Summer TN (mg/L)	1.14	1.23	1.19	1.01
Summer Chlorophyll *a* (µg/L)	8.3	12.2	19.5	19.2

2.3.3 BATHTUB Application

Both Copco and Iron Gate reservoirs are known to have low net trap efficiency for nutrients, due to a combination of short residence times and apparent nutrient regeneration from the sediments under stratified conditions (Butcher, 2008). Kann and Asarian (2007) estimated that Copco Reservoir (for 2004-2005 conditions) retained about 9 percent of influent TN and TP, while Iron Gate retained about 3 percent of influent TP and 10 percent of influent TN. The TMDL model estimated (for 2000 conditions) that Copco retained about 1 percent of TP and 4 percent of TN, while Iron Gate retained about 6 percent of TP and 18 percent of TN. The low net retention rates suggest that net sedimentation rates should be lower than the defaults specified for the BATHTUB scoping tool. Accordingly, the TN and TP sedimentation calibration factors were set to 0.1.

With the revised sedimentation factors, the BATHTUB scoping tool provides a good representation of summer average TN and TP observed in the epilimnion near the dam in both reservoirs (Figure 1 and Figure 2). The model also captures the spatial gradient from Copco to Iron Gate and the relative temporal change between 2002 and 2005 conditions for TP.

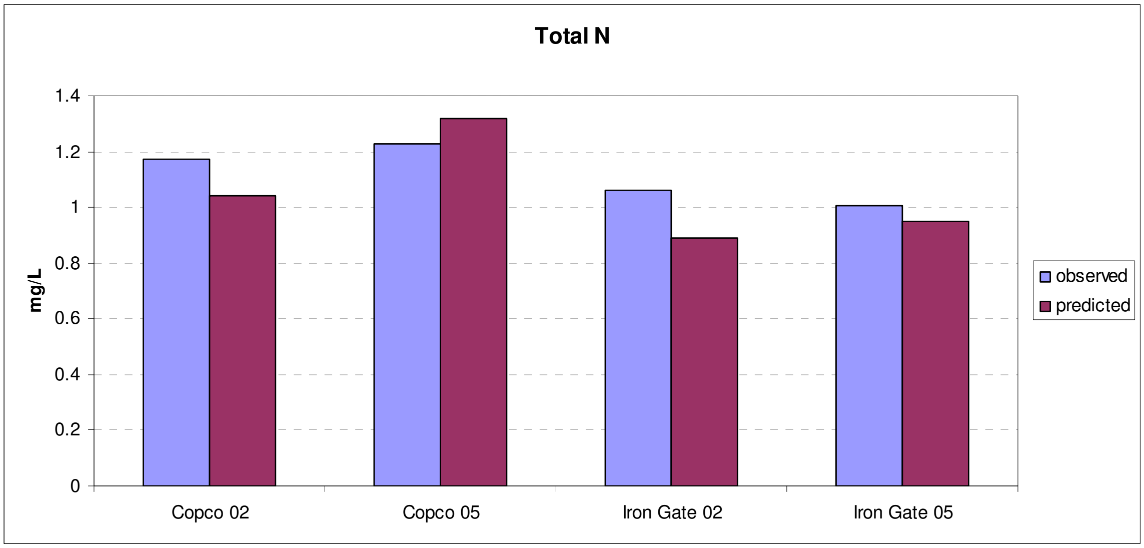


Figure 1. Observed and Predicted Total Nitrogen Concentrations in Copco and Iron Gate Reservoirs

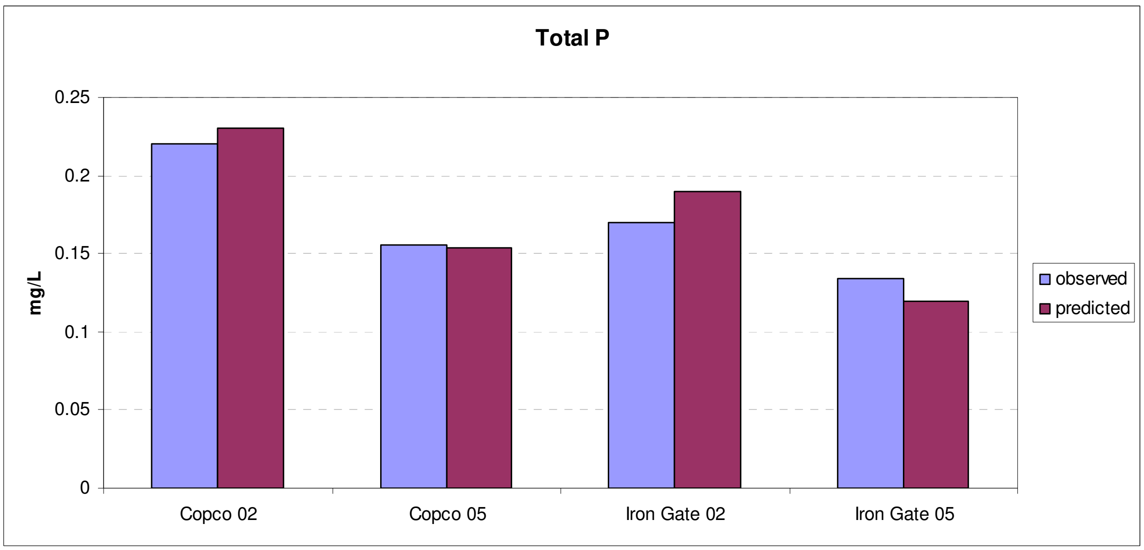


Figure 2. Observed and Predicted Total Phosphorus Concentrations in Copco and Iron Gate Reservoirs

Chlorophyll *a* results were generated without any changes to the default calibration factor of 1.0, and provide a reasonable match to observations (Figure 3). Given that chlorophyll *a* concentrations are highly variable in space and time, as well as the fact that chlorophyll *a* measurements may provide an imprecise measure of cyanobacterial density, these results are considered reasonable. In particular, small samples from right-skewed distributions, such as is typically observed for chlorophyll *a*, are prone to under-estimate the true mean concentration. Predictions for Copco could be brought closer in line with observations by decreasing the chlorophyll *a* calibration factor; however, the quantity and precision of available data do not appear to be sufficient to warrant such fine-scale adjustments.

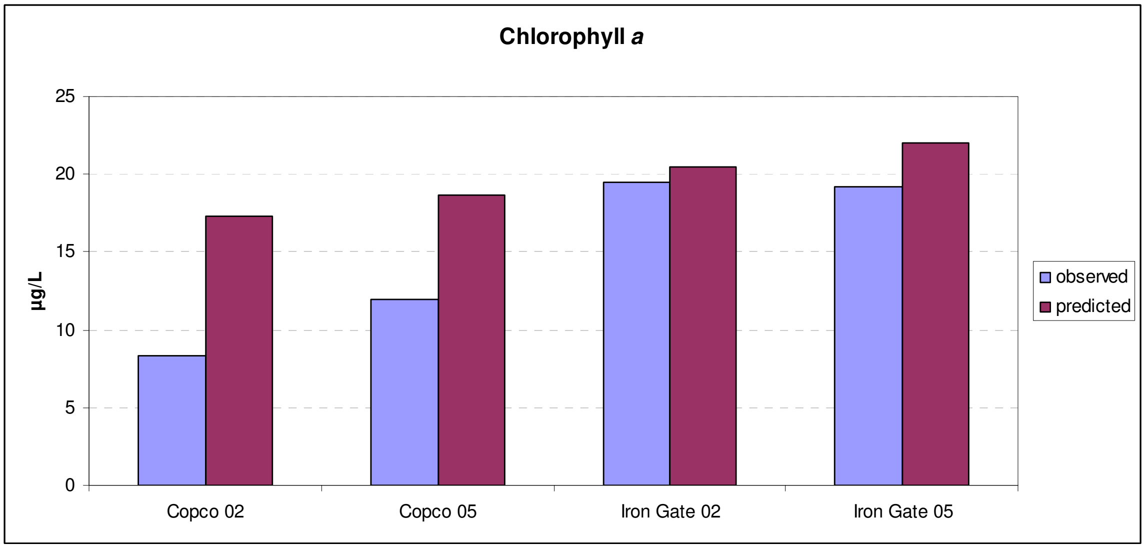


Figure 3. Observed and Predicted Chlorophyll *a* Concentrations in Copco and Iron Gate Reservoirs

The scoping model also predicts the exceedance probability for different concentration levels, based on the coefficient of variation (CV, standard deviation normalized to the mean) of concentrations. Results using the BATHTUB default CV (in natural log space) of 0.42 are shown in Figure 4, suggesting that occasional blooms in excess of 100 µg/L are consistent with the predicted summer average concentrations in Iron Gate, as well as in Copco Reservoir.

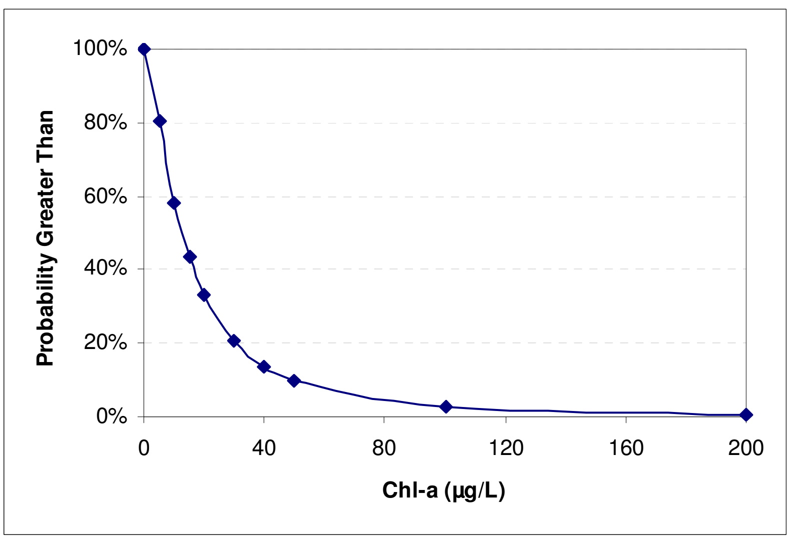


Figure 4. Predicted Distribution Curve for Chlorophyll *a* in Iron Gate Reservoir, 2005

Downing et al.'s (2001) regression equations for BGI as a function of TN and TP concentrations were applied to the predicted nutrient concentrations, and suggest that the algal community is likely to include a significant fraction of cyanobacteria on average (Table 4). The percentage of cyanobacteria predicted from TN concentrations is consistently lower than that predicted from TP concentrations, but both relationships indicate a potential for episodic cyanobacterial blooms, increasing the risk for microcystin toxin production.

Table 4. Cyanobacterial Dominance Predicted for Copco and Iron Gate Reservoirs

	Copco 2002	Copco 2005	Iron Gate 2002	Iron Gate 2005
BGI-P	0.27	-0.15	0.14	-0.27
Cyanobacteria % from BGI-P	56.7%	46.3%	53.5%	43.2%
BGI-N	-0.85	-0.54	-1.06	-0.98
Cyanobacteria % from BGI-N	29.8%	36.7%	25.7%	27.3%

Note: The "Blue Green Index" (BGI) is calculated using the regression relationships presented by Downing et al. (2001).

Application of the spreadsheet tool for year 2000 based on flows and nutrient loads predicted by the Klamath TMDL model yield similar results, with growing season average chlorophyll *a* estimated at 19.7 µg/L for Copco and 23.2 µg/L for Iron Gate. The cyanobacterial fractions of algal biomass are estimated at 64.0 and 59.9 percent using BGI-P, and 39.2 and 30.2 percent using BGI-N.

2.3.4 Potential Nutrient Numeric Endpoints

The BATHTUB scoping tool solves for combinations of TN and TP loading that are consistent with achieving a target growing season average concentration of chlorophyll *a*. Results consistent with achieving the CA NNE recommended BURC II/III boundary of 10 µg/L chlorophyll *a* as a growing season average concentration are shown in Figure 5 for the three years of model application.

The scoping tool predicts that the desired chlorophyll *a* target can be met by reducing phosphorus loading *or* nitrogen loading. The percentage reductions needed to achieve the 10 µg/L target are shown in Table 5. In terms of total algal biomass, it is not necessary to reduce loads of both nutrients to meet the target, as the growth will be controlled by the availability of the most limiting nutrient. These suggest that beneficial uses can be attained by reducing the TP load by approximately 90 percent or by reducing the TN load by approximately 65 percent. However, control by reducing only one nutrient would alter the N:P ratio, and changing the N:P ratio may well have other consequences for algal dynamics in the reservoir, as is discussed further in Section 2.4.

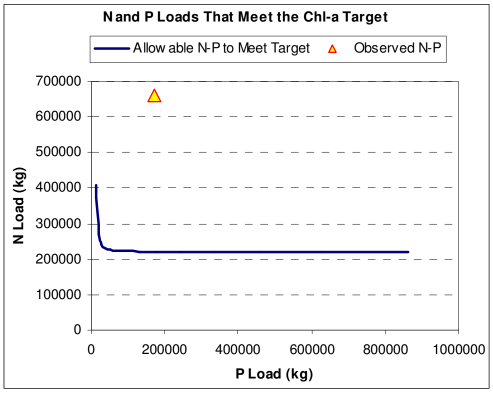
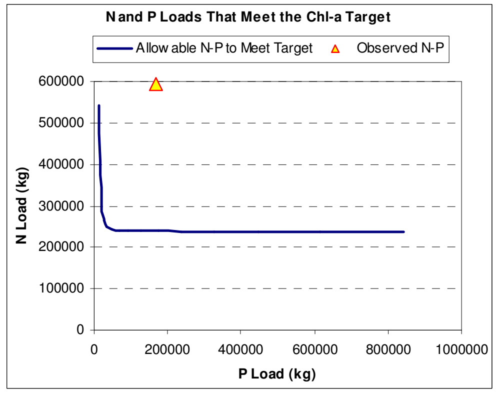
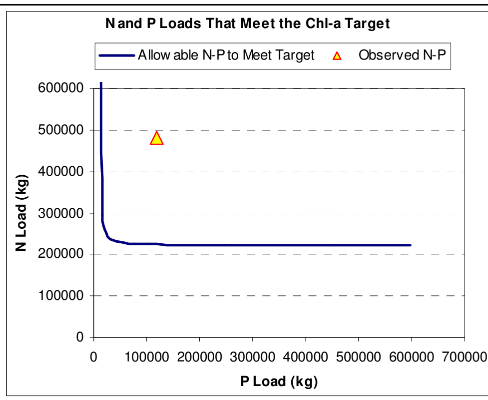
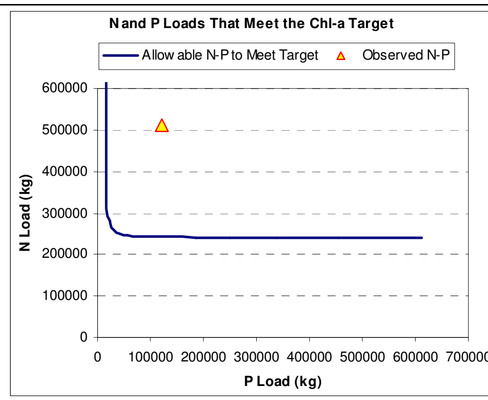
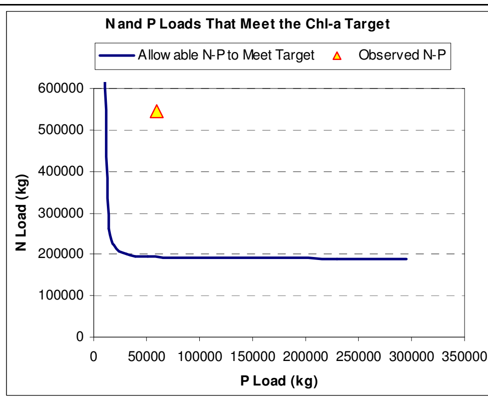
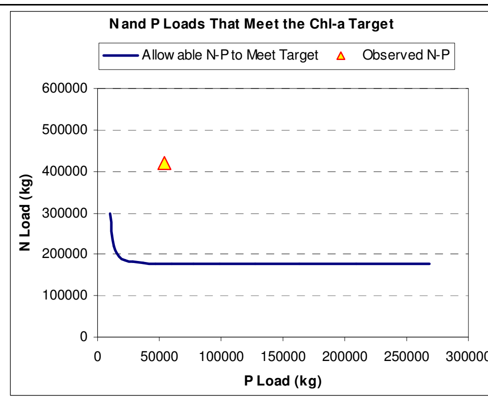
Year	Copco	Iron Gate
2000		
2002		
2005		

Figure 5. Allowable Load Curves to Achieve a 10 µg/L Summer Average Chlorophyll *a* Target

Table 5. Single Component Nutrient Reductions to Achieve a 10 µg/L Summer Average Chlorophyll *a* Target (April-September Loads)

Year	Total Phosphorus		Total Nitrogen	
	Copco	Iron Gate	Copco	Iron Gate
2000	89%	92%	67%	60%
2002	85%	89%	54%	53%
2005	81%	80%	65%	58%

The TMDL model is already calling for significant nutrient reductions to meet DO criteria. Under the dams-in water quality compliance scenario (T4BS1), the April-September 2000 phosphorus loads to Copco are reduced by 89 percent while the nitrogen loads are reduced 73 percent; the reductions in loads to Iron Gate are 88 percent and 74 percent, respectively. Notably, the proposed phosphorus reductions are very similar to those suggested in Table 5, while the proposed total nitrogen reductions in the compliance scenario are greater. Therefore, the T4BS1 scenario developed for dissolved oxygen management would also be expected to meet the algal density target, as developed in this document, to support the COLD and other beneficial uses in Iron Gate and Copco reservoirs.

In addition to reducing the total nitrogen and phosphorus loads, the T4BS1 scenario results in a change in the inorganic fraction of incoming nutrients, with a smaller inorganic fraction, which should also help damp algal response. Application of the BATHTUB tool for 2000 conditions with the T4BS1 nitrogen and phosphorus loads results in a predicted growing season average concentration of 6.6 µg/L in Copco and 4.1 µg/L in Iron Gate. Using Walker's default coefficient of variation for the natural log of chlorophyll *a* of 0.42 suggests that concentrations would be greater than 10 µg/L on 17.4 percent of growing season days in Copco and 2.8 percent of growing season days in Iron Gate.

The T4BS1 scenario also predicts reductions in cyanobacterial populations. With the reduced nutrient and algal settling rates used for BATHTUB application to existing conditions, calculations of the BGI from TN are low (10.8 and 7.2 percent of biomass as cyanobacteria in Copco and Iron Gate, respectively), while the BGI based on TP is reduced to near 25 percent (24.9 and 22.9 percent, respectively).

These results should be considered conservative (that is, including an implicit margin of safety) because the low net sedimentation rates of nutrients assumed for the application to existing conditions have not been altered. In fact, the T4BS1 scenario should result in greater dissolved oxygen concentrations at the sediment-water interface, resulting in lower rates of recycling of nutrients from the sediments, in turn causing higher net sedimentation rates for nutrients. If it is assumed that the effective net sedimentation rates increase to the default values given by Walker, the predicted summer average chlorophyll *a* concentrations in Copco and Iron Gate would decline to 5.0 and 3.0 µg/L, while the predicted cyanobacterial fractions of algal biomass would be 21 and 20 percent, respectively.

Predicted summer average nutrient concentrations in Iron Gate from the BATHTUB scoping tool – relevant to the analysis of downstream effects – are summarized in Table 6 for year 2000 conditions.

Table 6. Summer Average Nutrient Concentrations Predicted for Iron Gate Reservoir (Year 2000 Conditions)

	Existing Loads	T4BS1 Loads with Existing Sedimentation	T4BS1 Loads with Default Sedimentation	Change
TN (mg/L)	1.057	0.288	0.255	-76%
TP (mg/L)	0.267	0.037	0.030	-89%

These BATHTUB results are in good agreement with the CE-QUAL-W2 simulation of concentrations in Iron Gate outflow for the June-September 2000 period. The T4BS1 simulation (without benthic nutrient flux) shows a change relative to existing conditions of -73 percent for TN concentrations and -88.5 percent for TP concentrations.

2.4 MANAGEMENT TO REDUCE *MICROCYSTIS* BLOOMS IN RESERVOIRS

Conditions in Iron Gate and Copco reservoirs, including the risk of microcystin toxins, can clearly be mitigated by a general decrease in eutrophication potential, which would in turn reduce the frequency of cyanobacterial blooms, including *Microcystis* blooms. Other potential strategies to address microcystin levels include control of cyanobacterial dominance within blooms, and control of toxin-producing strains of *Microcystis* within cyanobacterial blooms. As demonstrated by Downing et al. (2001), the risk of cyanobacterial dominance increases with increasing levels of TN, TP, and algal biomass, and is also best addressed through a general reduction in eutrophication potential.

Many Cyanobacteria are able to control buoyancy, enabling them to alternate between light-rich (but nutrient poor) surface waters and nutrient rich (but light poor) waters lower in the water column, yielding a competitive advantage against passively floating algal species (Hyenstrand et al., 1998). Many bloom-forming Cyanobacteria are also able to tolerate higher temperatures than true algae. Lake management strategies that increase vertical mixing (counteracting the cyanobacterial buoyancy advantage) and decrease surface water temperatures may thus be useful pieces of an overall control strategy.

Earlier authors (e.g., Smith, 1983) had theorized that a key factor in promoting cyanobacterial dominance was a low N:P ratio, as many bloom-forming Cyanobacteria can fix atmospheric N_2 (although not *Microcystis aeruginosa*). Downing et al. demonstrate that this ratio is not a good predictor of cyanobacterial dominance.

While the N:P ratio is not a good predictor of general cyanobacterial dominance, it may play an important role in competition between different species of Cyanobacteria. Significantly, *Microcystis aeruginosa* does not fix atmospheric nitrogen, but the competing cyanobacterium *Aphanizomenon* does – suggesting that manipulation of nutrient ratios could cause a shift within cyanobacterial blooms from the toxin-producing *Microcystis* to non-toxin producing *Aphanizomenon*. Moisander et al. (2008) recently reported results of ongoing nitrogen and phosphorus fertilization experiments in Iron Gate and Copco using in-lake incubation chambers. Addition of inorganic nitrogen resulted in an increase in total phytoplankton biomass, *Microcystis* abundance, and microcystin concentrations under both high and low light conditions. Phosphorus additions increased *Microcystis* abundance only under low light conditions, whereas the addition of nitrogen or phosphorus decreased the relative abundance of *Aphanizomenon* by promoting growth of *Microcystis*. Based on this research, Moisander concluded that inputs of dissolved inorganic nitrogen to the reservoirs during the summer season are maintaining and increasing toxic blooms of *Microcystis*, and that reduction of nitrogen inputs to the reservoirs would reduce blooms of *Microcystis*. This suggests that management by reduction of nitrogen loads would yield dual benefits by both reducing the total algal biomass and shifting the cyanobacterial population away from *Microcystis* toward *Aphanizomenon*. The work is ongoing, and may yield valuable insights into optimal management of the reservoirs.

In sum, the proposed nutrient reductions appear to have good potential to address all five of the linkages between algal growth and beneficial use impairment discussed in Section 2.2.

1. Frequency of visible algal blooms will be reduced as average algal biomass decreases.
2. Production of microcystin toxins should decline as total algal biomass decreases and cyanobacterial dominance within the algal population is reduced.
3. Algal effects on the DO balance will be mitigated, as demonstrated in the existing TMDL model.

4. Export of organic matter downstream will be reduced as algal growth is reduced.
5. Reduction in cyanobacterial dominance will potentially result in a healthier aquatic ecosystem that supports an improved fishery.

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3 Klamath River below Iron Gate

The Klamath River watershed encompasses 15,722 square miles in the states of Oregon and California, flowing from the Cascades in Oregon westerly and southerly to the Pacific Ocean in Del Norte Co., CA (see Figure 6). The analysis in this section addresses the major part of the flowing, freshwater portions of the mainstem Klamath River in California, running from the outlet of Iron Gate Reservoir near the Oregon border in Siskiyou County, CA to the confluence with the Trinity River in Humboldt County, CA and represents a major update to the analysis presented in Tetra Tech (2007).

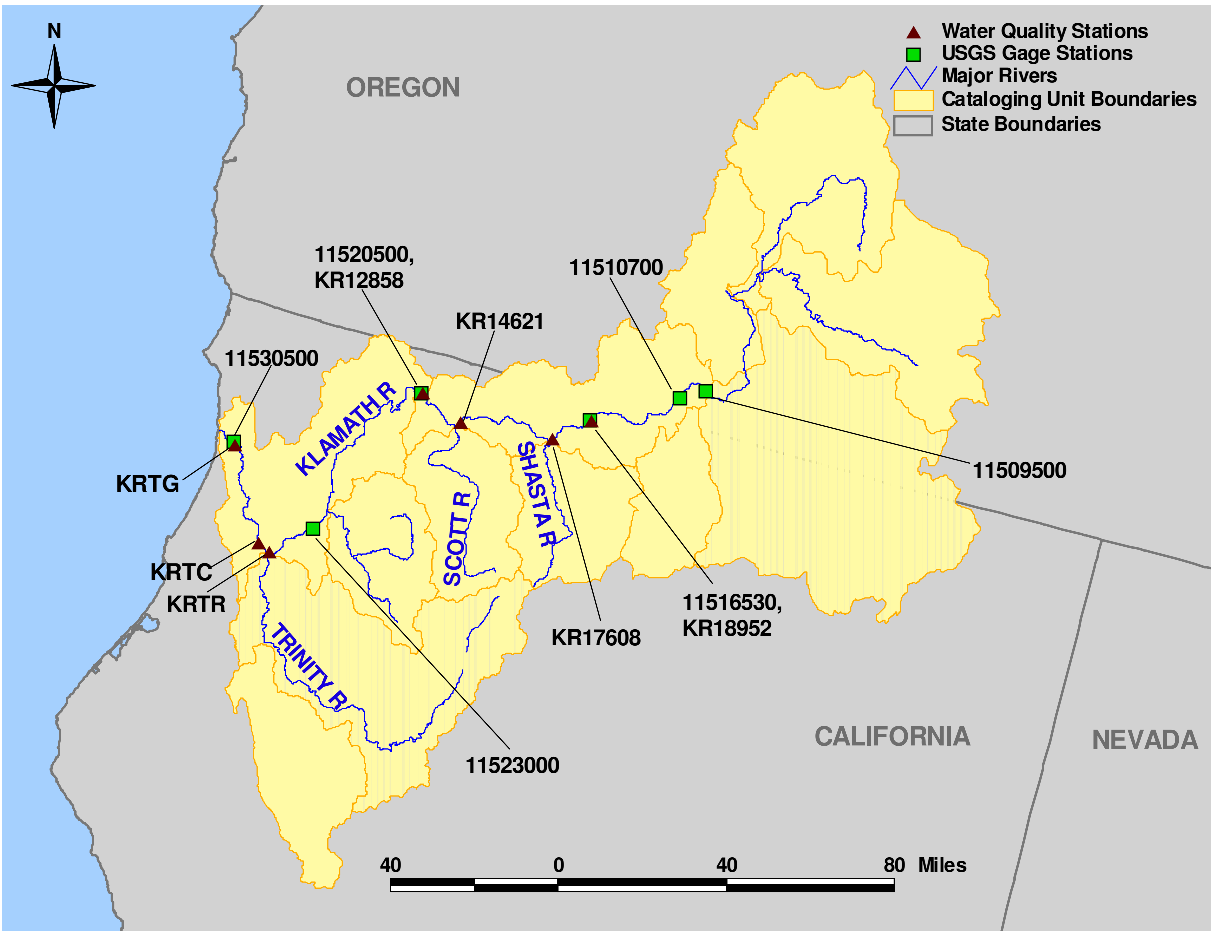

Figure 6. The Klamath River, Showing Selected Water Quality Sampling Stations and Flow Gages on the Lower Klamath River

3.1 Uses and Impairments

The Water Quality Control Plan (NCRWQCB, 2007) establishes multiple beneficial uses for the Klamath River below Iron Gate Reservoir (Table 7). A small portion of the river just upstream of the confluence with Trinity River is under the jurisdiction of the Hoopa Valley Tribe, while much of the Klamath River downstream of the Trinity River is under jurisdiction of the Yurok Tribe.

Table 7. Beneficial Uses of Klamath River below Iron Gate Reservoir

Code	Use	Status
MUN	Municipal and Domestic Supply	E
AGR	Agricultural Supply	E
IND	Industrial Service Supply	E
PRO	Industrial Process Supply	E
FRSH	Freshwater Replenishment	E
NAV	Navigation	E
POW	Hydropower Generation	E
REC1	Water Contact Recreation	E
REC2	Non-Contact Water Recreation	E
COMM	Commercial and Sport Fishing	E
WARM	Warm Freshwater Habitat	E
COLD	Cold Freshwater Habitat	E
WILD	Wildlife Habitat	E
RARE	Rare, Threatened, or Endangered Species	E
MIGR	Migration of Aquatic Organisms	E
SPWN	Spawning, Reproduction, and/or Early Development	E
AQUA	Aquaculture	P
CUL	Native American Culture	E

Notes: E – Existing Use; P – Potential Use; NA – Use not applicable.

California's North Coast Regional Water Quality Control Board has included the free-flowing portion of Klamath River down to the Trinity River on its Clean Water Act Section 303(d) list of impaired waters. Identified impairments include excursions of criteria for nutrients, temperature, and organic enrichment/low DO for segments of the river in California, which are classified for COLD and SPWN beneficial uses.

3.2 POTENTIAL NNE TARGETS

Nutrient loading in the Klamath River produces high levels of periphytic algae. The Hoopa Valley Tribal Environmental Protection Agency has adopted periphyton criteria for the reach of the Klamath River within the Hoopa Valley Indian Reservation. To date, the North Coast Regional Board has not established targets for this endpoint.

While periphyton is included in the Klamath River TMDL models, limited periphyton data were available for model calibration during the years of interest. Calibration focused largely on DO concentrations and diurnal variability in DO, which implicitly include the effects of periphyton and other aquatic vegetation, rather than calibrating directly to periphyton density.

It is important to evaluate periphyton as a response endpoint for several reasons. First, periphyton affects the balance of DO and pH in the river. Second, excess periphyton growth can directly impair COLD, SPWN, and REC designated uses. Finally, in the Klamath River excess periphyton growth (particularly development of *Cladophora* beds) may present an additional important source of risk for maintenance of a healthy salmonid population. This risk hypothesis is summarized in Kier Associates (2005) as follows:

> …*Ceratomyxa shasta* is a myxozoan parasite that causes major problems for the health of juvenile salmonids in the Klamath River. Infection rates are extremely high and in many years results in the death of significant portion of the juvenile salmonids in the Klamath River. Nichols and Foott (2005) estimated that in 2004, 45% of juvenile fall-run Chinook salmon were infected with *C. Shasta* and that the majority of those fish would not survive, and that impact of a loss of that many fish could rival the 2002 adult fish-kill where over 33,000 adult salmon died.
>
> High nutrient levels may be stimulating luxuriant growth of *Cladophora*, a filamentous green algal species. *Cladophora* beds are a favored habitat for polychaete worms that are a host for *C. Shasta* (Stocking and Bartholomew, 2004). The high incidence of *C. Shasta* in the Klamath River may be due to an increase in polychaete populations caused by an increase in polychaete habitat (Stocking and Bartholomew, 2004)… To reduce the incidence of *C. Shasta* infection in the Klamath River, it may be insufficient to improve pH and D.O. alone to reduce fish stress. It also may require reduction in parasite loads by reducing nutrients to reduce the prevalence of *Cladophora* and hence *C. Shasta*'s polychaete host.

Water quality objectives for DO and pH are defined in basin plans, and the relationship between these endpoints, planktonic algal growth, and nutrients is well addressed in the existing calibrated TMDL model. Where a site-specific calibrated nutrient response model exists, this provides the best means of developing appropriate site-specific nutrient numeric endpoints. The North Coast Regional Water Quality Control Board, however, has not yet proposed criteria for periphyton in this river (although the Hoopa have), and this aspect of nutrient response was not the primary focus of the existing TMDL modeling effort.

The Hoopa Valley Tribal Environmental Protection Agency (Kier Associates, 2005; Hoopa Valley TEPA, 2008) recently adopted periphyton standards for the short section of the lower Klamath River on the Hoopa Valley Reservation at Saints Bar just upstream of Trinity River. In addition to DO and pH, they selected periphyton density as an endpoint for criteria development, and initially recommended a maximum annual periphyton biomass of 100 mg/m^2 of periphyton chlorophyll *a*. The criterion was subsequently revised to read as follows (Hoopa Valley TEPA, 2008):

> *Periphyton -For the Klamath River only (Trinity River standards yet to be developed), the maximum annual periphyton biomass shall not exceed 150 mg chlorophyll a/m^2 of streambed area.*

The California NNE Approach (Tetra Tech, 2006) recommends setting response targets for benthic algal biomass in streams based on maximum density as mg/m^2 chlorophyll *a*. For the COLD and SPWN beneficial uses, the recommended BURC I/II boundary is 100 mg/m^2, while the BURC II/III boundary is 150 mg/m^2. Existing conditions in the Klamath are clearly often above the BURC II/III boundary, indicating impairment of these uses.

Of particular interest for the Klamath, the risk of *Cladophora* (a filamentous green algae) prevalence (and corresponding large polychaete populations) increases with increasing maximum benthic chlorophyll *a*. Welch et al. (1988) found that 20 percent or more cover by filamentous green algae was correlated with maximum benthic chlorophyll *a* greater than 100 mg/m^2, while Horner et al. (1983) concluded that biomass levels greater than 150 mg/m^2 often occurred with enrichment and when filamentous forms were more prevalent. These findings support the use of the BURC boundaries in establishing targets for the Klamath River. The Klamath River was historically mesotrophic (Kier Associates, 2005), and water quality conditions in the lower river are exacerbated by large blooms of nitrogen-fixing cyanobacteria (blue-green algae) in Upper Klamath Lake and in the Klamath reservoirs. This suggests that the BURC II/III boundary of 150 mg/m^2 maximum benthic chlorophyll *a* may be most appropriate for the Klamath. The CA NNE approach, however, also recognizes that nutrients occur naturally, and vary in relationship to soils, geology, and land cover, in some cases potentially resulting in benthic chlorophyll *a* concentrations in excess of 150 mg/m^2 under natural conditions. Where this is the case, the natural condition would supersede the proposed target.

3.3 Application of NNE Scoping Tools

The CA NNE approach proposes a numeric target for benthic chlorophyll *a*, which is a secondary or response indicator relative to nutrients. To achieve the target, an analysis is required to link nutrient concentrations or load to benthic algal response. Under a previous Work Assignment, Tetra Tech (2007) developed an analysis of potential nutrient numeric endpoints for the lower Klamath downstream of Iron Gate. That analysis relied on a compilation of nutrient monitoring data through 2004. Since that time, data have become available for 2005-2007, and a detailed review of the monitoring data has resulted in modifications of the data through 2004. The sections that follow thus represent an update, revision, and extension of the previous analysis for the free-flowing reaches of the Klamath River below Iron Gate Dam.

3.3.1 Benthic Biomass Tool

The CA NNE *Technical Approach to Develop Nutrient Numeric Endpoints for California* (Tetra Tech, 2006) includes (Appendix 3) the development of a simplified scoping tool of maximum periphyton density in streams. This NNE Benthic Biomass spreadsheet tool is distributed as an Excel spreadsheet. The tool calculates both algal density under average conditions and benthic chlorophyll *a*. Both are estimated using a variety of methods:

- Dodds (1997) method (both mean and maximum)
- Dodds (2002) method (both mean and maximum, using corrected parameters from 2006 erratum[1])
- Standard QUAL2K Model method (maximum)
- Revised QUAL2K Model method (maximum)
- Revised QUAL2K, with adjustment for days of biomass accrual (maximum)

The maximum algal contribution to dissolved oxygen deficit is also calculated, using the Revised QUAL2K Model method. Lastly, the tool allows the user to supply a target (either algal density or benthic chlorophyll *a*), select a calculation method, and the tool will display a graph of allowable TN and TP to meet the target.

The QUAL2K approach is based on the steady-state limit approximation of the benthic algae simulation contained in version 1 of the QUAL2K model (Chapra and Pelletier, 2003). This simulates benthic algal response to nutrient concentrations and light availability. An estimate of the maximum (spatially averaged) response to a given set of forcing functions is obtained as the steady-state asymptote of the model. Because detailed validation data were not available for California, parameters of the model were

[1] The original equations appeared in Dodds, W.K., V.H. Smith, and K. Lohman, 2002, Nitrogen and phosphorus relationships to benthic algal biomass in temperate streams (*Can. J. Fish. Aquat. Sci.*, 59:865-874). The equations were corrected in a 2006 erratum (*Can. J. Fish. Aquat. Sci.*, 63: 1190-1191). The Algal Biomass Spreadsheet beginning with v. 13 (2/28/07) incorporates the corrected coefficients provided in the erratum.

adjusted to obtain approximate agreement with the Dodds (2002) empirical model when applied to California EMAP and Regional Board 6 periphyton data (see Tetra Tech, 2006). It should be noted that this approach introduces considerable uncertainty into predictions for individual streams, and development of a calibrated, site-specific model would be preferable when sufficient data are available. Version 2 of QUAL2K (Chapra et al., 2006) contains significant modifications to the simulation of benthic algae, including an evaluation of nutrient limitation based on the Droop model of changes in intracellular nutrient quotas. Our analysis shows, however, that the changes to Version 2 result in only minor changes to the shape of the steady-state solution, and do not improve the ability of the model to match the Dodds predictions.

Tetra Tech (2006) also developed a "revised QUAL2K" method for predicting maximum periphyton biomass – also tuned to the Dodds (2002) results for the California data set. This approach uses the QUAL2K v.1 solution, but assumes that the "available" fraction of total nutrient used in the model varies as a function of concentration:

$$Availability\ Fraction\ (AF) = 1 - \frac{\gamma}{1 + \exp(\alpha - \beta \log_{10} C)}$$

in which α, β, and γ are parameters from a logistic regression model fit to data, as described in Tetra Tech (2006), and *C* is the total nutrient concentration. Availability here represents more than just the inorganic fraction of nutrients, as it may also reflect factors such as mat thickness, vertical gradients in the water column, and temporal variability in the inorganic fraction.

Interestingly, the total effect on the Monod growth limitation can be equivalently expressed as an effect on nutrient availability or as an inverse effect on the half-saturation constant:

$$\phi = \frac{AF \cdot C}{k_s + AF \cdot C} = \frac{C}{k_s / AF + C},$$

in which *AF*, the available fraction, is a function of total nutrient concentration, *C*, and k_s is the constant Monod half-saturation constant used in the standard QUAL2K model.

The NNE Benthic Biomass spreadsheet tool provides a simple, but robust method for relating nutrient concentrations to benthic algal density. Specifically, the maximum spatially averaged periphyton density is predicted as a function of summer nutrient concentrations and other hydrologic and physical characteristics. A variety of established prediction methods are included. These yield results that are generally similar but differ from one another, reflecting the uncertainty that is present in such predictions.

It is important to provide some clarification on the "maximum" density that is predicted by the tool. What the model predicts is the spatially averaged maximal supported response to a given set of forcing conditions, without reductions by grazing or intermittent die off. In other words, it is the average concentration expected under optimal growth conditions for a given set of nutrient concentrations. It is not the maximum point density that can be observed on a single rock, which can be considerably higher. In addition, it should not be considered as the maximum response to average nutrient conditions: if nutrient concentrations fluctuate above average conditions for a sufficient length of time, additional algal growth will likely occur. Finally, it should be noted that the maximum is difficult to observe. Even if accurate spatially averaged densities are measured, they will often be less than the model-predicted maximum. When performing correctly, the tool should provide an approximate upper-bound envelope on spatially averaged observations.

Because the NNE tools provide only a scoping-level analysis of nutrient targets, they may be superseded by a site-specific calibrated nutrient response model where available. The existing Klamath River TMDL models include, but are not calibrated to periphyton. Instead, calibration focused on DO because of concerns regarding the representativeness of the periphyton data that are available from the Klamath, due to small sample size and lack of replication. As noted above, accurate prediction of DO implicitly requires a reasonable representation of periphyton and other aquatic vegetation. Continued and improved periphyton sampling would further strengthen the TMDL model application and allow its extension to quantitative analysis of impacts other than DO.

3.3.2 Data

Data have been collected at many sites on the Klamath River, but few stations have consistent long runs of data. For the purpose of this analysis, seven sites on the mainstem Lower Klamath River in California were selected that had reasonable amounts of water quality and periphyton data. These sites are (see also Figure 6 above):

Table 8. Selected Water Quality Monitoring Stations on the Lower Klamath River

Station Number	Station Name	River Mile
KR18952	Klamath River below Iron Gate Dam	189.52
KR17608	Klamath River above Shasta River	176.08
KR14261	Klamath River above Scott River	142.61
KR12858	Klamath River at Seiad Valley	128.59
KRWE	Klamath River above Trinity River (Weitchpec)	43
KRTC	Klamath River below Trinity River above Tulley Creek	35.5-39.2
KRTG	Klamath River at Turwar	5.79

3.3.2.1 Algal Response Data

USEPA and cooperators undertook four rounds of periphyton sampling in the river in 2004 (Eilers, 2005). The published report describes the results of only one of these sampling rounds; results for the remainder were provided by the North Coast Regional Water Quality Control Board. All four sampling rounds followed the same sampling and analytical methodology.

Results of the periphyton sampling include benthic chlorophyll *a*, percent coverage, wet weight, and ash-free dry weight (AFDW). Unfortunately, the information on periphyton density (benthic chlorophyll *a* and AFDW) was obtained from relatively small and separate samples. Specifically, as described in Eilers (2005), determinations of benthic chlorophyll *a* and AFDW were each made by scraping an area of 25 mm x 75 mm from a single rock. The two measurements were made on separate samples, from separate rocks. Because there is not information from multiple points on multiple transects, the measurements may reflect a considerable amount of local variability, and may not be assumed to be representative of average densities in the reach sampled. Further, as the chlorophyll *a* and AFDW estimates come from separate rocks they are not necessarily paired samples, and inferences regarding the ratio of chlorophyll *a* and AFDW are suspect.

Results of the 2004 sampling are summarized for selected stations in Table 9.

Table 9. Summer 2004 Periphyton Sampling in the Klamath River

Station	Average Periphyton Chlorophyll *a* (mg/m²)	Maximum Periphyton Chlorophyll *a* (mg/m²)	Average Ash-Free Dry Weight (g/m²)	Maximum Ash-Free Dry Weight (g/m²)	Autotrophic Index (Average)
KR18952 – Klamath River below Iron Gate Dam	304.1	462.0	20.9	33.9	606.3
KR17608 – Klamath River above Shasta River	706.1	186.0	44.8	150.9	528.0
KR14261 – Klamath River above Scott River	120.4	353.0	68.7	141.3	684.6
KR12858 – Klamath River at Seiad Valley	65.5	122.0	25.6	54.4	1,982.2
KRWE – Klamath River above Trinity River	126.4	312.5	84.7	202.0	2,420.9
KRTC – Klamath River below Trinity	8.0	10.6	47.6	106.1	6,283.0
KRTG – Klamath River at Turwar	15.1	15.1	71.4	122.5	1,596.5

Notes: Samples at KR14261 combined with nearby samples from Walker Bridge Rd. Samples at KR17608 combined with nearby samples at Colliers Rest and Cottonwood Creek.

As noted above, the chlorophyll *a* and ash-free dry weight (AFDW) results are obtained from separate samples. Nonetheless, the autotrophic index (AI; ratio of AFDW to chlorophyll *a*) values are generally high, and appear to increase downstream. Collins and Weber (1978) suggest that an AI value greater than 400 is generally representative of "polluted" conditions in which the periphyton contains a high percentage of heterotrophs. In the lower Klamath, the AI values may reflect high levels of input of organic matter from eutrophic reservoirs upstream. The 2004 samples at KRTC and KRTG have very low chlorophyll *a* densities, but moderately high AFDW, suggesting largely heterotrophic communities.

Unfortunately, this sampling effort does not appear to provide a firm basis for calculating the ratio of chlorophyll *a* to AFDW (as mg/g), which is a key parameter for application of the QUAL2K-based prediction methods. The ratios from individual sample events reported by Eilers range from 0.1 to 96 mg/g, well outside of the range expected from algal stoichiometry, with a median of 1.1 and average of 7.1 (Figure 7) – probably due to the fact that the analyses are not from the same samples.

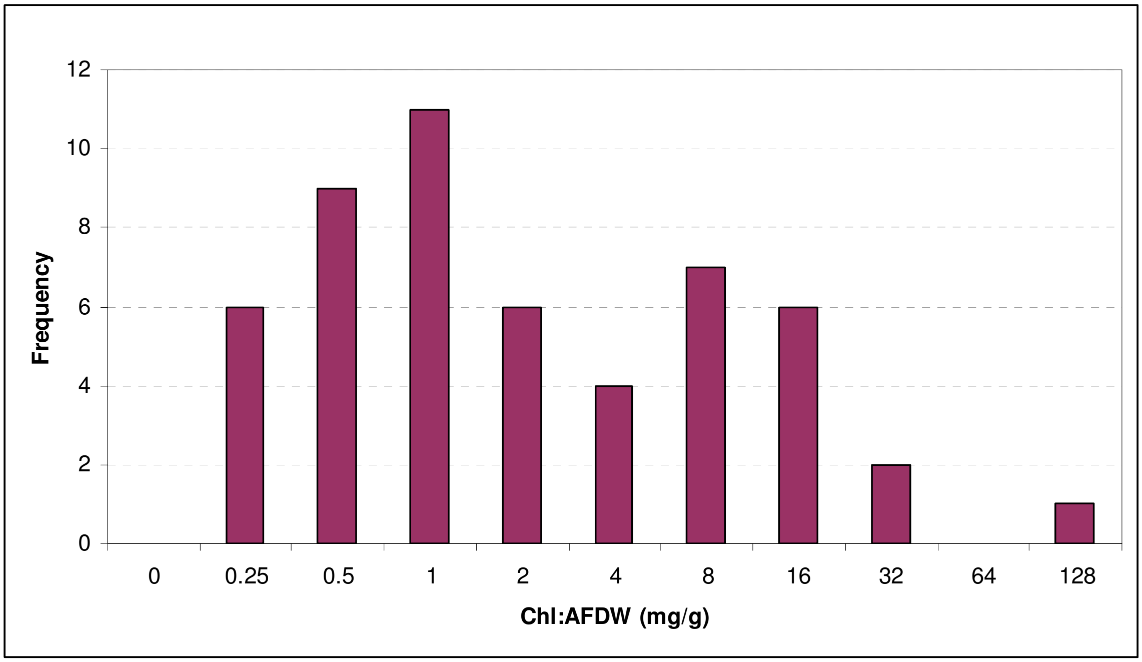

Figure 7. Histogram of Apparent Chlorophyll *a* to AFDW Ratios in 2004 Periphyton Data

Additional periphyton samples were collected by the Yurok Tribe in 2004 and 2006-2007 at KRWE (Weitchpec) and KRTG (Turwar). The 2004 results contain species composition data and AFDW, but not chlorophyll *a*. At KRWE, the average AFDW was 87.2, the maximum 122.5. At KRTG, the average AFDW was 108.2, the maximum 134.5. The 2006-2007 chlorophyll *a* results are shown in Table 10, reflecting revisions to the 2007 laboratory results reported to Tetra Tech by the Regional Board on April 7, 2008. AFDW was not reported for these data. The 2006 chlorophyll *a* results appear anomalously high, for unknown reasons. Communities at these stations were usually dominated by diatoms.

Table 10. Yurok Periphyton Sampling Results for 2006-2007

Station	Year	Average Periphyton Chlorophyll *a* (mg/m^2)	Maximum Periphyton Chlorophyll *a* (mg/m^2)
KRWE (Weitchpec)	2006	609.3	1086.2
	2007	123.6	326.0
KRTG (Turwar)	2006	325.8	651.7
	2007	73.4	163.0

It should be emphasized that it is very difficult to obtain reach average chlorophyll *a* densities in the Klamath, due to its size, depth, and velocity. It appears that all samples taken to date do not qualify as spatially averaged values, but are more representative of point concentrations. As a result, some of the observed maximum values are likely to be greater than the model predictions, which represent spatially averaged algal response under optimal growth conditions, not the maximum point density.

3.3.2.2 Chemical Water Quality

In contrast to periphyton, an extensive database of chemical water quality exists collected by multiple agencies. Earlier data were compiled into an Access database in 2004. Some of the earlier data have since been corrected and substantial amounts of additional data have been collected since 2004. Accordingly, Tetra Tech worked with the Regional Board to develop a comprehensive tabulation of nutrient monitoring data in the Klamath.

The river data were separated into three time periods, 1996-2001, 2002-2004, and 2005-2007, which correspond approximately to the periods for which the reservoir BATHTUB scoping tools have been developed (2000, 2002, and 2005), and the periods during which periphyton samples are available (2004 and 2006-2007).

Statistics were calculated for the summer season (June – September). As periphyton is expected to have a moderately long response time to ambient nutrient concentrations, extreme values may not be particularly relevant. Therefore, the central tendency and range of the ambient data were described by the mean, median, 25th percentile, and 75th percentile (Table 11). To account for the influence of fluctuations in nutrient concentration on maximum algal response, predictions are made at the 75th percentile value. The ratio of total N to total P at these stations is typically less than the Redfield ratio of 7.2 (representing the typical cellular composition of algae), suggesting that nitrogen may frequently be the nutrient that is most limiting on algal growth.

3.3.2.3 Physical Data

Flow gaging data, and associated measurements, are available from five USGS gages between Iron Gate Dam and the Klamath estuary. Additional information on stream geometry, velocity, and stage is available from the calibrated hydrodynamic model of the Lower Klamath (PacifiCorp, 2005).

Table 11. Summer Nutrient Water Quality at Klamath River Stations below Iron Gate

		1996-2001				2002-2004				2005-2007			
	Station	Count (days)	Mean	25%^{le}	75%^{le}	Count (days)	Mean	25%^{le}	75%^{le}	Count (days)	Mean	25%^{le}	75%^{le}
PO_4-P (mg/L)	KR18952	42	0.152	0.110	0.173	32	0.120	0.100	0.143	32	0.105	0.088	0.130
	KR17608	6	0.198	0.150	0.240	16	0.131	0.113	0.160	21	0.105	0.080	0.133
	KR14261	6	0.204	0.140	0.250	14	0.117	0.091	0.140	19	0.103	0.088	0.120
	KR12858	41	0.124	0.083	0.150	24	0.084	0.060	0.110	8	0.067	0.049	0.075
	KRWE	0	ND	ND	ND	24	0.039	0.027	0.053	5	0.041	0.021	0.062
	KRTC	11	0.041	0.031	0.051	19	0.027	0.015	0.036	4	0.035	0.033	0.044
	KRTG	9	0.025	0.020	0.032	29	0.022	0.014	0.031	4	0.024	0.022	0.029
Org-P (mg/L)	KR18952	42	0.046	0.009	0.053	32	0.069	0.040	0.080	32	0.039	0.010	0.053
	KR17608	6	0.026	0.000	0.040	14	0.076	0.030	0.110	19	0.032	0.000	0.035
	KR14261	6	0.022	0.000	0.028	14	0.085	0.051	0.086	19	0.055	0.013	0.056
	KR12858	41	0.106	0.009	0.040	22	0.050	0.028	0.071	8	0.024	0.016	0.030
	KRWE	0	ND	ND	ND	24	0.051	0.029	0.060	5	0.015	0.013	0.017
	KRTC	11	0.036	0.013	0.059	19	0.054	0.032	0.080	4	0.015	0.014	0.016
	KRTG	9	0.068	0.035	0.081	29	0.050	0.020	0.071	4	0.017	0.015	0.019

	Station	1996-2001				2002-2004				2005-2007			
		Count (days)	Mean	25%[le]	75%[le]	Count (days)	Mean	25%[le]	75%[le]	Count (days)	Mean	25%[le]	75%[le]
NO_2+NO_3-N (mg/L)	KR18952	50	0.296	0.110	0.421	31	0.161	0.110	0.205	43	0.169	0.097	0.238
	KR17608	6	0.166	0.064	0.260	25	0.122	0.070	0.160	20	0.187	0.118	0.263
	KR14261	6	0.117	0.050	0.167	13	0.094	0.050	0.130	17	0.129	0.096	0.120
	KR12858	37	0.172	0.050	0.260	16	0.079	0.040	0.110	16	0.069	0.005	0.107
	KRWE	0	ND	ND	ND	26	0.042	0.033	0.040	4	0.005	0.005	0.005
	KRTC	8	0.084	0.040	0.100	26	0.071	0.020	0.040	4	0.006	0.005	0.006
	KRTG	8	0.076	0.040	0.100	22	0.039	0.040	0.040	4	0.026	0.023	0.028
NH_3-N (mg/L)	KR18952	50	0.091	0.043	0.085	29	0.059	0.050	0.050	43	0.024	0.005	0.039
	KR17608	6	0.043	0.024	0.047	25	0.067	0.020	0.060	20	0.020	0.005	0.034
	KR14261	6	0.041	0.028	0.044	12	0.031	0.000	0.050	19	0.011	0.005	0.005
	KR12858	37	0.032	0.000	0.040	17	0.065	0.050	0.050	16	0.008	0.005	0.011
	KRWE	0	ND	ND	ND	21	0.042	0.050	0.050	4	0.004	0.005	0.005
	KRTC	8	0.058	0.050	0.050	25	0.087	0.010	0.050	4	0.005	0.005	0.005
	KRTG	8	0.061	0.050	0.050	15	0.075	0.050	0.050	4	0.005	0.005	0.005
Org-N (mg/L)	KR18952	42	0.816	0.488	0.727	23	0.761	0.488	1.027	32	0.898	0.675	1.072
	KR17608	6	0.641	0.560	0.680	14	0.756	0.505	0.964	19	0.944	0.760	1.034
	KR14261	6	0.670	0.661	0.724	6	0.834	0.558	1.036	19	0.796	0.575	0.936
	KR12858	37	0.577	0.380	0.650	10	0.434	0.355	0.469	8	0.492	0.384	0.600
	KRWE	0	ND	ND	ND	12	0.432	0.225	0.502	5	0.257	0.213	0.291
	KRTC	8	0.289	0.150	0.388	23	0.306	0.120	0.335	4	0.200	0.175	0.221
	KRTG	8	0.356	0.146	0.375	10	0.212	0.138	0.238	4	0.205	0.191	0.244
Total N (mg/L)	KR18952	42	1.210	0.758	1.150	27	0.942	0.630	1.118	41	1.083	0.866	1.260
	KR17608	6	0.849	0.720	0.971	18	0.878	0.615	1.108	18	1.051	0.889	1.185
	KR14261	6	0.828	0.758	0.872	6	0.949	0.673	1.176	17	0.937	0.693	1.125
	KR12858	37	0.781	0.500	1.000	16	0.566	0.540	0.600	17	0.559	0.479	0.648
	KRWE	0	ND	ND	ND	14	0.480	0.265	0.530	5	0.235	0.180	0.272
	KRTC	8	0.431	0.240	0.538	23	0.386	0.190	0.440	4	0.211	0.189	0.231
	KRTG	8	0.493	0.296	0.538	14	0.305	0.240	0.328	4	0.231	0.212	0.272

Notes: Total Nitrogen calculated as some of Total Kjeldahl Nitrogen (TKN) plus NO_3-N plus NO_2-N where available. Non-detects treated as one-half the detection limit. Organic N calculated as TKN minus NH_3-N. Organic P calculated as Total P minus PO_4-P.

3.3.3 NNE Tool Application

The California NNE benthic biomass scoping tool was applied to the Klamath River in California to provide a scoping-level estimate of nutrient targets. Details on the development and use of this tool are available in Tetra Tech (2006).

Physical parameters for the scoping tool are summarized in Table 12 and explained further below.

Table 12. Parameters Specified for the NNE Tool Application

Station	Typical Summer Velocity (m/s)	Summer Depth for Analysis (m)	Unshaded Summer Solar Radiation (cal/cm^2/d)	Light Extinction Coefficient (m^{-1})	Days of Accrual	Chlorophyll *a* to AFDW Ratio
KR18952	0.65	0.45	528	0.725	185.7	5
KR17608	0.65	0.45	584	0.725	185.7	4
KR14261	0.69	0.45	527	0.725	122.8	4
KR12858	0.61	0.45	527	0.725	122.8	4
KRWE	0.69	0.45	524	0.760	81.9	4
KRTC	0.69	0.45	524	0.760	81.9	4
KRTG	0.69	0.45	526	0.760	69.1	4

Velocity

Stream velocity at each site was input as the “typical” summer value shown in the output of the RMA model of the Klamath River.

Depth

The RMA model output provides information on stage (or maximum depth) at each station, and average depth can be inferred from flow and cross-sectional area. However, the Klamath is a relatively wide river, and much of the potential benthic algal problem is believed to be associated with shallower water. It is therefore appropriate to evaluate impact at shallower depths, where light extinction in the water column is less of a factor. The 2004 periphyton samples were all collected in shallow water at a depth of approximately 0.45 m. Therefore, this depth was used in the scoping model applications.

Solar Radiation

Unshaded solar radiation for the summer period (June-August) was estimated based on latitude using the routine incorporated in the Benthic Biomass spreadsheet. The spreadsheet incorporates an approximation for shading effects on light availability as well. No data on local canopy and topographic shading were available; however, the majority of the Lower Klamath channel appears to be relatively open, so no shading was assumed, except at Seiad Valley. In that reach, the river flows in a N-S direction, whereas other sampled reaches have an approximately E-W orientation. Therefore, there is likely to be more topographic and canopy shading at Seiad Valley, and a value of 40 percent shading was selected.

Light Extinction Coefficient

Light extinction was estimated from turbidity. In general, light extinction is a function of water itself, dissolved colored organic material, phytoplankton, and inanimate particulate matter (Effler et al., 2005), and occurs through a combination of adsorption and scattering. In flowing streams, scattering by inorganic particulates is usually the dominant factor in light extinction, while scattering in the water column is directly measured by a nephelometric turbidity meter as NTU (Gallegos, 1994). Therefore, an approximately linear relationship of light extinction to turbidity is expected in streams. Rather than implementing a complete optics model, we therefore rely on the simple empirical relationship of Walmsley et al. (1980), who established a regression relationship $K_e(PAR) = 0.1\ T + 0.44$, where $K_e(PAR)$ is the extinction rate of photosynthetically active radiation (PAR, per meter) and T is nephelometric turbidity (NTU). The relationship will vary according to the nature of suspensoids (Kirk, 1985), but is similar to results of other authors who suggest slopes of K_e relative to turbidity in the range of 0.06 to 0.12. Because turbidity has only a small effect on available light at the depths analyzed, the Walmsley relationship appears acceptable. The extinction coefficient was then estimated based on median summer turbidity, which ranged from 2.5 to 3.2 NTU.

Accrual

The scoping model provides an option to evaluate effects on expected maximum algal density based on days of accrual, using the relationship of Biggs (2000), where accrual time is defined as the number of days between events three-times the median flow. Accrual time was analyzed at each of the USGS gages. Because the Klamath is a large river with a multi-day response time, the number of events per year was estimated based on the count of times the hydrograph crossed the three-times-median threshold, rather than the number of individual days above the threshold. Resulting estimates (Table 13) were extrapolated to the nearest water quality monitoring station. The system shows a pattern of decreasing time between scouring events with distance downstream as additional major tributaries join.

Table 13. Estimated Days of Accrual (1985-2005 Data)

USGS Gage	Average Days of Accrual
11516530: Klamath River below Iron Gate	185.7
11520500: Klamath River near Seiad Valley	122.8
11523000: Klamath River at Orleans	81.9
11530500: Klamath River at Klamath	69.1

Half-Saturation Constants

Lacking site-specific data, half-saturation constants for nutrients are set at the levels described in Tetra Tech (2006). For the standard QUAL2K model, the optimized half-saturation constants were 0.206 mg/L for inorganic N and 0.00853 mg/L for inorganic P (Table 4 in Appendix 3 of Tetra Tech, 2006). For the revised QUAL2K model, the half-saturation constants are defined in relation to total nutrient concentrations, and vary from 0.0260 to 2.83 mg/L for total N, and from 0.0205 to 0.0470 mg/L for total P following the logistic regression model (Table 6 in Appendix 3 of Tetra Tech, 2006).

Chlorophyll *a* to AFDW Ratio

One of the most problematic parameters is the chlorophyll *a* to AFDW ratio (mg/g), where AFDW represents the fixed carbon biomass. The need for this parameter arises when the model formulation predicts biomass (as is done in the QUAL2K-based approach), while the target is specified as chlorophyll *a*. The ratio translates between the two, but can be highly variable. As noted above, only the 2004 sampling examined both AFDW and benthic chlorophyll *a*, but analyses were from small samples and the chlorophyll *a* and AFDW measures were obtained from scrapings from different rocks. These data do not provide a reliable basis for estimating the ratio in the Klamath.

Selection of an appropriate ratio is complicated by the fact that periphytic communities contain a mix of photosynthesizing autotrophs and heterotrophs, including bacteria and fungi, whose growth is based on allochthonous carbon sources. The models are supposed to predict only photosynthetic biomass, but heterotrophs can also take up nutrients from the water column, so the predicted response of biomass as a function of nutrient concentrations likely includes both heterotrophic and autotrophic biomass. Further complications arise because (1) some algae exhibit mixotrophy, in which they are able to assimilate energy from fixed carbon compounds as well as by photosynthesis, and (2) exudates of benthic phototrophic algae may support bacterial and fungal heterotrophic populations, thus tying the heterotroph density to photosynthetic production.

In the development of the QUAL2K method (Tetra Tech, 2006), parameters of QUAL2K were "tuned" to provide a match to the predictions of Dodds' (2002) empirical model of maximum algal density when a chlorophyll *a* to AFDW ratio of 2.5 was assumed. Selection of this value was an appropriate compromise for a cross-sectional dataset, as the ratio of 2.5 corresponds to an autotrophic index of 400, generally presented as the upper limit of clean water conditions.

The CA NNE document (Tetra Tech, 2006) also noted that "alternate, site-specific ratios may be appropriate in specific waterbodies where appropriate information is available." For the Klamath, the Dodds method appears to underpredict maximum observed chlorophyll *a*, which also introduces a tendency for the QUAL2K-based methods, which are tuned to the Dodds method, to underpredict the maxima. Therefore, the chlorophyll *a* to AFDW ratio was increased from 2.5 to 4.0 at all stations except the station below Iron Gate, where a value of 5.0 was used.

3.3.4 Exploratory Data Analysis

Before applying the spreadsheet tool, an exploratory analysis was undertaken to examine the correlation between benthic chlorophyll *a* and nutrient concentrations. Both the average and the maximum benthic chlorophyll *a* from the 2004 sampling are plotted against the 75th percentile of summer average TN and TP concentrations from 2002-2004 water quality monitoring data in Figure 8. This suggests that observed periphyton density is indeed correlated to nutrient concentrations, with the strongest correlation (shown by higher R^2 value) between the observed maximum chlorophyll *a* and TN concentrations.

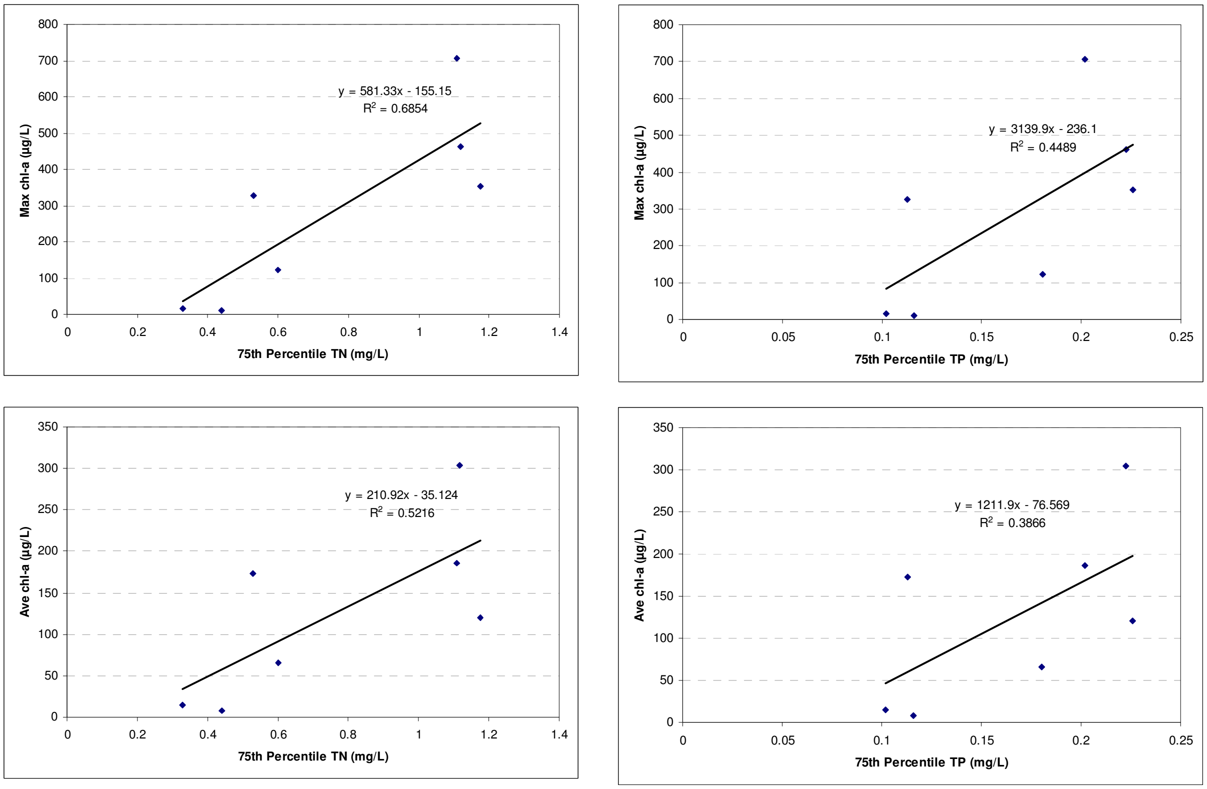

Figure 8. Relationship of Observed Periphyton Chlorophyll *a* to Nutrient Concentrations, 2004 Klamath Sampling

3.3.5 NNE Results

The NNE Benthic Biomass Predictor tool provides a variety of empirical and simplified parametric model approaches to predicting benthic algal response to ambient physical and chemical conditions. For this application, the tool was first used to predict maximum benthic chlorophyll *a* at each of the sites. As discussed in Tetra Tech (2006), benthic algal density is highly variable in time and space, and simplified models generally seem to do a better job of predicting the upper-bound estimate that describes maximum benthic algal density. The tool provides access to multiple predictions, but only three are presented here, all calculated at the 75^{th} percentile summer nutrient concentration, as described above in Section 3.3.2. Of the empirical approaches, results are shown for the latest version of the Dodds model (Dodds, 2002), while for parametric approaches the results for both the standard QUAL2K and revised QUAL2K models (which are tuned to correspond to the Dodds' results on small streams) are shown, the latter both with and without an accrual adjustment (Table 14). The accrual adjustment has little effect on the upstream stations (where the estimated days of accrual are large), but does have a noticeable effect from station KRWE downstream. Of the other available methods, the 1997 version of the Dodds model has been superseded by the more detailed analysis of Dodds (2002). The Dodds method is of particular interest for comparison because results do not depend on the chlorophyll *a* to AFDW ratio.

Table 14. Predicted and Observed Maximum Benthic Chlorophyll *a* (mg/m^2)

Station	Period	Standard QUAL2K	Revised QUAL2K	Revised QUAL2K with Accrual Adjustment	Dodds 2002	Observed Maximum	Observed Average
KR18952 (below Iron Gate)	1996-2001	547	478	477	245		
	2002-2004	426	489	488	248	462	304.1
	2005-2007	441	504	503	241		
KR17608 (above Shasta)	1996-2001	399	363	362	236		
	2002-2004	344	404	403	251	706	186
	2005-2007	398	433	432	236		
KR14261 (above Scott)	1996-2001	333	347	314	231		
	2002-2004	307	406	368	244	353	120.4
	2005-2007	249	375	339	214		
KR12858 (Seiad Valley)	1996-2001	294	264	238	214		
	2002-2004	217	204	185	181	122	65.5
	2005-2007	181	222	201	169		
KRWE (above Trinity)	1996-2001	ND	ND	ND	ND		
	2002-2004	200	261	188	160	312.5	126.4
	2005-2007	30	172	124	115	1086 (2006) 326 (2007)	609 (2006) 124 (2007)
KRTC (below Trinity)	1996-2001	281	250	180	153		
	2002-2004	200	212	153	142	10.6	8
	2005-2007	34	147	105	98		
KRTG (Turwar)	1996-2001	281	246	155	153		
	2002-2004	200	181	114	125	15.1	15.1
	2005-2007	91	163	103	99	652 (2006) 163 (2007)	326 (2006) 73 (2007)

Model predictions of maximum benthic chlorophyll *a* concentrations for 2002-2004 are plotted against the 2004 observations of maximum and average concentrations in Figure 9.

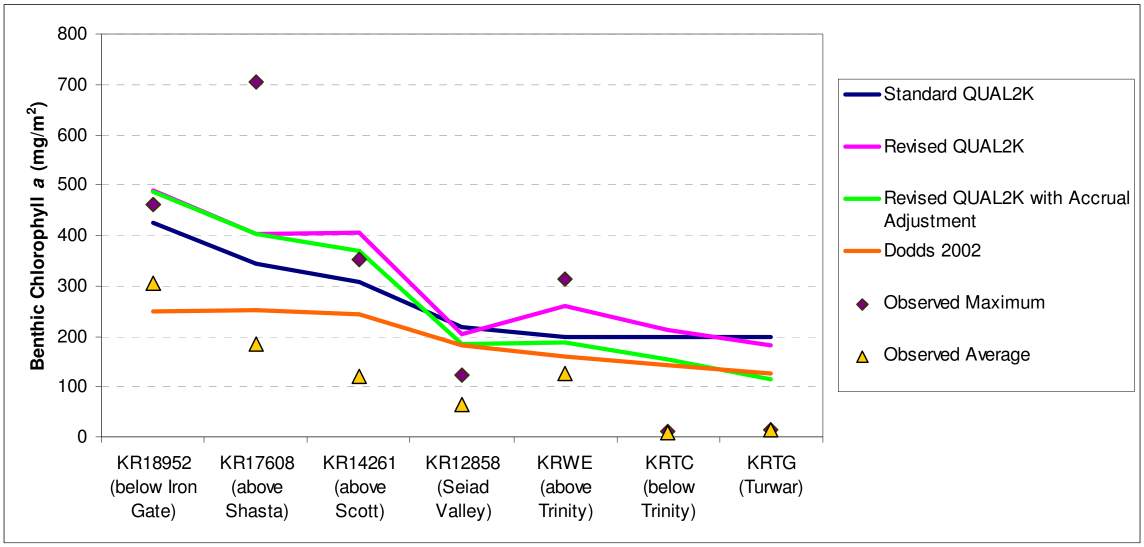

Figure 9. Model Predictions of Maximum Benthic Chlorophyll *a* for 2002-2004 and Observed Densities for 2004

None of the methods provide a perfect match to observations. Indeed, only general qualitative comparisons can be made, as the model predicts spatially averaged responses, whereas the observations reflect point data. In general, the revised QUAL2K approaches appear to do a reasonable job of replicating the spatial trend in observed maxima, while the Dodds results tend to be low. At three of seven stations, the predicted maximum using the QUAL2K approach is greater than the observed – which may only mean that the maximum was not sampled. At two other stations, the QUAL2K predictions are well less than the observed maximum. This may reflect the fact that the observed data are obtained from very small samples, without replication, that may not be representative of spatially averaged conditions in the reach.

Additional comments are warranted regarding several of the stations. For the station above Shasta, the plotted maximum of 706.1 mg/m^2 is for a sample taken at the mouth of Cottonwood Creek, a few miles upstream of station KR17608. Two samples taken at KR17608 had a maximum of only 81.5 mg/m^2. Reported maxima at the downstream stations of KRTC and KRTG were very low in 2004 (less than 20 mg/m^2); however, the Yurok samples from 2006 had a maximum of 652 mg/m^2 at KRTG. The 2004 results at these stations may be biased low relative to the seasonal maximum because they do not include samples from late summer, when periphyton densities are typically at their peak.

Both the data and the model representation of the data are subject to considerable uncertainty. Conditional on the suitability of the model, the tool can then be used to predict nutrient concentration targets needed to achieve a specified maximum algal density. As noted above, for the COLD and SPWN uses present in the Klamath, Tetra Tech (2006) recommends that the target should generally be between 100 mg/m^2 (BURC I/II boundary below which conditions may be deemed acceptable) and 150 mg/m^2 (BURC II/III boundary above which conditions are deemed unacceptable) for these designated uses.

For the Klamath, the models generally suggest that smaller reductions in total nitrogen than in total phosphorus are needed to reach the target range, and further that total phosphorus concentrations would need to be reduced to very low levels to achieve control of benthic algal growth by phosphorus alone. (Achieving the 100 mg/m^2 target by limiting phosphorus alone would require a total P goal of 2 µg/L.) This is consistent with the low observed total N to total P ratios, which suggest nitrogen limitation on algal growth. Therefore, nutrient limitations to achieve the maximum chlorophyll *a* targets are best expressed in terms of total nitrogen goals (from which corresponding total phosphorus goals may be inferred through use of the Redfield ratio of 7.2, as in Dodds et al., 1997). The resulting total nitrogen goals for a maximum benthic chlorophyll *a* concentration target of 150 mg/m^2 are shown in Table 15, while Table 16 shows the corresponding estimates for a target of 100 mg/m^2 maximum benthic chlorophyll *a*.

Table 15. Total Nitrogen and Phosphorus Goals (mg/L) for Target of 150 mg/m^2 Maximum Benthic Chlorophyll *a* (TP values based on using Redfield ratio of 7.2)

Station	Revised QUAL2K	Revised QUAL2K with Accrual Adjustment	Dodds 2002
KR18952	0.18/0.025	0.18/0.025	0.34/0.047
KR17608	0.23/0.032	0.23/0.032	0.30/0.042
KR14261	0.23/0.032	0.28/0.039	0.33/0.046
KR12858	0.38/0.053	0.44/0.061	0.38/0.053
KRWE	0.24/0.033	0.41/0.057	0.50/0.069
KRTC	0.24/0.033	0.41/0.057	0.49/0.068
KRTG	0.24/0.033	0.51/0.071	0.53/0.074

Table 16. Total Nitrogen and Phosphorus Goals (mg/L) for Target of 100 mg/m^2 Maximum Benthic Chlorophyll *a* (TP values based on using Redfield ratio of 7.2)

Station	Revised QUAL2K	Revised QUAL2K with Accrual Adjustment	Dodds 2002
KR18952	0.08/0.011	0.08/0.011	0.11/0.015
KR17608	0.11/0.015	0.11/0.015	0.10/0.014
KR14261	0.11/0.015	0.14/0.019	0.11/0.015
KR12858	0.19/0.026	0.23/0.032	0.13/0.018
KRWE	0.11/0.015	0.21/0.029	0.17/0.024
KRTC	0.11/0.015	0.21/0.029	0.17/0.024
KRTG	0.11/0.015	0.26/0.036	0.18/0.025

Results for the 150 mg/m^2 target are re-expressed as reductions in TN concentration relative to observed summer average concentrations for the 2005-2007 period based on the revised QUAL2K with accrual adjustment analysis in Table 17. Concentrations observed in the 1996-2001 period are somewhat different, but suggest a similar spatial pattern of needed reductions (Table 18).

Table 17. Reductions in TN Concentrations Relative to 2005-2007 Observations to Achieve the 150 mg/m^2 Target

Station	Percent Reduction in Summer TN Concentration	TN/TP 2005-2007 Summer Average Concentration (mg/L)	Revised QUAL2K with Accrual Adjustment TN/TP Goal (mg/L)
KR18952	83%	1.08/0.14	0.18/0.025
KR17608	78%	1.05/0.14	0.23/0.032
KR14261	70%	0.94/0.16	0.28/0.039
KR12858	21%	0.56/0.091	0.44/0.061
KRWE	0%	0.24/0.056	0.41/0.057
KRTC	0%	0.21/0.050	0.41/0.057
KRTG	0%	0.23/0.041	0.51/0.071

Table 18. Reductions in TN Concentrations Relative to 1996-2001 Observations to Achieve the 150 mg/m^2 Target

Station	Percent Reduction in Summer TN Concentration	TN/TP 2005-2007 Summer Average Concentration (mg/L)	TN/TP Goal (mg/L)
KR18952	85%	1.21/0.20	0.18/0.025
KR17608	73%	0.85/0.22	0.23/0.032
KR14261	66%	0.83/0.23	0.28/0.039
KR12858	44%	0.78/0.23	0.44/0.061
KRWE	No data	No data	0.41/0.057
KRTC	5%	0.43/0.077	0.41/0.057
KRTG	0%	0.49/0.093	0.51/0.071

Table 17 and Table 18 suggest that to achieve the desired reductions in benthic algal density at all stations would require reductions in summer TN concentrations of up to 85 percent. (Achieving targets by controlling TP directly would require reductions of approximately 98 percent at stations through Seiad Valley.) The results for the T4BS1 allocation scenario in Iron Gate Reservoir (see Section 3.3) indicate that this scenario, which is predicted to achieve lake targets, would result in reductions of about 73 percent in summer TN concentrations and about 89 percent in summer TP concentrations for the 2000 simulation. Thus, load reductions in excess of those needed to meet DO criteria and achieve lake planktonic chlorophyll *a* targets may be needed to meet maximum periphyton chlorophyll *a* targets in the Klamath below Iron Gate.

Application of the benthic biomass tool using the 75th percentile summer concentrations in the outflow from Iron Gate predicted by the T4BS1 scenario with benthic flux off results in a prediction of maximum benthic algal chlorophyll *a* at Station KR18952 below Iron Gate of 164 mg/m^2 – slightly in excess of the target – using the revised QUAL2K-based methods. For the same conditions, the Dodds (2002) approach yields a prediction of 84 mg/m^2, well below the target.

3.3.6 Natural Conditions Analysis

The draft CA NNE document (Tetra Tech, 2006) recommended an upper limit of 150 mg/m^2 chlorophyll *a* to support uses in waters of the State of California, yet also recommends that the target should not be set lower than the value expected under natural conditions. This target of 150 mg/m^2 has not been adopted by the State Board and remains open for further evaluation. [The Hoopa Valley Tribe has a regulatory target of 150 mg/m^2 that has been adopted and approved, and applies to the small section of the Klamath River that passes through the Hoopa Valley Tribal lands.]

To examine potential natural conditions in the Klamath River, concentration results from the TMDL Model T1BS natural conditions run were summarized for summer (June-September) conditions. This model run has point sources eliminated and dams out. Current flow leaving Upper Klamath Lake and Klamath Straits Drain in Oregon is continued, but with concentrations reduced to be compliant with the Upper Klamath Lake TMDL. The T1BS run uses 2000 meteorological conditions.

In the dams out simulation, nutrient retention and processing by the Klamath reservoirs is eliminated. This results in changes in the magnitude, timing, and speciation of nutrient loads reaching the lower Klamath River.

Output from the T1BS natural conditions was used to provide input to the NNE benthic biomass tool. Evaluation was made at four locations: below Iron Gate (KR18952), Seiad Valley (KR12858), above Trinity (KRWE), and at Turwar (KRTG). The range of summer average water quality for the natural conditions run is summarized at the 75th percentile level (as was done with the NNE tool to predict maximum benthic chlorophyll *a* in previous sections) and compared to recent observed water quality in Table 19.

Table 19. 75th Percentile of Natural Condition Water Quality (Model Run T1BS) Compared to Observed Water Quality in the Klamath River

	Station	T1BS	1996-2001 Observed	2002-2004 Observed	2005-2007 Observed
PO_4-P (mg/L)	KR18952 – Klamath River below Iron Gate	0.0190	0.173	0.143	0.130
	KR12858 – Klamath River at Seiad Valley	0.0515	0.150	0.110	0.075
	KRWE – Klamath River above Trinity River	0.0601	No Data	0.053	0.062
	KRTG – Klamath River at Turwar	0.0768	0.032	0.031	0.029
Org-P (mg/L)	KR18952	0.0216	0.053	0.080	0.053
	KR12858	0.0220	0.040	0.071	0.030
	KRWE	0.0184	No Data	0.060	0.017
	KRTG	0.0161	0.081	0.071	0.019
Total P (mg/L)	KR18952	0.0406	0.226	0.223	0.183
	KR12858	0.0735	0.190	0.181	0.105
	KRWE	0.0785	No Data	0.113	0.079
	KRTG	0.0929	0.113	0.102	0.108
NO_2+NO_3-N (mg/L)	KR18952	0.0777	0.421	0.205	0.238
	KR12858	0.0957	0.260	0.110	0.107
	KRWE	0.1093	No Data	0.040	0.005
	KRTG	0.1298	0.100	0.040	0.006
NH_3-N (mg/L)	KR18952	0.0831	0.085	0.050	0.039
	KR12858	0.1077	0.040	0.050	0.011
	KRWE	0.1256	No Data	0.050	0.011
	KRTG	0.1467	0.050	0.050	0.005
Org-N (mg/L)	KR18952	0.2671	0.727	1.027	1.072
	KR12858	0.2838	0.650	0.469	0.600
	KRWE	0.2502	No Data	0.502	0.291
	KRTG	0.2598	0.538	0.328	0.244
Total N (mg/L)	KR18952	0.4279	1.150	1.118	1.260
	KR12858	0.4872	1.000	0.600	0.648
	KRWE	0.4851	No Data	0.530	0.272
	KRTG	0.5364	0.538	0.328	0.272

Unlike monitoring results for existing (dams-in) conditions (see above, Table 11), the 75th percentile total nutrient concentrations during the summer tend to increase downstream under the TMDL Model T1BS run. This seems to occur because concentrations in most of the downstream tributaries were kept at existing levels for the T1BS scenario, while upstream concentrations leaving Iron Gate Dam decreased significantly. In addition, the model output reflects continuous subhourly simulation, while the observations are discrete day time grab samples, which may confound direct comparison.

Table 19 also shows that the 75th percentile summer total nitrogen concentrations under natural conditions appear to be greater than the concentrations estimated as needed to meet the 150 mg/m^2 maximum benthic chlorophyll *a* target in the analysis of existing conditions provided above in Table 15. This suggests that natural conditions may result in a tendency for elevated benthic algal densities in the Klamath River.

The dams-out condition will also result in more frequent scouring flows and less days of accrual (time between potential scouring events), which may tend to reduce maximum benthic algal growth. However, data were not available for a long-term analysis of the frequency of scouring flows for the T1BS model conditions. To approximate this effect, the days of accrual for the Revised QUAL2K application with accrual adjustment was set at 69.1 days – the value currently used for the Turwar gage, which is furthest downstream and least affected by the dams on the upper Klamath.

Results of applying the benthic biomass spreadsheet tool to the TMDL Model T1BS conditions are summarized in Table 20. Consistent with the predicted nutrient concentrations, there is no longer a strong spatial gradient in predicted maximum benthic chlorophyll *a* concentrations under the T1BS natural conditions scenario. The standard QUAL2K predictions are much higher than the other approaches due to the increased fraction of inorganic nutrients, which enter directly into the solution for this model, but not the other approaches. The Revised QUAL2K model with accrual adjustment suggests maxima right around the 150 mg/m^2 target, while the QUAL2K approaches without accrual adjustment predict higher densities. The Dodds (2002) approach also predicts maximum densities less than 150 mg/m^2, but results from this model were generally much lower than that obtained for other approaches in the analysis of existing conditions.

The predicted ability to meet the 150 mg/m^2 target using the Revised QUAL2K approach (with accrual adjustment) only occurs due to the assumption of reduced days of accrual. For example, if days of accrual at KRWE are assumed to be 81.9, as in the existing conditions (dams-in) application, the resulting predicted maximum benthic chlorophyll *a* density would be 166, rather than 145 mg/m^2. It is thus not clear from the benthic biomass spreadsheet analysis that the 150 mg/m^2 target could be met under natural conditions A more detailed analysis of the frequency of scouring flows expected under the dams-out natural conditions may be advisable to ascertain the extent to which this phenomenon is likely to limit excess benthic algal density.

Table 20. Predicted Maximum Benthic Chlorophyll *a* (mg/m2) Under TMDL Model Run T1BS Natural Conditions (Dams Out) for Year 2000

Station	Standard QUAL2K	Revised QUAL2K	Revised QUAL2K with Accrual Adjustment	Dodds 2002
KR 18952 (below Iron Gate)	338	250	157	113
KR12858 (Seiad Valley)	246	174	109	135
KRWE (above Trinity)	350	231	145	137
KRTG (Turwar)	377	246	154	147

3.4 DISCUSSION OF KLAMATH RIVER NNE RESULTS

Prediction of periphyton biomass is inherently difficult. This problem is compounded by several factors, including the weak relationship between periphyton biomass and benthic chlorophyll *a* and the sparse and uncertain data available for the Klamath River. The biomass to chlorophyll *a* relationship is expressed through the chlorophyll *a* to AFDW ratio, which is clearly a major source of uncertainty in the QUAL2K-based applications. The observed data are limited, and have been obtained from small samples that may not accurately reflect the reach-averaged conditions predicted by the tool.

Due to the uncertainties in predicting benthic chlorophyll *a*, it may be preferable to define periphyton targets for the Klamath River in terms of AFDW, although more data are needed to establish such a target.

As a result of these caveats, the main value of the benthic biomass tool is in predicting relative changes in benthic chlorophyll *a*, rather than precise estimates. It is clear that significant reductions in summer nutrient concentrations would be needed to meet a target of 150 mg/m^2 maximum benthic chlorophyll *a*; however, the predicted magnitude of the needed reductions is highly uncertain. The reductions that would occur as a result of the T4BS allocation scenario to achieve DO criteria will certainly result in improvements in periphyton density in the Klamath River, but may or may not be sufficient to achieve the BURC II/III target of 150 mg/m^2 maximum benthic chlorophyll *a*. Due to the considerable uncertainty in the NNE analysis. additional data should continue to be collected to build a better understanding of the relationship between nutrient concentrations and periphyton density and support the development of more sophisticated, site-specific models. The RMA model application for Klamath River TMDL development already provides a potential framework for evaluating the benthic algal target in the river; however, the model predictions need to be refined with more data to better assess impacts on beneficial uses in addition to effects on DO, including the formation of periphyton mats that may impair recreational uses, alter the benthic community, and potentially increase the detrimental effects of parasites on salmonid populations.

Finally, although the draft CA NNE document (Tetra Tech, 2006) recommends an upper limit of 150 mg/m^2 chlorophyll *a* to support uses, this target has not been adopted by the State or Regional Board and remains open for further evaluation. As mentioned previously, this target does apply to the small section of the Klamath River that passes through the Hoopa Valley Tribal lands, where a criterion of 150 mg/m^2 has been adopted and approved.

Targets should not be set lower than a value expected under natural conditions. As discussed in Section 3.3.6, the natural condition maximum benthic chlorophyll *a* concentration on Hoopa Valley lands is likely to be near 150 mg/m^2, but may be somewhat higher, depending on the assumptions regarding frequency of scour.

Perhaps more importantly, it would be consistent with the CA NNE approach to develop a site-specific target based on a risk analysis to support beneficial uses in the system. A key here may be establishing the periphyton conditions (and relevant indicator metrics) that are consistent with managing the parasite *Ceratomyxa shasta* at levels that are consistent with maintaining a healthy salmonid population; however, research has not yet advanced to the point where a quantitative target can be set on this basis.

4 References

Biggs, B. J. 2000. Eutrophication of streams and rivers: Dissolved nutrient-chlorophyll relationships for benthic algae. *J. N. Am. Benthol. Soc.*, 19:17-31.

Butcher, J.B. 2008. Nutrient Dynamics in the Klamath. Memorandum to Klamath TMDL Technical Team, February 12, 2008. Tetra Tech, Inc., Research Triangle Park, NC.

Chapra, S. and G. Pelletier. 2003. QUAL2K: A Modeling Framework for Simulating River and Stream Water Quality: Documentation and Users Manual. Civil and Environmental Engineering Dept., Tufts University, Medford, MA.

Collins, G.B. and C.I. Weber. 1978. Phycoperiphyton (algae) as indicators of water quality. *Trans. Am. Microscop. Soc.*, 97: 36-43.

Dodds, W. K., V.H. Smith, and B. Zander. 1997. Developing nutrient targets to control benthic chlorophyll-a levels in streams: a case study of the Clark Fork River. *Water Research*, 31(7): 1738-1750.

Dodds, W.K., V.H. Smith, and K. Lohman. 2002. Nitrogen and phosphorus relationships to benthic algal biomass in temperature streams. *Canadian Journal of Fisheries and Aquatic Science*, 59: 865-874. Errata published 2006, *Canadian Journal of Fisheries and Aquatic Science*, 63: 1190-1191.

Downing, J.A., S.B. Watson, and E. McCauley. 2001. Predicting cyanobacteria dominance in lakes. *Canadian Journal of Fisheries and Aquatic Science*, 58: 1905-1908.

Effler, S.W., R.K. Gelda, M.G. Perkins, and D.M. O'Donnell. 2005. Modeling light attenuation, Secchi disk, and effects of tripton in Seneca River, New York, USA. *Journal of the American Water Resources Association*, 41(4): 971-984.

Eilers, J.M. 2005. Periphyton in Selected Sites of the Klamath River, California. MaxDepth Aquatics, Bend, OR.

Gallegos, C.L. 1994. Refining habitat requirements of submersed aquatic vegetation: Role of optical models. *Estuaries*, 17: 198-219.

Hoopa Valley TEPA. 2008. Hoopa Valley Indian Reservation Water Quality Control Plan. Hoopa Valley Tribal Environmental Protection Agency, Hoopa Valley Tribe. February 14, 2008. http://www.hoopa-nsn.gov/documents/WQCP.pdf .

Horner, R.R., E.B. Welch, and R.B. Veenstra. 1983. Development of nuisance periphytic algae in laboratory streams in relation to enrichment and velocity, *Dev. Hydrobiol.*, 17: 121-134.

Hyenstrand, P., P. Blomqvist, and A. Petterson. 1998. Factors determining cyanobacterial success in aquatic systems – a literature review. *Arch. Hydrobiol. Spec. Issues Adv. Limnol.*, 15: 41-62.

Kann, J., and E. Asarian. 2005. 2002 Nutrient and Hydrologic Loading to Iron Gate and Copco Reservoirs, California. Kier Associates Final Technical Report to the Karuk Tribe Department of Natural Resources, Orleans, CA.

Kann, J. and E. Asarian. 2007. Nutrient Budgets and Phytoplankton Trends in Iron Gate and Copco Reservoirs, California, May 2005 - May 2006. Submitted to the State Water Resources Control Board, Sacramento, CA by the Karuk Tribe of California, Department of Natural Resources, Orleans, CA.

Kier Associates. 2005. Draft Nutrient Criteria for the Klamath River on the Hoopa Valley Indian Reservation. Prepared for the Hoopa Valley Tribal Environmental Protection Agency by Kier Associates, Mill Valley, CA, Nov. 2005.

Kirk, J.T.O. 1985. Effects of suspensoids (turbidity) on penetration of solar radiation in aquatic ecosystems. *Hydrobiologia*, 125: 195-208.

MELP. 1992. Ambient Water Quality Assessment and Objectives for Elk and Beaver Lakes, Saanich Peninsula, Water Management Branch, Environment and Resource Division, Ministry of Environment Lands and Parks, British Columbia, Canada.

Moisander, P.H., M. Ochiai, A. Lincoff, and S. Corum. 2008. Growth and toxin production of the cyanobacterium *Microcystis aeruginosa* in Klamath River reservoirs. Poster presented at Klamath Basin Water Quality Monitoring Coordination Group Spring Meeting, Yreka, CA, April 2008.

NCRWQCB. 2007. Water Quality Control Plan for the North Coast Region. North Coast Regional Water Quality Control Board, Santa Rosa, CA.

Nichols, K. and J.S. Foott. 2005. FY2004 Investigational Report: Health Monitoring of Juvenile Klamath River Chinook Salmon. U.S. Fish and Wildlife Service California-Nevada Fish Health Center, Anderson, CA.

PacifiCorp. 2005. Klamath Hydroelectric Project (FERC Project No. 2082), Response to November 10, 2005, FERC AIR GN-2, Klamath River Water Quality Model Implementation, Calibration, and Validation. PacifiCorp, Bend, OR.

Smith, V.H. 1983. Low nitrogen to phosphorus ratios favor dominance by blue-green algae in lake phytoplankton. *Science*, 221: 669-671.

Stocking, R.W. and J.L. Bartholomew. 2004. Assessing Links between Water Quality, River Health and Ceratomyxosis of Salmonids in the Klamath River System. Oregon State University, Corvallis, OR.

Tetra Tech. 2006. Technical Approach to Develop Nutrient Numeric Endpoints for California. Prepared for U.S. EPA Region IX and California State Water Resource Control Board by Tetra Tech, Inc., Lafayette, CA.

Tetra Tech. 2007. Nutrient Numeric Endpoints for TMDL Development: Klamath River Case Study. Submitted to USEPA Region IX by Tetra Tech, Inc., Research Triangle Park, NC

Trimbee, A.M. and E.E. Prepas. 1987. Evaluation of total phosphorus as a predictor of the relative biomass of blue-green algae with emphasis on Alberta lakes. *Canadian Journal of Fisheries and Aquatic Science*, 44: 1337-1342.

USEPA Region IX. 2008. Staff Report, Reconsideration of California's 2006 Section 303(d) List Omission of Microcystin Toxin Listings for Three Klamath River Segments and Determination to Add Microcystin Toxin Listing for Klamath River Hydrologic Unit (HU), Middle HA Hydrologic Area (HA), Oregon to Iron Gate. U.S. EPA Region IX, San Francisco, CA.

Walker, W.W. 1996. Simplified Procedures for Eutrophication Assessment and Prediction: User's Manual. Instruction Report W-96-2. U.S. Army Corps of Engineers. Water Operations Technical Support Program, Vicksburg, MS.

Walmsley, R.D., M. Butty, H. Van Der Piepen, and D. Grobler. 1980. Light penetration and the interrelationships between optical parameters in a turbid subtropical impoundment. *Hydrobiologia*, 70: 145-157.

Welch, E.B., J.M. Jacoby, R.R. Horner, and M.R. Seeley. 1988. Nuisance biomass levels of periphytic algae in streams. *Hydrobiologia*, 157: 161-168.

WHO. 2003. Guidelines for Safe Recreational Waters, Volume I – Coastal and Fresh Waters, Chapter 8: Algae and Cyanobacteria in Fresh Water. World Health Organization, Geneva.

APPENDIX 3

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MEMORANDUM

To:	Klamath TMDL Technical Team	**Date:**	February 12, 2008
From:	Jonathan Butcher	**Project:**	Klamath
Subject:	Nutrient Dynamics in the Klamath	**Tt Pjn:**	20729-02

Oregon DEQ (DEQ) and California's North Coast Regional Water Quality Control Board (Board) are developing Total Maximum Daily Loads (TMDLs) for the Klamath River to address impairments associated with dissolved oxygen, temperature, nutrients, pH, and chlorophyll *a* – all of which are ultimately affected by the dynamics of nutrients, algal growth, and organic matter transport in the system. The river begins at Upper Klamath Lake in Oregon and encompasses 15,722 square miles in the states of Oregon and California, flowing from the Cascades in Oregon westerly and southerly to the Pacific Ocean in Del Norte, CA. The system has several unusual characteristics. First, the gradient increases downstream. Second, the source of the river is an aging eutrophic lake, which leads to nutrient concentrations that are highest in the headwaters, while downstream tributaries generally have lower nutrient concentrations than the mainstem. Finally, there are a series of dams in the upper third of the watershed, forming a segmented system.

The Klamath is one of the major salmon rivers of the western United States, so interest in the protection, management, and restoration of the system is high. Nutrients in the system are dominated by the loading leaving Upper Klamath Lake, which cannot easily be controlled. The temporal and spatial pattern of water quality downstream is largely controlled by processes that retain, transform, or release nutrients within the impounded and free-flowing reaches, including growth of planktonic algae (primarily in impoundments), settling of nutrients to and regeneration of nutrients from the sediment (also primarily in impoundments), and uptake/release of nutrients by periphytic algae (primarily in free-flowing reaches).

PacifiCorp, which operates federally-licensed hydroelectric projects on the river, developed a simulation model of the river, linking CE-QUAL-W2 models of the impoundments with an RMA-11 model of the free-flowing reaches (PacifiCorp, 2005). This model was subsequently updated and recalibrated by Tetra Tech for USEPA, DEQ, and the Board, and forms a basis for developing the TMDL and potential management scenarios to meet the TMDL. While Tetra Tech has developed a draft model calibration report, a final public version of the report has not yet been released. Stakeholder review of the modeling effort has, however, provoked some questions regarding the processes controlling nutrient dynamics in the impounded and free-flowing reaches (particularly their relative importance), and whether the model accurately represents these processes (Asarian, 2007; PacifiCorp, 2007). In addition, several reports have been published on nutrient dynamics in the system.

To help resolve these issues, the Board and USEPA requested a review of the reports that analyze nutrient dynamics in the Klamath River system, with particular emphasis on evaluation of the effects of reservoirs in California on water quality relative to free-flowing reaches. The review was conducted by Dr. Jonathan Butcher, who is familiar with the Klamath River system, but was not directly involved in the model development effort.

1 Key Issues

The disputes over nutrient dynamics in the Klamath River system are intimately tied to the policy debate over the potential removal of hydropower dams in the Upper Klamath. PacifiCorp (2005) created the original linked water quality simulation models of the system (RMA-11 for the free-flowing reaches and CE-QUAL-W2 for the impoundments), and applied them to the 2000-2004 period, with calibration based on more intensive data collected in 2000. In a series of reports, Asarian and Kann (working variously on behalf of the Yurok and Karuk tribes) raised concerns that the model overestimated nutrient retention rates in the impoundments, while underestimating nutrient retention rates in the free-flowing reaches, resulting in an unrealistic estimate of benefits of the impoundments in controlling downstream nutrient concentrations (see Asarian and Kann, 2006a, 2006b).

Tetra Tech, for USEPA, subsequently recalibrated the PacifiCorp models for year 2000 (with validation application to the reaches above Iron Gate Dam for 2002). The recalibration effort did result in lower nutrient retention rates within the reservoirs and higher retention rates within the free-flowing segments – suggesting that some of the original criticisms of the model were correct. Asarian (2007) has continued to express concerns that the model under-represents nutrient retention in the free-flowing reaches of the river downstream of Iron Gate Dam – and thus does not provide a fair evaluation of the conditions that would result from conversion of impoundments back to free-flowing reaches. On the other side, PacifiCorp (2007) has contended that the analyses of Asarian and Kann are flawed in a variety of ways, while defending the model results.

The truth of the matter is that water quality data are fairly sparse in this system – which lends considerable uncertainty to both direct evaluations of observations and model setup and calibration. The station immediately below Iron Gate Dam (RM 189.73) has samples from 1996-2004, on a biweekly basis for 1998-2002 and monthly in other years. The key downstream station for evaluating nutrient retention at Seiad Valley (RM 130.85) has a similar density of samples only for 1998-2001. Further, samples have generally not been collected in January through April, meaning that a large portion of the total annual flow has not been sampled (see Figure 1). As a result, the mass balance and retention calculations of Asarian and Kann (2006a) are based on June through October, not complete years, preventing full closure of the mass balance.

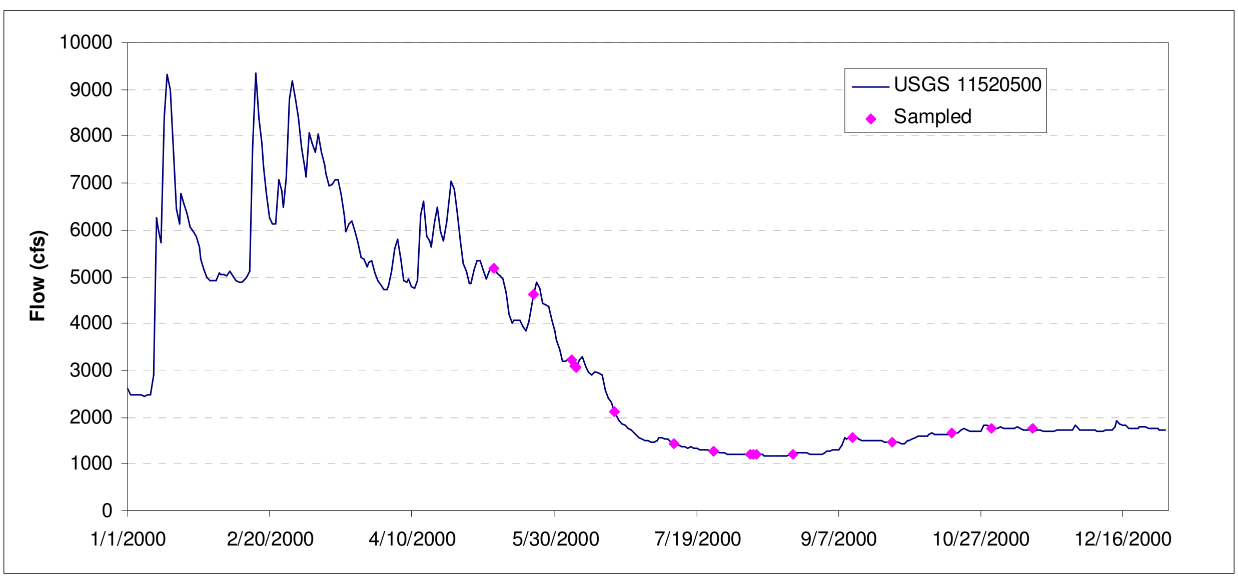


Figure 1. Daily Flows and Water Quality Samples, Klamath River at Seiad Valley, 2000

For the modeling, focus has been on 2000, as this is the year with the best information on tributary loads. Tetra Tech has run the complete, recalibrated model *only* for 2000. Indeed, due to the short residence time and elevated loads from the headwaters at Upper Klamath Lake, the model predictions are strongly determined by the boundary conditions (upstream load and relative dilution provided by the downstream tributaries), and results for years in which the boundary conditions are not well-defined are largely speculative.

It is also important to recognize that the patterns of nutrient retention are likely to vary significantly from year to year. The data analyzed by Asarian and Kann (2006a) show consistent seasonal retention of total Nitrogen between Iron Gate and Seiad Valley in some years (e.g., 2001 and 2002), but not in others. Notably, for 2000 the retention calculated for most sample dates appears to be close to the expected range of uncertainty for nitrogen concentration measurements[1] except for one date, which results in an estimation of net retention over the June-October period. The authors note (p. 42): "most of the positive retention in the Iron Gate (KR18973) to Seiad Valley (KR12858) reach for the 2000 season was due to a single high sample on 7/11/2000 at Iron Gate, when TKN was 4.5 mg/L… There are 313 TKN samples in the database below Iron Gate taken from 1971 to 2004 and this was the highest measurement, with no other samples above 2.0 mg/L…"

Both the empirical analyses of nutrient trend and the model predictions are uncertain as a direct result of the sparse data. Biweekly or monthly samples are likely to provide an inaccurate estimate of the nutrient mass entering or leaving a reach, introducing uncertainty into direct estimates of load, while similarly creating uncertainty in model forcing functions. Further, it is not appropriate to compare long term trends from the data to model results from a single year, as year-to-year variability is likely significant.

In sum, the empirical work of Asarian and Kann is most appropriate as a long-term, statistical estimate of typical removal rates. The model output, while also uncertain, provides an estimate for a specific set of flow and boundary conditions. The two should be qualitatively similar, but not identical.

2 River Retention of Nutrients

Physical and biological processes in river reaches can result in net removal or temporary retention of nutrients. One of the major processes for temporary retention is uptake of nutrients by periphyton. Periphytic algae, as well as heterotrophic organisms, require nutrients for growth and remove inorganic nutrients from the water column, converting them to organic biomass. Heterotrophs also remove organic matter as foodstock. This storage, however, is temporary. In addition to normal dieoff and predation, periphyton is subject to scour and transport downstream during high flow events.

Tanner and Anderson (1996) demonstrated that periphyton (dominantly *Cladophora*) were very effective in reducing dissolved inorganic nitrogen loads downstream of wastewater treatment plants in the South

[1] Total nitrogen is estimated as the sum of total Kjeldahl nitrogen (TKN) and nitrite-plus-nitrate nitrogen. For USGS analyses, relative standard deviations (RSDs) for these measurements in natural waters are typically in the range of 8 to 10 percent (e.g., Lambing and Cleasby, 2006), although Campbell (2001) reported RSD's less than 5 percent for Klamath River nutrient samples. Other laboratories may achieve differing levels of precision. More importantly, TKN is reported to the nearest 0.1 mg/L, while nitrite and nitrate nitrogen are reported to the nearest 0.01 mg/L, reflecting the underlying precision in the analytical methods. In the Klamath below Iron Gate, TKN often constitutes about 90 percent of total nitrogen. At a typical total nitrogen concentration of about 0.8 mg/L, there is thus a built in reporting uncertainty (reflecting the underlying analytical uncertainty) of around ±14 percent. Additional uncertainty is introduced by sampling procedures, as samples may not be fully representative of the complete flow-weighted average concentration passing a given point, and there may also be systematic changes in nutrient concentrations over the diurnal cycle due to algal influences. Finally, calculation of nutrient retention requires use of flows, which are also subject to measurement uncertainty, further decreasing the precision of mass transport estimates obtained by multiplying flow times concentration.

Umpqua River, OR. Similarly, locations in the Bow River in Alberta supported dense *Cladophora* and macrophyte growths that were sensitive to nitrogen load and effective in removing inorganic N from the water column (Sosiak, 2002). Such biological uptake is, however, largely temporary in nature, as biomass follows seasonal cycles with release of nutrients as biomass declines in the fall. Decaying periphyton mats may also promote anoxic conditions that lead to denitrification and loss of nitrogen from the system. Dodds (2003) summarized the role of periphyton in removing phosphorus from aquatic systems. Some of this storage is also temporary; however, Dodds also points out that localized increases in pH during photosynthesis can lead to increased precipitation of calcium phosphate, concurrent deposition of carbonate-phosphate complexes, and long term burial losses of phosphorus.

Temporary retention in river reaches also occurs as a result of settling and storage of particulate matter, including organic detritus. Inorganic orthophosphate and, to a lesser extent, ammonium can also sorb to sediment particles and settle out. These processes also largely constitute temporary retention, as the stored particulate matter can be remobilized by scouring flows.

Permanent removal of nutrient mass can also occur in several ways. For nitrogen, denitrification and conversion to nitrogen gas results in a loss of nitrogen from the water to the air. This may be balanced by fixation of atmospheric nitrogen by certain types of cyanophytes, but these are usually not dominant in flowing waters. Water lost to deep groundwater, agricultural diversions, or riparian wells can remove nutrients, and is more important for nitrogen, which is more soluble than phosphorus. Effective removal of phosphorus may also occur due to burial in deposits that are not readily remobilized (due, for instance, to stream meander and cutoffs), export to the floodplain, or conversion to tightly bound, insoluble mineral forms. These latter processes tend to be of less importance in higher gradient systems, so net rates of removal for TP are expected to be less than net rates of removal for TN in a system like the Klamath.

In general, temporary retention is most important during lower flow periods, which tend to coincide with the growing season. Temporary retention does not, in the end, change the nutrient load that is delivered downstream; however, it can significantly affect both the timing and bioavailability of load delivery. While extensive periphyton communities remain intact below a source area, they may substantially reduce the nutrients available to support algal growth downstream – as appears to be observed in the Klamath. High flows in the Klamath typically occur in the winter and spring. The net effect of temporary retention should thus be to shift much of the nutrient load from the summer and fall to the winter and early spring – a period for which there are very few water quality observations.

The likelihood of significant scour of periphyton can be evaluated in terms of days of accrual, using the relationship of Biggs (2000), where accrual time is defined as the number of days between events three-times the median flow. Accrual time was analyzed at each of the USGS gages. Because the Klamath is a large river with a multi-day response time, the number of events per year was estimated based on the count of times the hydrograph crossed the three-times-median threshold, rather than the number of individual days above the threshold. Resulting estimates (Table 1) show a pattern of decreasing time between scouring events with distance downstream as additional major tributaries join.

Table 1. Estimated Days of Accrual (1985-2005 Data)

USGS Gage	Average Days of Accrual
11516530: Klamath River below Iron Gate	185.7
11520500: Klamath River near Seiad Valley	122.8
11523000: Klamath River above Shasta River	81.9
11530500: Klamath River at Klamath	69.1

Nutrient concentrations measured in the Klamath tend to decrease with distance downstream from Iron Gate Dam, as has been noted by various authors. It is important to note, however, that nutrient retention needs to be evaluated as a mass balance, based on loads, not concentration trends. In the Klamath below Iron Gate, the concentrations of nutrients in many of the tributaries are generally lower than those in the mainstem; thus a reduction in mainstem concentration is expected solely as a result of dilution, regardless of whether there is any true retention.

2.1 REVIEW OF NUTRIENT MASS BALANCE ESTIMATES FOR THE LOWER KLAMATH

Asarian and Kann (2006b) evaluated the PacifiCorp modeling and contended that it overestimated retention in the reservoirs, while underestimating retention in flowing reaches. This analysis, however, is based primarily on comparison of longitudinal concentration distributions in the Klamath mainstem. This is potentially misleading for two reasons. First, the rate of change in concentration along the length of the river is in large part a function of nutrient concentrations in incremental tributary flow, which is not well characterized. Second, the sparseness of the monitoring data introduces considerable uncertainty into the analysis.

Asarian and Kann (2006a) do provide a mass balance evaluation in terms of loads, again concluding that retention in flowing reaches is underestimated by the model. The conclusions of this effort depend in part on how loads are estimated, which can be problematic for sparse data. Asarian and Kann did this as follows:

- Total N is calculated as the sum of Total Kjeldahl Nitrogen (TKN) and NO_3-N+NO_2-N.
- The biweekly (or monthly) concentration data were used to create a continuous daily estimate using linear interpolation between points.
- Resulting daily TN concentration was multiplied by flow to obtain load.
- Retention rates between stations were calculated for June-October, the period for which most monitoring is available.

As noted above, because only a seasonal estimate can be made, the approach measures net retention, not removal, and a significant portion of the retained load may be mobilized and moved downstream by winter flows. Methodologically, the other major concern is the use of linear interpolation.

Estimating constituent mass loads from point-in-time measurements of water-column concentrations presents many difficulties. Load is determined from concentration multiplied by flow, and while measurements of flow are continuous, only intermittent measurements of concentration are available. Calculating total load therefore requires “filling in” concentration estimates for days without samples. The process is further complicated by the fact that concentration and flow are often highly correlated with one another, and many different types of correlation may apply. For instance, if a load occurs primarily as a result of nonpoint soil erosion, flow and concentration will tend to be positively correlated; that is, concentrations will increase during high flows, which correspond to precipitation-washoff events. On the other hand, if load is attributable to a relatively constant point discharge, concentration will decrease as additional flow dilutes the constant load. In most cases, a combination of processes is found.

Preston et al. (1989) undertook a detailed study of advantages and disadvantages of various methods for calculating annual loads from tributary concentration and flow data. Their study demonstrates that simply calculating loads for days when both flow and concentration have been measured and using results as a basis for averaging is seldom a good choice. A method dependent on interpolation between measured concentrations is likely to have similar problems. Depending on the nature of the relationship between flow and concentration, more reliable results may be obtained by one of three approaches:

- Averaging Methods: An average (e.g., yearly, seasonal, or monthly) concentration value is combined with the complete time series of daily average flows
- Regression Methods: A linear, log-linear, or exponential relationship is assumed to hold between concentration and flow, thus yielding a rating-curve approach
- Ratio Methods: Adapted from sampling theory, load estimates by this method are based on the flow-weighted average concentration times the mean flow over the averaging period and performs best when flow and concentration are only weakly related.

No single method provided superior results in all cases examined by Preston et al.; the best method for extrapolating from limited sample data depends on the nature of the relationship between flow and concentration, which is typically not known in detail.

Thus, the accuracy of the interpolation approach will depend in large part on whether there is correlation between flow and concentration. If the two variables are truly independent, then no error will be introduced by this approach. If they are correlated, the approach is sub-optimal.

Reducing the potential impact of these issues is the fact that the Upper Klamath is a highly controlled system, with multiple reservoirs. These reservoirs should serve to damp out correlations between flow and concentration, particularly for the reach between Iron Gate and Seiad. As the river accumulates more uncontrolled tributary flow downstream, correlation may reemerge, rendering the load estimates suspect. (Indeed, this might be why Kann and Assarian detected no nitrogen retention below Orleans).

Campbell (2001) analyzed monitoring data from 1996 through 1998 from Keno Dam to Seiad Valley, and concluded that there was a negative correlation between flow and concentration for all nutrient species, and that this negative correlation became stronger downstream (as far as Seiad Valley). This type of situation can arise when nutrient loads are dominated by lake sources, and tributary stormflow contributions – even if elevated relative to baseflow – serve to dilute the mainstem concentration. Reexamination of the detailed 2000 USGS monitoring at Seiad Valley confirmed a negative correlation between TKN and flow, but showed essentially no correlation between TP and flow.

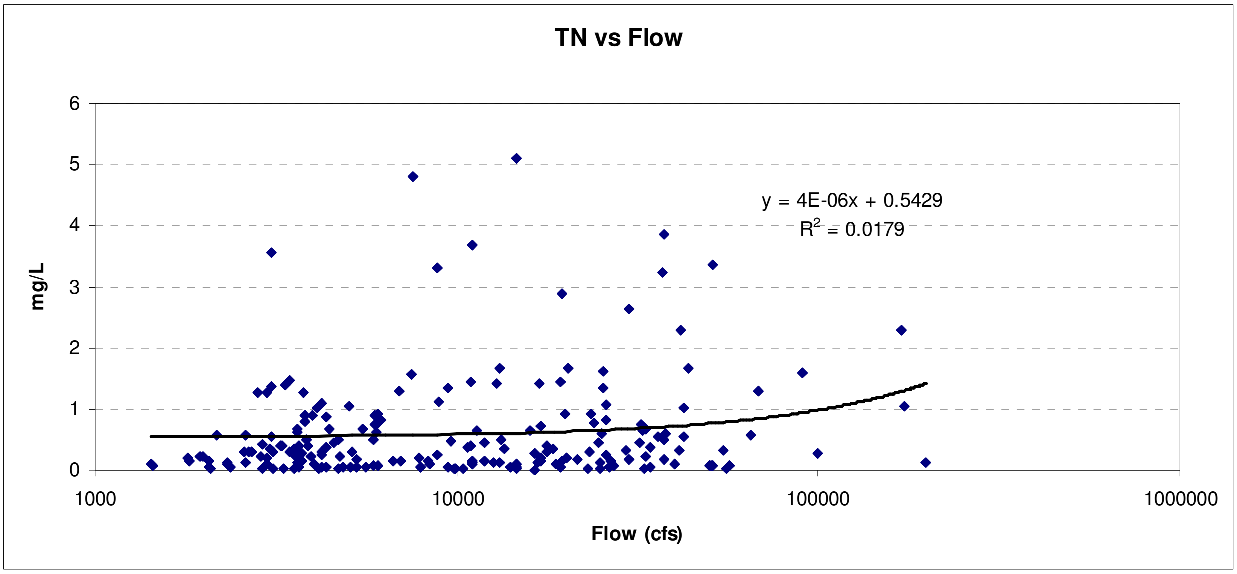
Further downstream, USGS nutrient water quality monitoring from 1973 to 2003 is available at Klamath, CA (USGS gage 11530500), and these data were examined as a check. As shown in Figure 2, concentration is only weakly related to flow at this station, and, while the slope is positive, it is not significant. The relationships remain weak if results are stratified into summer and winter seasons.

To the extent that flow and concentration are truly independent of one another, the simple interpolation method used by Asarian and Kann will not introduce error. However, where and when a negative correlation between flow and concentration exists, the interpolation approach will tend to overerestimate total load – because concentrations that are too high will tend to be applied to the high flow events that constitute the bulk of the total movement of mass. If, as expected, the negative correlation is strongest immediately downstream of Iron Gate and decreases downstream, this could introduce a bias that results in overestimation of the nutrient retention between Iron Gate and Seiad Valley.

Despite these caveats, the approach taken by Asarian and Kann seems likely to provide reasonable estimates of seasonal nutrient retention over the long term (although not removal, as full-year mass balances are not available). Asarian and Kann, however, attempt to take the analysis further, evaluating retention by reach first on a yearly, and then on a monthly basis. As each month is represented by only one or two sampling events (and these events likely did not sample the same parcel of water), this is asking too much of the sparse data. Due to the uncertainty present in the data and the method, the best that can be hoped for is a statistical convergence to a reasonable estimate. Interpretations of the magnitude of retention for individual months are at best suspect.

Due to changes in sample locations, more than two years of data are available only for the reach Iron Gate to Seiad Valley. For the whole analysis period evaluated by Asarian and Kann (1998-2002), the June-

October net retention of TN is 18.6 percent, or 0.31 percent per mile. It should be remembered that this seasonal estimate is likely an upper bound on the annual retention, as it includes temporary storage that will be flushed downstream during winter high flows.



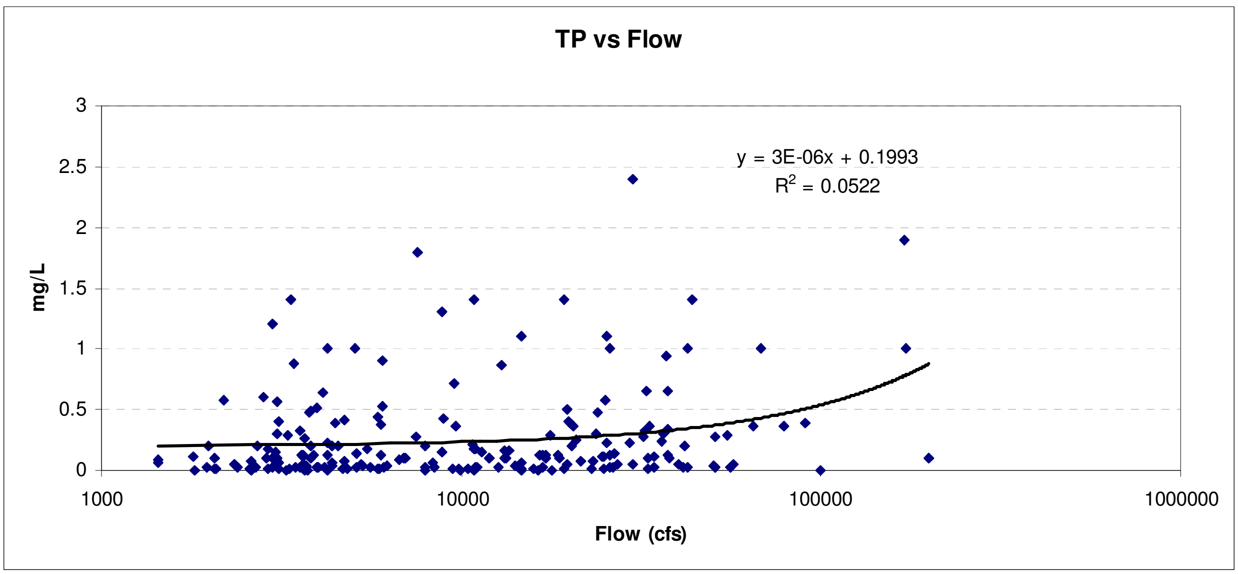


Figure 2. Relation of Nutrient Concentration to Flow, Klamath River at Klamath, CA

2.2 EXPECTED RANGE OF RIVER RETENTION ESTIMATES

USGS, as part of its Spatially Referenced Regressions on Watershed Attributes (SPARROW) project had developed generalized reach removal coefficients for TN and TP based on analysis of monitoring records of 381 USGS National Stream Quality Accounting Network (NASQAN) monitoring sites throughout the US (Smith et al., 1997). Removal is represented as an exponential decay process, such that the retention in a reach is given by

$$\text{Retention} = 1 - \exp(-\delta t),$$

where δ is a loss coefficient (day^{-1}) and t is travel time in days. The national coefficients originally developed by Smith et al. (1997) were revised by Smith et al. (2003a), as reported in Smith et al. (2003b). Median flows in the Klamath downstream of Iron Gate are greater than 1000 cfs, but less than 10,000 cfs, so the relevant national decay coefficients are 0.118 day^{-1} for TN and 0.098 day^{-1} for TP. The mean travel time from Iron Gate to Seiad is on the order of 2 days, so we would expect, as a long-term average, loss rates of about 21 percent for TN and 17 percent for TP. The growing season TN retention estimates for this reach given by Asarian and Kann range from 20 to 61 percent – but retention over the growing season is likely to be higher than annual net retention due to temporary storage in periphyton.

The SPARROW estimates of loss depend entirely on the decay coefficients, which are subject to considerable uncertainty and vary as a result of site-specific conditions. Other evidence is available in recently completed work of Armstrong and Ward (2008), who developed a simplified model of Klamath summer monitoring data for 2001-2005. Their application is a spreadsheet plug-flow model in which the decay rates for TN and TP are taken as calibration parameters. The methodology has some potential problems: First, it is sensitive to assumptions about tributary loads, which are poorly characterized for many of these years. Second, the approach fits individual decay rate estimates for each month in the dataset, which likely leads to over-fitting of the data. Finally, a single decay rate is applied for each month to the entire distance between Iron Gate and Turwar. However, the results are useful in providing another independent estimate of potential retention / loss rates in the Klamath River. Finally, the analyses cover only the June through October period, so one can examine only seasonal retention, not ultimate loss.

The decay rates fit by Armstrong and Ward range between 0.005 and 0.15 day^{-1} for both TN and TP, and are generally higher in the summer, suggesting that periphyton uptake may be a significant component of the retention. The authors do not provide an integrated summary of their decay rate estimates; however, examination of their Figure 33 suggests that the median decay rates were 0.005 day^{-1} for TN and 0.075 day^{-1} for TP. For two day travel between Iron Gate and Seiad, this would imply nitrogen retention of only 1 percent and phosphorus retention of 14 percent. (For individual months in which the estimated decay rate reached 0.15 day^{-1} the retention would be 26 percent.) These results suggest that the seasonal retention rate for TN in the Klamath could well be much less than predicted by SPARROW; however, they do not preclude the possibility that retention rates are much higher between Iron Gate and Seiad Valley than between Seiad Valley and Turwar, as suggested by Asarian and Kann (2006a). The results of Armstrong and Ward are also subject to considerable uncertainty. They report relative percent error on model-predicted concentration by month, ranging from 2 to 102 percent for total nitrogen (with median of 19 percent) and 3 to 22 percent for total phosphorus (with median of 11 percent).

2.3 RMA-11 IMPLEMENTATION

RMA-11 (King, 1998) simulates four state variables for nitrogen (nitrate, nitrite, ammonia, and organic N) and two state variables for phosphorus (dissolved P and organic P). Algal biomass also acts as a store of nutrients. Sorption of inorganic P to suspended sediment is represented as a sink, not a state variable, and thus forms a loss pathway from the system. Settling rates can be specified for organic N and organic P, again representing losses. While both deposition and scour of sediment are simulated by the model, the sediment mass balance is not directly linked to the nutrient mass balance (except through sorption of inorganic P). Algae take up inorganic nutrients during photosynthesis and convert them to organic nutrients, which are released during respiration (as inorganic nutrients) or decay (as organic nutrients). Algae can settle to the sediment, creating a sink for nutrients. (While the model documentation also discusses algal losses to grazing, this is apparently not implemented in the version of the model used for the Klamath.)

Thus, RMA-11 can potentially simulate internal nutrient losses (other than advection out of the system) in four ways: settling or grazing of algae, settling of organic N, settling of organic P, and sorption of inorganic P. RMA-11 can also simulate releases from the sediment of inorganic P and ammonium. Within the model, the phytoplankton settling rate was initially set to zero (PacifiCorp, 2005), but subsequently revised by Tetra Tech to match organic matter settling rates (0.05 m/day). PacifiCorp does not document the values for the other relevant rate constants; however, inspection of the model input shows that sorption losses of inorganic P are not simulated because TSS is not simulated. Net settling of organic N and organic P occurs in accordance with an organic matter settling velocity of 0.05 m/day (a very low value based on assumptions that net settling will be minimal in a fast-flowing river). No sediment releases of inorganic P or ammonium are specified.

Within the Klamath, periphytic algae can play an important role in nutrient cycling although quantitative data are limited and have been cited as a significant data gap (Flint et al., 2005). RMA-11 (King, 1998) has a rather simplistic representation of periphytic algae and algal-related nutrient cycling. This was somewhat remedied by project-motivated modifications to the RMA-11 (v41) code that separated algal respiration and death and added organic matter as a state component. Benthic algae are simulated as if they were planktonic algae, except not subject to advection or settling.

Despite the modifications to the algal code for the Klamath project, RMA-11 omits various processes that could potentially reduce its ability to accurately represent nutrient cycling in the free-flowing reaches of the Klamath. The importance of these processes is generally not known for the Klamath, so they can only be discussed in a speculative context. The majority of these processes are omitted from most other river water quality models as well. Among these are the following:

- RMA-11 does not simulate **denitrification**, the rationale being that this is not a significant pathway in free-flowing, relatively shallow rivers since denitrification bacteria require hypoxic conditions, as well as ample fixed carbon and nitrate supplies. In some rivers, however, there is evidence of significant denitrification occurring within the bed. The general thinking is that denitrification is of little significance in the well-oxygenated sediments of gravel-bed streams (Allan, 1995), and gravel-bed streams are more likely to convert ammonium to nitrate (e.g., research in the Williamette reported by Fernald et al., 2006). Denitrification in the Klamath mainstem is likely limited by the availability of organic matter in the bed. Anoxia under decaying periphyton mats could, however, form a locus for denitrification (Triska and Oremland, 1981). Omission of this pathway may cause the RMA-11 model to underestimate nitrogen loss rates in the river; however, the magnitude of this error is not known. Similarly, RMA-11 (like most other river water quality models) does not simulate chemical reactions that may precipitate inorganic phosphorus in inorganic forms.
- RMA-11 does not simulate **luxury uptake** of nutrients by periphytic algae. In many cases, algae may be able to uptake and store excess nutrients against future growth requirements (Droop, 1983). This phenomenon is more likely to be a significant factor when there is strong temporal variability in nutrient availability. The presence of upstream impoundments tends to smooth out temporal variability in the lower Klamath, and may thus reduce the impact of luxury uptake on retention.
- The Klamath version of RMA-11 simulates respiration as the inverse of photosynthesis. That is, while photosynthesis involves the uptake of inorganic nutrients and inorganic carbon to form biomass, respiration is assumed to release equal amounts of inorganic nutrients and carbon (PacifiCorp, 2005, Appendix A). In reality, the releases of nutrients (if they occur) are likely to be at least in part in organic form. Related to the previous bullet, there is no provision for intracellular storage of nutrients as fixed-carbon energy sources are oxidized. The result is that the model simulation of diurnal ammonium concentrations shows greater variability than

observed data during the growing season, with concentrations depressed during periods of photosynthesis, then enhanced during night-time respiration.

- The RMA-11 model, like most other river models, does not consider the interaction of stream nutrients with riparian perennial vegetation, which may provide for long term sequestration of nutrients. Riparian vegetation is most often thought to intercept nutrients derived from upland sources. However, in a gravel bed river nitrogen in the hyporheic zone derived from the river can be taken up directly by the roots of woody vegetation (Peterjohn and Correll, 1994; Naiman et al., 2000). Species such as alder may act as net nitrogen sources, however, due to their ability to fix atmospheric nitrogen. The net balance of these processes is unknown for the Klamath.

Together, these simplifying assumptions in RMA-11 would tend to result in an underestimate of retention and an over-estimation of the downstream transport of inorganic nutrients during the algal growing season. Denitrification seems likely to be the most significant omitted factor in the Klamath, but its impact is not known for this system.

As implemented for the Klamath, there are very few ultimate sinks for nutrients in RMA-11. Settling of organic nutrients and algae will constitute a loss, but this loss will be small, given the low settling velocity and short travel times. Nutrients taken up by periphyton will be temporarily retained, but will be re-released as periphyton dies off or is scoured. The simulation of periphyton in the model indeed begins with low periphyton biomass, increases to higher biomass in summer, then declines back toward zero (Figure 3).

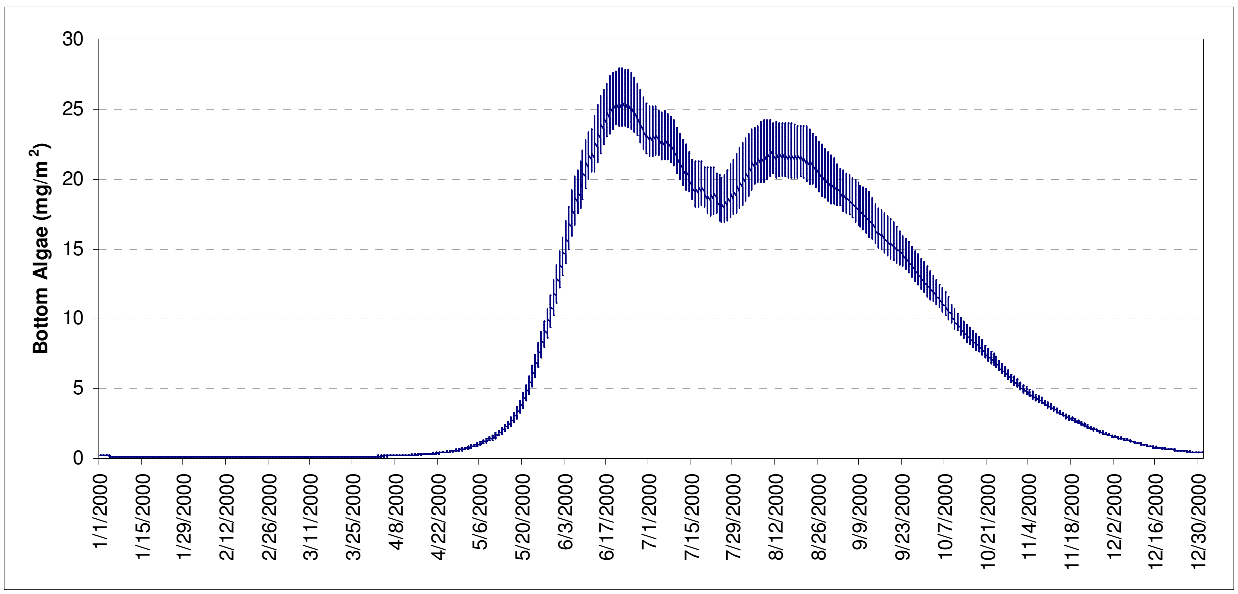


Figure 3. Periphyton Biomass Concentration Simulated for Klamath Upstream of Scott River

From Figure 3 we can conclude that periphyton, as simulated in the model, do not represent a significant net sink of nutrients, because the biomass declines back toward zero by the end of the year. It is also of interest to note that there is only one brief period (late May to early June) in which rapid accrual of periphyton biomass is simulated. Only during this period would we expect to see significant nutrient retention predicted for periphyton. During other periods, the periphyton are simulated as remaining at approximately steady biomass (in which case inorganic nutrient uptake should be balanced by output of inorganic and organic nutrients), or declining (in which case they will be creating a net increase in nutrient loads.)

Given the limitations of the RMA-11 code and the way it is parameterized for the Klamath, it appears clear that the model would not be expected to predict net removal of more than a few percent of total nutrient loads in free-flowing reaches of the river over the course of a year.

To test model behavior, a mass balance was constructed from the river and boundary flow and concentration data in the model. Loads were estimated on a monthly basis for TN, TP, NO_2+NO_3, PO_4, organic N, and organic P. The organic N and P components of non-living organic matter were calculated from organic matter concentrations according to the stoichiometry described in the model calibration report (organic N = 0.07 x organic matter; organic P = 0.0055 x organic matter). Within the Klamath, a noticeable fraction of the nutrient load may be transported in the form of living planktonic algae. Therefore, the planktonic algal biomass was also converted to organic N and organic P, using the same stoichiometry.

Model mass balance results were calculated for each river reach from Iron Gate to Seiad, but the net results over this whole distance are most informative (Table 2 and Table 3). For 2000, the model predicts TN loss/retention of 0.37 percent and TP loss/retention of 0.52 percent. For the period of June – September analyzed by Asarian and Kann (2006a), the TN retention predicted by the model is 1.05 percent. These results are less than estimated from the SPARROW methods or by the analyses of Asarian and Kann. They are, however, generally consistent with the analyses of the 2001-2005 data by Armstrong and Ward (2008), which suggest a TN retention rate of approximately 1 percent between Iron Gate and Seiad. As noted above, all these estimates of retention are subject to considerable uncertainty. This is an unavoidable result of the sparse data available. It is possible that RMA-11 would tend to underestimate seasonal nutrient retention rates due to the omission of various processes that can enhance nutrient retention and loss. However, the data are not sufficient to determine whether such an underestimation exists or is statistically significant. A comparison of nutrient losses on a full-year basis cannot be made, because both Asarian and Kann (2006a) and Ward and Armstrong (2008) worked with only seasonal nutrient data.

Table 2. Total P Mass Balance (kg) for RMA-11 Application for Year 2000, Klamath River from Iron Gate Dam to Seiad, CA

Month	IN	OUT	Change	Retention
1	37,751	36,027	-1,724	4.57%
2	68,409	68,106	-303	0.44%
3	72,501	72,325	-176	0.24%
4	55,820	55,551	-270	0.48%
5	56,498	56,220	-277	0.49%
6	38,889	39,155	266	-0.68%
7	23,875	23,416	-460	1.93%
8	27,364	26,949	-416	1.52%
9	25,776	26,123	348	-1.35%
10	23,951	24,095	143	-0.60%
11	19,410	19,746	337	-1.73%
12	15,159	15,288	129	-0.85%
Whole Year	465,403	462,999	-2,404	0.52%

Table 3. Total N Mass Balance (kg) for RMA-11 Application for Year 2000, Klamath River from Iron Gate Dam to Seiad, CA

Month	IN	OUT	Change	Retention
1	260,614	260,409	-205	0.08%
2	264,131	261,344	-2,787	1.06%
3	281,346	278,604	-2,742	0.97%
4	244,653	243,079	-1,573	0.64%
5	154,400	156,288	1,888	-1.22%
6	105,152	105,184	32	-0.03%
7	62,008	59,356	-2,652	4.28%
8	73,882	71,031	-2,852	3.86%
9	78,354	80,464	2,110	-2.69%
10	86,365	87,557	1,192	-1.38%
11	83,931	84,289	357	-0.43%
12	88,934	89,489	555	-0.62%
Whole Year	1,783,771	1,777,092	-6,679	0.37%

The model does predict a seasonal pattern of temporary retention in the spring and summer, followed by releases in the fall as periphyton densities decline. Plots of the cumulative changes in nitrogen and phosphorus component loads over the simulation year 2000 (Figure 4 and Figure 5) suggest that the spring to early summer period is dominated by the decay of organic matter to inorganic nutrients, followed by uptake of ammonium and inorganic P as periphyton growth accelerates in May and release of organic nutrients as the periphyton reaches senescence.

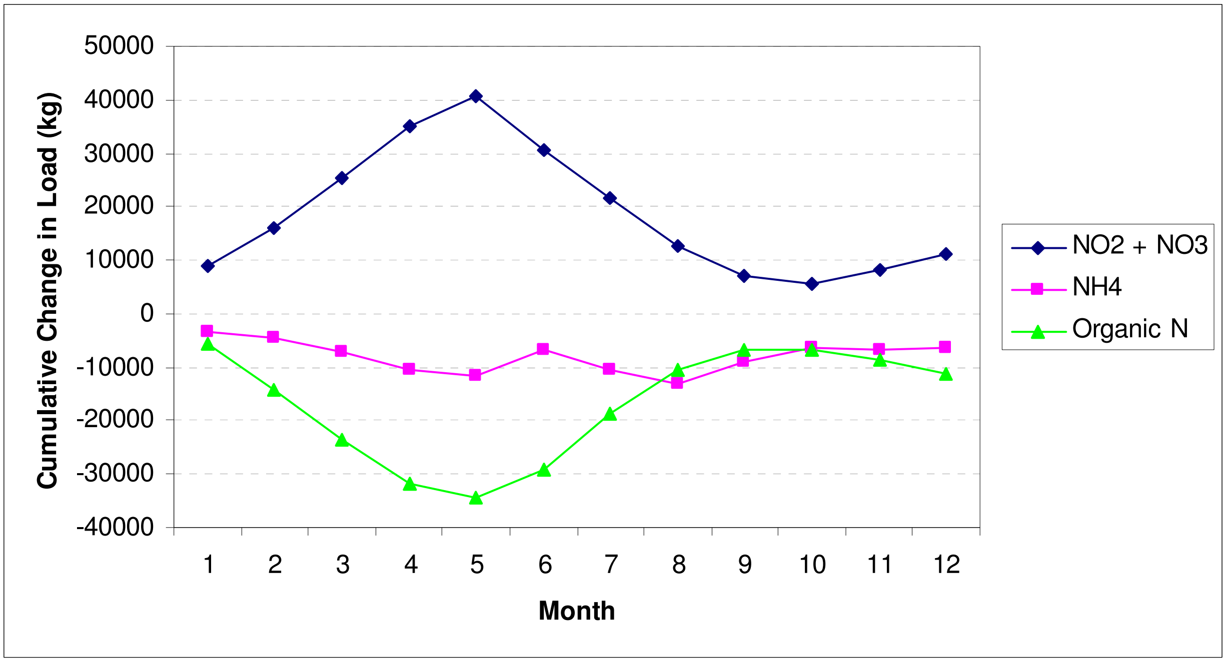


Figure 4. Cumulative Change in Nitrogen Load Predicted by Klamath River Model, Iron Gate to Seiad, for Year 2000

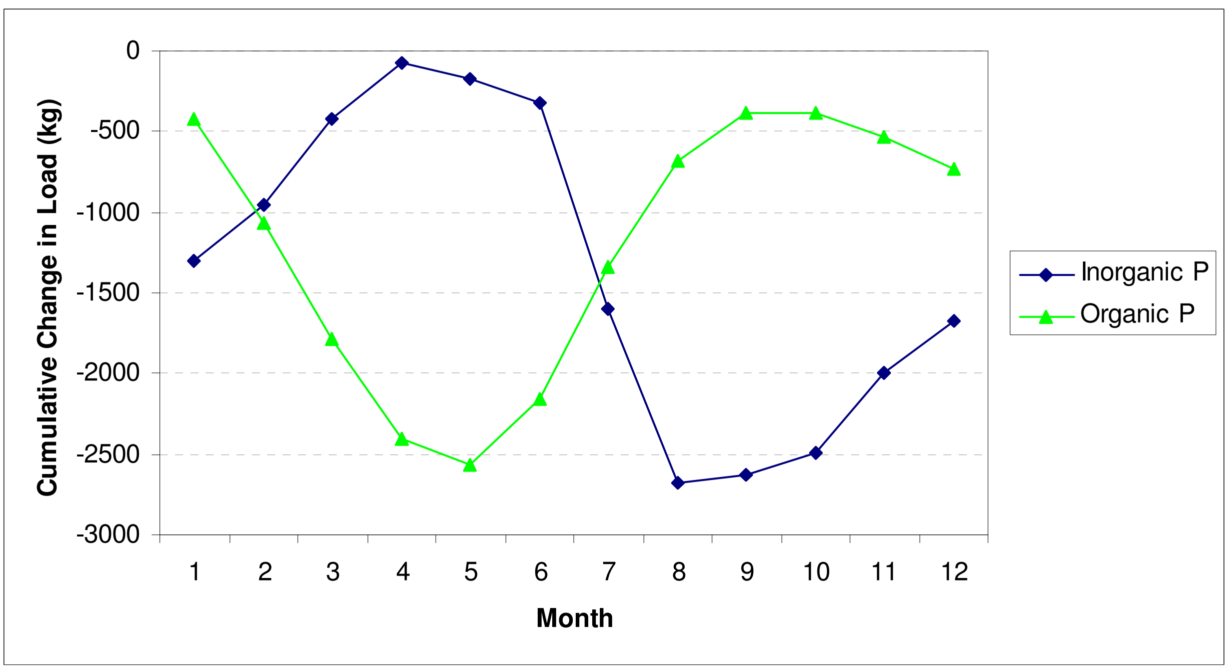


Figure 5. Cumulative Change in Phosphorus Load Predicted by Klamath River Model, Iron Gate to Seiad, for Year 2000

While the model predicts little change in total loads over the course of a year during transit from Iron Gate to Seiad Valley, the annual flow-weighted concentration does decline, by about 17 percent for TN and 19.5 percent for TP (Figure 6). This decline is almost entirely due to accumulation of flow from cleaner tributaries, which dilutes the load originating above Iron Gate dam – and points out the pitfalls inherent in trying to assess retention based only on concentration.

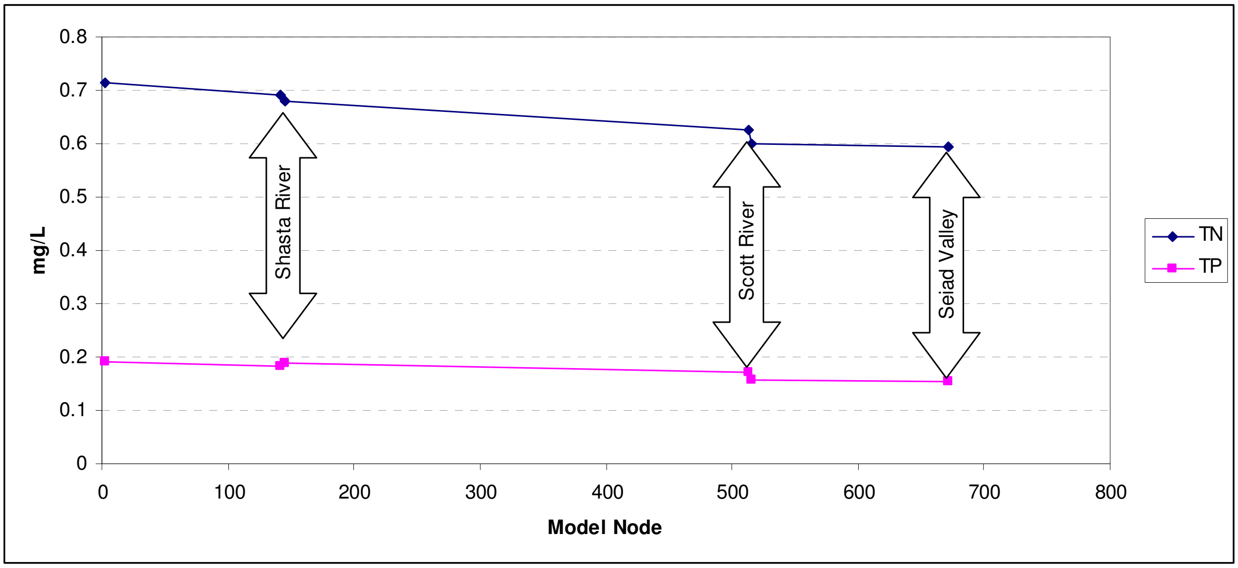


Figure 6. Annual Flow-Weighted Concentrations for 2000 Model Run

In sum, the RMA-11 model application predicts little nutrient loss in the free-flowing reaches of the Klamath, although there is seasonal retention. Even adjusted for partial year estimates, this is at odds with the estimates of Asarian and Kann (2006a), as well as estimates from the USGS SPARROW model. The result is not unexpected, given that RMA-11 provides few permanent sinks for nutrients. The importance of potential sinks (such as denitrification) is unclear, and the estimates from Asarian and Kann (based on limited data) and SPARROW (an approximate, national-scale method) are subject to considerable uncertainty. However, it does appear that the RMA-11 model may have some tendency to underestimate nutrient losses in the free-flowing reaches of the Klamath. The data are not sufficient to resolve whether these factors are significant relative to the overall mass balance, and the magnitude of any such effect cannot be fully resolved without more intensive sampling, coupled with model application to intensively sampled years.

3 Reservoir Retention of Nutrients

Reservoirs can be effective traps of influent nutrients. By design, reservoirs represent areas of a river system in which velocity is decreased and residence time increased. This encourages the settling of particulate material, including both nutrient-bearing organic detritus and nutrients sorbed to inorganic sediment. Reservoirs also encourage the growth of planktonic algae, and settling of dead algal detritus can increase loss rates.

In general, these factors would lead to increased nutrient loss in reservoirs as opposed to free-flowing reaches. The difference, however, depends on reservoir residence time (which is short in the Klamath reservoirs). In addition, there are several compensating factors. First, algal growth in deeper reservoirs is primarily planktonic, and plankton are readily advected downstream, unlike periphytic algae, so reservoirs with short retention times may provide less retention of nutrients than free-flowing reaches.

Second, under anoxic conditions there is typically significant evolution of phosphorus and ammonium from lake sediments (internal loading).

3.1 MASS BALANCE ANALYSES FOR RESERVOIR RETENTION IN THE KLAMATH

The first attempt at nutrient budgets for Iron Gate Reservoir was made by USEPA (1978), based on 1975 monthly sampling. They concluded that the mass of nitrogen leaving Iron Gate was 21 percent higher than inflow, while the reservoir retained 7 percent of the phosphorus mass. As noted by Kann and Asarian (2005), these estimates are based on limited data and are not corrected for changes in reservoir storage.

Kann and Asarian (2005, 2007) have produced two reports on the nutrient budgets of Iron Gate and Copco reservoirs. The first evaluated monthly sampling collected for relicensing purposes in 2002. Unfortunately, data were collected only for March through November, and do not include the full turnover period, so a full year mass balance cannot be created. As with their work on mass balances in the river, Kann and Asarian interpolated concentrations between sampling dates and attempted to evaluate the mass balance on a monthly basis. As with the river, the limited sampling basis and the associated uncertainty in mass calculations renders monthly calculations suspect. Over the period from April 1 to November 13, they estimated net retention in Copco of 36.29 metric tons of TP (26.3 percent of influent loads), and 48.20 metric tons of TN (8.1 percent of influent loads). Over the same period, Iron Gate was estimated to retain 32.4 metric tons of TP (27.3 percent of influent loads) and 65.8 metric tons of TN (12.4 percent of influent loads). Because the calculations do not include the full fall turnover or winter flushing flows, these can be taken as upper bounds on the annual retention. Both reservoirs showed a noticeable shift from inorganic N in the influent to organic N in the effluent, apparently due to algal uptake.

Kann and Asarian (2007) analyzed a complete year of biweekly data collected from May 2005 to May 2006 at several locations in Iron Gate and Copco and their tributaries. Over the entire year, Copco was estimated to retain 9.4 percent of influent phosphorus and 9.1 percent of influent nitrogen, while Iron Gate was estimated to retain 3.1 percent of influent phosphorus and 10.0 percent of influent nitrogen. The annual balances are, however, subject to considerable uncertainty due to large uncertainties in flow measurements (as well as the uncertainties in water quality sampling) over the winter high flow period. For the growing season, defined as May 18 2005 to October 5 2005, Copco was estimated to retain 3.3 percent of influent phosphorus and 18.2 percent of influent nitrogen, while Iron Gate was estimated to retain 0.5 percent of influent phosphorus and 15.3 percent of influent nitrogen. The phosphorus retention rates estimated for the 2005 growing season are dramatically lower than those obtained for 2002 data. Kann and Asarian attribute this difference to higher levels of dissolved P in inflows, coupled with internal P loading. Nitrogen retention estimates for the growing season are twice those obtained earlier for Copco and similar to the 2002 results for Iron Gate.

The differences in the retention rates estimated in the two studies may reflect actual differences in reservoir behavior from year to year. However, it is likely that much of the difference in estimates reflects uncertainties in estimation from limited data. For example, in the 2005-2006 data for Copco inflows, the coefficient of variation (standard deviation divided by the mean) is 0.29 for TP and 0.25 for TN, while the standard error on the mean is 6.2 percent of the influent mean value for TP and 5.3 percent of the influent mean value for TN. Over the summer growing period, the standard errors on the mean for both TP and TN are approximately 9 percent of the influent mean value. The retention estimates are thus generally within the range of two standard errors on the influent mean. This uncertainty or variation in the data supports the need for a modeling approach to interpolate through the limited observations.

As in the earlier report, Kann and Asarian (2007) attempted analyses of mass balances on a monthly basis, and detected periods of negative retention. As each month has only two samples, these estimates are highly uncertain, and results for any given month may be only an artifact of the data. As noted by PacifiCorp (2006), there is a lag time between nutrients entering Copco and being discharged from Iron Gate. As a result of this lag, "it is expected that at times the nutrient concentration in release waters from Iron Gate Reservoir…may be greater than in the inflowing waters to Copco reservoir on the same day, even though the reservoirs act to retain and reduce the loads from these nutrient 'events' as they move through the reservoirs."

3.2 EXPECTED RANGE OF RETENTION

As with the SPARROW estimates for stream reaches, there are simplified empirical methods for estimating nutrient retention in reservoirs that can be used to evaluate whether estimates based on limited observations are reasonable.

Under steady-state conditions,

$$\text{Retention} = 1 - \frac{C}{C_i},$$

where C is the mixed concentration at the dam, and C_i is the influent concentration. In a simple, first-order representation of sedimentation loss, this yields

$$\text{Retention} = 1 - \frac{1}{1 + BT},$$

where B is a first-order sedimentation loss coefficient and T is residence time. For TN, Bachman (1980) gives an estimate of B in terms of flushing rate, as

$$B_{TN} = 0.693\, T^{-0.55}.$$

Similarly, for TP, Vollenweider (1976) estimated

$$B_{TP} = T^{-0.5}.$$

An alternate analysis of TP retention based on an analysis of oxic lakes, exclusive of internal sources, is given by Nürnberg (1984) as

$$\text{Retention} = \frac{15}{18 + z/T},$$

where z is the average depth.

For the two downstream reservoirs in the Klamath system, Copco and Iron Gate, the relevant parameters are given in Table 4. Determination of a residence time is problematic for run-of-river reservoirs that are dominated by winter flow-through. Not only does residence time vary throughout the year, but in addition the reservoirs are not well-mixed in summer, and retention time in the hypolimnion may be much longer than in the epilimnion. For the period of May 2005 through May 2006 reported by Kann and Asarian (2007), the overall residence time in both reservoirs was on the order of 6 days, but the summer residence time of surface waters was around 20-25 days for Copco and 25-35 days for Iron Gate (but can reach as high as 50 days in Iron Gate). For this simple comparison, compromise values of 14 and 16 days were used, combined with summer mean depth.

Table 4. Hydraulic Parameters for Klamath Reservoirs (May 2004 – May 2005)

Impoundment	Residence Time (*T*, yrs)	Mean Depth (*z*, m)
Copco	0.0384	11.7
Iron Gate	0.0484	16.6

Note: Approximate values for summer growing period based on analysis of 2002 and 2004-2005 data in Kann and Asarian (2005, 2007)

Reservoir nutrient retention estimates obtained from the several empirical methods are shown in Table 5, along with the full-year estimates provided by Kann and Asarian (2007). The latter also provide a range of literature-based estimates (Kann and Asarian, 2007, Section 3.4.5.2). For short residence time lakes, the Vollenweider method gives significantly higher retention than that of Nürnberg, with the latter likely being more appropriate. The estimates of Kann and Asarian (2007) on an annual basis are in general agreement with the empirical estimates. Estimated retention is perhaps a little higher than predicted in Copco and lower in Iron Gate – which may reflect the fact that these two reservoirs are in series, with more easily removable material being retained upstream in Copco.

Table 5. Estimated Nutrient Retention for Copco and Iron Gate Reservoirs, 2004-2005

Parameter	Method	Copco	Iron Gate
TP	Vollenweider (1976)	16.4%	17.3%
TP	Nürnberg (1984)	4.6%	3.8%
TP	Range of 5 methods cited by Kann and Asarian (2007)	1.4% - 29%	-1.9% - 29%
TP – 2004-2005 data	Kann and Asarian (2007)	9.4%	3.1%
TN	Bachman (1980)	13.8%	14.5%
TN	Range of 2 methods cited by Kann and Asarian (2007)	8.7% - 10.3%	9.4% - 10.0%
TN – 2004-2005 data	Kann and Asarian (2007)	9.1%	10.0%

3.3 CE-QUAL-W2 IMPLEMENTATION

The CE-QUAL-W2 model (Cole and Wells, 2005) is a two-dimensional, longitudinal/vertical (laterally averaged) hydrodynamic and water quality model that is frequently applied to reservoirs. The model simulates inorganic nutrients (orthophosphate, ammonium, nitrite/nitrate) along with organic matter (labile and refractory, dissolved and particulate) and algae. Decay of organic matter and respiration/death of algae releases inorganic nutrients, while algal growth converts inorganic nutrients to organic matter. In addition to inflow and outflow, the model represents the following internal sources and sinks of nutrients:

Sources	Sinks
Release of PO_4 from sediment under anaerobic conditions Release of NH_4 from sediment under anaerobic conditions	Settling of PO_4 Settling of organic matter Settling of algae Denitrification (loss to atmosphere)

Unlike RMA-11 applications to rivers, the nutrient sinks in CE-QUAL-W2 can be significant. The current version of the model also has the ability to simulate macrophytes with direct uptake of nutrients from the sediment; however, this pathway is not considered important and is not implemented in the Klamath models.

Several other potential source/sink pathways are not included in the model, including:

- Release of inorganic nutrients from the sediment under aerobic conditions (usually not a significant process except in shallow lakes where wind-induced scour can redistribute sediment-sorbed nutrients into the water column).
- Release of organic matter from the sediment.
- Settling of NH_4 (like phosphorus, ammonium can sorb to particulate matter and settle out of the water column).
- Nitrogen fixation (some cyanophytes can fix gaseous nitrogen, resulting in a net input of nitrogen to the system).

It is expected that none of these pathways will be significant in the nutrient mass balance for the Klamath reservoirs. Nitrogen fixation is important in some systems where nitrogen supply is limited. The Klamath reservoirs, however, usually have adequate inorganic nitrogen supplies to support algal growth. Under these circumstances, N-fixing algae tend to uptake dissolved nitrogen directly from the water column as opposed to the air, as nitrogen fixation is a highly energy-demanding process (Welch and Jacoby, 2004).

As with the river simulation, the Klamath River model run output for year 2000 was used to examine the mass balance of nutrients in Iron Gate and Copco Reservoirs. The modelers provided the initial and ending storage volumes, which were combined with concentrations to estimate the change in nutrient storage over the course of the simulation. TN and TP mass balances for the two reservoirs for 2000 are summarized in Table 6 through Table 9.

For TP, the annual retention rate estimated for the model is 6.11 percent for Iron Gate and 1.22 percent for Copco. These are in the range predicted by the Nürnberg (1984) model, although the retention rate for Copco appears a bit low, and also in the range of literature estimates reported by Kann and Asarian. For TN, the annual retention rate estimated by the model is 17.63 percent for Iron Gate and 3.61 percent for Copco. The estimate for Iron Gate is similar to that from the Bachman (1980) estimator and higher than that estimated by Kann and Asarian (2007) for 2004-2005. The TN retention rate for Copco appears low relative to both the Bachman estimate and the analysis of Kann and Asarian based on 2004-2005 data. This could simply reflect differences between years. For instance, dam operations vary significantly over time and can have a major impact on nutrient retention. Another potential explanation for lower retention rates in Copco is the low concentrations of particulate organic matter in inflow to this reservoir, while the buildup of algal biomass in both Copco and Iron Gate may contribute to higher retention rates in the downstream impoundment.

Table 6. Total P Mass Balance (kg) for CE-QUAL-W2 Application for Year 2000, Iron Gate Reservoir

Month	IN	OUT	Change	Retention
1	33,813	22,900	-10,913	32.27%
2	54,050	52,012	-2,039	3.77%
3	57,213	52,394	-4,818	8.42%
4	40,121	36,947	-3,174	7.91%
5	40,596	36,641	-3,955	9.74%
6	27,439	25,963	-1,475	5.38%
7	23,515	19,633	-3,883	16.51%
8	28,110	26,485	-1,625	5.78%
9	20,355	24,417	4,062	-19.96%
10	20,773	21,126	352	-1.70%
11	11,517	16,129	4,612	-40.04%
12	11,343	11,670	327	-2.89%
Whole Year	368,845	346,318	-22,527	6.11%
Whole Year Retention (corrected for change in storage)			-22,521	6.11%

Table 7. Total N Mass Balance (kg) for CE-QUAL-W2 Application for Year 2000, Iron Gate Reservoir

Month	IN	OUT	Change	Retention
1	185,087	191,369	6,282	-3.39%
2	233,737	188,997	-44,740	19.14%
3	264,713	196,327	-68,387	25.83%
4	183,398	155,264	-28,135	15.34%
5	103,453	96,293	-7,160	6.92%
6	79,847	55,506	-24,342	30.49%
7	87,133	49,336	-37,797	43.38%
8	109,349	70,070	-39,279	35.92%
9	88,370	72,398	-15,972	18.07%
10	99,909	73,439	-26,470	26.49%
11	75,331	69,115	-6,217	8.25%
12	80,020	72,802	-7,217	9.02%
Whole Year	1,590,349	1,290,916	-299,433	18.83%
Whole Year Retention (corrected for change in storage)			-280,376	17.63%

Table 8. Total P Mass Balance (kg) for CE-QUAL-W2 Application for Year 2000, Copco Reservoir

Month	IN	OUT	Change	Retention
1	35,621	29,907	-5,714	16.04%
2	48,378	49,192	814	-1.68%
3	53,116	52,587	-529	1.00%
4	36,611	35,340	-1,270	3.47%
5	43,803	39,143	-4,659	10.64%
6	25,702	26,740	1,038	-4.04%
7	30,243	22,211	-8,033	26.56%
8	21,346	26,837	5,491	-25.72%
9	15,653	19,395	3,742	-23.90%
10	17,280	19,858	2,578	-14.92%
11	9,569	10,912	1,343	-14.04%
12	8,905	9,720	816	-9.16%
Whole Year	346,226	341,843	-4,383	1.27%
Whole Year Retention (corrected for change in storage)			-4,240	1.22%

Table 9. Total N Mass Balance (kg) for CE-QUAL-W2 Application for Year 2000, Copco Reservoir

Month	IN	OUT	Change	Retention
1	143,374	157,413	14,040	-9.79%
2	196,915	202,659	5,744	-2.92%
3	242,555	232,490	-10,065	4.15%
4	152,922	152,036	-886	0.58%
5	94,216	91,737	-2,480	2.63%
6	95,602	74,430	-21,172	22.15%
7	128,797	78,769	-50,028	38.84%
8	108,494	101,022	-7,473	6.89%
9	82,163	82,274	111	-0.14%
10	96,552	94,102	-2,450	2.54%
11	75,761	71,285	-4,476	5.91%
12	60,175	69,181	9,007	-14.97%
Whole Year	1,477,525	1,407,398	-70,127	4.75%
Whole Year Retention (corrected for change in storage)			-53,278	3.61%

Model-predicted reservoir cumulative retentions for nitrogen and phosphorus species are summarized for the two reservoirs in Figure 7 through Figure 10 (uncorrected for changes in storage). For Iron Gate, there is a steady loss of organic nutrients, accompanied by seasonal patterns in inorganic nutrient uptake and release that result in little net change over the course of the year. For Copco, the predicted cumulative loss of organic nutrients is smaller, with increases in inorganic nutrient mass in the fall.

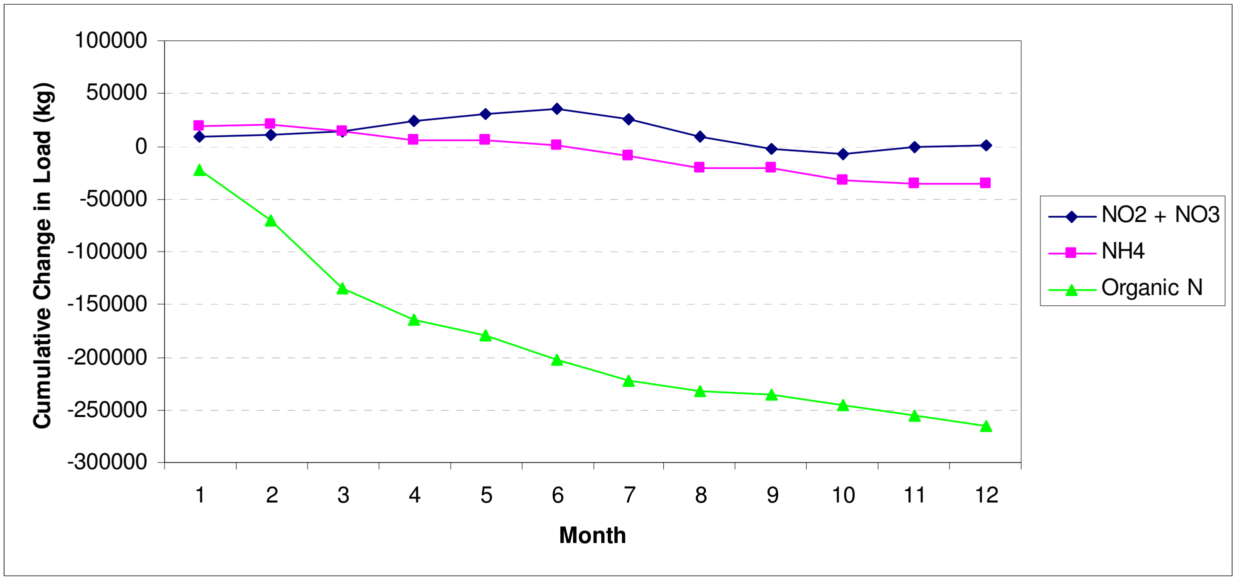


Figure 7. Cumulative Change in Nitrogen Load Predicted by Klamath River Model, Iron Gate Reservoir, for Year 2000

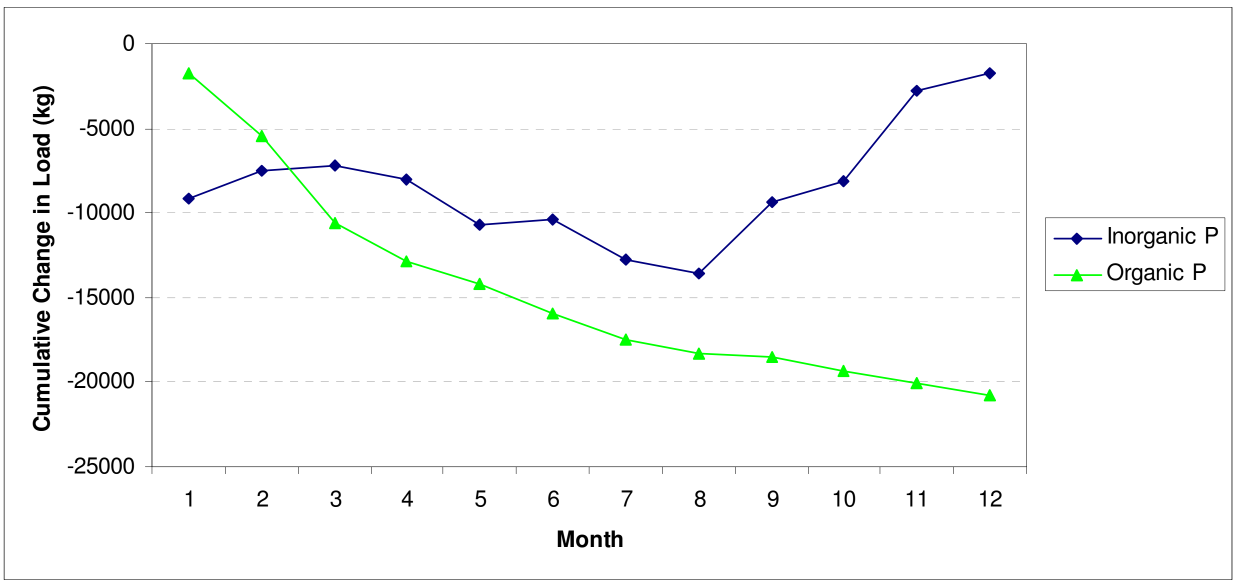


Figure 8. Cumulative Change in Phosphorus Load Predicted by Klamath River Model, Iron Gate Reservoir, for Year 2000

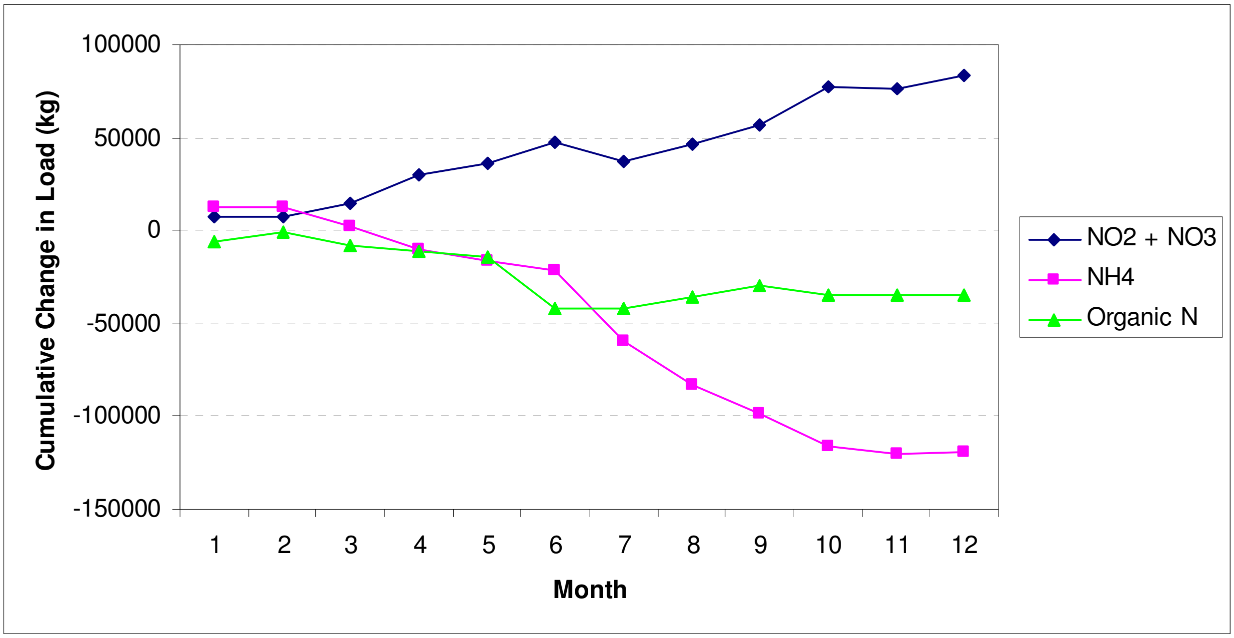


Figure 9. Cumulative Change in Nitrogen Load Predicted by Klamath River Model, Copco Reservoir, for Year 2000

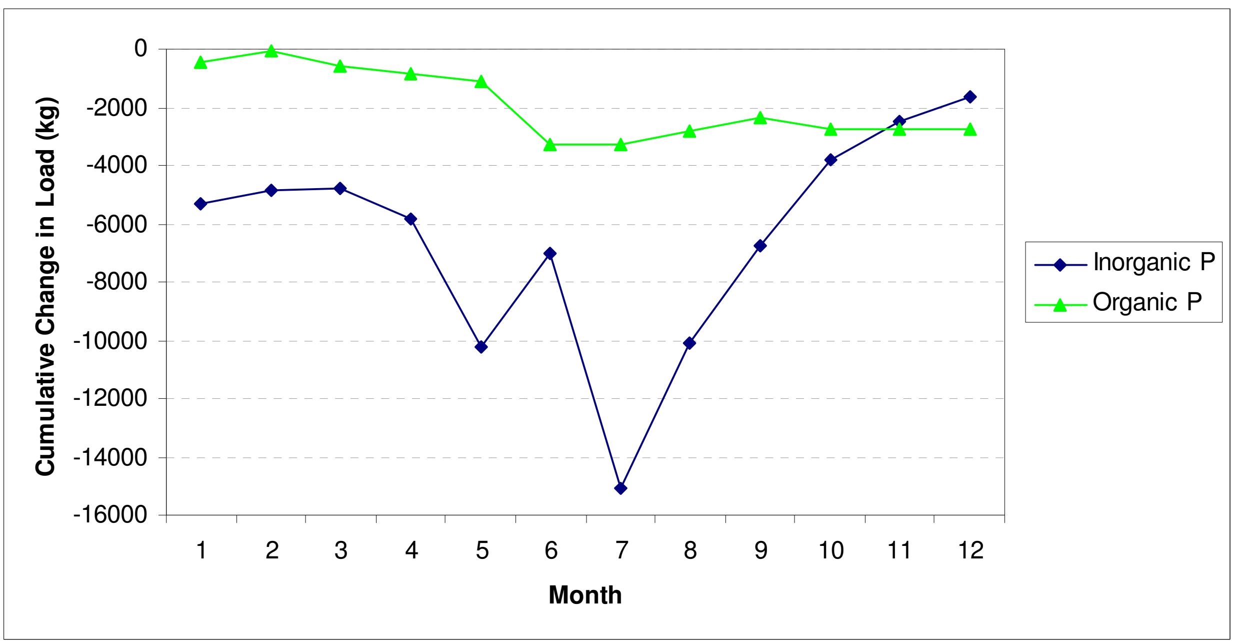


Figure 10. Cumulative Change in Phosphorus Load Predicted by Klamath River Model, Copco Reservoir, for Year 2000

4 Conclusions

The available monitoring data in the Klamath River system is not sufficient to provide a tight closure for nutrient mass balances, and estimates of nutrient retention and loss rates are thus uncertain. It is important to keep in mind the distinction between retention – which delays the transport of nutrients, but does not ultimately remove them – and loss – which results in the long-term removal of nutrients through transfer to stable sediments or the atmosphere.

Both flowing and impounded reaches of the Klamath provide opportunities for retention and loss of nutrients. The dominant process for retention in the system appears to be uptake by algae, which both delays transport downstream and converts inorganic to organic nutrient forms. Given the short residence time in the Klamath reservoirs, retention is likely more significant in flowing reaches, dominated by attached algae, than in the reservoirs, where planktonic algae may be washed downstream. Temporary retention benefits downstream reaches by reducing nutrient loads during the growing season; however, nutrient mass retained in algae is ultimately transported downstream to the estuary, largely after the end of the growing season.

Important loss pathways include denitrification with loss to the atmosphere of nitrogen and deposition of relatively insoluble forms of phosphorus to the sediment. These processes occur in both flowing and impounded reaches. Denitrification permanently removes nitrogen from the aquatic system, and is likely to be significant in the impoundments when the hypolimnion is anoxic. The argument is less clear for the flowing reaches, where oxic conditions are maintained, although some losses likely do occur in conjunction with decaying periphyton mats. For phosphorus, complexes that are insoluble under oxic conditions can often be remobilized under anoxic reducing conditions. This likely limits the annual removal of phosphorus in reservoirs where rapid deep burial is not occurring. (For the Klamath, the presence of reservoirs in series likely limits deep burial rates in the more downstream reservoirs.) For flowing reaches that maintain oxygenation, precipitated phosphorus may remain insoluble – but is prone to transport downstream sorbed to sediment.

Both the CE-QUAL-W2 model and the data analyses of Kann and Asarian (2005, 2007) predict limited amounts of TN and TP removal in Copco and Iron Gate reservoirs. Given the limitations of the available data and associated uncertainty, the model and data-based analyses appear to be in reasonable agreement with one another and with retention estimates based on empirical methods in the literature. The uncertainty in the data supports the need for a modeling approach to interpolate through the limited observations.

For the free-flowing reaches of the Klamath below Iron Gate dam, the RMA-11 model predicts some seasonal retention, but little ultimate loss of nutrients (less than 1% of annual TN and TP loads). In contrast, Asarian and Kann (2006a) contend that there is significant retention of TN between Iron Gate and Seiad. Their estimates are based on seasonal data only, so the annual rate of loss is unknown; however, the estimated seasonal retention rates are much greater than predicted by RMA-11, while appearing to be in approximate agreement with the USGS SPARROW model (Smith et al., 1997). The independent analyses of Armstrong and Ward (2008) do suggest that nutrient loss rates in the Klamath may indeed be quite low, which is consistent with the representation in the calibrated RMA-11 model. Overall, the available data are insufficient to precisely determine the true rates of annual nutrient loss in the free-flowing reaches of the Klamath. Although the RMA-11 model omits several processes such as denitrification that potentially affect nutrient loss rates, most of these processes are also omitted from most other river quality models and it is unclear if they are significant in the Klamath River.

In sum, the linked CE-QUAL-W2 and RMA-11 models of the Klamath appear to provide reasonable estimates of nutrient dynamics in the impoundments, while it is inconclusive whether or not nutrient retention and loss rates in the free-flowing reaches of the Klamath are significantly underestimated.

Despite this unresolved issue, the RMA-11 model appears to be a reasonable tool for assembling the TMDL, as long as the influence of model uncertainty on management decisions is acknowledged.

For the purposes of TMDL-based load allocations, the potential for underestimation of nutrient retention could be treated as a margin of safety (MOS). That is, the actual deleterious impacts of nutrient loads are likely to extend a lesser distance, and create less total algal biomass, than is predicted by the model. Therefore, a TMDL based on the model would include an implicit MOS insofar as the efficacy of nutrient reductions in controlling periphytic algal biomass in the river and its effect on the diurnal DO cycle is likely to be underestimated to some degree. Scenario analyses that depend on the relative retention rates of nutrients in flowing and impounded reaches (such as dam removal scenarios) must be approached with particular care, given the current level of uncertainty in the simulation of retention and loss rates. Interpretation of such scenarios will need to include an evaluation of the decision implications of model and data uncertainty. Additional, focused studies on potential nutrient loss mechanisms are recommended to further reduce uncertainty.

5 References

Allan, D.J. 1995. *Stream Ecology: Structure and Function of Running Waters*. Springer Verlag.

Armstrong, N.E. and G.H. Ward. 2008. Coherence of Nutrient Loads and AFWO Klamath River Grab Sample Water Quality Database. Prepared for U.S. Fish and Wildlife Service, Arcata, CA.

Asarian, E. 2007. Comments Concerning the Klamath River TMDL Model. Memorandum from Eli Asarian, Kier Associates, to Klamath Basin Tribal Water Quality Work Group, November 13, 2007 (draft)

Asarian, E. and J. Kann. 2006a. Klamath River Nitrogen Loading and Retention Dynamics, 1996-2004. Kier Associates Final Technical Report to the Yurok Tribe Environmental Program, Klamath, CA.

Asarian, E. and J. Kann. 2006b. Technical Memorandum: Evaluation of PacifiCorps's Klamath River Water Quality Model Predictions for Selected Water Quality Parameters. Prepared by Kier Associates and Aquatic Ecosystem Sciences for the Yurok Tribe Environmental Program, Klamath, California.

Bachman, R.W. 1980. Prediction of total nitrogen in lakes and reservoirs. Pp. 320-324 in Restoration of Lakes and Inland Waters: Proceedings of an International Symposium on Inland Waters and Lake Restoration, Portland, ME. EPA-440/5-81-010. Office of Water, U.S. Environmental Protection Agency, Washington, DC.

Biggs, B. J. 2000. Eutrophication of streams and rivers: Dissolved nutrient-chlorophyll relationships for benthic algae. *J. N. Am. Benthol. Soc*., 19:17-31.

Campbell, S.G. 2001. Water Quality and Nutrient Loading in the Klamath River between Keno, Oregon and Seiad Valley, California, from 1996-1998. Open-File Report 01-301. U.S. Geological Survey, Fort Collins, CO.

Cole, T.M. and S.A. Wells. 2005. CE-QUAL-W2: A Two-Dimensional, Laterally Averaged, Hydrodynamic and Water Quality Model, Version 3.5, Instruction Report EL-05-1, US Army Engineering and Research Development Center, Vicksburg, MS.

Dodds, W.K. 2003. The role of periphyton in phosphorus retention in shallow freshwater aquatic systems. *Journal of Phycology*, 39: 840-849.

Droop, MR. 1983. 25 years of algal growth kinetics: A personal view, *Botany*. Mar 26:99-112.

Fernald, A.G., D.H. Landers, and P.J. Wigington, Jr. 2006. Water quality changes in hyporheic flow paths between a large gravel bed river and off-channel alcoves in Oregon, USA. *River Research and Applications*, 22: 1111–1124.

Flint, L.E., A.L. Flint, D.S. Curry, S.A. Rounds, and M.C. Doyle. 2005. Water-Quality Data from 2002 to 2003 and Analysis of Data Gaps for Development of Total Maximum Daily Loads in the Lower Klamath River Basin, California. Scientific Investigations Report 2004-5255. U.S. Geological Survey, Reston, VA.

Kann, J., and E. Asarian. 2005. 2002 Nutrient and Hydrologic Loading to Iron Gate and Copco Reservoirs, California. Kier Associates Final Technical Report to the Karuk Tribe Department of Natural Resources, Orleans, CA.

Kann, J. and E. Asarian. 2007. Nutrient Budgets and Phytoplankton Trends in Iron Gate and Copco Reservoirs, California, May 2005 - May 2006. Submitted to the State Water Resources Control Board, Sacramento, CA by the Karuk Tribe of California, Department of Natural Resources, Orleans, CA.

King, I.P. 1998. RMA-11 - A Three Dimensional Finite Element Model for Water Quality in Estuaries and Streams, Version 2.6. Dept. of Civil and Environmental Engineering, University of California, Davis, CA.

Lambing, J.H. and T.E. Cleasby. 2006. Water-Quality Characteristics of Montana Streams in a Statewide Monitoring Network, 1999-2003. Scientific Investigations Report 2006-5046. U.S. Geological Survey, Helena, MT.

Naiman, R.J., R.E. Bilby, and P.A. Bisson. 2000. Riparian ecology and management in the Pacific coastal rain forest. *BioScience*, 50(11): 996-1011.

Nürnberg, G. K, 1984. The prediction of internal phosphorus loading in lakes with anoxic hypolimnia. *Limnol. Oceanogr.*, 29: 111-124.

PacifiCorp. 2005. Klamath River Water Quality Model Implementation, Calibration, and Validation. Klamath Hydroelectric Project (FERC Project No. 2082), Response to November 10, 2005, FERC AIR GN-2. PacificCorp, Portland, OR.

PacifiCorp. 2006. Appendix B: Causes and Effects of Nutrient Conditions in the Upper Klamath River. Klamath Hydroelectric Project (FERC Project No. 2082). PacifiCorp, Portland, OR.

PacifiCorp. 2007. PacifiCorp's Responses to Comments from Various Stakeholders on the September 2006 FERC DEIS for Hydropower License for the Klamath Hydroelectric Project (FERC Project No. 2082). PacifiCorp, Portland, OR.

Peterjohn, W.T. and D.L. Correll. 1984. Nutrient dynamics in an agricultural watershed: Observation of a riparian forest. *Ecology*, 65: 1466-1475.

Preston, S.D., V.J. Bierman, Jr., and S.E. Silliman. 1989. An evaluation of methods for the estimation of tributary mass loads. *Water Resources Research*, 25(6): 1379-1389.

Smith, R.A., G.E. Schwarz, and R.B. Alexander. 1997. Regional interpretation of water-quality monitoring data. *Water Resources Research*, 33(12): 2781-2798.

Smith, R.A., R.B. Alexander, and G.E. Schwarz. 2003a. Natural background concentrations of nutrients in streams and rivers of the conterminous United States. *Environmental Science & Technology*, 37(14): 3039-3047.

Smith, R.A., R.B. Alexander, and G.E. Schwarz. 2003b. Natural background concentrations of nutrients in streams and rivers of the conterminous United States, Supporting Information. *Environmental Science & Technology*, 37(14), online supplement es020663b.

Sosiak, A. 2002. Long-term response of periphyton and macrophytes to reduced municipal nutrient loading to the Bow River (Alberta, Canada). *Canadian Journal of Fisheries and Aquatic Sceinces*, 59: 987-1001.

Tanner, D.Q. and C.W. Anderson. 1996. Assessment of Water Quality, Nutrients, Algal Productivity, and Management Alternatives for Low-Flow Conditions, South Umpqua River Basin, Oregon, 1990–92. Water-Resources Investigations Report 96–4082. U.S. Geological Survey, Portland, OR.

Triska, F.J. and R.S. Oremland. 1981. Denitrification associated with periphyton communities. *Applied Environmental Microbiology*, 42(4):745-748.

USEPA. 1978. Report on Iron Gate Reservoir, Siskiyou County, California. EPA Region IX Working Paper No. 749. U.S. Environmental Protection Agency, Corvallis Environmental Research Laboratory, Corvallis, OR and Environmental Monitoring and Support Laboratory, Las Vegas, NV.

Vollenweider, R.A. 1976. Advances in defining critical loading levels for phosphorus in lake eutrophication. *Mem. Inst. Ital. Idrobiol.*, 33: 53-83.

Welch, E.B. and J.M. Jacoby. 2004. *Pollutant Effects in Freshwater, Applied Limnology* (3rd ed.). Spon Press, London.

Appendix 4

Effects of Temperature, Dissolved Oxygen/Total Dissolved Gas, Ammonia, and pH on Salmonids

Implications for California's North Coast TMDLs

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July 2008

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CHAPTER 1. TEMPERATURE

1.1 Introduction

Temperature is one of the most important environmental influences on salmonid biology. Most aquatic organisms, including salmon and steelhead, are poikilotherms, meaning their temperature and metabolism is determined by the ambient temperature of water. Temperature therefore influences growth and feeding rates, metabolism, development of embryos and alevins, timing of life history events such as upstream migration, spawning, freshwater rearing, and seaward migration, and the availability of food. Temperature changes can also cause stress and lethality (Ligon et al. 1999). Temperatures at sub-lethal levels can effectively block migration, lead to reduced growth, stress fish, affect reproduction, inhibit smoltification, create disease problems, and alter competitive dominance (Elliott 1981, USEPA 1999a). Further, the stressful impacts of water temperatures on salmonids are cumulative and positively correlated to the duration and severity of exposure. The longer the salmonid is exposed to thermal stress, the less chance it has for long-term survival (Ligon et al. 1999).

A literature review was performed to evaluate temperature needs for the various life stages of steelhead trout (*Oncorhynchus mykiss*), coho salmon (*Oncorhynchus kisutch*), and Chinook salmon (*Oncorhynchus tschawytscha).* The purpose of this review was to identify temperature thresholds that are protective of salmonids by life stage, as a basis for evaluating stream temperatures in California temperature TMDLs within the North Coast region.

This review included USEPA temperature guidance, Oregons' and Washingtons' temperature standards reviews, reports that compiled and summarized existing scientific information, and laboratory and field studies. When possible, species-specific needs were summarized by the following life stages: migrating adults, spawning and incubation/emergence, and freshwater rearing and growth. Additionally, the effects of temperature on disease and lethality are also discussed. Some of the references reviewed covered salmonids as a general class of fish, while others were species specific. Information for fall run coho salmon, spring/summer, fall, and winter steelhead, and spring and fall run Chinook salmon are compiled by life stage in Table 1 through Table 12.

1.2 Temperature Metrics

In considering the effect of temperature on salmonids, it is useful to have a measure of chronic and acute (i.e. sub-lethal and lethal) temperature exposures. A common measure of chronic exposure is the maximum weekly average temperature (MWAT). The MWAT is the maximum seasonal or yearly value of the mathematical mean of multiple, equally spaced, daily temperatures over a running seven-day consecutive period (Brungs and Jones 1977, p.10). In other words, it is the highest single value of the seven-day moving average temperature. A common measure of acute effects is the instantaneous maximum. A third metric, the maximum weekly maximum temperature (MWMT), can be used as a measure of both chronic and acute effects. The MWMT is also known as the seven-day average of the daily maximum temperatures (7-DADM), and is the maximum seasonal or yearly-value of the daily maximum temperatures over a running seven-day consecutive period. The MWMT is useful because it describes the maximum temperatures in a stream, but is not overly influenced by the maximum temperature of a single day.

Much of the information reported in the literature characterizes temperature needs with terms such as "preferred" or "optimum". Preferred stream temperatures are those that fish most frequently inhabit when allowed to freely select temperatures in a thermal gradient (USEPA 1999a). An optimum range provides suitable temperatures for feeding activity, normal physiological response, and normal behavior (without symptoms of thermal stress) (USEPA 1999a). Optimal temperatures have also been described as those temperatures at which growth rates, expressed as weight gain per unit of time, are maximal for the life stage (Armour 1991).

Salmonid stocks do not tend to vary much in their life history thermal needs, regardless of their geographic location. In the 2001 USEPA document, *Summary of Technical Literature Examining the Physiological Effects of Temperature on Salmonids*, the case is made that there is not enough significant genetic variation among stocks or among species of salmonids to warrant geographically specific water temperature standards.

> Climate conditions vary substantially among regions of the State and the entire Pacific Northwest. …Such [varying climatic] conditions could potentially have led to evolutionary adaptations, resulting in development of subspecies differences in thermal tolerance. …[However,] the literature on genetic variation in thermal effects indicates occasionally significant but very small differences among stocks and increasing differences among subspecies, species, and families of fishes. Many differences that had been attributed in the literature to stock differences are now considered to be statistical problems in analysis, fish behavioral responses under test conditions, or allowing insufficient time for fish to shift from field conditions to test conditions (Mathur & Silver 1980, Konecki et al. 1993, both as cited in USEPA 2001).

Additionally:

> There are many possible explanations why salmonids have not made a significant adaptation to high temperature in streams of the Pacific Northwest. Temperature tolerance is probably controlled by multiple genes, and consequently would be a core characteristic of the species not easily modified through evolutionary change without a radical shift in associated physiological systems. Also, the majority of the life cycle of salmon and steelhead is spent in the ocean rearing phase, where the smolt, subadults, and adults seek waters with temperatures less than 59°F (15°C) (Welch et al, 1995, as cited in USEPA 2001).

As a result, literature on the temperature needs of coho and Chinook salmon and steelhead trout stemming from data collected in streams outside Northern California are cited in this document and are considered relevant to characterizing the thermal needs of salmonids, which use Northern California rivers and streams.

1.3 Adult Migration and Holding

All of the adult migration and holding temperature needs referenced in this section can be found in Table 1 through Table 3. Salmon and trout respond to temperatures during their upstream migration (Bjornn and Reiser 1991). Delays in migration have been observed in response to temperatures that were either too cold or too warm. Most salmonids have evolved with the temperature regime they historically used for migration and spawning, and deviations from the normal pattern can affect survival (Spence et al. 1996).

In a 2003 USEPA document entitled *EPA Region 10 Guidance for Pacific Northwest State and Tribal Water Quality Standards*, it is recommended that the 7-DADM should not exceed 18°C in waters where both adult salmonid migration and "non-core" juvenile rearing occur during the period of summer maximum temperatures. The document does not define what constitutes the "summer" period. Non-core juvenile rearing is defined as moderate to low density salmon and trout rearing usually occurring in the mid or lower part of the basin, as opposed to areas of high density rearing which are termed "core" rearing areas. This criterion is derived from analysis and synthesis of past laboratory and field research. The USEPA believes that this temperature recommendation will protect against lethal conditions, prevent migration blockage, provide optimal or near optimal juvenile growth conditions, and prevent high disease risk by minimizing the exposure time to temperatures which can lead to elevated disease rates.

A 7-DADM temperature of 20°C is recommended by the USEPA (2003) for waterbodies that are used almost exclusively for migration during the period of summer maximum temperatures.

> EPA believes that a 20°C criterion would protect migrating juveniles and adults from lethal temperatures and would prevent migration blockage conditions. However, EPA is concerned that rivers with significant hydrologic alterations (e.g., rivers with dams and reservoirs, water withdrawals, and /or significant river channelization) may experience a loss of temperature diversity in the river, such that maximum temperatures occur for an extended period of time and there is little cold water refugia available for fish to escape maximum temperatures. In this case, even if the river meets a 20°C criterion for maximum temperatures, the duration of exposure to 20°C temperatures may cause adverse effects in the form of increased disease and decreased swimming performance in adults, and increased disease, impaired smoltification, reduced growth, and increased predation for late emigrating juveniles…(USEPA 2003).

Therefore, the USEPA recommends a narrative provision to protect and, if possible, restore the natural thermal regime accompany the 7-DADM 20°C criterion for rivers with significant hydrologic alterations.

In an exhaustive study of both laboratory and field studies of temperature effects on salmonids and related species, USEPA (1999a, 2001) concluded that temperatures of approximately 22-24°C limit salmonid distribution, i.e., they totally eliminate salmonids from a location. USEPA (1999a) also notes that changes in competitive interactions between fish species can lead to a transition in dominance from salmonids to other species at temperatures 2-4°C lower than the range of total elimination.

1.3.1 Steelhead Trout Migration

In a 2002 review of numerous studies, Washington State Department of Ecology (WDOE) concluded that daily average temperatures of 21-24°C are associated with avoidance behavior and migration blockage in steelhead trout. WDOE suggests that the MWMT should not exceed 17-18°C, and daily maximum temperatures should not exceed 21-22°C to be fully protective of adult steelhead migration.

Table 1: Effects of Temperature in Considering Adult Steelhead and Migration

<table>
<tr><th>C</th><th colspan="3">MIGRATION</th></tr>
<tr><td>24</td><td rowspan="4">21-24 Average daily temperature associated with avoidance and migration blockage (2)</td><td colspan="2" rowspan="2">22-24 Temperature range which eliminates salmonids from an area (3,4)</td></tr>
<tr><td>23</td></tr>
<tr><td>22</td><td rowspan="2">21-22 Daily maximum temperature should not exceed this to be fully protective (2)</td><td rowspan="5">18-22 Temperature range at which transition in dominance from salmonids to other species occurs (4)</td></tr>
<tr><td>21</td></tr>
<tr><td>20</td><td colspan="2">20 MWMT should not exceed this in waterbodies used almost exclusively for migration. Should be used in conjunction with a narrative provision about protecting/restoring the natural thermal regime for rivers with significant hydrologic alterations (1)</td></tr>
<tr><td>19</td><td colspan="2"></td></tr>
<tr><td>18</td><td rowspan="2">17-18 MWMT should not exceed this to be fully protective (2)</td><td>18 MWMT should not exceed this where migration and non-core rearing occur (1)</td></tr>
<tr><td>17</td><td colspan="2"></td></tr>
</table>

Sources: (1) USEPA 2003, (2) WDOE 2002, (3) USEPA 2001, (4) USEPA 1999a

1.3.2 Chinook Salmon Migration and Holding

USEPA (2001) cited various literature sources that identified thermal blockages to Chinook salmon migration at temperatures ranging from 19-23.9°C, with the majority of references citing migration barriers at temperatures around 21°C.

A radio tracking study on spring Chinook revealed that when maximum temperatures of 21.1°C were reached, a thermal barrier to migration was established (Bumgarner et al. 1997, as cited by USEPA 1999a). Bell (1986) reviewed various studies and notes spring Chinook migrate at water temperatures ranging from 3.3-13.3°C, while fall Chinook migrate at temperatures of 10.6-19.6°C. Preferred temperatures for Chinook range from 7.2-14.5°C (Bell 1986). Based on a technical literature review, WDOE (2002) concluded that daily maximum temperatures should not exceed 21-22°C during Chinook migration.

Table 2: Effects of Temperature in Considering Adult Chinook and Migration and Holding

°C	MIGRATION			
24		22-24 Temperature range which eliminates salmonids from an area (3,5)	19-23.9 Range of temperatures causing thermal blockage to migration (3)	
23	23 Klamath Basin fall Chinook begin migration upstream at temperatures as high as 23C if temperatures are rapidly falling (6)			
22	22 Klamath Basin fall Chinook will not migrate upstream when mean daily temperatures are 22C or greater (6)			18-22 Temperature range at which transition in dominance from salmonids to other species occurs (5)
21	21-22 Daily maximum temperature should not exceed this range to be protective of migration (2)	21 Most references cite as thermal block to migration (3) 21 Klamath Basin fall Chinook will not migrate upstream if temperatures are 21C or above and rising (6)		
20	20 MWMT should not exceed this in waterbodies used almost exclusively for migration. Should be used in conjunction with a narrative provision about protecting/restoring the natural thermal regime for rivers with significant hydrologic alterations (1)			
19		10.6-19.6 Temperature range where adult fall Chinook migrate (4)		
18			18 MWMT should not exceed this where migration and non-core rearing occur (1)	
17	16-17 MWMT should be below this where Chinook are holding (2)			
16				
15				
14	7.2-14.5 Preferred temperatures for Chinook (4)		13-14 Average daily temperature should be below this where spring Chinook are holding (2)	
13				
12			3.3-13.3 Temperature range where adult spring Chinook migrate (4)	
11				
10				
9				
8				
7				
6				
5				
4				
3				

Sources: (1) USEPA 2003, (2) WDOE 2002, (3) USEPA 2001, (4) Bell 1986, (5) USEPA 1999a, (6) Strange 2006

Utilizing radio telemetry to track the movements and monitor the internal body temperatures of adult fall Chinook salmon during their upriver spawning migration in the Klamath basin, Strange (2006) found that fall Chinook will not migrate upstream when mean daily temperatures are ≥22°C. Strange also noted that adult fall Chinook in the

Klamath basin will not migrate upstream if temperatures are 21°C or above and rising, but will migrate at temperatures as high as 23°C if temperatures are rapidly falling.

Spring Chinook begin entering freshwater streams during a relatively cool-water season but must hold throughout the warm summer period, awaiting cooler spawning temperatures (ODEQ 1995a). The cumulative effects of management practices such as elevated water temperatures, reduced cover from large woody debris, and reduced resting pool area due to pool filling increase the susceptibility of holding adult fish to mortality from thermal effects (The Oregon Department of Environmental Quality [ODEQ] 1995a). WDOE states that where spring Chinook are holding over for the summer prior to spawning the average daily water temperature should be below 13-14°C and the MWMT should be below 16-17°C (WDOE 2002).

1.3.3 Coho Salmon Migration

Migration for coho is delayed when water temperatures reach 21.1°C, and the preferred water temperatures for coho range from 11.7-14.5°C (Bell 1986). In California coho salmon typically migrate upstream when water temperatures range from 4-14°C (Briggs, 1953 and Shapovalov and Taft, 1954, as cited by Hassler, 1987). WDOE reviewed various studies and concluded that to be protective of adult coho migration, MWMTs should not exceed 16.5°C (WDOE 2002).

Table 3: Effects of Temperature in Considering Adult Coho and Migration

<table>
<tr><th>°C</th><th colspan="3">MIGRATION</th></tr>
<tr><td>24</td><td colspan="2" rowspan="3">22-24 Temperature range which eliminates salmonids from an area (3,6)</td><td></td></tr>
<tr><td>23</td><td></td></tr>
<tr><td>22</td><td rowspan="5">18-22 Temperature range at which transition in dominance from salmonids to other species occurs (6)</td></tr>
<tr><td>21</td><td colspan="2">21.1 Migration is delayed when temperatures reach this value (4)</td></tr>
<tr><td>20</td><td colspan="2">20 MWMT should not exceed this in waterbodies used almost exclusively for migration. Should be used in conjunction with a narrative provision about protecting/restoring the natural thermal regime for rivers with significant hydrologic alterations (1)</td></tr>
<tr><td>19</td><td colspan="2"></td></tr>
<tr><td>18</td><td colspan="2">18 MWMT should not exceed this where migration and non-core rearing occur (1)</td></tr>
<tr><td>17</td><td colspan="3"></td></tr>
<tr><td>16</td><td colspan="3">16.5 MWMT should not exceed this value to be fully protective (2)</td></tr>
<tr><td>15</td><td colspan="3"></td></tr>
<tr><td>14</td><td rowspan="3">11.7-14.5 Preferred temperature range (4)</td><td colspan="2" rowspan="4">4-14 Temperature range at which migration typically occurs (5)</td></tr>
<tr><td>13</td></tr>
<tr><td>12</td></tr>
<tr><td>11</td><td>11.4 Preferred temperature (7)</td></tr>
</table>

Sources: (1) USEPA 2003, (2) WDOE 2002, (3) USEPA 2001, (4) Bell 1986, (5) Briggs 1953, Shapovalov and Taft 1954, as cited by Hassler 1987, (6) USEPA 1999a, (7) Reutter and Herdendorf 1974

1.4 Spawning, Incubation, and Emergence

All of the spawning, incubation, and emergence temperature needs referenced in this section can be found in Table 4 through Table 7. Many sources have stated that temperature affects the time of migration i adults and thus the time of spawning, which influences the incubation temperature regime, which in turn influences survival rates, development rates, and growth of embryos and alevins (Murray and McPhail 1988). USEPA Region 10 recommends that the 7-DADM temperatures should not exceed 13°C for salmonid spawning, egg incubation, and fry emergence (USEPA 2003). Optimum temperatures for salmonid egg survival ranges from 6-10°C (USEPA 2001).

1.4.1 Steelhead Spawning, Incubation, and Emergence

In a discussion paper and literature summary evaluating temperature criteria for fish species including salmonids and trout, WDOE (2002) cites studies showing that steelhead were observed spawning in temperatures ranging from 3.9-21.1°C, and that the preferred temperatures for steelhead spawning range from 4.4-12.8°C. In a review of various studies, Bell (1986) concludes that steelhead spawning occurs at water temperatures ranging from 3.9-9.4°C.

Steelhead and rainbow trout eggs had the highest survival rates between 5-10°C according to Myrick and Cech (2001), and while they can tolerate temperatures as low as 2°C or as high as 15°C, mortality is increased at these temperatures. WDOE (2002) reviewed literature on the survival of steelhead and rainbow trout embryos and alevins at various temperatures and concluded that the average water temperature should not exceed 7-10°C throughout development, and the maximum daily average temperature should be below 11-12°C at the time of hatching (WDOE 2002).

Table 4: Effects of Temperature in Considering Steelhead Incubation and Emergence

<table>
<tr><th>°C</th><th colspan="3">INCUBATION AND EMERGENCE</th></tr>
<tr><td>15</td><td colspan="3">15 Steelhead and rainbow trout eggs can survive at temperatures as high as this but mortality is high compared to lower temperatures (3)</td></tr>
<tr><td>14</td><td colspan="3"></td></tr>
<tr><td>13</td><td colspan="3">13 MWMT should not exceed this value to be protective of spawning, egg incubation, and fry emergence (1)</td></tr>
<tr><td>12</td><td colspan="3" rowspan="2">11-12 Maximum daily average temperature should be below this range at the time of hatching (2)</td></tr>
<tr><td>11</td></tr>
<tr><td>10</td><td rowspan="6">5-10 Steelhead and rainbow trout eggs had the highest survival within this range (3)</td><td rowspan="5">6-10 Optimum temperature for salmonid eggs survival to hatching (4)</td><td rowspan="4">7-10 Average daily temperature should not exceed this range throughout embryo development (2)</td></tr>
<tr><td>9</td></tr>
<tr><td>8</td></tr>
<tr><td>7</td></tr>
<tr><td>6</td><td></td></tr>
<tr><td>5</td><td colspan="2"></td></tr>
<tr><td>4</td><td colspan="3"></td></tr>
<tr><td>3</td><td colspan="3"></td></tr>
<tr><td>2</td><td colspan="3">2 Steelhead and rainbow trout eggs can survive at temperatures as low as this but mortality is high compared to higher temperatures (3)</td></tr>
</table>

Sources: (1) USEPA 2003, (2) WDOE 2002, (3) Myrick and Cech 2001, (4) USEPA 2001

Table 5: Effects of Temperature in Considering Steelhead, Chinook, and Coho Spawning

<table>
<tr><th>°C</th><th colspan="3">Steelhead</th><th colspan="3">Chinook</th><th colspan="2">Coho</th><th>All Salmonids</th></tr>
<tr><td>21</td><td rowspan="19">3.9-21.2 Steelhead observed spawning in this temp. range (2)</td><td colspan="2"></td><td colspan="3"></td><td colspan="2"></td><td></td></tr>
<tr><td>20</td><td colspan="2"></td><td colspan="3"></td><td colspan="2"></td><td></td></tr>
<tr><td>19</td><td colspan="2"></td><td colspan="3"></td><td colspan="2"></td><td></td></tr>
<tr><td>18</td><td colspan="2"></td><td colspan="3"></td><td colspan="2"></td><td></td></tr>
<tr><td>17</td><td colspan="2"></td><td></td><td></td><td rowspan="13">5.6-17.7 Range of temps. associated with spawning from references reviewed (2)</td><td colspan="2"></td><td></td></tr>
<tr><td>16</td><td colspan="2"></td><td></td><td></td><td colspan="2"></td><td></td></tr>
<tr><td>15</td><td colspan="2"></td><td rowspan="3">13-15.5 Temp. range at which pre-spawning mortality becomes pronounced in ripe spring Chinook (4)</td><td></td><td colspan="2"></td><td></td></tr>
<tr><td>14</td><td colspan="2"></td><td>14.5 Majority of refs. cite daily max temps. associated with spawning below this level (2)</td><td colspan="2"></td><td></td></tr>
<tr><td>13</td><td></td><td></td><td rowspan="9">5.6-13.9 Recommended temperature range for spawning (5)</td><td>13 Daily maximum temp. not to exceed this value to be protective (6)</td><td rowspan="10">4.4-13.3 Typical temps. during which spawning occurs (2)</td><td>13 MWMT not exceed this value during spawning, egg incubation, and fry emergence (1)</td></tr>
<tr><td>12</td><td></td><td rowspan="9">4.4-12.8 Preferred temp. range for spawning (2)</td><td rowspan="8">5.6-12.8 Recom-mended temperature range for spawning (4)</td><td></td><td></td></tr>
<tr><td>11</td><td></td><td></td><td></td></tr>
<tr><td>10</td><td></td><td>10 MWAT not exceed this value to be protective (6)</td><td></td></tr>
<tr><td>9</td><td rowspan="7">3.9-9.4 Temp. range where spawning occurs (3)</td><td rowspan="6">4.5-9.4 Preferred spawning temperature range (3)</td><td></td></tr>
<tr><td>8</td><td></td></tr>
<tr><td>7</td><td></td></tr>
<tr><td>6</td><td></td></tr>
<tr><td>5</td><td></td></tr>
<tr><td>4</td><td colspan="3"></td><td></td></tr>
<tr><td>3</td><td></td><td colspan="3"></td><td colspan="2"></td><td></td></tr>
</table>

Sources: (1) USEPA 2003, (2) WDOE 2002, (3) Bell 1986, (4) ODEQ 1995a, (5) Reiser and Bjornn 1979 as cited by Armour et al. 1991, (6) Brungs and Jones 1977

1.4.2 Chinook Spawning, Incubation, and Emergence

ODEQ (1995a) reviewed numerous studies and recommended a temperature range of 5.6-12.8°C for spawning Chinook. A discussion paper and literature summary by WDOE in 2002 found that the literature reviewed noted a wide range of temperatures associated with Chinook spawning (5.6-17.7°C), although the majority of these temperature observations cite daily maximum temperatures below 14.5°C. A spawning temperature range of 5.6-13.9°C is recommended for spring, summer, and fall Chinook salmon populations in the Pacific Northwest (Reiser and Bjornn 1979, as cited by Armour et al. 1991). When ripe adult spring Chinook females experience temperatures above 13-15.5°C, pre-spawning adult mortality becomes pronounced (ODEQ 1995a). Additionally, there is decreased survival of eggs to the eyed stage and alevin development is inhibited due to the exposure of the ripe female to warm temperatures, even if the stream temperatures during the egg and alevin development are appropriate (ODEQ 1995a).

Table 6: Effects of Temperature in Considering Chinook Incubation and Emergence

<table>
<tr><th>°C</th><th colspan="6">INCUBATION AND EMERGENCE</th></tr>
<tr><td>20</td><td colspan="6" rowspan="4">17.5-20 The highest single day maximum temperature should not exceed this range to protect eggs and embryos from acute lethal conditions (2)</td></tr>
<tr><td>19</td></tr>
<tr><td>18</td></tr>
<tr><td>17</td></tr>
<tr><td>16</td><td colspan="5"></td><td rowspan="16">1.7-16.7 Eggs can survive these temps. but mortality is greatly increased at the extremes (3)</td></tr>
<tr><td>15</td><td colspan="5"></td></tr>
<tr><td>14</td><td rowspan="10">5-14.4 Recom-mended temp. range for incubation (4)</td><td rowspan="2">13.5-14.5 Daily maximum temperatures should not exceed this from fertilization through initial fry development (5)</td><td colspan="2">14 Moderate embryo survival (6)</td><td rowspan="13">2-14 Range of temps. for normal embryo develop-ment (6)</td></tr>
<tr><td>13</td><td colspan="2">13 MWMT should not exceed this value to be protective of spawning, egg incubation, and fry emergence (1)</td></tr>
<tr><td>12</td><td></td><td rowspan="9">4-12 Lowest levels of egg mortality at these temps. (3)</td><td rowspan="2">11-12.8 Average daily temperatures should be below this range at beginning of incubation (2)</td></tr>
<tr><td>11</td><td>11 High embryo survival (6)</td></tr>
<tr><td>10</td><td>9-10 Optimal temp. should be below this range (5)</td><td rowspan="5">6-10 Optimum temperature for salmonid eggs survival to hatching (5)</td></tr>
<tr><td>9</td><td>8-9 Seasonal ave. temps. should not exceed this range from fertilization through initial fry development (2)</td></tr>
<tr><td>8</td><td>8 High embryo survival (6)</td></tr>
<tr><td>7</td><td></td></tr>
<tr><td>6</td><td></td></tr>
<tr><td>5</td><td>5 High embryo survival (6)</td><td></td></tr>
<tr><td>4</td><td></td><td></td><td></td></tr>
<tr><td>3</td><td colspan="4"></td></tr>
<tr><td>2</td><td colspan="4">2 Poor embryo survival (6)</td></tr>
<tr><td>1</td><td colspan="5"></td></tr>
</table>

Sources: (1) USEPA 2003, (2) WDOE 2002, (3) Myrick and Cech 2001, (4) Reiser and Bjornn 1979, as cited by Armour et al. 1991, (5) USEPA 2001, (6) Murray and McPhail 1988

WDOE (2002) reviewed numerous references on the effects of various temperatures on Chinook incubation and development and used these studies to derive the temperatures that are protective of Chinook salmon from fertilization through fry development. These reviewed references include laboratory studies assessing Chinook embryo survival at various constant temperatures, studies attempting to mimic naturally fluctuating temperatures experienced by incubating eggs, studies which have made stepwise reductions in the incubation temperatures as incubation progressed to evaluate survival of eggs, and studies on the effects of transferring eggs to optimal constant incubation temperatures after they had been exposed to higher temperatures for various periods. As a result of this review, WDOE (2002) recommends that average daily temperatures remain below 11-12.8°C at the initiation of incubation, and that the seasonal average should not exceed 8-9°C in order to provide full protection from fertilization through initial fry development. The highest single day maximum temperature should not exceed 17.5-20°C to protect eggs and embryos from acute lethal conditions (WDOE 2002).

USEPA (2001) reviewed multiple literature sources and concluded that optimal protection from fertilization through initial fry development requires that temperatures be maintained below 9-10°C, and that daily maximum temperatures should not exceed 13.5-14.5°C. Reiser and Bjornn (1979, as cited by Armour et al. 1991) recommended temperatures of 5.0-14.4°C for spring, summer and fall Chinook salmon incubation in the Pacific Northwest. Myrick and Cech (2001) reviewed studies on the Sacramento-San Joaquin River and concluded that the lowest levels of Chinook egg mortality occurred at temperatures between 4-12°C, and while eggs can survive at temperatures from 1.7-16.7°C, mortality is greatly increased at the temperature extremes.

Embryo survival was studied in a laboratory experiment conducted by Murray and McPhail (1988). They incubated five species of Pacific salmon, including Chinook, at five incubation temperatures (2, 5, 8, 11, 14°C). Chinook embryo survival was high at 5, 8, and 11°C, but survival was moderate at 14°C and poor at 2°C. As a result of their study, Murray and McPhail concluded that the range of temperatures for normal embryo development is > 2°C and <14°C (Murray and McPhail 1988).

1.4.3 Coho Spawning, Incubation, and Emergence

In 2002, WDOE found that several studies and literature reviews state that spawning activity in coho may typically occur in the range of 4.4-13.3ºC. According to a review by Bell (1986), preferred spawning temperatures range from 4.5-9.4ºC. Brungs and Jones (1977) used existing data on the optimum and range of temperatures for coho spawning and embryo survival to create criteria using protocols from the National Academy of Sciences and National Academy of Engineering. The resultant criteria were that the MWAT should not exceed 10ºC and the daily maximum temperature should not exceed 13ºC to be protective of coho (Brungs and Jones 1977, p.16).

In a discussion paper and literature summary WDOE (2002) reviewed studies that assessed the survival of embryos and alevin at various temperatures. Based on the findings of these studies WDOE (2002) has determined that the average daily temperature during the incubation period should be at or below 8-10ºC to fully support this coho salmon life stage. According to a review of various literature sources by Bell

(1986), the preferred emergence temperatures for coho range from 4.5-13.3ºC. USEPA (2001) concluded that to fully support pre-emergent stages of coho development MWMTs should not exceed 9-12°C.

Table 7: Effects of Temperature in Considering Coho Incubation and Emergence

<table>
<tr><th>°C</th><th colspan="5">INCUBATION AND EMERGENCE</th></tr>
<tr><td>14</td><td colspan="5">14 Upper limit for normal embryo development (5)</td></tr>
<tr><td>13</td><td colspan="3">13 MWMT should not exceed this value to be protective of spawning, egg incubation, and fry emergence (1)</td><td>13 Daily maximum temperature should not exceed this value to be protective (6)</td><td rowspan="10">4.5-13.3 Preferred emergence temperature range (3)</td></tr>
<tr><td>12</td><td colspan="2"></td><td rowspan="4">9-12 MWMT should not exceed this range to be fully protective (4)</td><td></td></tr>
<tr><td>11</td><td colspan="2"></td><td></td></tr>
<tr><td>10</td><td rowspan="5">6-10 Optimum temperature for salmonid eggs survival to hatching (4)</td><td rowspan="3">8-10 Ave. daily temp. during incubation should be at or below this to be supportive (2)</td><td>10 MWAT should not exceed this to be protective (6)</td></tr>
<tr><td>9</td><td></td></tr>
<tr><td>8</td><td></td><td></td></tr>
<tr><td>7</td><td colspan="3"></td></tr>
<tr><td>6</td><td colspan="3"></td></tr>
<tr><td>5</td><td></td><td colspan="3"></td></tr>
<tr><td>4</td><td></td><td colspan="3"></td></tr>
</table>

Sources: (1) USEPA 2003, (2) WDOE 2002, (3) Bell 1986, (4) USEPA 2001, (5) Murray and McPhail 1988, (6) Brungs and Jones 1977

Murray and McPhail (1988) incubated five species of Pacific salmon, including coho, at five temperatures (2, 5, 8, 11, 14°C) to determine embryo survival at various temperatures. Coho embryos suffered increased mortality above 11°C although survival was still high. They concluded that the upper limit for normal coho embryo development is 14°C (Murray and McPhail 1988).

1.5 Freshwater Rearing and Growth

All of the freshwater rearing and growth temperature needs referenced in this section can be found in Table 8 through Table 10. Temperature affects metabolism, behavior, and survival of both juvenile fish as well as other aquatic organisms that may be food sources. In streams of the Northern California Coast, including the Klamath River, young Chinook, coho and steelhead may rear in freshwater from one to four years before migrating to the ocean.

In an exhaustive study of both laboratory and field studies of temperature effects on salmonids and related species, USEPA (1999a) concluded that temperatures of approximately 22-24°C limit salmonid distribution, i.e., they totally eliminate salmonids from a location. USEPA (1999a) also notes that changes in competitive interactions between fish species can lead to a transition in dominance from salmonids to other species at temperatures 2-4°C lower than the range of total elimination.

To protect salmon and trout during summer juvenile rearing the USEPA (2003) for Region 10 provided a single guidance metric designating 16°C as the 7-DADM temperature that should not be exceeded in areas designated as "core" rearing locations. Core rearing areas are defined as areas with moderate to high densities of summertime salmonid juvenile rearing generally found in the mid- to upper portions of river basins. This criterion will protect juvenile salmonids from lethal temperatures, provide optimal to upper optimal conditions for juvenile growth depending on the time of year, avoid temperatures where salmonids are at a competitive disadvantage with other fish species, protect against increased disease rates caused by elevated temperatures, and provide temperatures which salmonids prefer according to scientific studies.

1.5.1 Steelhead Freshwater Rearing and Growth

Nielsen et al. (1994) studied thermally stratified pools and their use by juvenile steelhead in three California North Coast rivers including the Middle Fork Eel River, Redwood Creek at Redwood National Park, and Rancheria Creek, located in the Navarro River watershed. In detailed observations of juvenile steelhead behavior in and near thermally stratified pools in Rancheria Creek, Nielsen et al. (1994) noted behavioral changes including decreased foraging and increased aggressive behavior as pool temperature reached approximately 22°C. As pool temperature increased above 22°C, juveniles left the observation pools and moved into stratified pools where temperatures were lower.

Wurtsbaugh and Davis (1977, as cited by USEPA 2001) found that steelhead trout growth could be enhanced by temperature increases up to 16.5°C. Using a risk assessment approach which took into account "realistic food estimates", Sullivan et al. (2000) report temperatures of 13-17.0°C (MWAT), 14.5-21°C (MWMT), and 15.5-21°C (annual maximum) will ensure no more than a 10% reduction from maximum growth for steelhead. Reduction from maximum growth will be ≤20% for temperatures ranging from 10-19.0°C (MWAT), 10-24°C (MWMT), and 10.5-26°C (annual maximum).

A literature review was conducted by WDOE (2002) in which studies to determine the water temperature that would allow for maximum growth of steelhead trout were analyzed. These included laboratory studies conducted at constant and fluctuating temperatures. One of the studies was conducted using feeding rates comparable to those observed in natural creeks, although most of the laboratory studies were conducted under satiated feeding conditions. As a result of this review of laboratory studies conducted at constant temperatures, WDOE (2002) concludes that under satiated rations growth may be maximized at temperatures as high as 17.2-19°C. Results from laboratory studies using variable temperatures show maximum growth occurs at average daily temperatures between 15.5-18°C, and that under feeding rates similar to natural conditions at various times of the year maximum growth rates occurred at mean temperatures of 13.3°C (spring season), 15.2°C (fall season) and 16.2°C (summer season).

Table 8: Effects of Temperature in Considering Juvenile Steelhead Rearing and Growth

°C	REARING AND GROWTH					
26						21-26 Annual maximum temp. which will ensure no more than 20% reduction from max. growth (4)
25						
24	22-24 Temperature range which totally eliminates salmonids from area, limiting their distribution (6)				21-24 MWMT which will ensure no more than 20% reduction from max growth (4)	
23		>22 Juveniles left observation pools and moved to pools with lower temperatures (2)				
22		22 Decreased foraging, increased aggressive behavior (2)		18-22 Temperature range at which transition in dominance from salmonids to other species occurs (6)		
21					14.5-21 MWMT which will ensure no more than 10% reduction from maximum growth (4)	15.5-21 Annual maximum temperature which will ensure no more than 10% reduction from maximum growth (4)
20						
19		17-19 MWAT will ensure no more than 20% reduction from max. growth (4)	17.2-19 Growth may be maximized at temperatures as high as this under satiated feeding conditions, lab studies at constant temperature (5)			
18				15.5-18 Average daily temperatures at which maximum growth occurs under satiated feeding, lab studies at varying temps (5)		
17		13-17 MWAT range which will ensure no more than 10% reduction from maximum growth (4)				
16	16.5 Growth enhanced by temp. increases up to this temp. (3) 16.2 Mean temp. at which max. growth occurred during the summer, lab studies using natural feeding conditions and varying temps. (5)		16 MWMT should not exceed this value to be protective of core rearing locations (1)			
15	15.2 Mean temp. at which max. growth occurred during the fall, lab studies using natural feeding conditions and varying temps. (5)					10.5-15.5 Annual maximum temperature which will ensure no more than 20% reduction from maximum growth (4)
14					10-14.5 MWMT which will ensure no more than 20% reduction from maximum growth (4)	
13	13.3 Mean temp. at which max. growth occurred during the spring, lab studies using natural feeding conditions and varying temps. (5)	10-13 MWAT will ensure no more than 20% reduction from maximum growth (4)				
12						
11						
10						

Sources: (1) USEPA 2003, (2) Nielsen et al. 1994, (3) Wurtsbaugh and Davis 1977, as cited by USEPA 2001, (4) Sullivan et al. 2000, (5) WDOE 2002, (6) USEPA 1999a

1.5.2 Chinook Freshwater Rearing and Growth

In a laboratory study, Brett (1952) demonstrated that juvenile Chinook salmon, acclimated to a temperature of 20°C, selectively aggregated in areas where the temperature was in the region of 12-13°C.

ODEQ (1995a), reviewed numerous studies and concluded for juvenile spring Chinook salmon rearing, positive growth takes place at temperatures between 4.5-19°C, and that optimum rearing production is between 10.0-15.6°C. However, as the extremes of this temperature range are reached growth reaches zero. Above and below these thresholds growth becomes negative as feeding ceases and respiration rates increase and/or decrease rapidly.

After synthesizing data from several sources USEPA (2001), came up with the same recommended optimum temperature zone for all Chinook salmon as ODEQ (1995a) of 10.0-15.6°C. While there is research suggesting that some Chinook stocks exhibit adequate rearing capabilities above 15.6°C, USEPA (2001) conclude that anything over this threshold significantly increases the risk of mortality from warm-water diseases.

In a laboratory study Marine and Cech (2004) studied the incremental effects of chronic exposure to three temperature regimes (13-16 °C, 17-20 °C, and 21-24 °C) on Chinook juveniles during rearing and smoltification. Their findings reflected that Chinook juveniles reared at the 17-20 ºC and 21-24 ºC temperature ranges experienced significantly decreased growth rates, impaired smoltification indices, and increased predation vulnerability compared with juveniles reared at 13-16 ºC.

In a field study Chinook grew faster in a stream where temperatures peaked at 16°C compared to a stream where temperatures peaked at 20°C (ODFW 1992, as cited by WDOE 2002). WDOE (2002) reviewed literature on Chinook growth including laboratory studies conducted at a constant temperature, laboratory studies conducted at fluctuating temperatures, and field studies to evaluate the water temperature that would be protective of Chinook and allow for maximum growth. Most of the laboratory studies were conducted under satiated feeding conditions, although one of the studies was conducted using feeding rates more comparable to those observed in natural creeks. As a result of this review of laboratory studies conducted at constant temperatures, WDOE (2002) concludes that maximum growth is expected to occur with exposure to constant temperatures from 15.6-19°C. However, increased growth at temperatures above 15.6°C was inconsistently greater, and under natural rations the temperatures at which maximum growth occurs may decline by as much as 4.2°C. Recommendations based on the review of two laboratory studies conducted at fluctuating temperatures are that "…average temperatures below 19°C are necessary to support maximum growth rates in Chinook salmon, and that the average temperature that produces maximum growth rates likely lies between 15-18°C (median 16.5°C)".

Table 9: Effects of Temperature in Considering Juvenile Chinook Rearing and Growth

<table>
<tr><th>°C</th><th colspan="5">REARING AND GROWTH</th></tr>
<tr><td>24</td><td colspan="2" rowspan="3">22-24 Temperature range which totally eliminates salmonids from area, limiting their distribution (7)</td><td></td><td colspan="2" rowspan="4">21-24 Decreased growth, impaired smoltification, increased predation compared to juveniles reared at 13-16 (6)</td></tr>
<tr><td>23</td><td></td></tr>
<tr><td>22</td><td rowspan="5">18-22 Temperature range at which transition in dominance from salmonids to other species occurs (7)</td></tr>
<tr><td>21</td><td colspan="2"></td></tr>
<tr><td>20</td><td colspan="2"></td><td rowspan="4">17-20 Decreased growth, impaired smoltification, increased predation compared to juveniles reared at 13-16 (6)</td><td></td></tr>
<tr><td>19</td><td>19 Temperatures above this do not support maximum growth, lab studies at varying temperatures (3)</td><td rowspan="5">15.6-19 Maximum growth expected according to lab studies conducted at constant temperature and satiated rations. Under natural feeding conditions maximum growth may occur at temperatures as much as 4.2C lower (3)</td><td rowspan="16">4.5-19 Temperature range at which positive growth takes place (5)</td></tr>
<tr><td>18</td><td rowspan="4">15-18 Average temperature where maximum growth occurs, lab studies conducted at varying temperatures (3)</td></tr>
<tr><td>17</td><td></td></tr>
<tr><td>16</td><td>16 Chinook grew faster in a stream where temperatures peaked at 16 than when they peaked at 19C (3)

16 MWMT should not exceed this value to be protective of core rearing locations (2)</td><td rowspan="4">13-16 Increased growth, unimpaired smoltification, lower predation compared to juveniles reared at 21-24, or 17-20 (6)</td></tr>
<tr><td>15</td><td rowspan="6">10-15.6 Optimal temperature range for rearing (5)</td></tr>
<tr><td>14</td><td rowspan="5">10-15.6 Temperature range for optimal growth. Anything over this threshold increases the risk of mortality from warm water disease (1)</td><td></td></tr>
<tr><td>13</td><td></td></tr>
<tr><td>12</td><td></td><td>12-13 Juvenile Chinook acclimated to 20 selectively aggregate to these water temperatures (4)</td></tr>
<tr><td>11</td><td></td><td></td></tr>
<tr><td>10</td><td></td><td></td></tr>
<tr><td>9</td><td colspan="4"></td></tr>
<tr><td>8</td><td colspan="4"></td></tr>
<tr><td>7</td><td colspan="4"></td></tr>
<tr><td>6</td><td colspan="4"></td></tr>
<tr><td>5</td><td colspan="4"></td></tr>
<tr><td>4</td><td colspan="4"></td></tr>
</table>

Sources: (1) USEPA 2001, (2) USEPA 2003, (3) WDOE 2002, (4) Brett 1952, (5) ODEQ 1995a, (6) Marine and Cech 2004, (7) USEPA 1999a

1.5.3 Coho Freshwater Rearing and Growth

In a study of juvenile coho presence and absence in the Mattole watershed, Welsh et al. (2001) used logistic regression to determine that an MWAT greater than 16.8°C or a MWMT greater than 18.1°C may preclude the presence of juvenile coho salmon in the stream. The criterion correctly determined the presence or absence of juvenile coho in 18 of 21 streams. Welsh et al. (2001) also reported that juvenile coho were found in all streams with an MWAT less than 14.5°C, or a MWMT less than 16.3°C.

Sullivan et al. (2000) reviewed sub-lethal and acute temperature thresholds from a wide range of studies, incorporating information from laboratory-based research, field observations, and risk assessment approaches. Using a risk assessment approach based on "realistic food estimates" Sullivan et al (2000) suggest that MWATs ranging from 12.5-14.5°C for coho will result in no more than a 10% reduction from maximum growth, and that a range for the MWAT of 9-18.5°C will reduce growth no more than 20% from maximum. Sullivan et al. (2000) also calculated temperature ranges for MWMT (13-16.5°C) and the annual maximum temperature (13-17.5°C) that will result in no more than a 10% reduction in maximum growth. They further calculated ranges for MWMT (9-22.5°C) and the annual maximum temperature (9.5-23°C) that will result in no more than a 20% growth loss.

In an attempt to determine the water temperature that will allow for maximum growth of coho salmon, WDOE (2002) reviewed literature on laboratory studies conducted at a constant temperature and fluctuating temperatures, and field studies. The two laboratory studies reviewed were conducted under satiated feeding conditions. Shelbourn (1980, as cited by WDOE 2002) found that maximum growth occurred at a constant temperature of 17°C, while Everson (1973, as cited by WDOE 2002) tested fish at different temperatures and determined that coho had the greatest growth at the temperature test regime from 12.1-20.8°C (median 16.5°C). While the various field studies reviewed did not provide an estimate of the temperature best for maximum growth they did allow for WDOE (2002) to conclude that weekly average temperatures of 14-15°C were more beneficial to growth than lower temperature regimes, and daily maximum temperatures of 21-26°C were detrimental to growth.

Brett (1952) acclimated five different species of salmon to various temperatures ranging from 5-24°C and found that coho salmon showed the greatest preference for temperatures between 12-14°C. It was also determined that coho showed a general avoidance of temperatures above 15°C even in fish who were acclimated to temperatures as high as 24°C.

Konecki et al. (1995a) raised two groups of juvenile coho salmon under identical regimes to test the hypothesis that the group from a stream with lower and less variable temperature would have a lower and less variable preferred temperature than the group from a stream with warmer and more variable temperatures. Results reflected that the two groups tended to differ in their preferred temperature range as predicted above, but the differences were slight. Konecki et al. (1995a) concluded that the temperature preference of juvenile coho salmon in their study was 10-12°C.

Table 10: Effects of Temperature in Considering Juvenile Coho Rearing and Growth

°C	REARING AND GROWTH				
26	21-26 Daily maximum temperatures in this range are detrimental to growth, according to field studies (3)				
25					
24			22-24 Temperature range which totally eliminates salmonids from an area, limiting their distribution (9)		
23					17.5-23 Annual maximum temperature will ensure no more than 20% reduction from maximum growth (2)
22					
21			16.5-22.5 MWMT will ensure no more than 20% reduction from maximum growth (2)	18-22 Temperature range at which transition in dominance from salmonids to other species occurs (9)	
20		12.1-20.8 Greatest growth occurs in this temperature range under satiated conditions, lab study (7)			
19					
18	18.1 MWMT above this may preclude the presence of juvenile coho in steams (5)				
17	14.5-18.5 MWAT will ensure no more than 20% reduction from maximum growth (2)			17 Maximum growth at this constant temperature, at satiated rations in a lab study (6)	13.5 17.5 Annual maximum temperature will ensure no more than 10% reduction from maximum growth (2)
16			13-16.5 MWMT will ensure no more than 10% reduction from maximum growth (2)	16.8 MWAT above this may preclude the presence of juvenile coho in streams (5) 16.3 Juveniles found in all streams with MWMT less than this value (5) 16 MWMT not exceed this value to be protective of core rearing locations (1)	
15				>15 Juveniles show avoidance, even those acclimated to 24C (4) 14-15 Weekly average temperatures in this range are more beneficial than lower temperatures (3)	
14	14.5 Juvenile coho found in all streams with MWAT less than this value (5)			12-14 Preferred temperature range (4)	
13	12.5-14.5 MWAT will ensure no more than 10% reduction from maximum growth (2)		9-13 MWMT will ensure no more than 20% reduction from maximum growth (2)		9.5-13.5 Annual maximum temperature will ensure no more than 20% reduction from max. growth (2)
12	9-12.5 MWAT will ensure no more than 20% reduction from maximum growth (2)			10-12 Preferred temperature range (8)	
11					
10					
9					

Sources: (1) USEPA 2003, (2) Sullivan et al. 2000, (3) WDOE 2002, (4) Brett 1952, (5) Welsh et al. 2001, (6) Shelbourn 1980, as cited by WDOE 2002, (7) Everson 1973, as cited by WDOE 2002, (8) Konecki et al. 1995a, (9) USEPA 1999a

1.6 Lethality

All of the lethal temperatures referenced in this section can be found in Table 11. WDOE (2002) reviewed literature on three types of studies (constant exposure temperature studies, fluctuating temperature lethality studies, and field studies) and used this information to calculate the MWMT that, if exceeded, may result in adult and juvenile salmonid mortality. The resultant MWMTs for these various types of studies are as follows: constant exposure studies 22.64°C, fluctuating lethality studies 23.05°C , and field studies 22.18°C.

1.6.1 Steelhead Lethality

Coutant (1970, as cited by USEPA 1999a) found that Columbia River steelhead, which were acclimated to a river temperature of 19°C, had a lethal threshold of 21°C. Bell (1986) reviewed various studies and states that the lethal threshold for steelhead is 23.9°C. According to the California Department of Fish and Game (2001, p.419), temperatures of 21.1°C have been reported as being lethal to adults.

1.6.2 Chinook Lethality

In a laboratory study, Brett (1952) acclimated five different species of juvenile salmon to various temperatures ranging from 5-24°C. At temperatures of 24°C and below there was 100% survival of fish during the one-week duration of the experiment. Brett (1952) concluded that the lethal temperature (temperature where survival becomes less than 100%) was between 24.0 and 24.5°C, and the ultimate upper lethal temperature was 25.1°C (temperature at which 50% of the population is dead after infinite exposure). A review of numerous studies led Bell (1986) to conclude that the upper lethal temperature for Chinook is 25°C. Myrick and Cech (2001) reviewed literature on studies from the Central Valley and found data to suggest that the chronic (exposure >7 days) upper lethal limit for juvenile Chinook is approximately 25°C.

1.6.3 Coho Lethality

In a review of various literature sources, Bell (1986) found that the upper lethal temperature for coho is 25.6°C. Brett (1952) concluded that the ultimate upper lethal temperature of juvenile coho salmon was 25.0°C (temperature at which 50% of the population is dead after infinite exposure). Thomas et al. (1986) conducted a study to determine the mortality of coho subjected to fluctuating temperatures. It was determined that the LT50 (the temperature at which 50% of the population will die) for fish acclimated to a 10-13°C cycle was 26°C for presmolts (age-2 fish), and 28°C for age-0 fish.

Table 11: Effects of Temperature in Considering Lethality and Salmonids

°C	Steelhead	Chinook	Coho	All Salmonids
28			28 LT50[1] for age 0-fish acclimated to a 10-13C cycle (6)	
27				
26			26 LT50[1] for presmolts (age 2-fish) acclimated to a 10-13C cycle (6)	
25		25.1 Upper lethal temp. at which 50% of the population would die after infinite exposure, juvenile Chinook acclimated to temperatures from 5-24C (4)	25.6 Upper lethal threshold (3)	
		25 Upper lethal threshold (3)	25 Upper lethal temp. at which 50% of the population would die after infinite exposure, juvenile coho acclimated to temps. from 5-24C (4)	
		25 Chronic (exposure >7 days) upper lethal limit for juvenile Chinook (5).		
24		24-24.5 Survival becomes less than 100% for juvenile Chinook acclimated to temperatures from 5-24C (4)		
23	23.9 Upper lethal threshold for steelhead (3)			23.05 do not exceed this value to prevent adult and juvenile mortality, data from fluctuating temp. studies (1)
22				22.64 do not exceed this value to prevent adult and juvenile mortality, data from constant exposure studies (1)
				22.18 do not exceed this value to prevent adult and juvenile mortality, data from field studies (1)
21	21.1 Temperature lethal to adults (7)			
	21 Lethal threshold for steelhead acclimated to 19C (2)			

[1] Maximum temperature in the cycle at which 50% mortality occurred
Sources: (1) WDOE 2002, (2) Coutant 1970, as cited by USEPA 1999a, (3) Bell 1986, (4) Brett 1952, (5) Myrick and Cech 2001, (6) Thomas et al. 1986, (7) California Department of Fish and Game (CDFG) 2001

1.7 Disease

All of the effects of temperatures on disease risk in salmonids referenced in this section can be found in Table 12. WDOE (2002) reviewed studies of disease outbreak in salmonids and estimates that an MWMT of less than or equal to 14.38°C (midpoint of 12.58-16.18 range) will virtually prevent warm water disease effects. To avoid serious

Table 12: Effects of Temperature in Considering Disease and Salmonids

<table>
<tr><th>°C</th><th colspan="2">Ich</th><th colspan="2">Ceratomyxosis</th><th>Columnaris</th><th colspan="2">Disease (general)</th></tr>
<tr><td>26</td><td></td><td rowspan="6">21-26.7 Optimum temp. range for Ich, compilation of temps. from three references (3,4,5)</td><td colspan="2"></td><td></td><td colspan="2"></td></tr>
<tr><td>25</td><td></td><td colspan="2"></td><td></td><td colspan="2"></td></tr>
<tr><td>24</td><td>>24 Lifecycle takes less than 4 days (5)</td><td colspan="2"></td><td></td><td colspan="2"></td></tr>
<tr><td>23</td><td rowspan="3">21-23.9 Life cycle takes as few as 3-4 days (5)</td><td>23.3 Juvenile coho salmon and rainbow trout time from exposure to death is 12.5 and 14 days respectively (9)</td><td rowspan="13">6.7-23.3 Juvenile rainbow trout have little or no ability to overcome infection, and mortality varied from 75-86% (9)</td><td>23.3 Juvenile spring Chinook mortality was 92%, and time from exposure to death was 2.3 days (13)</td><td colspan="2"></td></tr>
<tr><td>22</td><td></td><td>22.2 Mortality is 100% in juvenile sockeye exposed to C. columnaris (10)</td><td colspan="2"></td></tr>
<tr><td>21</td><td></td><td>>21.1 Temperatures at this level are associated with a 28-74% infection rate in Chinook (11)</td><td colspan="2"></td></tr>
<tr><td rowspan="3">20</td><td rowspan="5">18.3-21.2 Serious outbreaks of Ich occur (4)</td><td rowspan="3">20 Lifecycle takes 1 week (6)</td><td rowspan="3">20.5 Mortality is 84% in juvenile coho exposed to C. shasta (9).</td><td>20.5 Mortality in juvenile steelhead and coho from Columnaris was 100%, and 70% in juvenile spring Chinook (13)</td><td rowspan="3">>20.88 MWMTs over this value can result in severe infections and catastrophic outbreaks (1)</td><td rowspan="5">18-20 Temperature range which is associated with a high risk of disease in rearing juveniles and migrating adults (2)</td></tr>
<tr><td>20.5 In juvenile steelhead and coho time from exposure to death was 1.6-1.7 days (13)</td></tr>
<tr><td>20 Average water temperature at which low virulence strains show signs of outbreak (3, 12)</td></tr>
<tr><td>19</td><td></td><td></td><td></td><td></td></tr>
<tr><td>18</td><td></td><td></td><td></td><td></td></tr>
<tr><td>17</td><td colspan="2"></td><td></td><td>17.8 Mortality rates were 52, 92, and 99% for juvenile spring Chinook, steelhead and coho respectively (13)</td><td>17.38 MWMT should not be exceeded to avoid serious rates of infection and mortality (1)</td><td rowspan="5">14-17 Temperature range which is associated with an elevated risk of disease in rearing juveniles and migrating adults (2)</td></tr>
<tr><td>16</td><td colspan="2"></td><td></td><td>16.1 Mortality is 30% in juvenile sockeye exposed to C. columnaris (10)</td><td></td></tr>
<tr><td rowspan="2">15</td><td colspan="2">>15.6 Associated with outbreaks in salmonid fingerlings, especially Chinook (3)</td><td rowspan="2">15 Mortality is 22% in juvenile coho exposed to C. shasta (9).</td><td>15.6 Average water temperature at which low virulence strains show signs of outbreak (3)</td><td rowspan="2"></td></tr>
<tr><td colspan="2">15.5 Lifecycle of Ich takes 2 weeks (5)</td><td>15 Mortality was 31, 56, and 51% for juvenile spring Chinook, steelhead, and coho respectively (13)</td></tr>
<tr><td>14</td><td colspan="2"></td><td></td><td></td><td>14.38 MWMT will virtually prevent all warm water disease (1)</td></tr>
</table>

Table 12 (continued):Effects of Temperature in Considering Disease and Salmonids

°C	Ich	Ceratomyxosis		Columnaris	Disease (general)
13			6.7-23.3 Juvenile rainbow trout have little or no ability to overcome infection, and mortality varied from 75-86% (9)		12-13 Temperature range which minimizes the risk of disease in rearing juveniles and migrating adults (2)
12				12.8 After 7 days of infection mortality is 60-100% (majority of tests 100%) (12)	
				12.2 Mortality was 4-20% in juvenile spring Chinook, steelhead, and coho respectively. Time from exposure to death ranged from 7.6-12.2 days (13).	
11		10-11 *C. shasta* appears to be come infective (4)			
10	10 Lifecycle takes more than 5 weeks (5)				
		<10 Steelhead show evidence of *C. shasta* in ~38 days (8)			
9		9.4 Juvenile coho time from exposure to death is 146 days, mortality is 2% (9)		3.9-9.4 No mortality in spring Chinook, steelhead, or coho from Columnaris (13)	
8					
7	7 Lifecycle takes 20 days (6)				
	<7 Lifecycle takes more than 5 weeks (7)				
6			6.7 Juvenile rainbow trout time from exposure to death is 155 days (9)		
			3.9-6.7 No mortality in Juvenile coho exposed to *C. shasta* (9)		
5					
4					
3					

Sources: (1) WDOE 2002, (2) USEPA 2003, (3) Bell 1986, (4) CDWR 1988, (5) Piper et al 1982, (6) Nigrelli et al. 1976, as cited by Dickerson et al. 1995, (7) Durborow et al. 1998, (8) Leitritz and Lewis, 1976, (9) Udey et al. 1975, (10) Ordal and Rucker 1944, as cited by Pacha et al. 1970, (11) USEPA 1999a, (12) Pacha et al. 1970, (13) Holt et al. 1975 rates of infection and mortality the MWMT should not exceed 17.38°C (midpoint of 15.58-19.18 range), and that severe infections and catastrophic outbreaks become a serious concern when the MWMTs exceed 20.88°C (midpoint of 18.58-23.18 range).

In a summary of temperature considerations, USEPA (2003) states that disease risks for juvenile rearing and adult migration are minimized at temperatures from 12-13°C, elevated from 14-17°C, and high at temperatures from 18-20°C.

Acknowledging that there are many diseases that affect salmonids, the following discussion will focus on three which are common in the Klamath Basin: Ichthyophthiriasis (Ich), Ceratomyxosis, and Columnaris. *Ichthyophthirius multifiliis* is a protozoan parasite that causes the disease known as Ichthyophthiriasis (Ich). The disease ceratomyxosis is caused by a parasite, *Ceratomyxa shasta* (*C. shasta*). Columnaris disease is a bacterial infection caused by *Flavobacterium columnare* (synomyms*: Bacillus columnaris, Chondrococcus columnaris, Cytophaga columnaris, Flexibacter columnaris*).

1.7.1 Ichthyophthiriasis (Ich)
Nigrelli et al. (1976, as cited by Dickerson et al. 1995) proposed that there are physiological races of Ich, which are related to the temperature tolerance of the host fishes. Thus, there are races of Ich that infect cold-water (7.2-10.6°C) fishes such as salmon, and others that infect warm-water (12.8-16.1°C) tropical fishes. Bell (1986) discusses Ich and states that at water temperatures above 15.6°C, this disease often breaks out in salmon fingerlings, especially Chinook. CDWR (1988) states that serious outbreaks of Ich occur at temperatures from 18.3-21.2°C.

Numerous studies and reviews have been conducted on the optimal temperature for Ich. Piper et al. (1982, p.316.) wrote that optimal temperatures range from 21-23.9°C. CDWR (1988) stated the optimum temperature for Ich is in the range of 25 to 26.7°C, while Bell (1986) states optimum temperatures are noted from 21.2-26.7°C.

Temperature is an important factor in the persistence of Ich infections in salmonids. The growth period varies from 1 week at 20 °C to 20 days at 7 °C (Nigrelli et al. 1976, as cited by Dickerson et al. 1995). Piper et al. (1982, p.316) state that at optimal temperatures of 21-23.9°C, the life cycle may take as few as 3-4 days. The cycle requires 2 weeks at 15.5°C, and more than 5 weeks at 10°C (Piper et al. 1982, p.316). Durborow et al. (1998) note that to complete its lifecycle, Ich requires from less than 4 days at temperatures higher than 24°C, to more than 5 weeks at temperatures lower than 7°C. Although studies report varying lengths of time for Ich to complete its lifecycle at similar temperatures, it is clear that the speed at which Ich develops increases as temperatures increase.

1.7.2 Ceratomyxosis
In reviewing the literature on Ceratomyxosis (a disease caused by the parasite, C. shasta), it is clear that as water temperatures increase, the intensity of the disease increases, and the incubation period decreases (CDWR 1988, Letritz and Lewis, Udey et al. 1975). At

water temperatures greater than 10°C, steelhead will show evidence of Ceratomyxosis in approximately 38 days (Leitritz and Lewis 1976, p.154). In a study of juvenile coho salmon by Udey et al. (1975), time from exposure to death was more than 90% temperature dependent, and increased from 12.5 days at 23.3°C, to 146 days at 9.4°C. These results show the accelerating effect of higher temperatures on the progress of the disease. The time from exposure to death of juvenile rainbow trout was nearly 97% temperature dependent, increasing from 14 days at 23.3°C to 155 days at 6.7°C (Udey et al. 1975).

C. shasta appears to become infective at temperatures around 10-11°C (CDWR 1988). According to Leitritz and Lewis (1976, p.154), steelhead from the Klamath River are quite susceptible to *C. shasta* infections and suffer severe losses when exposed.

Udey et al. (1975) conducted a study to determine the relation of water temperature to Ceratomyxosis in juvenile rainbow trout and coho salmon. Rainbow trout from the Roaring River Hatchery, and coho from Fall Creek Salmon Hatchery (both in Oregon) were used in this experiment. Groups of 25 fish exposed to *C. shasta* were transferred to 12.2°C water, and then were tempered to one of eight experimental temperatures from 3.9 to 23.3°C (2.8°C increments).

In the juvenile coho salmon experiment, Udey et al. (1975) found that percent mortality increased progressively from 2% at 9.4°C to 22% at 15.0°C and 84% at 20.5°C. No deaths occurred in coho salmon maintained at 3.9 and 6.7°C, indicating that ceratomyxosis in coho can be suppressed by water temperatures of 6.7°C or below (Udey et al. 1975).

Tests conducted by Udey et al. (1975) on rainbow trout juveniles indicate that once infection is initiated, juvenile rainbow trout have little or no ability to overcome *C. shasta* infections at water temperatures between 6.7 and 23.3°C. Fatal infections varied from 75-86% at temperatures ranging from 6.7 to 15.0°C (Udey et al. 1975). Mortality in trout held at 20.5 and 23.3°C were lower (72% and 52% respectively) due to losses from *Flexibacter columnaris*, which occurred well before the onset of deaths caused by *C. shasta*, in spite of efforts to control it with terramycin (Udey et al. 1975). The results from Udey et al. (1975) also reflected no deaths occurred in juvenile trout held at 3.9°C.

1.7.3 Columnaris

The importance of temperature on infections of Columnaris has been demonstrated in numerous laboratory studies. Ordal and Rucker (1944, as cited by Pacha et al. 1970) exposed juvenile sockeye salmon to *C. columnaris* and studied the effect of temperature on the disease. In these studies, the overall mortality ranged from 30% in fish held at 16.1°C to 100% in those held at 22.2°C (Ordal and Rucker 1944, as cited by Pacha et al. 1970). USEPA (1999a) cites studies that conducted surveys of Columnaris infection frequency on Chinook in the Snake River in July and early August of 1955-1957, which revealed 28-75% of fish infected when water temperature was >21.1°C.

Low virulence strains of Columnaris show signs of outbreak when average water temperatures are over 20°C (Bell 1986, Pacha et al. 1970). Bell (1986) states that outbreaks of high virulence strains occur when average water temperatures reach 15.6°C, and Pacha et al. (1970) found mortalities of 60-100% (majority of tests 100%) occur at temperatures of 12.8°C after 7 days of infection. With regard to strains of higher virulence, while these strains are capable of beginning infection and producing disease at water temperatures as low as 12.8°C, the disease process becomes progressively slower as the water temperature is lowered (Pacha et al. 1970).

Holt et al. (1975) performed a study on the relation of water temperature to Columnaris in juvenile steelhead trout and juvenile coho and spring Chinook salmon. Tests were performed on groups of 25-35 fish at eight temperatures ranging from 3.9°C to 23.3°C (2.8°C increments). At 20.5°C mortality was 100% in juvenile steelhead trout and coho salmon, 70% in juvenile spring Chinook salmon, and at temperatures 23.3°C juvenile spring Chinook mortality was 92% (Holt et al. 1975). Mortality rates were 52, 92, and 99% at 17.8°C for juvenile spring Chinook, steelhead trout, and coho salmon respectively, and mortality dropped to 31, 56, and 51% at 15.0°C (Holt et al. 1975). At 12.2°C mortality varied from 4 to 20% among juveniles of the three species, and at temperatures of 9.4°C and below, no deaths due to the experimental infection with *F. columnaris* occurred (Holt et al. 1975). Holt et al. (1975) state that these results indicate that under the conditions of these experiments Columnaris disease was completely suppressed by water temperatures of 9.4°C or below.

In general, data from laboratory studies indicates that as water temperatures increase, the time to death decreases (Pacha et al. 1970). With juvenile steelhead trout and juvenile coho and spring Chinook salmon as the temperature increased above 12.2°C, the disease process was progressively accelerated, resulting in a minimum time to death at 20.5 or 23.3°C and a maximum at 12.2°C (Holt et al. 1975). In these juvenile salmonids Holt et al. (1975) found the mean time to death decreased from 7.6-12.2 days at 12.2°C to 1.6-1.7 days at 20.5°C for juvenile coho and steelhead, and 2.3 days at 23.3°C for juvenile spring Chinook (Holt et al. 1975).

1.8 TMDL Temperature Thresholds

Currently there are no numeric temperature standards in the *Water Quality Control Plan for the North Coast Region* (Basin Plan). Thus, information from this literature review will be utilized by Regional Water Board staff to selected chronic and acute temperature thresholds for evaluation of stream temperatures in TMDLs. Chronic temperature thresholds (MWMTs) were selected from the USEPA document *EPA Region 10 Guidance For Pacific Northwest State and Tribal Temperature Water Quality Standards* (2003), and are presented in Table 13. The Region 10 guidance is the product of a three-year interagency effort, and has been reviewed by both independent science review panels and the public. Acute lethal temperature thresholds were selected based upon best professional judgment of the literature, and are presented in Table 14.

Table 13: Life Stage Temperature Thresholds

Life Stage	MWMT (°C)
Adult Migration	20
Adult Migration plus Non-Core[1] Juvenile Rearing	18
Core[2] Juvenile Rearing	16
Spawning, Egg Incubation, and Fry Emergence	13

[1] Non-Core is defined as moderate to low density salmon and trout rearing usually occurring in the mid or lower part of the basin (moderate and low not defined).
[2] Core is defines as areas of high density rearing (high is not specifically defined).
Source: USEPA 2003

Table 14: Lethal Temperature Thresholds

Lethal Threshold[1] (°C)			
Life Stage	**Steelhead**	**Chinook**	**Coho**
Adult Migration and Holding	24	25	25
Juvenile Growth and Rearing	24	25	25
Spawning, Egg Incubation, and Fry Emergence	20	20	20

[1] The lethal thresholds selected in this table are generally for chronic exposure (greater than seven days). Although salmonids may survive brief periods at these temperatures, they are good benchmarks from the literature for lethal conditions.

In some cases it may be necessary to calculate MWATs for a given waterbody, and compare these to MWAT thresholds. USEPA (2003) states that for many rivers in the Pacific Northwest the MWMT is about 3°C higher than the MWAT (USEPA 2003, as cited by Dunham et al. 2001and Chapman 2002). Rather than list MWAT thresholds in this document using the 3°C difference suggested above, the Regional Water Board will consider stream temperatures within each individual TMDL waterbody. Thus the Regional Water Board will calculate both MWMTs and MWATs for the waterbody, and characterize the actual difference between these temperature metrics for the watershed using an approach similar to that used in Sullivan et al. (2000). Once this relationship is understood, MWAT thresholds for each life stage can be identified and compared to the watershed MWATs.

The freshwater temperature thresholds presented in this section are applicable during the season or time of year when the life stage of each species is present. Periodicity information is not discussed in this document and will be presented in each individual TMDL staff report. Where life history, timing, and/or species needs overlap, the lowest of each temperature metric applies.

CHAPTER 2. DISSOLVED OXYGEN and TOTAL DISSOLVED GAS

2.1 Introduction

Adequate concentrations of dissolved oxygen in fresh water streams are critical for the survival of salmonids. Fish have evolved very efficient physiological mechanisms for obtaining and using oxygen in the water to oxygenate the blood and meet their metabolic demands (WDOE 2002). Reduced levels of dissolved oxygen can impact growth and development of different life stages of salmon, including eggs, alevins, and fry, as well as the swimming, feeding and reproductive ability of juveniles and adults. Such impacts can affect fitness and survival by altering embryo incubation periods, decreasing the size of fry, increasing the likelihood of predation, and decreasing feeding activity. Under extreme conditions, low dissolved oxygen concentrations can be lethal to salmonids. High levels of total dissolved gas concentrations (TDG), including dissolved oxygen, can result in gas bubble disease and death for salmonids.

Literature reviewed for this analysis included EPA guidance, other states' standards, reports that compiled and summarized existing scientific information, and numerous laboratory studies. When possible, species-specific requirements were summarized for the following life stages: migrating adults, incubation and emergence, and freshwater rearing and growth. The following information applies to salmonids in general, with specific references to coho, Chinook, steelhead, and other species of salmonids as appropriate.

2.2 Effects of Low Dissolved Oxygen Concentrations on Salmonids

2.2.1 Adult Migration

Reduced concentrations of dissolved oxygen can negatively affect the swimming performance of migrating salmonids (Bjornn and Reiser 1991). The upstream migration by adult salmonids is typically a stressful endeavor. Sustained swimming over long distances requires high expenditures of energy and therefore requires adequate levels of dissolved oxygen. Migrating adult Chinook salmon in the San Joaquin River exhibited an avoidance response when dissolved oxygen was below 4.2 mg/L, and most Chinook waited to migrate until dissolved oxygen levels were at 5 mg/L or higher (Hallock et al. 1970).

2.2.2 Incubation/Emergence

Low levels of dissolved oxygen can be directly lethal to salmonids, and can also have sublethal effects such as changing the rate of embryological development, the time to hatching, and size of emerging fry (Spence et al. 1996). The embryonic and larval stages of salmonid development are especially susceptible to low dissolved oxygen levels as their ability to extract oxygen is not fully developed and their relative immobility inhibits their ability to migrate to more favorable conditions. The dissolved oxygen requirements for successful incubation of embryos and emergence of fry is tied to intragravel dissolved oxygen levels. Intragravel dissolved oxygen is typically a function of many chemical, physical, and hydrological variables, including: the dissolved oxygen concentration of the overlying stream water, water temperature, substrate size and porosity, biochemical oxygen demand of the intragravel water, sediment oxygen demand, the gradient and velocity of the stream, channel configuration, and depth of water. As a result the dissolved oxygen concentration within the gravels can be depleted causing problems for salmonid embryos and larvae, even when overlying surface water oxygen levels are suitable (USEPA 1986a).

Studies note that water column dissolved oxygen concentrations are typically estimated to be reduced by 1-3 mg/L as water is transmitted to redds containing developing eggs and larvae (WDOE 2002). USEPA (1986a) concluded that dissolved oxygen levels within the gravels should be considered to be at least 3 mg/L lower than concentrations in the overlying water. ODEQ (1995b) expect the loss of an average of 3 mg/L dissolved oxygen from surface water to the gravels.

2.2.3 Incubation Mortality

Phillips and Campbell (1961, as cited by Bjornn and Reiser 1991) concluded that intragravel dissolved oxygen must average 8 mg/L for embryos and alevins to survive well. After reviewing numerous studies Davis (1975) states that a dissolved oxygen concentration of 9.75 mg/L is fully protective of larvae and mature eggs, while at 8 mg/L the average member of the incubating population will exhibit symptoms of oxygen distress, and at 6.5 mg/L a large portion of the incubating eggs may be affected. Bjornn and Reiser (1991) reviewed numerous references and recommend that dissolved oxygen should drop no lower than 5 mg/L, and should be at or near saturation for successful incubation.

In a review of several laboratory studies, ODEQ (1995b) concluded that at near optimum (10°C) constant temperatures acute mortality to salmonid embryos occurs at relatively low concentrations of dissolved oxygen, near or below 3 mg/L. Field studies reviewed by ODEQ (1995b) demonstrate that embryo survival is low when the dissolved oxygen content in the gravels drops near or below 5 mg/L, and survival is greater at 8 mg/L.

Silver et al. (1963) performed a study with Chinook salmon and steelhead trout, rearing eggs at various constant dissolved oxygen concentrations and water velocities. They found that steelhead embryos held at 9.5°C and Chinook salmon embryos held at 11°C experienced complete mortality at dissolved oxygen concentrations of 1.6 mg/L. Survival of a large percentage of embryos reared at oxygen levels as low as 2.5 mg/L appeared to be possible by reduction of respiration rates and consequent reduction of growth and development rates.

In a field study Cobel (1961) found that the survival of steelhead embryos was correlated to intragravel dissolved oxygen in the redds, with higher survival at higher levels of dissolved oxygen. At 9.25 mg/L survival was 62%, but survival was only 16% at 2.6 mg/L. A laboratory study by Eddy (1971) found that Chinook salmon survival at 10.4 mg/L (13.5 °C) was approximately 67%, however at dissolved oxygen levels of 7.3 mg/L (13.5 °C) survival dropped to 49-57.6%. At temperatures more suitable for Chinook incubation (10.5 °C) Eddy (1971) found the percent survival remained high (over 90%) at dissolved oxygen levels from 11 mg/L to 3.5 mg/L; however, as dissolved oxygen levels decreased, the number of days to hatching increased and the mean dry weight of the fry decreased substantially. WDOE (2002) also points out that the studies above did not consider the act of emerging through the redds, and the metabolic requirements to emerge would be expected to be substantial. Therefore, it is likely that higher oxygen levels may be needed to fully protect hatching and emergence, than to just support hatching alone.

2.2.4 Incubation Growth

Embryos can survive when dissolved oxygen is below saturation (and above a critical level), but development typically deviates from normal (Bjornn and Reiser 1991). Embryos were found to be smaller than normal, and hatching either delayed or premature, when dissolved oxygen was below saturation throughout development (Doudoroff and Warren 1965, as cited by Bjornn and Reiser 1991).

Garside (1966) found the number of days it took for rainbow trout to go from fertilization to hatching increased as dissolved oxygen concentrations and water temperature decreased. In this study, rainbow trout were incubated at temperatures between 2.5 - 17.5°C and dissolved oxygen levels from 2.5 - 11.3 mg/L. At 10°C and 7.5°C the total time for incubation was delayed 6 and 9 days respectively at dissolved oxygen levels of 2.5 mg/L versus embryos incubated at approximately 10.5 mg/L.

Silver et al. (1963) found that hatching of steelhead trout held at 9.5°C was delayed 5 to 8 days at dissolved oxygen concentrations averaging 2.6 mg/L versus embryos reared at 11.2 mg/L. A smaller delay of hatching was observed at oxygen levels of 4.2 and 5.7 mg/L, although none was apparent at 7.9 mg/L. For Chinook salmon held at 11°C, Silver et al. observed that embryos reared at oxygen levels lower than 11 mg/L experienced a delay in hatching, with the most significant delay in those reared at dissolved oxygen levels of 2.5 mg/L (6 to 9 days). The size of both Chinook and steelhead embryos increased with increases in dissolved oxygen up to 11.2 mg/L. External examination of embryos revealed abnormal structural development in Chinook salmon tested at dissolved oxygen concentrations of 1.6 mg/L, and abnormalities in steelhead trout at concentrations of 1.6 and 2.6 mg/L. The survival of Chinook salmon after hatching was only depressed at the 2.5 mg/L level, the lowest level at which hatching occurred, with lower mortalities occurring at higher velocities. Post hatching survival of steelhead trout could not be determined due to numerous confounding factors.

Shumway et al. (1964) conducted a laboratory study to determine the influence of oxygen concentration and water movement on the growth of steelhead trout and coho salmon embryos. The experiments were conducted at a temperature of 10°C and oxygen levels generally ranging from 2.5 - 11.5 mg/L and flows from 3 to 750 cm/hour. It was concluded that the median time to hatching decreased and size of fry increased as dissolved oxygen levels increased. For example, steelhead trout embryos reared at 2.9 mg/L hatched in approximately 41 days and had a wet weight of 17 mg, while embryos reared at 11.9 mg/L hatched in 36 days and weighed 32.3 mg. The authors found that a reduction of either the oxygen concentration or the water velocity will reduce the size of fry and increase the incubation period, although the affect of various water velocities tested was less than the effect of the different dissolved oxygen concentrations tested.

WDOE (2002) reviewed various references and found that at favorable incubation temperatures a mean oxygen concentration of 10.5 mg/L will result in a 2% reduction in growth. At other oxygen concentrations, growth is reduced as follows: 8% reduction at oxygen levels of 9 mg/L, 10% reduction at 7 mg/L, and a 25% reduction at 6 mg/L.

2.2.5 Incubation Avoidance/Preference

Alevin showed a strong preference for oxygen concentrations of 8 - 10 mg/L and moved through the gravel medium to these concentrations, avoiding concentrations from 4 - 6 mg/L (WDOE 2002).

2.2.6 Emergence Mortality

"The hatching time, size, and growth rate of developing embryos is proportional to the dissolved oxygen concentrations up to 8 mg/L or greater. The ability of fry to survive their natural environment may be related to the size of fry at hatch (ODEQ 1995b)." McMahon (1983) recommends dissolved oxygen levels be ≥ 8 mg/L for high survival and emergence of fry. In a review of controlled field and lab studies on emergence, WDOE (2002) states that average intragravel oxygen concentrations of 6 - 6.5 mg/L and lower can cause stress and mortality in developing embryos and alevin. It is also noted that field studies on emergence consistently cite intragravel oxygen concentrations of 8 mg/L or greater as being associated with or necessary for superior health and survival, oxygen concentrations below 6 - 7 mg/L result in a 50% reduction in survival through emergence, and oxygen concentrations below 5 mg/L result in negligible survival. According to various laboratory studies, the threshold for complete mortality of emerging salmonids is noted to occur between 2 - 2.5 mg/L (WDOE 2002).

After reviewing numerous literature sources, the USEPA (1986a) concluded that the embryonic and larval stages of salmonid development will experience no impairment when water column dissolved oxygen concentrations are 11 mg/L. This translates into an intragravel dissolved oxygen concentration of 8 mg/L (USEPA assumes a 3 mg/L loss between the surface water and gravels). Table 15 from the USEPA (1986a) lists the water column and intragravel dissolved oxygen concentrations associated with various health effects. These health affects range from no production impairment to acute mortality.

Table 15: Dissolved oxygen concentrations and their effects salmonid embryo and larval stages

Level of Effect	Water Column DO (mg/L)	Intragravel DO (mg/L)
No Production Impairment	11	8*
Slight Production Impairment	9	6*
Moderate Production Impairment	8	5*
Severe Production Impairment	7	4*
Limit to Avoid Acute Mortality	6	3*

* A 3 mg/L loss is assumed between the water column dissolved oxygen levels and those intragravel.
Source: USEPA 1986a

2.2.7 Freshwater Rearing and Growth

2.2.7.1 Swimming and Activity

Salmonids are strong active swimmers requiring highly oxygenated waters (Spence 1996), and this is true during the rearing period when the fish are feeding, growing, and avoiding predation. Salmonids may be able to survive when dissolved oxygen concentrations are low (<5 mg/L), but growth, food conversion efficiency, and swimming performance will be adversely affected (Bjornn and Reiser 1991). Davis (1975) reviewed numerous studies and reported no impairment to rearing salmonids if dissolved oxygen concentrations averaged 9 mg/L, while at oxygen levels of 6.5 mg/L "the average member of the community will exhibit symptoms of oxygen distress", and at 4 mg/L a large portion of salmonids may be affected. Dahlberg et al. (1968) state that at temperatures near 20°C any considerable decrease in the oxygen concentration below 9 mg/L (the air saturation level) resulted in some reduction of the final swimming speed. They found that between dissolved oxygen concentrations of 7 to 2 mg/L the swimming speed of coho declined markedly with the decrease in dissolved oxygen concentration.

In a laboratory study, Davis et al. (1963) reported that the maximum sustainable swimming speeds of wild juvenile coho salmon were reduced when dissolved oxygen dropped below saturation at water temperatures of 10, 15, and 20°C. Air-saturation values for these dissolved oxygen concentrations were cited as 11.3, 10.2, and 9.2 mg/L respectively. They found that the maximum sustained swimming speeds (based on first and second swimming failures at all temperatures) were reduced by 3.2 - 6.4%, 5.9 - 10.1%, 9.9 - 13.9%, 16.7 - 21.2%, and 26.6 - 33.8% at dissolved oxygen concentrations of 7, 6, 5, 4, and 3 mg/L respectively. The authors also conducted tests on juvenile Chinook salmon and found that the percent reductions from maximum swimming speed at temperatures ranging from 11 to 15°C were greater than those for juvenile coho. At the dissolved oxygen concentrations listed above swimming speeds were decreased by 10%, 14%, 20%, 27%, and 38% respectively.

WDOE (2002) reviewed various data and concluded that swimming fitness of salmonids is maximized when the daily minimum dissolved oxygen levels are above 8 - 9 mg/L. Jones et al. (1971, as cited by USEPA 1986a) found the swimming speed of rainbow trout was decreased 30% from maximum at dissolved oxygen concentrations of 5.1 mg/L and 14°C. At oxygen levels of 3.8 mg/L and a temperature of 22°C, they found a 43% reduction in the maximum swimming speed.

2.2.7.2 Growth

In a review of constant oxygen exposure studies WDOE (2002) concluded salmonid growth rates decreased less than 10% at dissolved oxygen concentrations of 8 mg/L or more, less than 20% at 7 mg/L, and generally less than 22% at 5 - 6 mg/L. Herrmann (1958) found that the mean percentage of weight gain in juvenile coho held at constant dissolved oxygen concentrations was 7.2% around 2 mg/L, 33.6% at 3 mg/L, 55.8% near 4 mg/L, and 67.9% at or near 5 mg/L. In a laboratory study Fischer (1963) found that the growth rates of juvenile coho exposed to constant oxygen concentrations ranging from 2.5 to 35.5 mg/L (fed to satiation, temperature at approximately 18 °C) dramatically decreased with decreases in the oxygen concentration below 9.5 mg/L (air saturation level). WDOE (2002) concludes that a monthly or weekly average concentration of 9 mg/L, and a monthly average of the daily minimum concentrations should be at or above 8 - 8.5 mg/L to have a negligible effect (5% or less) on growth and support healthy growth rates.

Food conversion efficiency is related to dissolved oxygen levels and the process becomes less efficient when oxygen concentrations are below 4 - 4.5 mg/L (ODEQ 1995b). Bjornn and Reiser (1991) state that growth, food conversion efficiency, and swimming performance are adversely affected when dissolved oxygen concentrations are <5 mg/L. The USEPA (1986a) reviewed growth data from a study conducted by Warren et al. (1973) where tests were conducted at various temperatures to determine the growth of coho and Chinook. USEPA cites that, with the exception of tests conducted at 22 °C, the results supported the idea that the effects of low dissolved oxygen become more severe at higher temperatures.

Brett and Blackburn (1981) performed a laboratory study to determine the growth rate and food conversion efficiency of young coho and sockeye salmon fed full rations. Tests were performed at dissolved oxygen concentrations ranging from 2 to 15 mg/L at a constant temperature of 15°C, the approximate optimum temperature for growth of Pacific Salmon. Both species showed a strong dependence of growth on the environmental oxygen concentrations when levels were below 5 mg/L. For coho, zero growth was observed at dissolved oxygen concentrations of 2.3 mg/L. The mean value for maximum coho growth occurred at 4 mg/L, and at dissolved oxygen concentrations above this level growth did not appear to be dependant on the dissolved oxygen. Sockeye displayed zero growth at oxygen levels of 2.6 mg/L, and reached the zone of independence (growth not dependant on dissolved oxygen levels) at 4.2 mg/L. Brett and Blackburn (1981) conclude that the critical inflection from oxygen dependence to independence occurs at 4 - 4.2 mg/L for coho and sockeye.

Herrmann et al. (1962) studied the influence of various oxygen concentrations on the growth of age 0 coho salmon held at 20 °C. Coho were held in containers at a constant mean dissolved oxygen level ranging from 2.1 - 9.9 mg/L and were fed full rations. The authors concluded that oxygen concentrations below 5 mg/L resulted in a sharp decrease in growth and food consumption. A reduction in the mean oxygen levels from 8.3 mg/L to 6 and 5 mg/L resulted in slight decreases in food consumption and growth. Weight gain in grams per gram of food consumed was slightly depressed at dissolved oxygen concentrations near 4 mg/L, and were markedly reduced at lower concentrations. At oxygen levels of 2.1 and 2.3 mg/L, many fish died and the surviving fish lost weight and consumed very little food.

USEPA (1986a) calculated the median percent reduction in growth rate of Chinook and coho salmon fed full rations at various dissolved oxygen concentrations. They calculated no reduction in growth at dissolved oxygen concentrations of 8 and 9 mg/L, and a 1% reduction in growth at 7 mg/L for both species. At 6 mg/L Chinook and coho growth were reduced by 7% and 4% respectively. Dissolved oxygen levels of 4 mg/L result in a

29% reduction in growth for Chinook salmon and 21% reduction in growth for coho. At 3 mg/L there was a 47% decrease in Chinook growth and a 37% reduction in coho growth. USEPA (1986a) states that due to the variability inherent in growth studies the reductions in growth rates seen above 6 mg/L are not usually statistically significant, while reductions in growth at dissolved oxygen levels below 4 mg/L are considered severe.

2.2.7.3 Avoidance and Preference

Salmonids have been reported to actively avoid areas with low dissolved oxygen concentrations, which is likely a useful protective mechanism that enhances survival (Davis 1975). Field and laboratory studies have found that avoidance reactions in juvenile salmonids consistently occur at concentrations of 5 mg/L and lower, and there is some indication that avoidance is triggered at concentrations as high as 6 mg/L. Therefore these dissolved oxygen levels should be considered a potential barrier to the movement and habitat selection of salmonids (WDOE 2002).

Spoor (1990) performed a laboratory study on the distribution of fingerling brook trout in dissolved oxygen concentration gradients. Sixteen gradients between 1 and 8.9 mg/L were used for the study to determine what level of dissolved oxygen is preferred by the brook trout. It was found that in the absence of a gradient with dissolved oxygen concentrations at 6 mg/L or more throughout the system, the fish moved freely without showing preference or avoidance. Movement from low to higher oxygen concentrations were noted throughout the study. Fish moved away from water with dissolved oxygen concentrations from 1 - 1.9 mg/L within one hour, moved away from water with dissolved oxygen concentrations of 2 - 2.9 mg/L within 1 - 2 hours, and moved away more slowly from concentrations of 3 - 3.9 mg/L. From his study, Spoor (1990) concluded that brook trout will avoid oxygen concentrations below 4 mg/L, and preferred oxygen levels of 5 mg/L or higher.

Whitmore et al. (1960) performed studies with juvenile coho and Chinook salmon to determine their avoidance reaction to dissolved oxygen concentration of 1.5, 3 , 4.5, and 6 mg/L at variable river water temperatures. Juvenile Chinook salmon showed marked avoidance of oxygen concentrations near 1.5, 3, and 4.5 mg/L in the summer at mean temperatures ranging from 20.7 - 22.8°C, but no avoidance to levels near 6 mg/L at a mean temperature of 18.4°C. Chinook did not show as strong an avoidance to these oxygen levels in the fall when water temperatures were lower, ranging from 11.8 - 13.2°C. Chinook showed little avoidance of dissolved oxygen concentrations near 4.5 mg/L during the fall, and no avoidance to concentrations near 6 mg/L. In all cases avoidance became progressively larger with reductions in the oxygen concentration below 6 mg/L. Seasonal differences of avoidance are most likely due to differences in water temperature. At temperatures ranging from 18.4 - 19°C juvenile coho salmon showed some avoidance to all of the above oxygen concentrations, including 6 mg/L. Their behavior was more erratic than that of Chinook, and their avoidance of concentrations near 4.5 mg/L and lower was not as pronounced at corresponding temperatures. The juvenile coho often started upon entering water with low dissolved oxygen and then darted around until they found their way out of the experimental channel.

USEPA (1986a) performed a literature review and cites the effects of various dissolved oxygen concentrations on salmonid life stages other than embryonic and larval (Table 16). These effects range from no impairment at 8 mg/L to acute mortality at dissolved oxygen levels below 3 mg/L.

Table 16: Dissolved oxygen concentrations and their effects on salmonid life stages other than embryonic and larval

Level of Effect	Water Column DO (mg/L)
No Production Impairment	8
Slight Production Impairment	6
Moderate Production Impairment	5
Severe Production Impairment	4
Limit to Avoid Acute Mortality	3

Source: USEPA 1986a

2.2.8 Lethality

Salmonid mortality begins to occur when dissolved oxygen concentrations are below 3 mg/L for periods longer than 3.5 days (USEPA 1986a). A summary of various field study results by WDOE (2002) reports that significant mortality occurs in natural waters when dissolved oxygen concentrations fluctuate the range of 2.5 - 3 mg/L. Long-term (20 - 30 days) constant exposure to mean dissolved oxygen concentrations below 3 - 3.3 mg/L is likely to result in 50% mortality of juvenile salmonids (WDOE 2002). According to a short-term (1 - 4 hours) exposure study by Burdick et al. (1954, as cited by WDOE, 2002), in warm water (20 - 21°C) salmonids may require daily minimum oxygen levels to remain above 2.6 mg/L to avoid significant (50%) mortality. From these and other types of studies, WDOE (2002) concluded that juvenile salmonid mortality can be avoided if daily minimum dissolved oxygen concentration remain above 3.9 mg/L, and the monthly or weekly average of minimum concentrations remains above 4.6 mg/L.

2.3 Effects of High Total Dissolved Gas Concentrations on Salmonids

High levels of total dissolved gas (TDG), including dissolved oxygen, can be harmful to salmonids and other fish and result in “gas bubble disease”. This occurs when dissolved gases in their circulatory system come out of solution and form bubbles which block the flow of blood through the capillary vessels (USEPA 1986b). There are several ways TDG supersaturation can occur, including excessive algal photosynthesis which can create supersaturated dissolved oxygen conditions (USEPA 1986b). Thus, to protect salmonids and other freshwater fish the USEPA has set criteria for TDG stating that levels should not exceed 110% of the saturation value.

Numerous studies have been conducted to determine the mortality rate of salmonids exposed to various levels of TDG. Mesa et al. (2000) conducted laboratory experiments on juvenile Chinook and steelhead, exposing them to different levels of TDG and found no fish died when held at 110% TDG for up to 22 days. When fish were exposed to 120% TDG, 20% of juvenile Chinook died within 40 to 120 hours while 20% of juvenile steelhead died within 20 to 35 hours. At TDG levels of 130% Chinook mortality reached 20% after 3 to 6 hours and steelhead mortality was 20% after 5 to 7 hours. Gale et al. (2001) held adult female spring Chinook at mean TDG levels ranging from 114.1% to 125.5% and found the time to first mortality ranged from 10 to 68 hours.

USEPA (1986b) discusses various studies on the effects of TDG on salmonids. The following studies are all cited from the USEPA 1986 water quality criteria document. Bouck et al. (1975) found TDG levels of 115% and above to be acutely lethal to most species of salmonids, and levels of 120% TDG are rapidly lethal to all salmonids. Conclusions drawn from Ebel et al. (1975) and Rulfison and Abel (1971) include the following:

- Adult and juvenile salmonids confined to shallow water (1 m) with TDG levels above 115% experience substantial levels of mortality.
- Juvenile salmonids exposed sublethal levels TDG supersaturation are able to recover when returned to normally saturated water, while adults do not recover and generally die.

CHAPTER 3. AMMONIA

3.1 Introduction

According to the USEPA (1986b, p.17), acute concentrations of ammonia can cause loss of equilibrium, hyperexcitability, increased breathing, cardiac output and oxygen uptake, and, in extreme cases, convulsions, coma, and death of fish. Lower concentrations of ammonia can result in reduced hatching success, reduced growth and morphological development, and pathologic changes in tissues of gills, livers, and kidneys.

The information in the following sections was extracted from the USEPA document titled: *1999 Update of Ambient Water Quality Criteria for Ammonia*. The information presented applies to salmonids in general.

3.2 Ammonia Speciation

Ammonia in water exists primarily in two forms, un-ionized ammonia (NH_3) and ammonium ion (NH_4^+) (USEPA 1999b, p.2). The fraction of each of these two forms, or ammonia speciation, varies markedly with temperature and pH (USEPA 1999b, p.2). The pH-dependence of the relative amounts of un-ionized ammonia and ammonium ion at 25°C are presented in Figure 1 below (USEPA 1999b, p.2). Ammonia speciation also depends on ionic strength, although in freshwater this effect is much smaller than the effects of temperature and pH (USEPA 1999b, p.3)

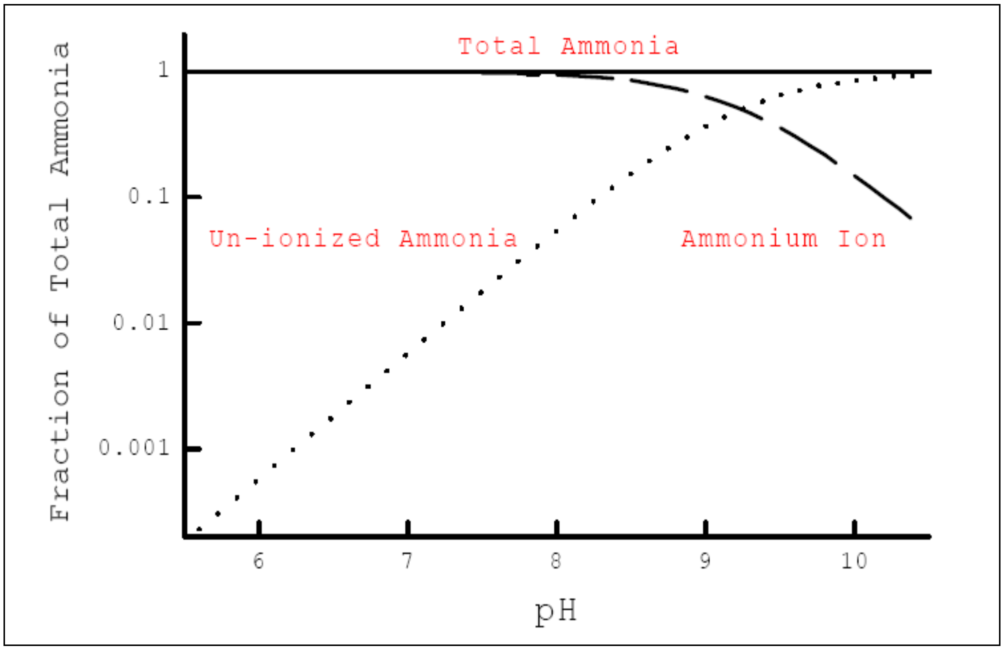

Figure 1: Chemical Speciation of Ammonia
Source: USEPA 1999b, p.3

3.3 Ammonia Toxicity

These speciation relationships are important to ammonia toxicity because un-ionized ammonia is much more toxic than ammonium ion. The importance of un-ionized ammonia was first recognized when it was observed that increased pH caused total ammonia to appear to be much more toxic (Chipman 1934; Wuhrmann and Woker 1948). It is not surprising that un-ionized ammonia is the more toxic form, because it is a neutral molecule and thus is able to diffuse across the epithelial membranes of aquatic organisms much more readily than the charged ammonium ion. Ammonia is unique among regulated pollutants because it is an endogenously produced toxicant that organisms have developed various strategies to excrete, which is in large part by passive diffusion of un-ionized ammonia from the gills. High external un-ionized ammonia concentrations reduce or reverse diffusive gradients and cause the buildup of ammonia in gill tissue and blood (USEPA 1999b, p.3).

Because of the importance of un-ionized ammonia, it became a convention in the scientific literature to express ammonia toxicity in terms of un-ionized ammonia, and water quality criteria and standards followed this convention. However, there are reasons to believe that ammonium ion can contribute significantly to ammonia toxicity under some conditions. Observations that ammonia toxicity is relatively constant when expressed in terms of un-ionized ammonia come mainly from toxicity tests conducted at pH>7.5. At lower pH, toxicity varies considerably when expressed in terms of unionized ammonia and under some conditions is relatively constant in terms of ammonium ion (Erickson 1985). Also, studies have established that mechanisms exist for the transport of ammonium ion across gill epithelia (Wood 1993), so this ion might contribute significantly to ammonia exchange at gills and affect the buildup of ammonia in tissues if its external concentration is sufficiently high. Thus, the very same arguments employed for the importance of un-ionized ammonia can also be applied in some degree to ammonium ion. This is not to say that ammonium ion is as toxic as unionized ammonia, but rather that, regardless of its lower toxicity, it can still be important because it is generally present in much greater concentrations than un-ionized ammonia (USEPA 1999b, p.3,4).

3.4 Ammonia Criteria

The USEPA has utilized the above information to create pH-dependant acute and pH- and temperature-dependent chronic criterion for total ammonia (NH_3 and NH_4^+) as nitrogen in freshwater (Tables 17, 18, 19).

Table 17: pH-Dependent Values of the Criterion Maximum Concentration (CMC) of Total Ammonia as Nitrogen (mg N/L) in Freshwater when Salmonids are Present

Acute Criterion[1]			
pH	**CMC Total NH3 mgN/L**	**pH**	**CMC Total NH3 mgN/L**
6.5	32.6	7.8	8.11
6.6	31.3	7.9	6.77
6.7	29.8	8.0	5.62
6.8	28.1	8.1	4.64
6.9	26.2	8.2	3.83
7.0	24.1	8.3	3.15
7.1	22.0	8.4	2.59
7.2	19.7	8.5	2.14
7.3	17.5	8.6	1.77
7.4	15.4	8.7	1.47
7.5	13.3	8.8	1.23
7.6	11.4	8.9	1.04
7.7	9.65	9.0	0.885

[1] The one-hour average concentration of total ammonia nitrogen (NH_3 and NH_4^+) should not exceed this value more than once every 3 years.
Source: USEPA 1999b, p.86

Table 18: Temperature and pH-Dependent Values of the Criterion Continuous Continuation (CCC) for Total Ammonia as Nitrogen (mg N/L) in Freshwater when Fish Early Life Stages are Present

Chronic Criterion[1]

CCC for Fish Early Life Stages Present, mg N/L										
pH	Temperature, C									
	0	14	16	18	20	22	24	26	28	30
6.5	6.67	6.67	6.06	5.33	4.68	4.12	3.62	3.18	2.80	2.46
6.6	6.57	6.57	5.97	5.25	4.61	4.05	3.56	3.13	2.75	2.42
6.7	6.44	6.44	5.86	5.15	4.52	3.98	3.50	3.07	2.70	2.37
6.8	6.29	6.29	5.72	5.03	4.42	3.89	3.42	3.00	2.64	2.32
6.9	6.12	6.12	5.56	4.89	4.30	3.78	3.32	2.92	2.57	2.25
7.0	5.91	5.91	5.37	4.72	4.15	3.65	3.21	2.82	2.48	2.18
7.1	5.67	5.67	5.15	4.53	3.98	3.50	3.08	2.70	2.38	2.09
7.2	5.39	5.39	4.90	4.31	3.78	3.33	2.92	2.57	2.26	1.99
7.3	5.08	5.08	4.61	4.06	3.57	3.13	2.76	2.42	2.13	1.87
7.4	4.73	4.73	4.30	3.78	3.32	2.92	2.57	2.26	1.98	1.74
7.5	4.36	4.36	3.97	3.49	3.06	2.69	2.37	2.08	1.83	1.61
7.6	3.98	3.98	3.61	3.18	2.79	2.45	2.16	1.90	1.67	1.47
7.7	3.58	3.58	3.25	2.86	2.51	2.21	1.94	1.71	1.50	1.32
7.8	3.18	3.18	2.89	2.54	2.23	1.96	1.73	1.52	1.33	1.17
7.9	2.80	2.80	2.54	2.24	1.96	1.73	1.52	1.33	1.17	1.03
8.0	2.43	2.43	2.21	1.94	1.71	1.50	1.32	1.16	1.02	0.897
8.1	2.10	2.10	1.91	1.68	1.47	1.29	1.14	1.00	0.879	0.773
8.2	1.79	1.79	1.63	1.43	1.26	1.11	0.973	0.855	0.752	0.661
8.3	1.52	1.52	1.39	1.22	1.07	0.941	0.827	0.727	0.639	0.562
8.4	1.29	1.29	1.17	1.03	0.906	0.796	0.700	0.615	0.541	0.475
8.5	1.09	1.09	0.990	0.870	0.765	0.672	0.591	0.520	0.457	0.401
8.6	0.920	0.920	0.836	0.735	0.646	0.568	0.499	0.439	0.386	0.339
8.7	0.778	0.778	0.707	0.622	0.547	0.480	0.422	0.371	0.326	0.287
8.8	0.661	0.661	0.601	0.528	0.464	0.408	0.359	0.315	0.277	0.244
8.9	0.565	0.565	0.513	0.451	0.397	0.349	0.306	0.269	0.237	0.208
9.0	0.486	0.486	0.442	0.389	0.342	0.300	0.264	0.232	0.204	0.179

[1] The thirty-day average concentration of total ammonia (NH_3 and NH_4^+) should not exceed this value more than once every three years. Additionally, the highest four day average within the thirty-day period should not exceed 2.5 times the CCC (USEPA 1999b, p.87).

Table 19: Temperature and pH-Dependent Values of the Criterion Continuous Continuation (CCC) for Total Ammonia as Nitrogen (mg N/L) in Freshwater when Fish Early Life Stages are Absent

Chronic Criterion[1]

CCC for Fish Early Life Stages Absent, mg N/L

pH	Temperature									
	0-7	8	9	10	11	12	13	14	15*	16*
6.5	10.8	10.1	9.51	8.92	8.36	7.84	7.35	6.89	6.46	6.06
6.6	10.7	9.99	9.37	8.79	8.24	7.72	7.24	6.79	6.36	5.97
6.7	10.5	9.81	9.20	8.62	8.08	7.58	7.11	6.66	6.25	5.86
6.8	10.2	9.58	8.98	8.42	7.90	7.40	6.94	6.51	6.10	5.72
6.9	9.93	9.31	8.73	8.19	7.68	7.20	6.75	6.33	5.93	5.56
7.0	9.60	9.00	8.43	7.91	7.41	6.95	6.52	6.11	5.73	5.37
7.1	9.20	8.63	8.09	7.58	7.11	6.67	6.25	5.86	5.49	5.15
7.2	8.75	8.20	7.69	7.21	6.76	6.34	5.94	5.57	5.22	4.90
7.3	8.24	7.73	7.25	6.79	6.37	5.97	5.60	5.25	4.92	4.61
7.4	7.69	7.21	6.76	6.33	5.94	5.57	5.22	4.89	4.59	4.30
7.5	7.09	6.64	6.23	5.84	5.48	5.13	4.81	4.51	4.23	3.97
7.6	6.46	6.05	5.67	5.32	4.99	4.68	4.38	4.11	3.85	3.61
7.7	5.81	5.45	5.11	4.79	4.49	4.21	3.95	3.70	3.47	3.25
7.8	5.17	4.84	4.54	4.26	3.99	3.74	3.51	3.29	3.09	2.89
7.9	4.54	4.26	3.99	3.74	3.51	3.29	3.09	2.89	2.71	2.54
8.0	3.95	3.70	3.47	3.26	3.05	2.86	2.68	2.52	2.36	2.21
8.1	3.41	3.19	2.99	2.81	2.63	2.47	2.31	2.17	2.03	1.91
8.2	2.91	2.73	2.56	2.40	2.25	2.11	1.98	1.85	1.74	1.63
8.3	2.47	2.32	2.18	2.04	1.91	1.79	1.68	1.58	1.48	1.39
8.4	2.09	1.96	1.84	1.73	1.62	1.52	1.42	1.33	1.25	1.17
8.5	1.77	1.66	1.55	1.46	1.37	1.28	1.20	1.13	1.06	0.990
8.6	1.49	1.40	1.31	1.23	1.15	1.08	1.01	0.951	0.892	0.836
8.7	1.26	1.18	1.11	1.04	0.976	0.915	0.858	0.805	0.754	0.707
8.8	1.07	1.01	0.944	0.885	0.829	0.778	0.729	0.684	0.641	0.601
8.9	0.917	0.860	0.806	0.756	0.709	0.664	0.623	0.584	0.548	0.513
9.0	0.790	0.740	0.694	0.651	0.610	0.572	0.536	0.503	0.471	0.442

[1] The thirty-day average concentration of total ammonia (NH_3 and NH_4^+) should not exceed this value more than once every three years. Additionally, the highest four day average within the thirty-day period should not exceed 2.5 times the CCC.
Source: USEPA 1999b, p.88

CHAPTER 4. pH

4.1 Introduction

The pH of freshwater streams is important for adult and juvenile salmonid development. Chronic effects from low pH can occur at levels that are not toxic to adult fish but that impair reproduction including altered spawning behavior, reduced egg viability, decreased hatchability, and reduced survival of the early life stages (Jordahl and Benson 1987). The early life stages of salmonid development are most vulnerable to low pH (Jordahl and Benson 1987). Chronic high pH levels in freshwater streams can decrease activity levels of salmonids, create stress responses, decrease or cease feeding, and lead to a loss of equilibrium (Murray and Ziebell 1984; Wagner et al. 1997). Additionally, high temperatures can exacerbate the effects of high pH levels on salmonids (Wagner et al. 1997). If pH reaches extremely low or high levels, death can occur (Wagner et al. 1997).

Literature reviewed for this analysis included numerous laboratory and field studies. The following information applies to salmonids in general.

4.2 Effects of High pH

Wagner et al. (1997) conducted laboratory and field studies and found that pH values of greater than 9.4 will result in the death of rainbow trout, especially at temperatures ranging from 19-22 C. Fresh water pH values of 9.0 or greater resulted in significant stress responses in rainbow trout.

Wilkie and Wood (1996) found that Lahontan cutthroat trout exposed to high pH waters (9.4) permanently lowered their rate of nitrogenous waste production to avoid the potentially toxic build-up of internal ammonia. However, rainbow trout, kokanee, and brown trout were unable to adapt to the high pH and died.

Murray and Ziebell (1984) found that rainbow trout are not able to acclimate to pH levels of 10.0 or higher and that their ability to tolerate pH above 9.0 depends on the rate of acclimation. Gradual acclimation (0.2 to 0.4 of a pH unit/day) allowed rainbow trout to acclimate to a pH of 9.8 and continue feeding, although they showed signs of distress and their activity was greatly reduced by the end of 4 days when the pH reached 9.9 (Table 20). The maximum pH tolerated before fish began dying was 10.2.

Rapid acclimations tests conducted by Murray and Ziebell (1984) yeilded the following results:

> Rainbow trout mortalities were 40% or greater in preliminary acclimation tests in which pH was increased to 9.6 and 9.7 in 3 and 5 hours. These results were comparable to previous shock tests (unpublished data). Consequently, in later experiments, acclimation time was increased to 6 hours and pH values were lowered to 9.3 and 9.5.

Trout in the pH 9.5 experiments exhibited adverse reactions and mortalities were similar to those seen in preliminary tests at pH 9.6 and 9.7. All fish began to show marked signs of stress within 12 hours, and within 24 hours the mortalities in replicated experiments were 30, 40, and 50% respectively. At 49 hours the last deaths occurred that brought mortalities to 50% in each replicate. All remaining living fish were distressed and did not feed. After 72 hours had elapsed, the survivors resumed feeding and their condition improved until the experiments were terminated at 120 hours.

In the pH 9.3, 6-hour acclimation experiments trout exhibited only minor adverse reactions. The primary behavioral changes were a decrease in swimming activity and a temporary loss of appetite. After 48 hours all fish resumed normal feeding and became progressively more active. No mortalities occurred in any of the replicated experiments, and all fish behaved normally when the experiments were terminated at 120 hours Murray and Ziebell (1984).

Table 20: Reactions of 10 rainbow trout to various pH levels during gradual acclimation experiments (0.2 to 0.4 of a pH unit/day)

Day	pH Range	Reactions and Condition of Trout
1	8.6-8.9	Normal
2	8.9-9.2	Activity decreased but feeding normal
3	9.2-9.7	Activity further decreased but feeding continued
4	9.7-9.9	Minor distress shown but feeding continued
5	9.9-10.3	Some fish lost equilibrium at 10.0, and feeding ceased. Loss of equilibrium increased at 10.1 and eyes of some fish developed corneal opacities; 50% of fish lost equilibrium at pH 10.2 and mortality was 60% at pH 10.3

Source: Murray and Ziebell (1984)

4.3 Effects of Low pH

"Chronic effects of low pH on fish populations may occur at pH levels that are not toxic to adult fish but that impair reproduction, and ultimately lead to population extinction (Jordahl and Benson 1987)." A study was conducted by Weiner et al. (1986) to determine the effects of low pH on the reproductive success of rainbow trout. It was determined that exposure of adult salmonids to pH values below 5.5 negatively effected reproduction. Adult rainbow trout were exposed to pH 4.5, 5.0, 5.5, and 6.5-7.1 during the final 6 weeks of reproductive maturation. Weiner et al. found that pH values of 5.5 and below impaired the creation of eggs in females and sperm in males.

Jordahl and Benson (1987) report that reproductive failure occurred in adult brook trout due to low pH in a freshwater stream with pH levels ranging from 5.0-5.8, while trout in a reference stream with pH ranging from 6.1-7.2 did not experience reproductive failure. Additionally, brook trout were absent from a highly acidic freshwater stream with pH ranging from 4.7-5.4 leading Jordahl and Benson to conclude that breeding females may avoid acidic tributaries.

In addition to effecting adult salmonids, highly acidic freshwater (low pH) can have a detrimental effect on eggs and juvenile salmonids. Weiner et al. (1986) determined that juvenile rainbow trout mortality was greatly increased at pH levels of 5.5 and below, and that no eggs survived when exposed to pH levels below 4.5. Hulsman and Powels (1983) found the mortality of rainbow trout yolk-sac larvae approached 100% within 5 days of exposure to pH 4.6 and 5.4, whereas exposure to pH 6.0 resulted in less than 3% mortality.

Jordahl and Benson (1987) conducted a study to determine the effect of low pH on juvenile brook trout survival and found that survival rates were highest in a freshwater stream with pH values ranging from 6.1-7.2 and lower in acidified streams with pH levels of 4.7-5.8. At pH values of 5.0 and lower, growth was retarded and the development of yolk-sac larvae was considerably prolonged. Additionally, larval activity was depressed, pigmentation was reduced, and incomplete hatching was observed in streams with low pH values of 4.7-5.8, but not in the stream with pH ranging from 6.1-7.2. Jordahl and Benson concluded that mean pH values of 5.0-5.4 can cause acid stress on developing juveniles, while pH levels from 6.1-7.2 are above ranges that negatively effect juvenile brook trout development and survival.

REFERENCES

Armour, C.L. 1991. Guidance for evaluating and recommending temperature regimes to protect fish. U.S. Fish and Wildlife Service Biological Report 90(22). 13 pp.

Bell, M.C.. 1986. Fisheries handbook of engineering requirements and biological criteria. Fish Passage Development and Evaluation Program. U.S. Army Corps of Engineers. 209pp.

Bjornn, T. and D. Reiser. 1991. Habitat requirements of salmonids in streams. In Meehan, W. ed., Influences of Forest and Rangeland Management on Salmonids Fishes and Their Habitat. American Fisheries Society Special Publication 19. pp. 83-138.

Brett, J.R. 1952. Temperature Tolerance in Young Pacific Salmon, Genus Oncorhynchus. Pacific Biological Station, and Department of Zoology, University of Toronto. J. Fish Res. Board Can. 9(6): 265-308 + appendices.

Brett, J. R., and J.M. Blackburn. 1981. Oxygen requirements for growth of young coho (*Oncorhynchus kisutch*) and sockeye (*O. nerka*) salmon at 15C. Can. J. Fish. Aquat. Sci. 38:399-404.

Brungs, W.A., and B.R. Jones. 1977. Temperature criteria for freshwater fish: Protocol and procedures. Environmental Research Laboratory, Duluth, MN. U.S. Environmental Protection Agency. EPA-600/3-77-061. 136pp.

California Department of Fish and Game (CDFG). 2001. California's Living Marine Resources: A Status Report. Leet, W.S., C.M. Dewees, R. Klingbeil, and E.J. Larson [eds.]. The Resources Agency. Sacramento, CA. December 2001. 552pp. + appendices. Available at: <http://www.dfg.ca.gov/mrd/status/steelhead_rainbow_trout.pdf>. Website accessed on July 21, 2004.

California Department of Water Resources (CDWR). 1988. Water temperature effects on Chinook salmon (*Oncorhynchus tshawytscha*) with emphasis on the Sacramento River: a literature review. Northern District Office Report, Red Bluff, California. 42pp.

Cobel, D.W. 1961. Influence of water exchange and dissolved oxygen in redds on survival of steelhead trout embryos. Transactions of the American Fisheries Society. 90:469-474.

Dahlberg, M.L., D.L. Shumway, and P. Doudoroff. 1968. Influence of dissolved oxygen and carbon dioxide on swimming performance of largemouth bass and coho salmon. Journal of the Fisheries Research Board of Canada. 25(1):49-70.

Davis, G.E., J. Foster, C.E. Warren, and P. Doudoroff. 1963. The influence of oxygen concentration on the swimming performance of juvenile pacific salmon at various temperatures. Transactions of the American Fisheries Society. 92:111-124.

Davis, J.C. 1975. Minimal dissolved oxygen requirements of aquatic life with emphasis on canadian species: a review. Journal of the Fisheries Research Board of Canada. 32:2295-2332.

Dickerson, H.W. and D.L. Dower. 1995. *Ichthyophthirius multifiliis* and *Cryptocaryon irritans* (Phylum Ciliophora). In Woo, P.T.K. ed., Fish Disease and Disorders. ISBN 085198 823 7; p.181-227.

Durborow, R.M., A.J. Mitchell, and M.D. Crosby. 1998. Ich (White Spot Disease). Southern Regional Aquaculture Center, Delta Research and Extension Center, Mississippi State University. Stoneville, Mississippi. 6pp.

Eddy, R.M. 1971. The influence of dissolved oxygen concentration and temperature on the survival and growth of Chinook salmon embryos and fry. Masters of Science Thesis. Oregon State University. Corvallis, Oregon. 45pp.

Elliott, J. 1981. Some aspects of thermal stress on freshwater teleosts. In Pickering, A.D. ed., Stress and Fish: Academic Press, London, p. 209-245.

Fischer, R.J. 1963. Influence of Oxygen Concentration and of its Diurnal Fluctuations on the Growth of Juvenile Coho Salmon. Masters of Science Thesis. Oregon State University. Corvallis, Oregon. 48pp.

Gale, W.L., A.G. Maule, A. Postera, and M. Peter-Swihart. 2001. Effects of Supersaturated Water on Reproductive Success of Adult Salmonids. Bonneville Power Administration project no. 2000-58. December 2, 2001. 33 pp.

Garside, E.T. 1966. Effects of oxygen in relation to temperature on the development of embryos of brook trout and rainbow trout. J. Fish. Res. Bd. Canada 23(8)1121-1134.

Hallock, R.J., R.F. Elwell, and D.H. Fry, Jr. 1970. Migrations of adult king salmon *Oncorhynchus tshawytsca* in the San Joaquin Delta as demonstrated by the use of sonic tags. California Department of Fish and Game, Fish Bulletin 151. 92pp.

Hassler, T.J. 1987. Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (Pacific Southwest). Coho Salmon. U.S. Fish and Wildlife Service Biological Report 82(11.70). U.S. Army Corps of Engineers, TR EL-82-4. 19pp.

Herrmann, R.B. 1958. Growth of juvenile coho salmon at various concentrations of dissolved oxygen. Masters of Science Thesis. Oregon State University. Corvallis, Oregon. 82pp.

Herrmann, R.B., C.E. Warren, and P. Doudoroff. 1962. Influence of oxygen concentration on the growth of juvenile coho salmon. Transactions of the American Fisheries Society. 91:155-167.

Holt, R.A., J.E. Sanders, J.L. Zinn, J.L. Fryer, and K.S. Pilcher. 1975. Relation of Water Temperature to *Flexibacter columnaris* Infection in Steelhead Trout (*Salmo gairdneri*), Coho (*Oncorhynchus kisutch*) and Chinook (*O. tshawytscha*) Salmon. J. Fish. Res. Board Can. 32:1553-1559.

Hulsman P.F. and P.M. Powles. 1983. Mortality of Walleye Eggs and Rainbow Trout Yolk-Sac Larvae in Low-pH Waters of the LaCloche Mountain Area, Onterio. Transactions of the American Fisheries Society. 112:680-688.

Jordahl and Benson, 1987. Effect of Low pH on Survival of Brook Trout Embroys and Yolk-Sac Larvae in West Virginia Streams. Transactions of the American Fisheries Society. 116:807-816.

Konecki, T.C., C.A. Woody, and T.P. Quinn. 1995a. Temperature preference in two populations of juvenile coho salmon, *Oncorhynchus kisutch*. Northwest Science. 69 (2): 417-421.

Konecki, T.C., C.A. Woody, and T.P. Quinn. 1995b. Critical thermal maxima of coho salmon (*Oncorhynchus kisutch*) fry under field and laboratory acclimation regimes. Can. J. Zool. 73:993-996.

Leitritz, E. and R.C. Lewis. 1976. Trout and salmon culture. California Department of Fish and Game. Fish Bulletin 164. 197pp.

Ligon, F., A. Rich, G. Rynearson, D. Thornburgh, and W. Trush. 1999. Report of the Scientific Review Panel on California Forest Practice Rules and Salmonid Habitat: Prepared for the Resource Agency of California and the National Marine Fisheries Sacramento, Calif. 92pp. + appendices.

Marine, K.R., and J.J. Cech. 2004. Effects of High Water Temperature on Growth, Smoltification, and Predator Avoidance in Juvenile Sacramento River Chinook Salmon. North American Journal of Fisheries Management 24:198-210.

McMahon, T.E. 1983. Habitat suitability index models: Coho salmon. U.S. Department of Interior, Fish and Wildlife Service. FWS/OBS-82/10.49. 29pp.

Mesa, M.G., L.K. Weiland, and A.G. Maule. 2000. Progression and Severity of Gas Bubble Trauma in Juvenile Salmonids. Transactions of the American Fisheries Society. 129:174-185.

Murray and Ziebell. 1984. Acclimation of Rainbow Trout to High pH to Prevent Stocking Mortality in Summer. The Progressive Fish-Culturist. 46(3):176-179.

Murray, C.B., and J.D. McPhail. 1988. Effect of incubation temperature on the development of five species of Pacific salmon (*Oncorhynchus*) embryos and alevins. Can. J. Zool. 66:266-273.

Myrick C.A., and J.J. Cech. 2001. Temperature Effects on Chinook Salmon and Steelhead: a Review Focusing on California's Central Valley Populations. Bay-Delta Modeling Forum. Technical Publication 01-1. 57pp.

Nielsen, J.L., T.E. Lisle, and V. Ozaki. 1994. Thermally stratified pools and their use by steelhead in Northern California streams. Transactions of the American Fisheries Society, 123:613-626. Available at: <http://www.humboldt.edu/~storage/pdfmill/Batch_9/thermally.pdf >. Website accessed on August 27, 2004.

Oregon Department of Environmental Quality (ODEQ). 1995a. Temperature: 1992-1994 Water quality standards review. Final Issue Paper. 122pp. Available at: <http://www.fishlib.org/Bibliographies/waterquality.html>. Website accessed on August 20, 2004.

Oregon Department of Environmental Quality (ODEQ). 1995b. Dissolved Oxygen: 1992-1994 Water quality standards review. Final Issue Paper. 166pp. Available at: <http://www.fishlib.org/Bibliographies/waterquality.html>. Website accessed August 20, 2004.

Pacha, R.E. and E. J. Ordal. 1970. Myxobacterial diseases of salmonids. In Snieszko, S.F. ed., A symposium on diseases of fishes and shellfishes. Special Publication No. 5, American Fisheries Society, Washington, D.C. p.243-257.

Piper, R.G., I.B. McElwain, L.E. Orme, J.P. McCraren, L.G. Fowler, and J.R. Leonard. 1982. Fish hatchery management. U.S. Department of Interior, Fish and Wildlife Service, Washington D.C. 517 pp.

Reutter, J.M. and C.E. Herdendorf. 1974. Laboratory Estimates of the Seasonal Final Temperature Preferenda of Some Lake Erie Fish. Presented at the 17th Conference for the International Association for Great Lakes Research. Center for Lake Erie Area Research, Ohio State University. Columbus, Ohio. Clear Technical Report No. 20. 13pp. + figures & tables.

Shumway, D.L., C.E. Warren, and P. Doudoroff. 1964. Influence of oxygen concentration and water movement on the growth of steelhead trout and coho salmon embryos. Transactions of the American Fisheries Society. 93:342-356.

Silver, S.J., C.E. Warren, P. Doudoroff. 1963. Dissolved oxygen requirements of developing steelhead trout and Chinook salmon embryos at different water velocities. Transactions of the American Fisheries Society. 92(4):327-343.

Spence, B.C., G.A. Lomicky, R.M. Hughes, and R.P. Novitzki. 1996. An ecosystem approach to salmonid conservation. TR-4501-96-6057. ManTech Environmental Research Services Corp., Corvallis, OR (Available from the National Marine Fisheries Service, Portland, OR). 356pp.

Spoor, W.A. 1990. Distribution of fingerling brook trout, ,*Salvelinus fontinalis* (Mitchill), in dissolved oxygen concentration gradients. J. Fish. Biol. 36:363-373.

Strange, J. 2006. Adult Chinook Salmon Migration in the Klamath River Basin: 2005 Sonic Telemetry Study Report (DRAFT). Yurok Tribal Fisheries Program, and School of Aquatic and Fishery Sciences- University of Washington in collaboration with Hoopa Valley Tribal fisheries. April 2006. 93pp.

Sullivan K., D.J. Martin, R.D. Cardwell, J.E. Toll, and S. Duke. 2000. An analysis of the effects of temperature on salmonids of the Pacific Northwest with implications for selecting temperature criteria. Sustainable Ecosystems Institute. Portland, OR. 147 pp. Available at: <http:/www.sei.org/pub.html# reports>. Website accessed on June 11, 2004.

Thomas, R.E., J.A. Gharrett, M.G. Carls, S.D. Rice, A. Moles, and S. Korn. 1986. Effects of Fluctuating Temperature on Mortality, Stress, and Energy Reserves of Juvenile Coho Salmon. Transactions of the American Fisheries Society 115:52-59.

Udey, L.R., J.L. Fryer, and K.S. Pilcher. 1975. Relation of water temperature to ceratomyxosis in rainbow trout (*Salmo gairdneri*) and coho salmon (*Oncorhynchus kisutch*). J. Fish. Res. Board Can. 32:1545-1551.

U.S. Environmental Protection Agency (USEPA). 1986a. Ambient Water Quality Criteria for Dissolved Oxygen. Office of Water. EPA 440/5-86-003. 46pp.

U.S. Environmental Protection Agency (USEPA). 1986b. Quality Criteria for Water. Office of Water. EPA 440/5-86-001. 477pp. Available at: <http://epa.gov/ waterscience/criteria/goldbook.pdf>. Website accessed August 12, 2005.

U.S. Environmental Protection Agency (USEPA). 1999a. A review and synthesis of effects of alternation to the water temperature regime on freshwater life stages of salmonids, with special reference to Chinook salmon. Region 10, Seattle, WA.

EPA 910-R-99-010. 279pp. Available at: <http://www.critfc.org/tech/EPA/report.htm>. Website accessed on June 11, 2004.

U.S. Environmental Protection Agency (USEPA). 1999b. 1999 Update of Ambient Water Quality Criteria for Ammonia. Office of Water. EPA-822-R-99-014. 147pp.

U.S. Environmental Protection Agency (USEPA). 2001. Issue Paper 5: Summary of technical literature examining the effects of temperature on salmonids. Region 10, Seattle, WA. EPA 910-D-01-005. 113pp. Available at: <http://yosemite.epa.gov/R10/water.nsf>. Website accessed on July 2, 2004.

U.S. Environmental Protection Agency (USEPA). 2003. EPA Region 10 Guidance for Pacific Northwest State and Tribal Water Quality Standards. Region 10, Seattle, WA. EPA 910-B-03-002. 49pp. Available at: <http://www.epa.gov/r10earth/temperature.htm>. Website accessed on June 23, 2004.

Washington State Department of Ecology (WDOE). 2002. Evaluating Criteria for the Protection of Freshwater Aquatic Life in Washington's Surface Water Quality Standards: Dissolved Oxygen. Draft Discussion Paper and Literature Summary. Publication Number 00-10-071. 90pp.

Wagner, E.J., T. Bosakowski, and S. Intelmann. 1997. Combined Effects of Temperature and High pH on Mortality and the Stress Response of Rainbow Trout after Stocking. Transactions of the American Fisheries Society. 126:985-998.

Weiner G.S., C.B. Schreck, and H.W. Li 1986. Effects of Low pH on Reproduction of Rainbow Trout. Transactions of the American Fisheries Society. 115:75-82.

Welsh, H.W., Jr., G.R. Hodgson, B.R. Harvey, and M.F. Roche. 2001. Distribution of juvenile coho salmon in relation to water temperatures in tributaries of the Mattole River, California. North American Journal of Fisheries Management 21:464-470.

Whitmore, C.M., C.E. Warren, and P. Doudoroff. 1960. Avoidance reactions of salmonid and centrarchid fishes to low oxygen concentrations. Transactions of the American Fisheries Society. 89:17-26.

Appendix 5

Fish and Fishery Resources of the Klamath River Basin

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July 2008

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1.1 Introduction

The Klamath River basin contains 83 species of fish, 45 of which are native to the Klamath drainage and 38 that have been introduced and are non-native. Fourteen of the native fish species in the basin have been granted special federal and/or state status (Table 1).

Table 1: Native Fish Species in the Klamath River Basin with Special Federal and/or State Status

SPECIES	STATUS
Shortnose sucker, *Chasmistes brevirostris*	Endangered-OR, CA, and Federal
Lost River sucker, *Deltistes luxatus*	Endangered-OR, CA, and Federal
Coho salmon, *Oncorhynchus kisutch*	Critical -OR; Threatened-CA and Federal;
Bull trout, *Salvelinus confluentus*	Critical-OR; Endangered-CA; Threatened-Federal
Delta Smelt, *Hypomesus transpacificus*	Threatened-CA and Federal
Coastal cutthroat trout, *Oncorhynchus clarki clarki*	Special Concern-CA
Eulachon, *Thaleichthys pacificus*	Special Concern-CA
Longfin smelt, *Spirinchus thaleichthys*	Special Concern-CA
Redband/Rainbow trout, *Oncorhynchus mykiss gairdneri*	Vulnerable-OR
Chum Salmon, *Oncorhynchus keta*	Special Concern-CA
Klamath largescale sucker, *Catostomus snyderi*	Special Concern-Federal
Slender sculpin, *Cottus tenuis*	Special Concern-Federal
Pacific Lamprey, *Lampetra tridentata*	Vulnerable-OR; Special Concern-Federal
Green sturgeon, *Acipenser medirostris*	Special Concern- CA and Federal

Sources: California Department of Fish and Game (CDFG) 2006b, p.4-6; National Research Council (NRC) 2004, p.181, 251, & 252; Oregon Natural Heritage Information Center (ONHIC) 2004, p.8-11.

The following discussion of fish species and resources in the basin is divided into three parts: fish species found above Iron Gate Dam in California and Oregon, fish species found from Iron Gate Dam to the Ocean in California, and Chinook, steelhead, and coho salmonids from Iron Gate Dam to the Ocean in California.

1.2 Fish above Iron Gate Dam in the Klamath River Basin, California and Oregon

The Klamath River basin above Iron Gate Dam hosts 18 native and 19 non-native fish species (Table 2). Native fish persisting in this area of the basin include lamprey, trout, and sucker species including the endangered shortnose and Lost River suckers. Introduced fish include various sunfish, catfish, and perch species.

Table 2: Fish Found Above Iron Gate Dam in the Klamath River Basin

NATIVE	
Klamath River lamprey, *Lampetra similis*	Klamath largescale sucker, *Catostomus snyderi*
Miller Lake Lamprey, *Lampetra milleri*	Klamath smallscale sucker, *Catostomus rimiculus*
Pit-Klamath brook lamprey, *Lampetra lethophaga*	Redband/Rainbow trout, *Oncorhynchus mykiss gairdneri*
Klamath tui chub, *Siphatales bicolor bicolor*	Bull trout, *Salvelinus confluentus*
Blue chub, *Gila coerulea*	Klamath Lake sculpin, *Cottus princeps*
Klamath speckled dace, *Rhinichthys osculus klamathensis*	Slender sculpin, *Cottus tenuis*
Shortnose sucker, *Chasmistes brevirostris*	Upper Klamath marbled sculpin, *Cottus klamathensis klamathensis*
Lost River sucker, *Deltistes luxatus*	

Table 2 (continued): Fish Found Above Iron Gate Dam in the Klamath River Basin

NON-NATIVE	
Goldfish, *Carassius auratus*	Brown trout, *Salmo trutta*
Golden shiner, *Notemigonus chrysoleucas*	Sacramento perch, *Archoplites interruptus*
Fathead minnow, *Pimephales promelas*	White crappie, *Pomoxis annularis*
Yellow bullhead, *Ameiurus natalis*	Black crappie, *Pomoxis nigromaculatus*
Brown bullhead, *Ameiurus nebulosus*	Green sunfish, *Lepomis cyanellus*
Black bullhead, *Ameiurus melas*	Bluegill, *Lepomis macrochirus*
Channel catfish, *Ictalurus punctatus*	Pumpkinseed, *Lepomis gibbosus*
Kokanee salmon, *Oncorhynchus nerka*	Largemouth bass, *Micropterus salmoides*
Brook trout, *Salvelinus fontinalis*	Yellow perch, *Perca flavescens*

Source: NRC 2004, p.181, 189; PacifiCorp 2004, p.4-5 to 4-7.

1.2.1 Distribution and Status of Native Fish

The following information on fish distribution and status is mainly derived from NRC 2004, p.181-193, with additional information taken from Behnke 1992, p.19, 20 and PacifiCorp 2004, p. 4-12, 4-13, and 4-33.

Four species of suckers inhabit the Klamath River basin above Iron Gate Dam. The shortnose and Lost River suckers are large, long-lived, late-maturing and live in lakes but spawn primarily in streams. Shortnose and Lost River suckers have been found in the reservoirs between Keno and Iron Gate Dam. The Klamath Tribes refer to the shortnose and Lost River suckers as qapdo and c'waam, respectively. These fish were a primary food source for the Klamath and Modoc Indians from historic times until the 1980s when severe declines in the fish populations caused the Klamath Tribes to close their fishery. Historically, Lost River and shortnose suckers were present in the Lost River and Klamath River above Iron Gate Dam and their tributaries (Moyle 2002, USFWS 2002 Appendix D as cited by NRC 2004, p.190, 191). Their current distribution and numbers have decreased from a combination of extirpations and redistribution through water management (NRC p.191). The Klamath Tribes historically harvested tens of thousands of pounds of c'waam and qapdo. Now they are restricted to a single fish each year for ceremonial purposes. Both species are currently on the federal, Oregon, and California endangered species list. Klamath smallscale suckers are considered to be rare in the Klamath River basin. The status of Klamath largescale suckers is poorly understood although it is surmised that lake populations are probably declining in abundance while river populations are probably abundant. Periodicity information for all four sucker species within the Klamath River basin in Oregon is presented in Figure 1.

Ancestors of the redband trout (resident rainbow trout) entered the Klamath River basin when it was connected to the Columbia basin via the Snake River, and coastal rainbow trout (steelhead) later entered the basin from the ocean. Redband/rainbow trout have persisted in the basin above Iron Gate Dam because of their ability to thrive in lake and stream conditions that would be lethal to most salmonids. Currently, redband/rainbow trout numbers are high in both lakes and rivers of the basin above Iron Gate Dam, and these trout support a strong summer fishery. Redband/rainbow trout are currently present in both Copco and Iron Gate Reservoir (Pacificorp 2004, p.4-53 – 4-55, 4-58).

The redband/rainbow trout population in the J.C. Boyle peaking reach (J.C. Boyle Dam to Copco 1 reservoir) supports a high quality recreational fishery and has been described by the National Park Service as highly productive and self-sustaining. In 1984 the adult population in the upper 6 miles of the reach was estimated as 890 fish per mile, and in the 5 miles below this area (near the Oregon-California border) the population was estimated to be 1,911 fish per mile. Populations in Shovel Creek are healthy according to CDFG surveys in the early 1990's. Periodicity information for redband/rainbow trout within the Klamath River basin in Oregon is presented in Figure 1.

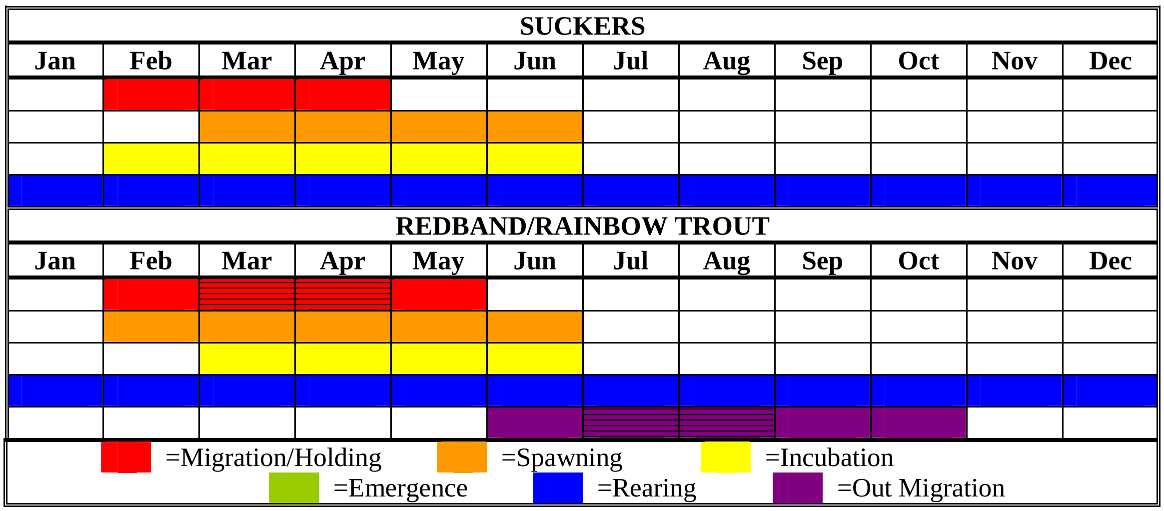

Figure 1: Sucker and Redband/Rainbow Trout Periodicity for the Klamath River in Oregon

= Lesser Use =Lesser Use

Source: FISHPRO 2000

Bull trout have been extirpated, or are at risk of extirpation, from most of the areas they once existed in the Klamath River basin. Bull trout are known to be or have been present in 10 creeks in the basin above Iron Gate Dam: four tributaries to the Sprague River, four tributaries to the Sycan River, and two tributaries to Upper Klamath Lake. The current distribution of bull trout is limited to the headwaters upstream of Upper Klamath Lake. Populations are listed as threatened by the federal government, critical by Oregon, and endangered by California.

The abundance of Klamath Lake sculpin in the basin above Iron Gate Dam is estimated to be in the millions. The presence of these sculpin has not changed from historical distributions and they are found in springs and creeks flowing into the west side of Upper Klamath Lake, Upper Klamath Lake, and Agency Lake. Upper Klamath marbled sculpin are the most widely distributed sculpin present in the basin. They are found in most streams and rivers in the Klamath River basin above Iron Gate Dam, and common in Upper Klamath Lake although they are largely absent from the reservoirs in California. Although slender sculpin were historically common in Upper Klamath Lake and the Williamson, Sprague, Sycan, and Lost Rivers, a survey conducted during the mid 1990's found them to be present only in Upper Klamath Lake and the Lower Williamson River. Overall, the slender sculpin have disappeared from much of their native range, are uncommon in areas where they are present today, and are listed as a species of concern by the federal government.

Klamath River and Pit-Klamath brook lamprey are abundant and widespread in small streams of the basin above Iron Gate Dam. Klamath tui chub have decreased in abundance in the Lost River over the last 30 years, but are typically among the most abundant species found during fish kills in Upper Klamath Lake. Blue chub populations throughout the basin are in decline, however they are probably the most abundant native fish in Upper Klamath Lake. The status of Klamath speckled dace is currently unknown although it appears to be common in the basin with the exception of the Lost River.

1.2.2 Distribution and Status of Non-Native Fish

The following information on fish distribution and status is mainly derived from NRC 2004, p.188-189, with additional information taken from PacifiCorp 2004, p.4-30, 4-31.

Fifteen of the non-native species in the Klamath River basin above Iron Gate Dam were introduced for sport fishing or for bait. Most of these species are not common in the basin, although some are abundant and widespread. The effect of these fish on native fishes is poorly understood.

Yellow perch, brown bullhead, and pumpkinseed are abundant in the reservoirs, sloughs and ponds of the basin above Iron Gate Dam. Brook trout, brown trout, and non-native strains of rainbow trout are common in streams above Iron Gate Dam and have replaced native redband/rainbow trout and bull trout in many areas. Bullhead and perch are the most abundant non-native species found in Copco Reservoir, while Iron Gate Reservoir hosts large populations of perch, bass, and crappie. Non-native trout are also found in Iron Gate and Copco reservoirs. Fathead minnows are often the most abundant species encountered during fish sampling, and are common in Upper Klamath Lake and the Lost River system. Declines in tui and blue chub numbers have been associated with the increased presence of fathead minnows. Sacramento perch is also present in the Klamath River in the area from below Upper Klamath Lake to Iron Gate Reservoir and throughout the Lost River, although its numbers are not particularly high where present.

1.3 Fish below Iron Gate Dam in the Klamath River Basin, California

A total of 46 fish species (27 native and 19 non-native) are found in the Klamath River basin below Iron Gate Dam (Table 3). Native fish currently present in this region of the Klamath River include lamprey, sturgeon, sculpin, and salmonids including the state and federally listed coho salmon. Introduced fish include bass, bullheads, and several species of sunfish.

Table 3: Fish Found Below Iron Gate Dam in the Klamath River Basin

NATIVE	
Pacific Lamprey, *Lampetra tridentata**	Eulachon, *Thaleichthys pacificus**
River lamprey, *Lampetra ayersi**	Surf smelt, *Hypomesus pretiosus*
Klamath River lamprey, *Lampetra similes*	Longfin smelt, *Spirinchus thaleichthys**
Green sturgeon, *Acipenser medirostris**	Prickly sculpin, *Cottus asper*
White sturgeon, *Acipenser transmontanus**	Sharpnose sculpin, *Clinocottus acuticeps*
Klamath speckled dace, *Rhinichthys klamathensis osculus*	Coastrange sculpin, *Cottus aleuticus*
Klamath smallscale sucker, *Catostomus rimiculus*	Pacific staghorn sculpin, *Leptocottus armatus*
Shiner perch, *Cymatogaster aggregata*	Lower Klamath marbled sculpin, *Cottus klamathensis polyporus*
Starry flounder, *Platichthys stellatus*	Threespine stickleback, *Gasterosteus aculeatus***
Pacific herring, *Clupea pallasi*	Arrow goby, *Clevelandia ios*
Topsmelt, *Atherinops affinis*	Pink salmon, *Oncorhynchus gorbuscha**
Coho salmon, *Oncorhynchus kisutch**	Steelhead (rainbow trout), *Oncorhynchus mykiss**
Chinook salmon, *Oncorhynchus tshawytscha**	Coastal cutthroat trout, *Oncorhynchus clarki clarki**
Chum salmon, *Oncorhynchus keta**	
NON-NATIVE	
American shad, *Alosa sapidissima**	Sockeye salmon, *Oncorhynchus nerka*
Goldfish, *Carassius auratus*	Bluegill, *Lepomis macrochirus*
Fathead minnow, *Pimephales promelas*	Pumpkinseed, *Lepomis gibbosus*
Golden shiner, *Notemigonus chrysoleucas*	Largemouth bass, *Micropterus salmoides*
Brown bullhead, *Ameiurus nebulosus*	Spotted bass, *Micropterus punctulatus*
Yellow bullhead, *Ameiurus natalis*	Smallmouth bass, *Micropterus dolomieui*
Wakasagi, *Hypomesus nipponensis*	Yellow perch, *Perca flavescens*
Green sunfish, *Lepomis cyanellus*	Delta smelt, *Hypomesus transpacificus*
Brook trout, *Salvelinus fontinalis*	Brown trout, *Salmo trutta***

*Anadromous.
**Some anadromous, some non-migratory
Source: NRC 2004, p.251-253; PacifiCorp 2004, p.4-5 to 4-7.

1.3.1 Distribution and Status of Native Fish

Unless otherwise noted, the following information on fish distribution and status is derived from NRC 2004, p.252-277. Chinook and coho salmon, and steelhead trout habitat and distribution, populations, and periodicity are discussed in great detail in section 1.4.

Anadromous species present in the Klamath River basin below Iron Gate Dam include Chinook, coho, pink, and chum salmon, steelhead and coastal cutthroat trout, eulachon, white and green sturgeon, and Pacific lamprey.

Chum salmon are periodically observed in the basin, and maintain a small population in the Klamath River. Historically chum were more abundant, although their numbers were never very large. Coastal cutthroat trout mainly occur in smaller tributaries in the lower 22 miles of the Klamath River, and have been observed in tributaries to the Trinity River. Pink salmon probably once existed in the Klamath River, although they appear to be extirpated from all areas in California and only occasionally stray into streams along the California coast. In 2003, 2 pink salmon fry were found in the Klamath River between Iron Gate Dam and the Interstate 5 bridge (Corum 2006).

Spring/summer steelhead were once widely distributed in the Klamath River and Trinity River basins and were present in the headwaters of most larger tributaries. Their numbers have declined from historic levels, and NMFS considers stocks depressed and in danger of extinction. Fall and winter steelhead are currently widely distributed in the basin below Iron Gate Dam. Their numbers are believed to be declining from historic levels although past and present estimates of abundance are not readily available. NMFS considers winter steelhead to be in low abundance and at some risk of extinction (Busby et al. 1994 as cited by NRC 2004, p.233), but has not listed them under the ESA (NRC 2004, p.274).

Spring and fall run Chinook populations and distribution have decreased dramatically since the early 1900's. Historically, spring Chinook were found in tributaries throughout the basin, although they are now only present in the Salmon and Trinity Rivers. Large numbers of fall Chinook used to spawn in the basin above Iron Gate Dam, but no longer have access to these areas. In the early 1900's as many as 100,000 spring Chinook were found in the basin, but current populations range from 100 to 1000 fish. Fall Chinook populations have also declined as is evidenced by the Shasta River run which were around 80,000 fish in the 1930's and in the last 10 years have generally been well below 10,000 fish.

Coho were once abundant and widely distributed in the Klamath River and its tributaries at least as far up as Spencer Creek in Oregon (Hamilton et. al. 2005, p.16). Trinity River wild coho stocks have experienced a 96% decline in numbers from historic levels. Coho in the Klamath River basin are currently on the state and federal endangered species lists due to the long-term decline in numbers and distribution.

Eulachon were historically present in large numbers in the lower 8 miles of the river, however since the 1970's their numbers have been too low to support the once flourishing tribal fishery. It is estimated that 70-80% of all green sturgeon are produced in the lower Klamath and Trinity Rivers where several hundred are taken every year by the tribal fishery. There is some evidence that green sturgeon numbers in the basin below Iron Gate Dam have decreased in recent years, although a proposal to list them as threatened was declined by the NMFS in 2003. At the present time they are listed as a species of special concern by the federal government. The historic distribution of Pacific lamprey is unknown, however it is certain that they entered the area above Klamath Falls, Oregon in the basin above Iron Gate Dam at least occasionally. Today Pacific lamprey populations are declining in all coastal rivers, and they are listed as a species of concern by the federal government.

Non-anadromous species common in the Klamath River below Iron Gate Dam and its low gradient tributaries include speckled dace, Klamath smallscale suckers, lower Klamath marbled sculpin, threespine stickleback, and Klamath River lamprey. Dace, stickleback, sculpin, and suckers probably utilize nutrients brought into the streams by anadromous species, and may suffer heavy predation by juvenile salmonids.

1.3.2 Distribution and Status of Non-Native Fish

The following information on non-native fish distribution and status is derived from NRC 2004, p.236-237.

The Klamath River basin below Iron Gate Dam is dominated by native fish, although non-native species have a stronger presence in highly altered areas such as reservoirs and ponds. Large populations of brown bullhead and other non-natives are present in the Shasta River due to introductions and the warmth of these waters. Non-native fish continually enter the Klamath River below Iron Gate Dam from the basin above the Dam where they are extremely abundant (NRC 2004, p.277).

1.4 Chinook salmon, steelhead trout, and coho salmon below Iron Gate Dam in the Klamath River Basin, California

Anadromous salmonids in the Klamath River basin are limited to the area of the basin within California below Iron Gate Dam, which is a barrier to anadromy. Anadromous salmonid runs currently utilizing this portion Klamath River basin include spring and fall Chinook, coho salmon, and spring/summer, fall, and winter steelhead trout. Some authors recognize three runs of steelhead in the basin based on the timing of their entrance to the estuary and tributaries (Hopelain 1998; Shaw et al. 1998; Trihey and Associates, Inc. 1996; USFWS 1979), while others recognize two runs based on sexual maturity at the time of entrance to the river (Hardy 1999; Hardy and Addley 2006; KRBFTF 1991; Moyle 2002). This appendix discusses steelhead based on three runs: spring/summer, fall, and winter. All six salmonid runs in the Klamath River basin have experienced declines in populations and distribution since the early 1900's. The decline of anadromous species in the basin can be attributed to a variety of factors including over harvest, land-use practices, mining, stream habitat alterations, agriculture, and changes in water quality and temperature (Hardy and Addley 2006, p.7). Significant effects are also attributed to water allocation practices and dam construction, which has altered flow regimes (Hardy and Addley 2006, p.7). The following discussion reviews the habitat and distribution, status, and periodicity of these six salmonid runs.

1.4.1 Habitat and Distribution

The information in this section was synthesized from the following sources: CDFG 1965, p.369; Hamilton et al. 2005; Hardy 1999, p.19, 20; Hardy and Addley 2006, p.3, 5, 10-20; and NRC 2004, p.289, 290, 295, & 296.

The continued survival and persistence of sustainable populations of salmonids in the Klamath River basin depends on the amount and suitability of the habitat. Historically, anadromous species within the basin extended above Upper Klamath Lake in Oregon, and into the Sprague and Williamson River systems and other tributaries. Chinook salmon historically migrated into tributaries of Upper Klamath Lake, and steelhead trout were found in the Klamath River basin above Iron Gate Dam as well. Coho salmon distribution extended at least to the vicinity of Spencer Creek.

In 1918, the completion of Copco No.1 Dam on the Klamath River became the first migration barrier for anadromous species and eliminated over 100 miles of potential anadromous fish habitat in the basin. However, reduced access to tributaries in the upper areas of the Klamath River basin likely occurred as early as 1912-1914 when the Lost River diversion canal and Chiloquin Dam were constructed (Hardy and Addley 2006, p.5). The final barrier to upstream migration in the mainstem Klamath River occurred in 1962 with the completion of Iron Gate Dam. The construction of Lewiston and Trinity dams on the Trinity River in 1963 blocked access to over 109 miles of salmonid spawning habitat. Dwinnell dam was constructed on the Shasta River in 1926 and created a barrier to migration, blocking access to 22% of the historical salmonid spawning habitat.

A habitat survey published by the CDFG in 1965 found that there were 805 miles of habitat in the Klamath River basin below Iron Gate Dam suitable for Chinook, 813 miles of habitat suitable for coho, and 1,616 miles of habitat suitable for steelhead. More current information from Hardy and Addley estimate that there are about 701 miles of Chinook, 786 miles of coho, and 1121 miles of steelhead habitat in the basin below Iron Gate Dam.

The following figures show the current distribution of Chinook (Figure 2), steelhead (Figure 3), and coho (Figure 4) runs in the Klamath River basin as well as the areas where these species have been extirpated in the basin. These figures are based on readily available data and thus do not necessarily reflect all locations of presence or areas of extirpation. Rather, the figures show the general decrease in the distribution of salmonids in the basin from historic levels. Locations at which fish presence is not indicated on the map do not necessarily indicate the absence of fish in these areas, as surveys to determine presence/absence may not have been conducted at all locations within the basin.

“Spring Chinook have been known to occupy the lower reaches of many mid-Klamath tributaries during their adult migration (Cyr 2006).” In addition to those areas shown in Figure 2, spring Chinook are occasionally found in very small numbers in the following locations: Beaver Creek, Lower Scott River, and Bogus Creek (Brucker 2006; USFS 2006). The occasional presence of spring Chinook in tributaries of the Klamath River above the Salmon River in very low, dwindling numbers, reflects the fact that they are at high risk of extirpation from these areas.

It is believed that fall and spring Chinook and coho, in addition to steelhead, were once present above Dwinnell Dam on the Shasta River. Hardy and Addley (2006, p.12) report that Dwinnell Dam blocked access to habitat that was historically utilized by steelhead in the headwaters of the Shasta River, and thus Figure 3 reflects steelhead extirpation above Dwinnell Dam. The NRC (2004, p.289) state that the construction of Dwinnell Dam blocked access to 22% of the historical salmonid habitat above the dam. However, to date no reference was found which specifically stated the historic presence of Chinook or coho above Dwinnell Dam, though the habitat was suitable for their presence in many tributaries above the dam.

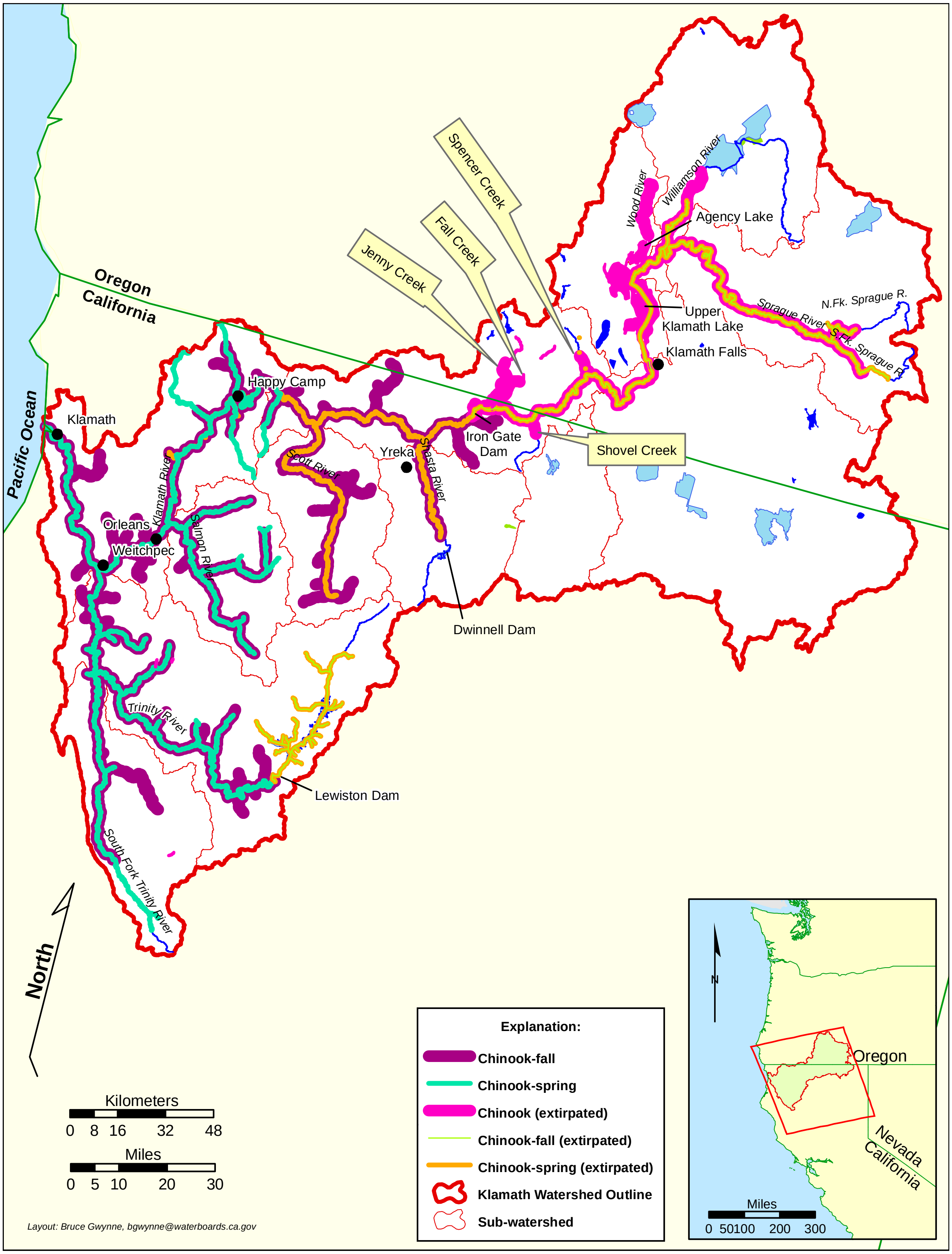

Figure 2: Current Distribution and Areas of Extirpation of Chinook Salmon Runs in the Klamath River Basin
Note: The data for “Chinook (extirpated)” did not differentiate between fall and spring Chinook runs.
Sources: Hamilton et al. 2005, p.12; Moffett and Smith 1950, p.23 & 27; Moyle 2002, p.259; USFS 1996; USFS 2006.

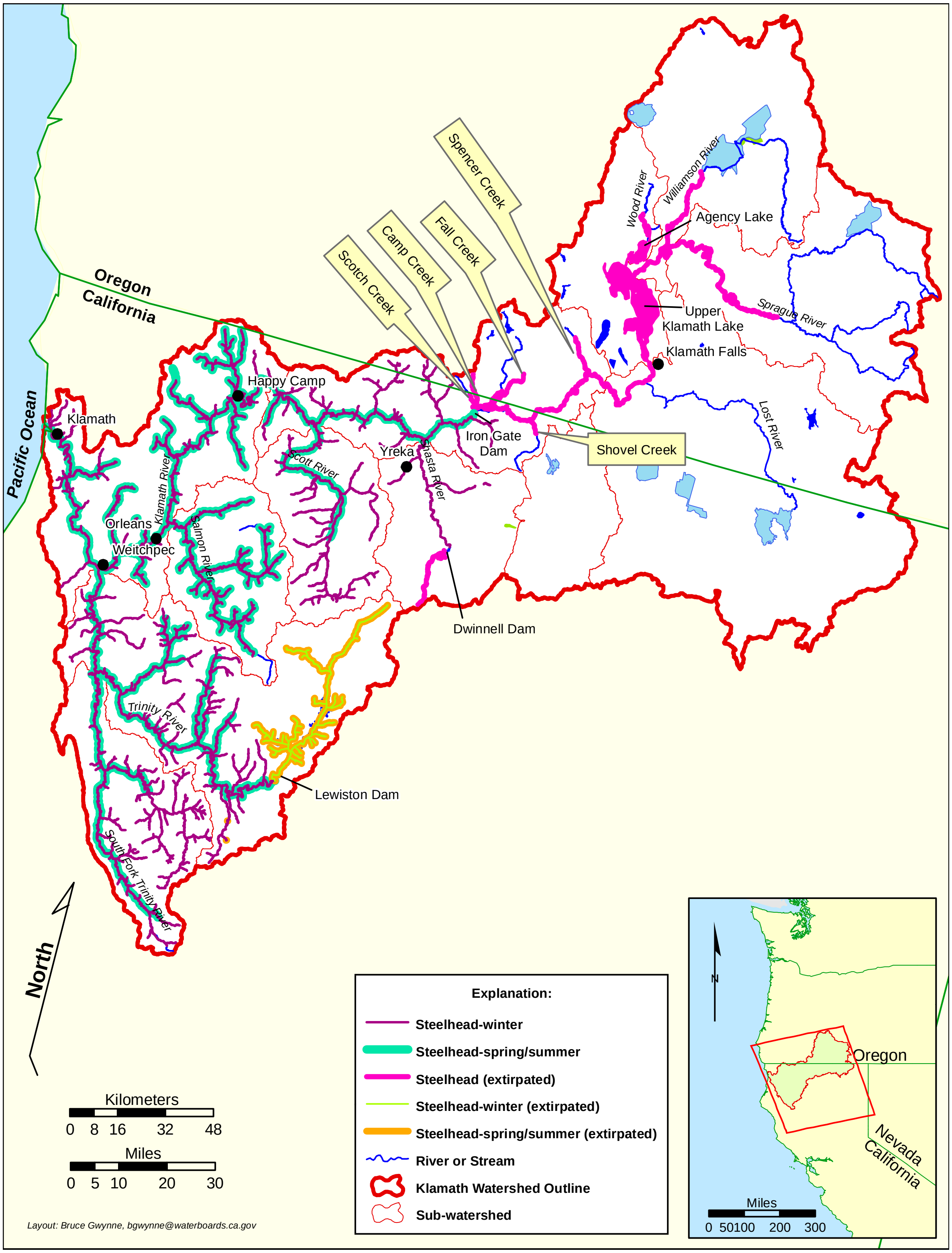

Figure 3: Current Distribution and Areas of Extirpation of Steelhead Trout Runs in the Klamath River Basin
Note: The data for "Steelhead (extirpated)" did not differentiate between spring/summer, fall, and winter runs. The USFS recognizes only winter steelhead (as opposed to fall and winter) and thus information for "Steelhead-winter" and "Steelhead-winter (extirpated)" included data on both fall and winter steelhead runs.
Sources: Hamilton et al. 2005, p.12; Hardy and Addley 2006, p.12; Rushton 2005, p.16 & 17; USFS 1996.

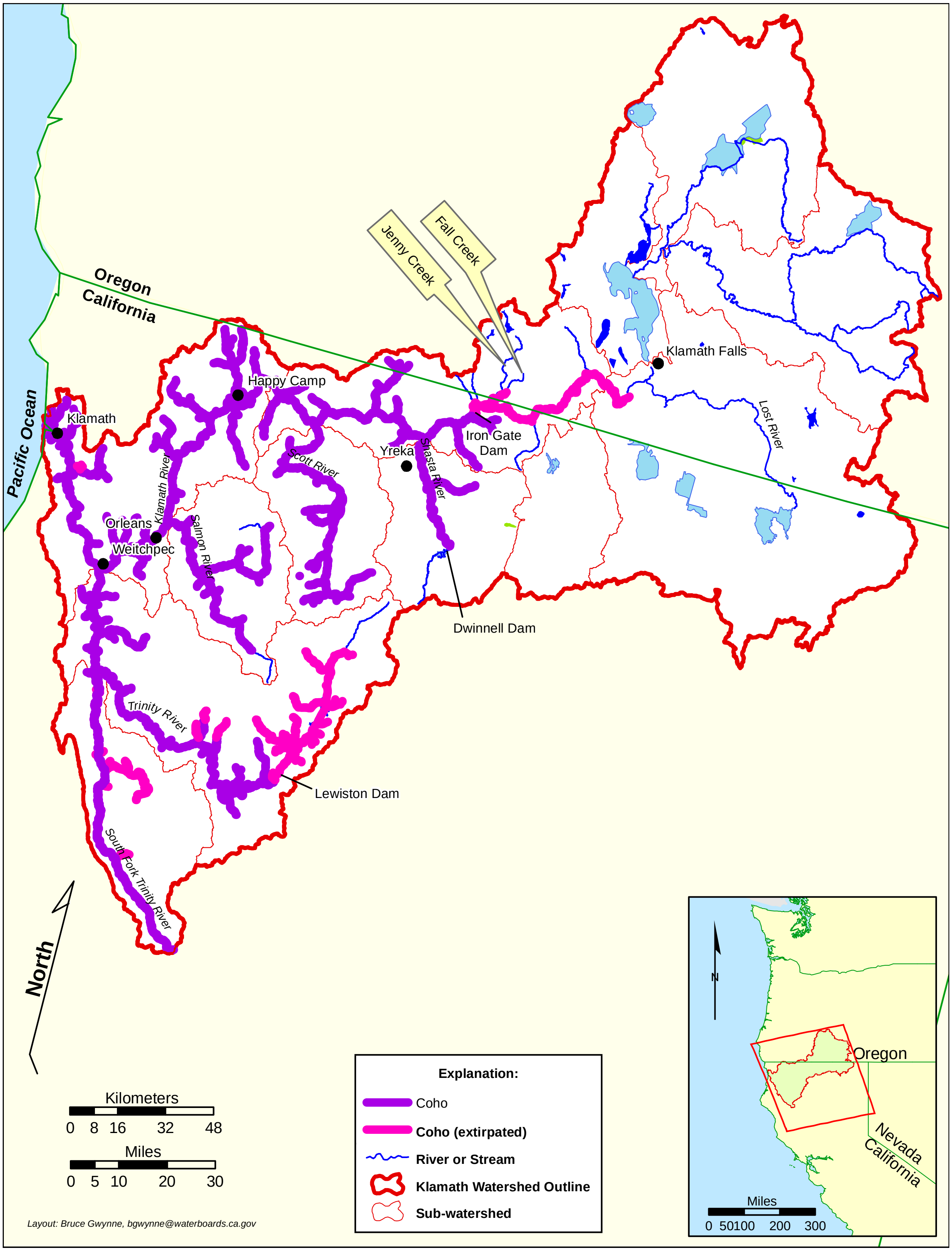

Figure 4: Current Distribution and Areas of Extirpation of Coho Salmon Runs in the Klamath River Basin
Sources: Brown and Moyle 1991, p.14; Brown et al. 1994, p.243; CDFG 2002, p.42; Cyr 2006; Hamilton et al. 2005, p.12; USFS 1996.

1.4.2 Populations

Salmonid populations in the Klamath River basin have declined since the early 1900s. During the period from 1876 to 1933 the salmon runs entering the Klamath River supported a large commercial fishery and several canneries near the mouth of the river (Moyle 2002, p.258). In 1931, Snyder wrote that the fishery of the Klamath River basin is very important because with proper management it can be maintained, although he also states that depletion of the Klamath salmon is apparent and occurring at an "alarming rate" which artificial propagation alone may not remedy (Snyder 1931, p.9, 121). Utilizing information from Snyder (1931), the NRC (2004, p.267, 268) estimated that the annual total catch in the Klamath River basin during the period from 1916-1927 was probably 120,000 to 250,000 fish, and thus the number of potential spawners was considerably higher. Although historically there were large runs of salmonids in the basin, data indicate that current populations are much lower than historic levels.

1.4.2.1 Chinook Salmon

Historic and current records reflect that Chinook salmon were, and continue to be, the most abundant anadromous species in the Klamath River basin. An approximation of total annual catch plus escapement for the period from 1915-1928 estimated there were 300,000 to 400,000 Chinook in the basin (Rankle 1982 as cited by Hardy and Addley 2006, p.7). An estimate of spawner abundance from CDFG in 1965 estimated that on average there were 168,000 Chinook per year in the Klamath River basin (CDFG 1965, p.369). In 1972, Coots estimated that 148,000 Chinook entered the basin (Coots 1973 as cited by Hardy and Addley 2006, p.7).

1.4.2.2 Fall Chinook Salmon

Overall, fall Chinook numbers in the Klamath River basin have dramatically declined during the past century (Hardy and Addley 2006, p.7). The fall Chinook run once totaled as many as 500,000 fish annually (Moyle 2002, p.258). Fall Chinook numbers in the Shasta River watershed alone, historically numbered 20,000-80,000 fish per year (Regional Water Board 2006, p.1-25). Fall Chinook population estimates in the Klamath River basin for the period from 1978-2007 have ranged from a high of 239,559 fish in 1987 to fewer than 35,000 fish in 1991 (Figure 5). In 2002 it was estimated that the fall Chinook population in the basin was 170,014 fish, of which approximately 32,533 were killed (97.1% of the total fish killed) in mid to late September due to a combination of factors including disease, high water temperatures, and low river flow (CDFG 2004, p.III; USFWS 2003a, p.ii; USFWS 2003b, p.ii). This conservative estimate of the number of fall Chinook killed in 2002 is figured from the number of dead fish observed in the area of the fish kill and does not included dead fish that were washed out of the estuary or settled too deep in the water to be visible during surveys (USFWS 2003b, p.1-7). Thus, the estimate of 32,533 dead fall Chinook (19% of the estimated population in 2002) is very conservative and it is likely the actual number of fall Chinook killed was much higher (CDFG 2004, p.III, 158; USFWS 2003b, p.13). Information for 2007 reflect a total estimated run size of 132,167 fall Chinook in the Klamath River basin (CDFG 2008). NRC (2004, p.268) states that in some respects, "…it is remarkable that fall-run Chinook salmon in the Klamath River are doing as well as they seem to be. Both adults migrating upstream and juveniles moving downstream face water temperatures that are bioenergetically unsuitable or even lethal."

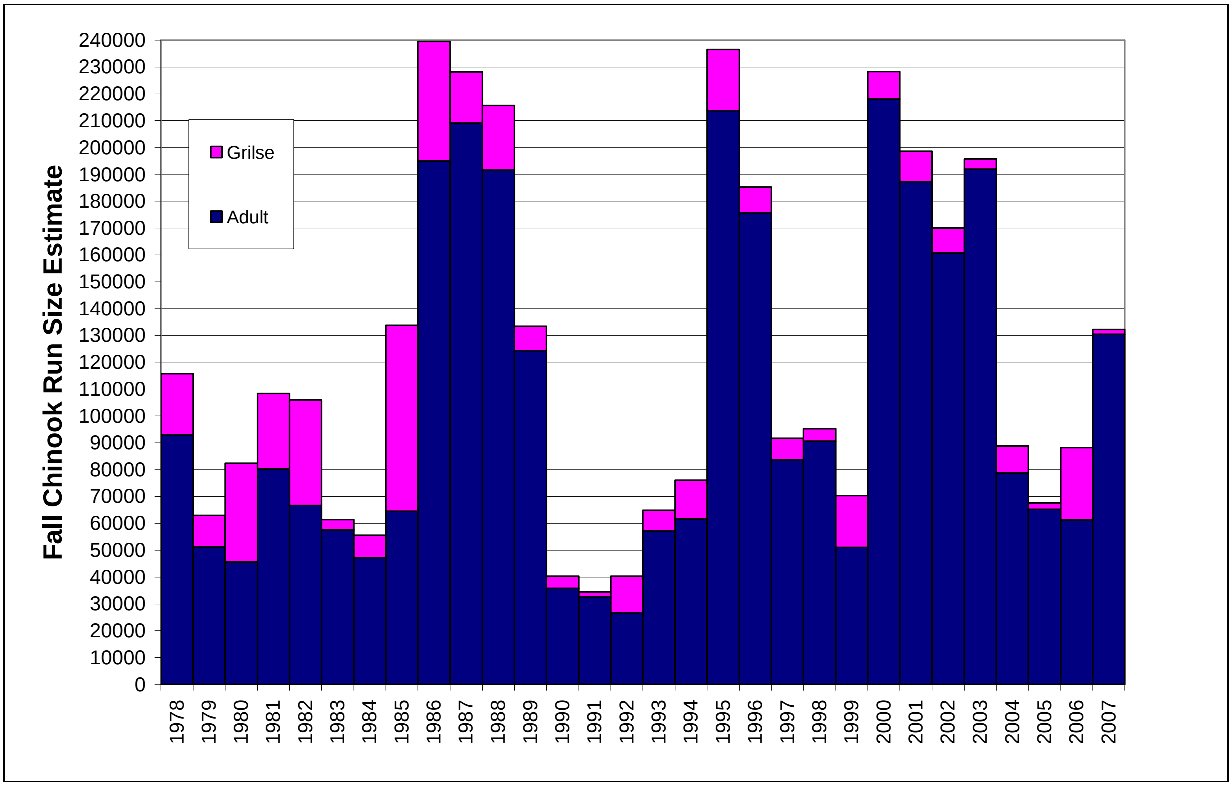

Figure 5: Klamath River Basin Fall Chinook Run Size Estimate, 1978-2007
Note: Run size estimate includes hatchery spawners, natural spawners, and in-river harvest totals. Data from 2007 is preliminary. Grilse are Chinook that return to freshwater to spawn after spending only one year in the ocean.
Source: CDFG 2008

Hatchery returns to Iron Gate and Trinity River hatcheries comprised 6-44% of the fall Chinook populations during the period from 1978-2007 (CDFG 2008). Natural spawners in the Klamath River and its tributaries comprised and estimated 13-39% (Figure 6) of the population during 1991-2007 (CDFG 2008). During 2004 and 2005 the estimated number of fall Chinook natural spawners in the basin has fallen below the Pacific Fishery Management Council goal of a minimum of 35,000. Natural spawning numbers in the basin during these years was estimated to be 28,516 and 27,857 respectively.

In 2006, the National Marine Fishery Service expected the number of natural spawners to be below 35,000 and established an emergency management measure, which closed a majority of the commercial fisheries and greatly reduced the recreational fishery from Cape Falcon, OR, to Point Sur, CA during the period from May 1 through August 31, 2006 (Federal Register 2006, p.26254, 26257). The actual number of natural spawners returning to the Klamath River basin in 2006 (as estimated by CDFG) was 44,546.

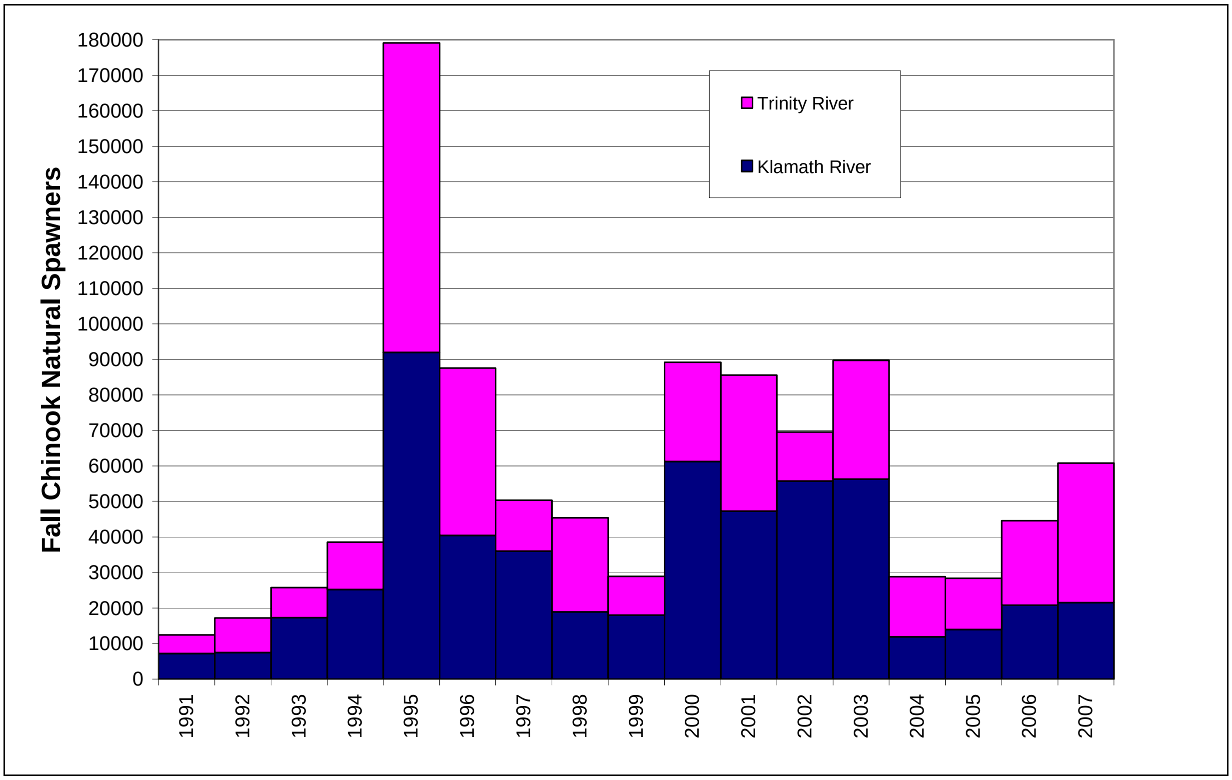

Figure 6: Klamath River Basin Fall Chinook Natural Spawner Estimate, 1991-2007
Note: Data from 2007 is preliminary.
Source: CDFG 2008

The following text on hatchery fall Chinook is from NRC (2004, p.267):

> Hatcheries for Chinook salmon have been operating continuously since 1917. Both the Iron Gate Hatchery and the Trinity River Hatchery produce large numbers of spring-run (13%) and fall-run (87%) juvenile Chinook of native stock (Myers et al. 1998). The hatcheries release 7-12 million juveniles into the river each year (about 70% from the Iron Gate Hatchery, all fall run). The fish generally have been released over a 2-3 days in late May or early June and take 1-2 mo (mean, 31 days) to reach the estuary (M. Wallace, CDFG, unpublished data, 2002), although some fish probably remain in pools for most of summer. Smaller fish take longer than larger fish to reach the estuary, but because they are feeding and growing on the way downstream, all juveniles are about the same size when they reach it. About 40% of the juvenile fish in the estuary in 2000 were of hatchery origin (CDFG, unpublished data, 2000); this is presumably a fairly typical figure. Adult Chinook returning to the hatcheries are roughly one third of the total run—30% in 1999, 44% in 2000, and 28% 2001 (CDFG, unpublished data, 2001). There has been an increase in the percentage of hatchery fish in the run in recent years—up from 18% in 1978-1982, and 26% in 1991-1995 (Meyers et al. 1998). Their contribution to natural spawning is not known, but estimates for the

> Trinity River suggest that it is roughly the same as the percentage of hatchery returns (Myers et al. 1998).

1.4.2.3 Spring Chinook Salmon

The Klamath River basin was known historically for its large run of spring Chinook salmon, which is currently a vestige of its former self (West 1991, p.3). In 1931, Snyder wrote that the spring Chinook migration in the basin, while once very pronounced, “has now come to be limited as to the number of individuals, and is of relatively little economic importance” (Snyder 1931, p.19). A population of more than 100,000 spring-run Chinook was once present in the basin, although this estimate is probably low because spring-run fish were the main run of Chinook in the Klamath River in the 1800’s (Moyle 2002, p.259). Access to prime coldwater habitat in the headwaters of the Shasta, Klamath, and Trinity Rivers has been blocked by the construction of dams thus contributing to the decline of spring Chinook. Spring Chinook runs above Trinity Dam historically included an estimated 5,000 fish in the mainstem Trinity and 1,000-5,000 fish in each of four tributaries above Lewiston Dam (Moyle et al. 1995, p.40). Historic run size estimates in each of the Sprague River, Williamson River, Shasta River, and Scott River alone were at least 5,000 fish (CDFG 1990 as cited by Moyle 2002, p.259).

> Runs in the Sprague and Williamson Rivers were probably extirpated before 1900 as the result of dams constructed in Oregon; if any fish remained, they were eliminated with the construction of Copco Dam across the main river in California in 1917. The run in the Shasta River, probably the largest tributary run in the Klamath drainage, disappeared in the early 1930s as a result of habitat degradation and increased summer water temperatures caused by Dwinnell Dam. The smaller Scott River run was extirpated in the early 1970s by a variety of causes (Moyle 2002, p.259).

By the 1980’s, habitat alterations had reduced or eliminated much of the cold water habitat and deep pools that spring-run Chinook require resulting in their elimination from much of their former habitat (NRC 2004, p.269). It is estimated that only 3% of the historic habitat available to spring Chinook is currently used by this run (Spring Salmon Summit 2005, p.10). Extant spring run Chinook populations in the Klamath River basin only remain in the Trinity and the Salmon Rivers. Population estimates for spring Chinook during the period from 1980-2006 have ranged from a high of 69,004 fish to fewer than 1,945 (Figure 7). Trinity River Hatchery returns have made up 14-68% of these populations during 1980-2006, and on average comprise 28% of the population.

An average of 10,320 natural spring Chinook spawners have returned to the Klamath River basin annually during the period from 1990-2006, and estimates have ranged from 1,618-35,719 fish (Figure 8). The only substantial wild populations still persisting in the basin are found in the Salmon River (Campbell and Moyle 1991 as cited by Moyle et al. 1995, p.40). Monitoring records of spring Chinook adults in the Salmon River during this period reflect an average of 601 fish returning to the stream annually, with a range from 90 (2005) to 1,485 (1995).

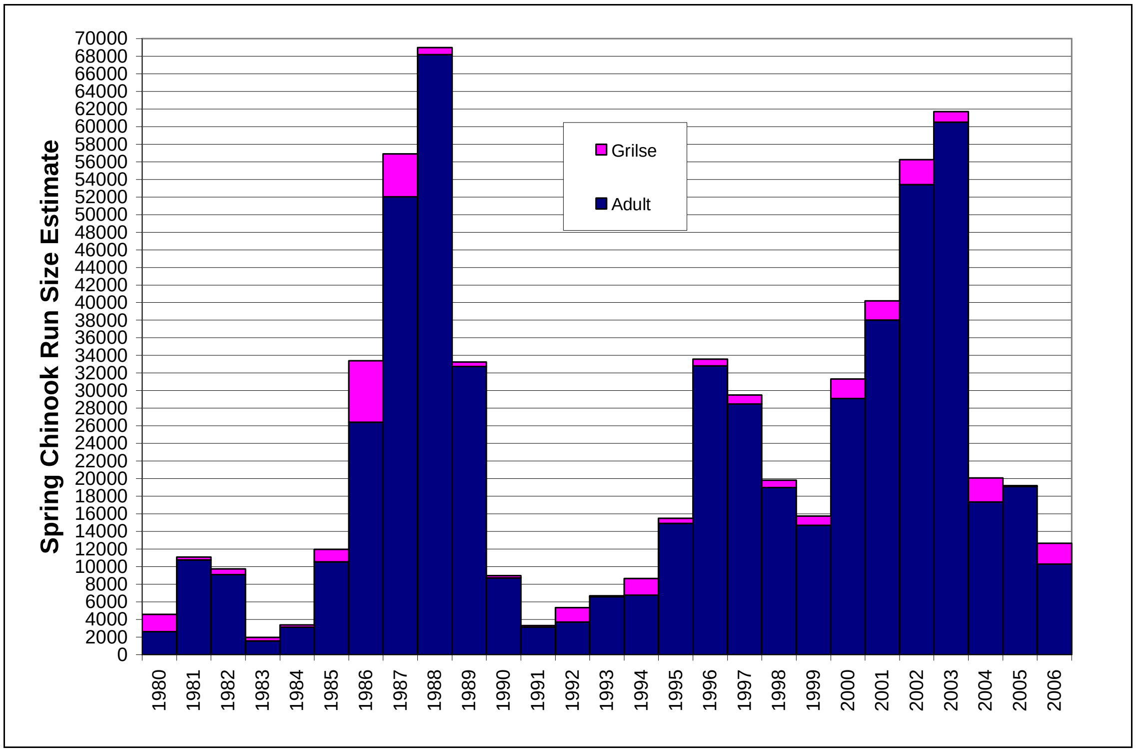

Figure 7: Klamath River Basin Spring Chinook Run Size Estimate, 1980-2006
Note: Run size estimate includes hatchery spawners, natural spawners, and in-river harvest totals. Grilse are Chinook that return to freshwater to spawn after spending only one year in the ocean.
Source: CDFG 2006a

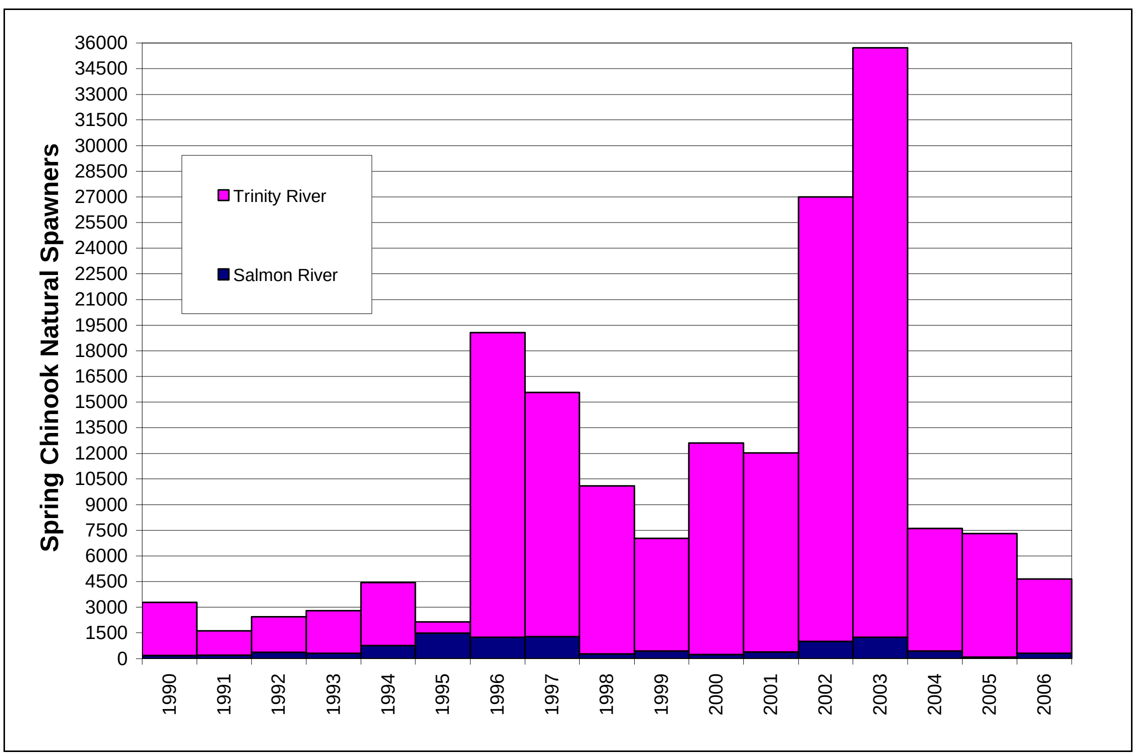

Figure 8: Klamath River Basin Spring Chinook Natural Spawner Estimates, 1990-2006
Source: CDFG 2006a

1.4.2.4 Steelhead Trout

Steelhead are common in the Klamath River basin below Iron Gate Dam where three runs are known to occur: spring/summer, fall, and winter. All three of these runs have a life-history stage called the half-pounder, which is an immature fish that migrates to the sea in the spring but returns to freshwater in the late summer. Fall and winter run steelhead are fairly common in the basin, although they are less abundant than historical levels, while spring/summer steelhead are in danger of extinction (Moyle 2002, p.280). It is likely that steelhead runs exceeded several million fish prior to the 1900s (Hardy and Addley 2006, p.6). An estimate of steelhead spawner abundance by CDFG (1965, p.369) estimated an average of 221,000 steelhead in the Klamath River basin annually.

Hardy and Addley (2006, p.6) state:

> The best quantitative historical run sizes in the Klamath and Trinity river systems were estimated at 400,000 fish in 1960 (USFWS 1960, cited in Leidy and Leidy 1984), 250,000 in 1967 (Coots 1967), 241,000 in 1972 (Coots 1972) and 135,000 in 1977 (Boydston 1977). Busby et al., (1994) reported that the hatchery influenced summer/fall-run in the Klamath Basin (including the Trinity River stocks) during the 1980's numbered approximately 10,000 while the winter-run component of the run was estimated to be approximately 20,000. Monitoring of adult steelhead returns to the Iron Gate Hatchery have shown wide variations since monitoring began in 1963. However, estimates during the 1991 through 1995 period have been extremely low and averaged only 166 fish per year compared to an average of 1935 fish per year for 1963 through 1990 period (Hiser 1994). In 1996, only 11 steelhead returned to Iron Gate Hatchery. The National Marine Fisheries Service (NMFS) considers that based on available information, Klamath Mountain Province steelhead populations are not self-sustaining and if present trends continue, there is a significant probability of endangerment (NMFS 1998); however, steelhead were not listed under the Endangered Species Act of 1973 (ESA).

Annual counts of spring/summer steelhead in holding areas throughout the Klamath River basin have ranged from 500 to 3,000 fish (Roeloffs 1983, as cited by Hopelain 1998, p.1). In the 1990’s it was estimated that there were 1000-1500 spring/summer steelhead adults divided among eight populations in the basin (Barnhart 1994, Moyle et al. 1995, Moyle 2002 as cited by NRC 2004, p.274). NMFS considers spring/summer steelhead stocks depressed and in danger of extinction (Busby et al. 1994 as cited by NRC 2004, p.274).

Fall steelhead represent the largest of the three steelhead runs and were estimated to include 55,000-75,000 spawning adults and 150,000-225,000 half-pounders during the period from 1980-1982 (D.P. Lee, CDFG, pers. comm. as cited by Hopelain 1998, p.1).

Run size estimates for winter steelhead were 170,000 in the 1960s, 129,000 in the 1970s, and 100,000 in the 1980s (Busby et al. 1994 as cited by NRC 2004, p.273). Current population estimates for winter steelhead have not been conducted, although Hopelain (1998, p.1) estimated a run-size of about 5,000 to 25,000 during 1980-1982. It is presumed that winter steelhead abundance is still declining although estimates, both past and present, are not very reliable (NRC 2004, p.273).

The following text on hatchery winter steelhead is from NRC (2004, p.272, 273):

> The Iron Gate Hatchery produces about 200,000 and the Trinity River Hatchery about 800,000 winter steelhead smolts per year (Busby et al. 1994). The fish are released into the rivers in the last 2 wk of March, and most reach the estuary about a month later (M. Wallace, CDFG, personal communication), coincident with the emigration of wild smolts. Diets of outmigrating smolts are similar to those of wild smolts, although the consumption of a greater variety of taxa and fewer organisms by the hatchery fish than by wild fish suggests that they have lower feeding efficiency than wild fish (Boles 1990). Otherwise, the interactions between hatchery and wild fish in the Klamath are not known, although hatchery steelhead released into a stream will dominate the wild steelhead (McMichael et al. 1999), potentially increasing the mortality in wild fish from predation, injury, or reduced feeding. Hatchery steelhead also can have adverse effects on juveniles of other salmonids, especially Chinook and coho salmon, through aggressive behavior and predation (Kelsey et al. 2002).
>
> In the 1970s and early 1980s, adults of hatchery origin made up about 8% of the run of Klamath River steelhead and 20-34% of the run in the Trinity River (Busby et al. 1994). As numbers of wild steelhead decline, the percentage of hatchery fish in the population presumably will increase. There is some indication that the runs most heavily influenced by hatchery steelhead in the Trinity River have a lower frequency of half-pounders in the population than do wild populations (Hopelain 1998).

Although steelhead population estimates for the Klamath River basin have not been conducted on a regular basis, adult steelhead return numbers to the Iron Gate Hatchery, Trinity River Hatchery, and Shasta River Fish Counting Facility are available and are presented for the period from 1970-2005 in Figure 9. Adult steelhead returns to these three locations in the basin have ranged from a high of 10,837 fish in 2004 to a low of 529 fish in 1999, with an average return of 3,328 fish over the last 36 years.

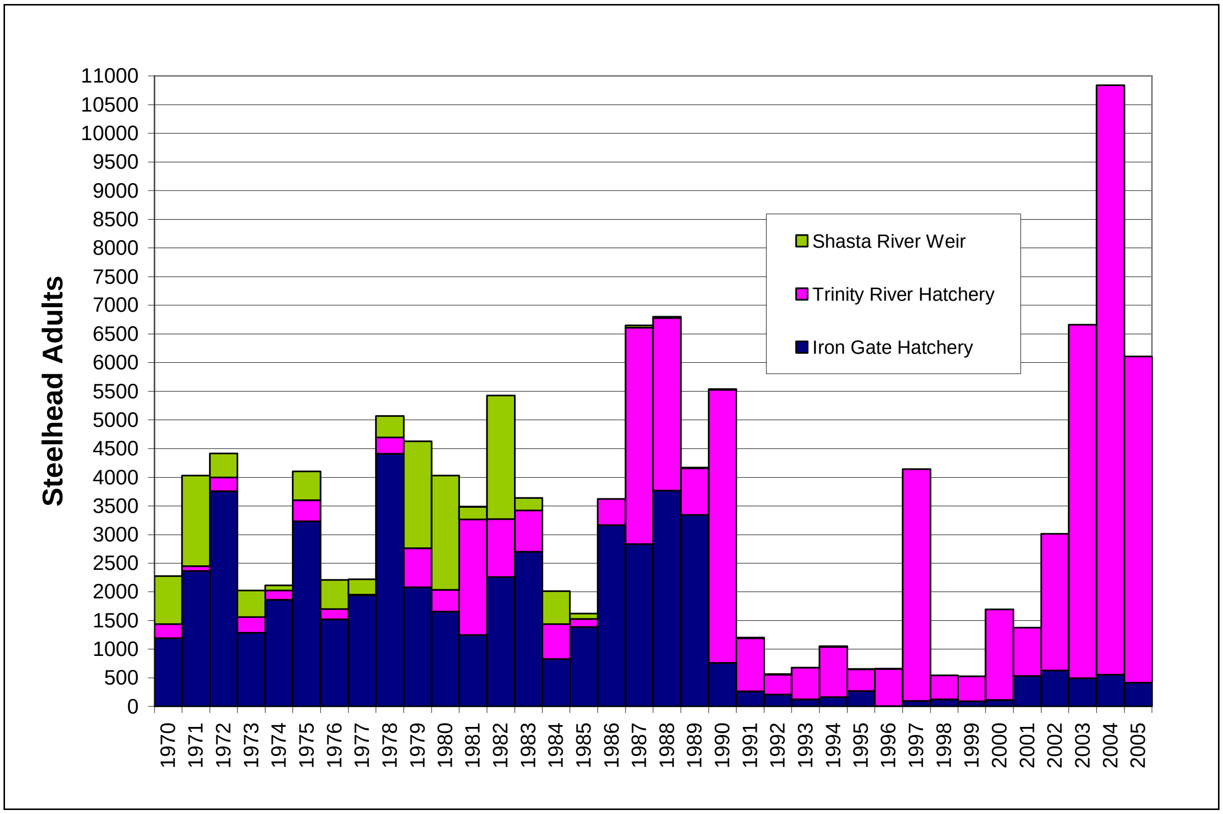

Figure 9: Klamath River Adult Steelhead Returns to Iron Gate Hatchery, Trinity River Hatchery, and the Shasta River Fish Counting Facility, 1970-2005
Note: Steelhead data were not available from the Shasta River Fish Counting Facility for the period of 1997-2005 and thus information is only presented for Iron Gate and Trinity River Hatchery Returns.
Sources: Klamath River Information System (KRIS) 2006; Marshall 2005; and Rushton 2005.

1.4.2.5 Coho Salmon

It is clear from the information available that coho salmon populations statewide have undergone a dramatic decline from historic levels (Brown and Moyle 1991, p.8; Brown et al. 1994; CDFG 2002, p.1). The Southern Oregon/Northern California Coast Evolutionary Significant Unit (SONCC ESU), which encompasses Klamath River basin stocks, has been listed as threatened by the State of California and the federal government. Coho salmon occupy only 61% of the SONCC ESU streams that were previously identified as historical coho salmon streams (CDFG 2002, p.2).

Maximum estimates for coho spawners in California during the 1940's range from 200,000-500,000 fish (Sagar and Glova 1988 as cited by Moyle 2002, p.250). Brown et al. (1994) state that California coho populations are probably less than 6% of what they were in the 1940s, and there has been at least a 70% decline since the 1960s. In 1994, Brown et al. estimated the coho salmon population in California to be 30,000 fish, with natural spawners comprising 43% of the total population or 13,240 fish. This figure is said to be "optimistic because we assumed coho salmon still occur in streams for which there are no current data; it is likely, therefore, that we have underestimated the magnitude of decline (Brown et al. 1994)."

Historical spawning escapement estimates for the Klamath River basin approximate 15,400-20,000 coho, with 8,000 of these fish originating in the Trinity River (USFWS 1979, App. as cited by Brown et al. 1994). In 1965, CDFG estimated 15,400 coho spawners per year in the basin (CDFG 1965, p.369). In 1994, Brown et al. estimated a total abundance of 18,125 coho in the basin, including 1,860 native and naturalized fish. Brown et al. (1994) published the results of presence and absence counts for coho salmon in the basin. Of the 41 tributaries monitored (113 tributaries where they were known to have existed historically), coho were detected in only 21 and absent in the other 20 (Brown et al. 1994). Current population estimates for coho in the Klamath River basin have not been conducted, although adult coho return numbers to the Iron Gate Hatchery, Trinity River Hatchery, and Shasta River Fish Counting Facility are available and are presented for the period from 1964-2005 in Figure 10. Adult coho returns from these combined locations during the last 42 years averaged 5949 fish.

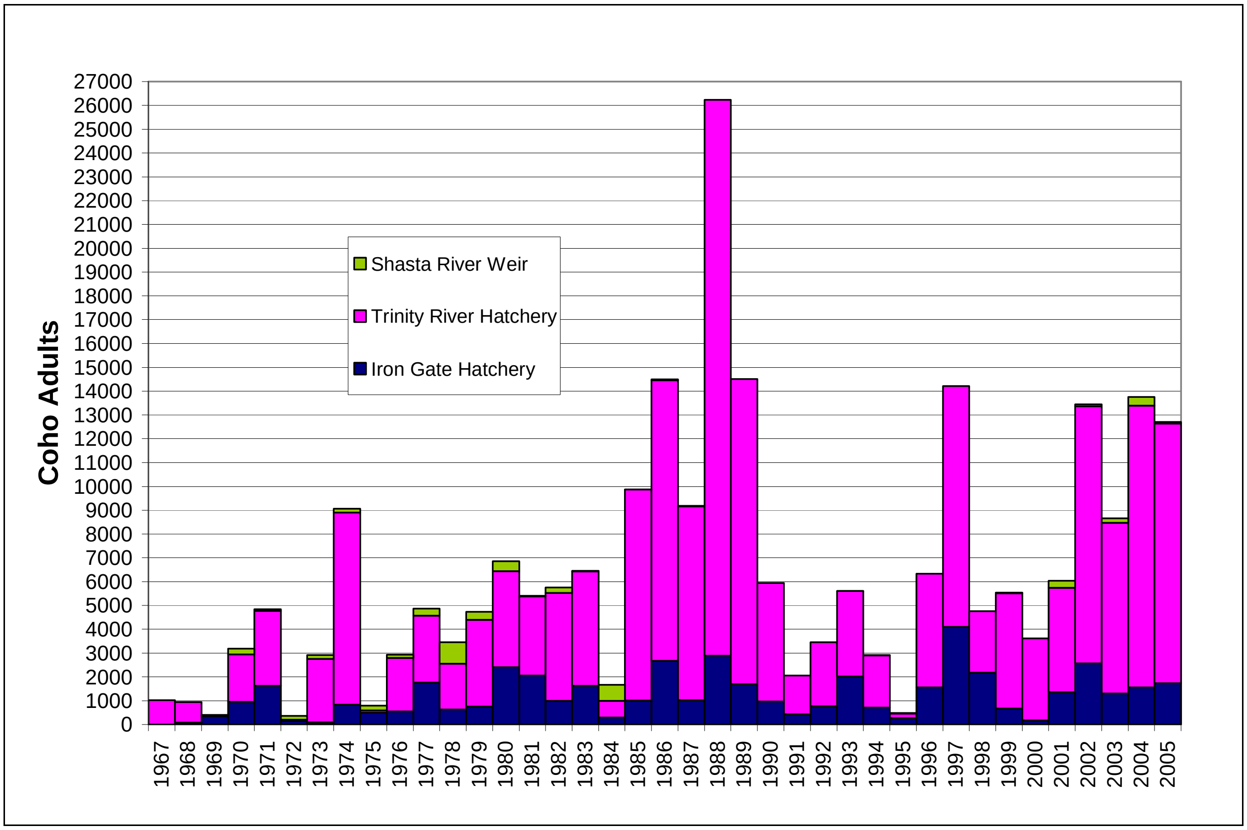

Figure 10: Klamath River Adult Coho Returns to Iron Gate Hatchery, Trinity River Hatchery, and the Shasta River Fish Counting Facility, 1964-2005

Sources: Hampton 2004, p.1; Hampton 2005a, p.1; Hampton 2005b; KRIS 2006; Marshall 2005; and Rushton 2005.

Natural production of coho salmon in the Klamath River basin is considered minimal, with Iron Gate and Trinity River Hatcheries the major sources of most coho salmon in the basin (KRFMC 1991, App. as cited by Brown et al. 1994). The following text from NRC (2004, p.262, 263) discusses hatchery coho in the Klamath River basin:

Coho salmon have been an important part of the Klamath basin fish fauna since prehistoric times (CDFG 2002), and many attempts have been made to augment their populations in the Klamath basin. The first attempt occurred in 1895, when 460,000 fish from Redwood Creek—part of the same evolutionarily significant unit (ESU) as Klamath River coho—were stocked in the Trinity River. It is not known whether these fish, which were taken from a small stream, survived and contributed to later populations. Hatchery production of coho salmon in the Klamath basin began in the 1910-1911 season and continued for another 5 yr. From 1919 to 1942, six additional plants of hatchery-reared fish, all apparently of local origin, were conducted (CDFG 2002). The principal hatcheries today are the Iron Gate Hatchery (operating since 1966) on the Klamath and the Trinity River Hatchery (operating since 1963) on the Trinity River. Faced with a declining egg supply, operators of the two hatcheries at various times brought in fertilized eggs from the Eel and Noyo rivers in California and the Cascade and Alsea rivers in Oregon (CDFG 2002). Thus, present hatchery stocks probably are of mixed origin. Although a few hatchery fish have been planted in tributaries, hatchery fish are for the most part released as smolts into the main stem on the assumption that they will head directly to the sea.

Genetic studies of the contribution of hatchery coho to wild populations in the Klamath basin are not available. Brown et al. (1994) inferred that most wild coho stocks in the basin were partially mixed with hatchery stocks because the two hatcheries are at the far upstream end of coho distribution and produce large numbers of fish. In recent years, the Trinity River Hatchery has released an average of 525,000 coho per year and the Iron Gate Hatchery about 71,000 per year (CDFG 2002), although historically the Iron Gate Hatchery has released about 500,000 coho per year (CDFG, unpublished data, 2002). The coho typically are reared to the smolt stage and marked with a maxillary clip before release, which occurs between March 15 and May 1. They reach the estuary in concert with wild smolts, which peak in late May and early June, but typically are longer than the wild fish—about 170-185 mm vs 135-145 mm (M. Wallace, CDFG, unpublished data, 2002). Although the effect of large numbers of hatchery coho on wild coho is not known for the Klamath, hatchery fish may dominate wild fish when the two are together (Rhodes and Quinn 1998). In any event, hatchery fish are apparently more numerous than their wild counterparts. In 2000 and 2001, 61% and 73%, respectively, of the smolts captured in the estuary were of hatchery origin (M. Wallace, CDFG, unpublished data, 2002).

The percentage of hatchery fish in the spawning population has not been estimated directly, but Brown et al. (1994) estimated that 90% of the adult coho in the system returned directly to the hatcheries or spawned in the rivers in their immediate vicinity. Other hatchery coho no doubt stray into other streams, but the percentage is not known (CDFG 2002). In a survey of spawning coho in the Shasta River in 2001, individuals from the Iron Gate and Trinity River hatcheries were identified; seven of 23 carcasses examined were hatchery fish (CDFG, unpublished data, 2001). Regardless of origin, natural-spawning coho in the basin's tributaries have managed to maintain timing of runs and other life-history features that fit the basin's hydrologic cycle well.

1.4.3 Periodicity

Adult and juvenile Chinook and steelhead are present year round in the Klamath River basin below Iron Gate Dam (Figures 11 and 13), and mainstem Klamath River below the Dam (Figures 12 and 14). Adult coho are present in the basin from August to February (Figure 15) and in the mainstem Klamath River from September through January (Figure 16), while juvenile coho are present year round. The following sections discuss the presence of salmonids in the Klamath River basin at various life stages throughout the year, known as "periodicity." Data on individual Chinook and steelhead runs in Figures 11, 12, 13, 14 below, are based on readily available information and do not necessarily reflect the entire use period for that run/species. The "All" information rows for Chinook and steelhead represent periods where one or more of the runs are utilizing the basin, and thus is a summary of all information on the individual runs and run timing information for the species in general.

Unless otherwise noted, the text in the following section is primarily from Hardy 1999 (p.5-7), Hardy and Addley 2006 (p.14), NRC 2004 (p.254-258, 264-266, 270-274), and USFWS 1979 (p.16, 27, 29, 30), with additional information from Moyle (2002, p.254), and Salmon River Restoration Council (SRRC) and Klamath Tribe Department of Natural Resources (KTDNR) 2006.

1.4.3.1 <u>Chinook Salmon</u>

Chinook periodicity information for the Klamath River basin below Iron Gate Dam is presented in Figure 11, and information for Chinook periodicity in the mainstem Klamath River is presented in Figure 12.

Fall Chinook are generally slower in their upstream migration than spring Chinook. It takes approximately 2-4 weeks for fall Chinook to reach upstream spawning grounds (USGS 1998 as cited by NRC 2004, p.265). Fall Chinook spawn in the lower reaches of tributaries and in the mainstem Klamath River, although less than 33% spawn in the mainstem. Half of the spawning that occurs in the mainstem takes place in the 13 miles of the river below Iron Gate Dam, although significant spawning occurs as far down as Happy Camp and limited spawning occurs as far downstream as Orleans. Eggs generally incubate for 50-60 days when water temperatures range from 5-14.4 C. Fry move downstream after emergence and often take up residence in shallow water on the edges of the stream in flooded vegetation, where they remain for various lengths of time, although some outmigrate directly to the estuary. The NRC (2004, p.265) reports that juveniles rearing in the Klamath River or larger tributaries reside there for 3-9 months but move downstream continuously. Shaw et. al. (1998, p.29) state that juvenile rearing in the mainstem between Iron Gate Dam and Seiad Creek is likely to occur year round. Belchik (1997) reports that rearing juvenile salmonids reside in pockets of cool water, thermal refugia, in the Klamath River when mainstem water temperatures become unsuitable during the summer. Type I, II, and III Chinook exist in the Klamath River basin and thus outmigration occurs year round. Juvenile fall Chinook move into the estuary at a smaller size and reside there longer when conditions in the river are unfavorable, such as times of warm water temperatures. It appears that many juveniles leave the estuary after only a few weeks, and outmigrate to the ocean (Wallace 2000 as cited by NRC 2004, p.265).

Spring Chinook are thought to migrate more deliberately and further upstream than fall Chinook. Spring Chinook migrate as far upstream as they can go in larger tributaries, which allows them to access habitat often inaccessible to fall Chinook due to low flows and high temperatures during the summer and fall. Spring Chinook are persistent in their upstream migration and don't rest until they have reached holding areas where they remain until they spawn. Migrating spring Chinook hold in deep pools for 2-

CHINOOK												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
All												
Fall												
Spring		M	M	M/H	M/H	M/H	M/H	H	H	H		
All												
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=Migration/Holding =Spawning =Incubation
=Emergence =Rearing =Out Migration

Figure 11: Chinook Periodicity in the Klamath River Basin
M=Migration, M/H=Migration and Holding, H=Holding
Sources: Hardy 1999, p.6, 7, & 34; Hardy and Addley 2006, p.96; KRBFTF 1991, p.4-8, 4-9, 4-12; Leidy and Leidy 1984; NRC 2004, p.269; Olson per comm., as cited by West 1991, p.9; PacifiCorp 2004, p.4-25; Shaw et al. 1998; Snyder 1931, p.19; SRRC and KTDNR 2006; Scott River Watershed Council (SRWC) 2004, p.6-17; Trihey and Associates, Inc. 1996, p.12, 17; USFWS 1979, p.16; USFWS 1999, p.19, 38; USFWS 2001, p. 13, 22; West 1991, p.9.

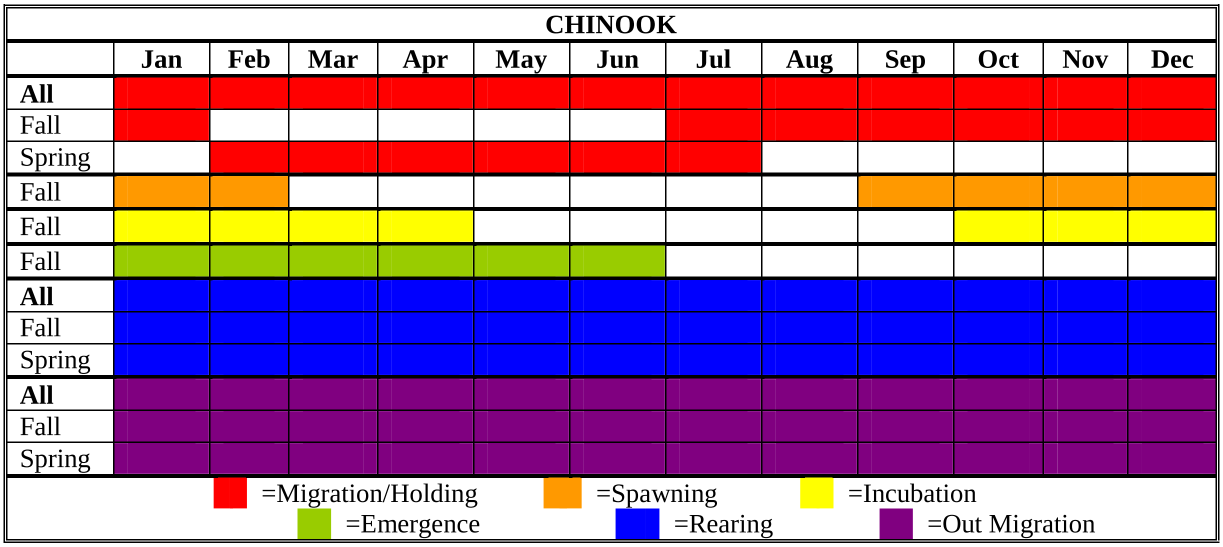

Figure 12: Chinook Periodicity in the Mainstem Klamath River

Sources: Hardy 1999, p.34; Hardy and Addley 2006, p.96; NRC 2004, p.264-267; Rushton 2005; Shaw et al. 1998; USFWS 1979, p.16; USFWS 1999, p.16; USFWS 2001, p. 59, 62, 65, & 68

4 months (throughout the summer) as their gonads fully develop, and then spawn the following fall and winter. Spring Chinook are susceptible to high water temperatures that can result in decreased fecundity of females (decreases egg viability) as they hold throughout the summer (McCullough 1999 as cited by NRC 2004, p.269). Incubation takes approximately 40-60 days, and alevin and fry remain in the gravel for 2-4 weeks before emergence. Spring Chinook will typically rear in freshwater for a year after emergence before heading to the ocean (Healey 1991 as cited by NRC 2004, p.268).

1.4.3.2 Steelhead Trout

Information on steelhead periodicity in the Klamath River basin below Iron Gate Dam is presented in Figure 13, and steelhead periodicity in the mainstem Klamath River is presented in Figure 14.

With the exception of half-pounders, steelhead remain in the ocean for 1-3 years before initiating their spawning run and may spawn 3-4 times during their life. Incidence of repeat spawning reported by Hopelain (1998, p.21) were 17.6-47.9% for fall steelhead, 40-63.3% for spring/summer steelhead, and 33.1% for winter steelhead. Although steelhead generally use the mainstem Klamath River as a migration corridor, some spawning does occur in the mainstem. The mainstem is also very important to the juvenile rearing life stage of steelhead. Fall run steelhead typically enter the Klamath River basin during the summer and hold for several months before moving to spawning areas in smaller tributaries. The early part of the fall steelhead run consists primarily of half-pounders. Franklin (2006) notes that half-pounders have entered the Klamath River as early as July, although most references cite migration beginning in August. Spring/summer steelhead enter the Klamath River in early spring and hold in deep pools until they spawn the following winter. High water temperatures can decrease the viability of eggs in female spring/summer steelhead holding throughout the summer and fall. Steelhead eggs typically incubate for 4 –7 weeks, although the length of time for incubation is a function of water temperature, taking longer in cooler temperatures.

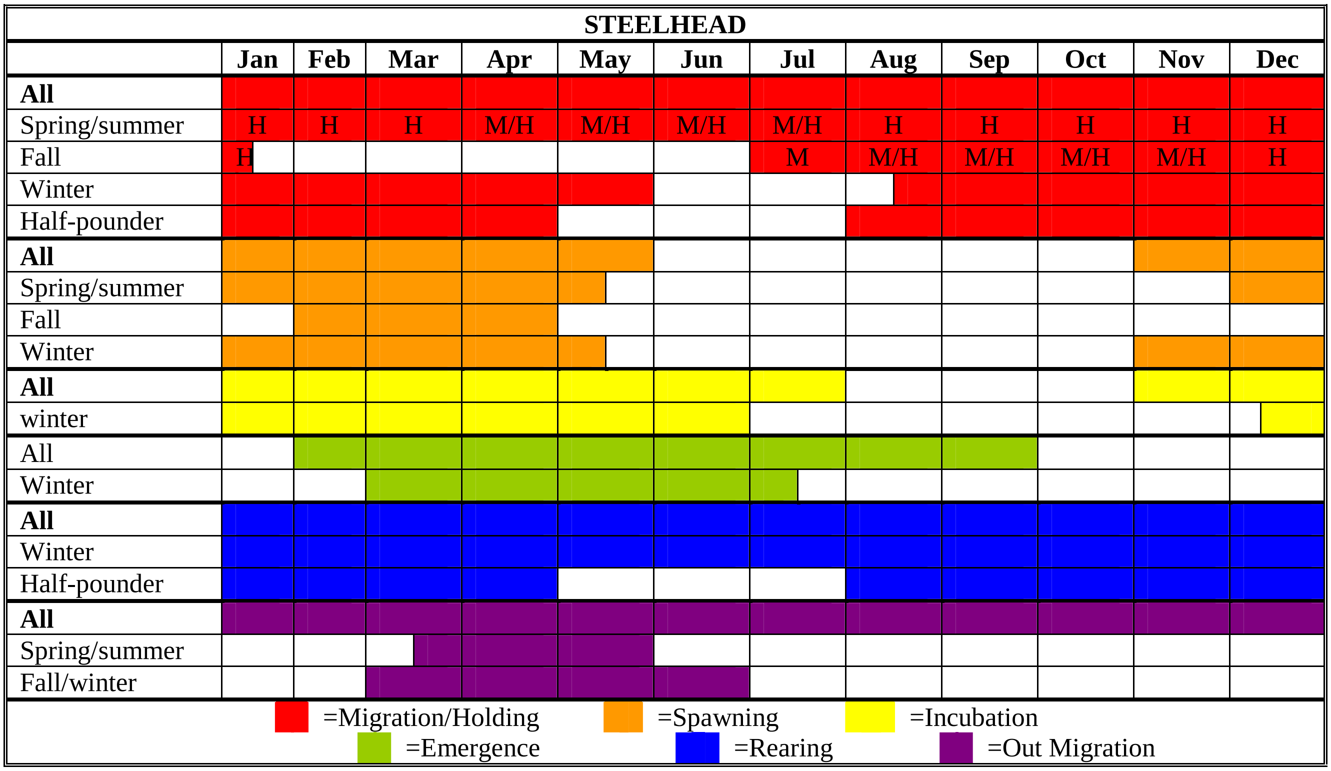

Figure 13: Steelhead Periodicity in the Klamath River Basin

M=Migration, M/H=Migration and Holding, H=Holding

Sources: Barnhart 1994 as cited by NRC 2004, p.271; Hardy 1999, p.5, 6 & 34; Hardy and Addley 2006, p.96 ; Hopelain 1998, p.1; Leidy and Leidy 1984; NRC 2004, p.271, 272; Shaw et al. 1998; Trihey and Associates, Inc. 1996, p.13; USFWS 1979, p.29, 30; USFWS 1999, p.28, 49; USFWS 2001, p.36, 44.

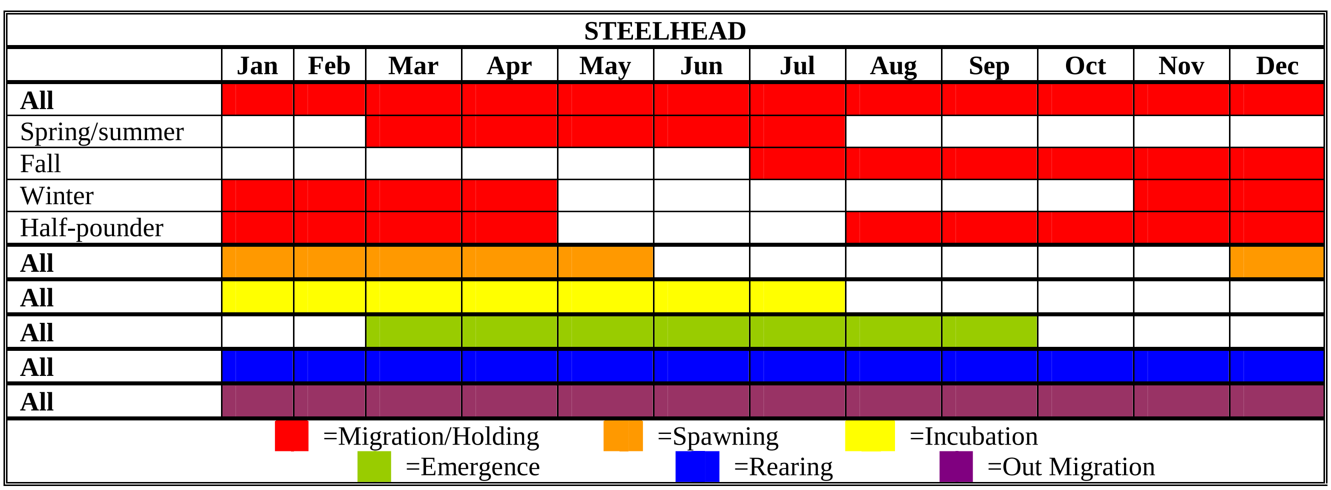

Figure 14: Steelhead Periodicity in the Mainstem Klamath River

Sources: Hardy 1999, p.34; Hardy and Addley 2006, p.96; Hopelain 1998, p.12; NRC 2004, p.271-273; Rushton 2005; Shaw et al. 1998; USFWS 1979, p.29 & 30; USFWS 1999, p.27; USFWS 2001, p. 61, 64, 67, & 70.

After emergence, fall and winter steelhead juveniles distribute themselves widely throughout the basin, and many move out of the tributaries and into the mainstem to rear (NRC 2004, p.271). Juvenile spring/summer steelhead typically occupy the same upper stream reaches where they were spawned. Shaw et al. (1998, p.31) report that young of the year steelhead emigrate to the mainstem and most likely rear there for a year before emigrating as two year olds. Cool water areas, thermal refugia, of the mainstem Klamath River are utilize by rearing juvenile salmonids during the summer once mainstem temperatures become unsuitably warm (Belchik 1997). Juvenile steelhead normally spend 2 years in freshwater before they enter the ocean, although some emigrate after 1 or 3 years.

1.4.3.3 Coho Salmon

Coho periodicity information for the Klamath River basin below Iron Gate Dam is presented in Figure 15, and information on coho periodicity in the mainstem Klamath River is presented in Figure 16.

In the Klamath River basin, coho salmon have a 3-year lifecycle during which they spend 1-1½ years in freshwater before moving to the ocean, and then return to the river to spawn at age 3. Occasionally males, called "jacks", will return to the river to spawn as 2-year-olds. Coho upstream migrations are typically linked to pulse flows associated with rain events in the basin. They generally spawn in tributaries, however they have been observed spawning at tributary confluences, in side channels, and along the shoreline of the mainstem Klamath River. Eggs incubate for approximately 7 weeks and alevins remain in the gravel for 2-3 weeks before emerging.

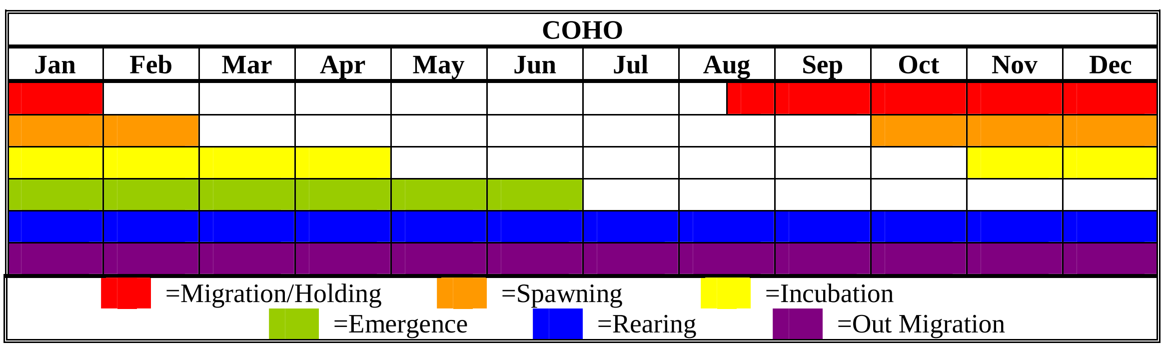

Figure 15: Coho Periodicity in the Klamath River Basin

Sources: Hardy 1999, p.6 & 34; Hardy and Addley 2006, p.96; Leidy and Leidy 1984; NRC 2004, p.7, 8; Shaw et al. 1998; Snyder 1931, p.16, 23; SRRC and KTDNR 2006; SRWC 2004, p.6-17; Trihey and Associates, Inc. 1996, p.13, 17; USFWS 1979, p.27; USFWS 1999, p.26, 43; USFWS 2001p.32, 40.

Upon emergence from the gravels coho juveniles seek areas of low velocity with an abundance of food, such as the stream margins. The NRC reports that coho juveniles live in the mainstem Klamath River despite temperatures that regularly exceed 24C (M. Rhode, CDFG, personal communication, USFWS, unpublished data, 2002 as cited by NRC 2004, p.257). These juveniles are mainly found in pools at the mouths of tributaries where temperatures are 2-6C lower than in the mainstem. Belchik (1997) reports that cool water areas, thermal refugia, of the mainstem Klamath River are utilize by rearing juvenile salmonids, including coho, during the summer once mainstem temperatures become unsuitably warm. The Karuk tribe have collected data which shows that coho use the mainstem Klamath River even during the hottest periods of the year if suitable thermal refugia is available (Corum 2006). Shaw et. al. (1998, p.30) states that coho likely rear in the mainstem Klamath River between Iron Gate Dam and Seiad Creek year round, although they do not necessarily inhabit the mainstem on a continuous basis due to the high bioenergetic demands. Coho juveniles typically rear in freshwater for 1 year before outmigration occurs.

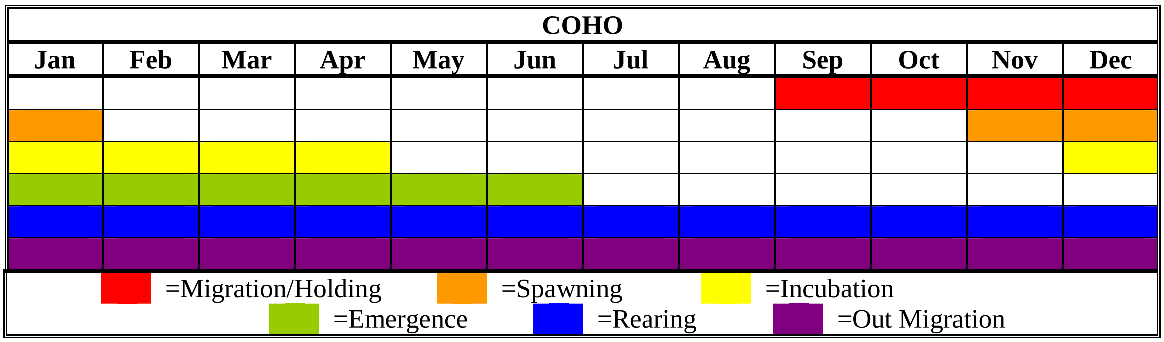

Figure 16: Coho Periodicity in the Mainstem Klamath River
Sources: Hardy 1999, p.34; NRC 2004, p.254, 255, 258, & 259; Rushton 2005; Shaw et al. 1998; USFWS 1979, p.27, USFWS 1999, p.23; USFWS 2001, p. 60, 63, 66, & 69.

REFERENCES

Behnke, R.J. 1992. Native Trout of Western North America. Bethesda, MA. American Fisheries Society Monograph 6.

Belchik, M. 1997. Summer Locations and Salmonid Use of Cool Water Areas in the Klamath River. Iron Gate Dam to Seiad Creek, 1996. Yurok Tribal Fisheries Program. Klamath, CA. 13pp.

Brown, L.R. and P.B. Moyle. 1991. Status of Coho Salmon in California: Report to the National Marine Fisheries Service. Department of Wildlife and Fisheries Biology, University of California, Davis. 98pp.

Brown, L.R., P.B. Moyle, and R.M. Yoshiyama. 1994. Historical Decline and Current Status of Coho Salmon in California. North American Journal of Fisheries Management. 14(2):237-261.

Brucker, P. 2006. Personal communication with Petey Brucker of the Salmon River Restoration Council via e-mail to Katharine Carter (Regional Water Board Staff) on July 14, 2006. Copy was printed for the files.

California Department of Fish and Game (CDFG). 1965. California Fish and Wildlife Plan. Volume III, Supporting Data. Part B-Inventory Salmon-Steelhead & Marine Resources. 356pp.

California Department of Fish and Game (CDFG). 2002. Status Review of California Coho Salmon North of San Francisco. Report to the California Fish and Game Commission. The Resources Agency. Sacramento, CA. 232pp +appendices.

California Department of Fish and Game (CDFG). 2004. September 2002 Klamath River Fish-Kill: Final Analysis of Contributing Factors and Impacts. Northern California-North Coast Region. 173pp.

California Department of Fish and Game (CDFG). 2006a. Klamath River Basin Spring Chinook Salmon Spawner Escapement, River Harvest and Run-size Estimates. Megatable. 9pp.

California Department of Fish and Game (CDFG). 2006b. State and Federally listed Endangered and Threatened Animals of California. California Department of Fish and Game, Habitat Conservation Division, Wildlife and Habitat Data Analysis Branch, California Natural Biodiversity Database. The Resources Agency. January 2006. 11pp.

California Department of Fish and Game (CDFG). 2008. Klamath River Basin Fall Chinook Salmon Spawner Escapement, In-river Harvest and Run-size Estimates. 12pp.

Corum, A. 2006. Personal communication with Alex Corum of the Karuk Tribe Department of Natural Resources via e-mail to Katharine Carter (Regional Water Board Staff) on June 26, 2006. Copy was printed for the files.

Cyr, L. 2006. Personal communication with LeRoy Cyr of the United States Forest Service, Orleans Ranger District, Six Rivers National Forest via e-mail to Katharine Carter (Regional Water Board Staff) on July 10, 2006. Copy was printed for the files.

Federal Register. 2006. Fisheries off West Coast States; West Coast Salmon Fisheries; 2006 Management Measures and a Temporary Rule. National Oceanic and Atmospheric Administration, Department of Commerce. Thursday, May 4, 2006. Volume 71, No. 86, pages 26254-26266.

FISHPRO. 2000. Fish Passage Conditions on the Upper Klamath River. July 2000. Port Orchard, WA.

Franklin, R. 2006. Personal communication with Robert Franklin, Senior Hydrologist of the Hoopa Valley Tribal Fisheries Department via e-mail to Katharine Carter (Regional Water Board Staff) on June 15, 2006. Copy was printed for the files.

Hamilton, J.B., G.L. Curtis, S.M. Snedaker, and D.K. White. 2005. Distribution of Anadromous Fishes in the Upper Klamath River Watershed Prior to Hydropower Dams-A Synthesis of Historical Evidence. Fisheries 30(4):10-20.

Hampton, M. 2004. Shasta River Fish Counting Facility, Chinook and Coho Salmon Observations in 2003, Siskiyou County, CA. California Department of Fish and Game. Yreka, CA. 19 pp.

Hampton, M. 2005a. Shasta River Fish Counting Facility, Chinook and Coho Salmon Observations in 2004, Siskiyou County, CA. California Department of Fish and Game. Yreka, CA. 19 pp.

Hampton, M. 2005b. Chinook and coho salmon update for Shasta River and Bogus Creek. E-mail and attachments from Mark Hampton of the California Department of Fish and Game on December 9, 2005, 12:29PM. Forwarded to Matt St. John of Regional Water Board Staff by David Webb January 9, 2006, 2:41PM. Copy was printed for the files

Hardy, T.B. 1999. Evaluation of Interim Instream Flow Needs in the Klamath River, Phase I, Final Report. Report prepared for USDI. Institute for Natural Systems Engineering. Utah Water Research Laboratory. Utah State University. Logan UT. August. 55pp.+appendices.

Hardy, T.B. and R.C. Addley. 2006. Evaluation of Interim Instream Flow Needs in the Klamath River, Phase II, Final Report. Report prepared for USDI. Institute for Natural Systems Engineering. Utah Water Research Laboratory. Utah State University. Logan UT. July 31, 2006. 304pp.

Hopelain, J.S. 1998. Age, Growth, and Life History of Klamath River Basin Steelhead Trout (*Oncorhynchus mykiss irideus*) as Determined from Scale Analysis. California Department of Fish and Game. Inland Fisheries Division Administrative Report No. 98-3. 23pp.

Klamath Resource Information System (KRIS). 2006. KRIS Klamath Chart Table Page, Shasta Racks data 1930-2002. Available at: <http://www.krisweb.com/>. Website accessed January 18, 2006.

Klamath River Basin Fisheries Task Force (KRBFTF). 1991. Long Range Plan for The Klamath River Basin Conservation Area Fishery Restoration Program. Assistance from William M. Kier Associates. 403pp.

Leidy, R.A. and G.R. Leidy. 1984. Life Stage Periodicities of Anadromous Salmonids in the Klamath River Basin, Northwestern California. US Fish and Wildlife Service, Sacramento, CA. 21pp. +appendix.

Marshall, L.E. 2005. Annual Report: Trinity River Salmon and Steelhead Hatchery, 2004-2005. Department of Fish and Game. Fisheries Programs Branch. Northern California, North Coast Region. 10pp.

Moffett, J.W. and S.E. Smith. 1950. Biological Investigations of the Fishery Resources of Trinity River, Calif. Special Scientific Report: Fisheries No. 12. United States Fish and Wildlife Service. Washington, D.C. 69pp.

Moyle P.B., R.M. Yoshiyama, J.E. Williams, and E.D. Wikramanayake. 1995. Fish Species of Special Concern In California. Department of Wildlife and Fisheries Biology, U.C. Davis. Davis, CA. 272pp.

Moyle, P.B. 2002. Inland Fishes of California, 2nd Ed. Berkeley and Los Angeles, CA. University of California Press.

National Research Council of the National Academies (NRC). 2004. Endangered and Threatened Fishes in the Klamath River Basin. Washington, D.C. National Academies Press.

North Coast Regional Water Quality Control Board (Regional Water Board). 2006. Staff Report for the Action Plan for the Shasta River Watershed Temperature and Dissolved Oxygen Total Maximum Daily Loads. May 3,2006. 259pp.+appendices.

Oregon Natural Heritage Information Center (ONHIC). 2004. Rare, Threatened, and Endangered Species in Oregon. Oregon Natural Heritage Information Center, Oregon State University. Portland, OR. May 2004. 105pp.

PacifiCorp. 2004. Final Technical Report: Fish Resources. Klamath Hydroelectric Project (FERC Project No. 2082). Fish Resources. PacifiCorp, Portland, OR. February 2004. 180 pp.

Rushton, K.W. 2005. Annual Report: Iron Gate Hatchery, 2004-2005. Department of Fish and Game. Inland Fisheries. Northern California, North Coast Region. 19pp.

Salmon River Restoration Council (SRRC) and Karuk Tribe Department of Natural Resources (KTDNR). 2006. Personal Communication with Petey Brucker of the SRRC via e-mail to Katharine Carter (Regional Water Board Staff) on April 14, 2006, 3:00PM. Copy was printed for the files.

Scott River Watershed Council (SRWC). 2004. Initial phase of the Scott River Watershed Council Strategic Action Plan.

Shaw, T.A., C. Jackson, D. Nehler, and M. Marshall. 1998. Klamath River (Iron Gate Dam to Seiad Creek) Life Stage Periodicities for Chinook, Coho, and Steelhead. USDI-Fish and Wildlife Service, Coastal Calif. Fish and Wildlife office, Arcata, CA. 43 pp. + appendices.

Snyder, J.O. 1931. Salmon of the Klamath River, California. Calif. Dept. of Fish and Game, Vol. 10, No. 4. 121 pp.

Spring Salmon Summit. 2005. Spring Salmon Summit Minutes/Notes of the Discussion. Petey Brucker ed. 26pp.

Trihey and Associates, Inc. (Trihey and Assoc.). 1996. Instream Flow Requirements for Tribal Trust Species in the Klamath River. Prepared on behalf of the Yurok Tribe. Concord, CA. 42pp.

United States Fish and Wildlife Service (USFWS). 1979. Final Report, Hoopa Valley Indian Reservation, Inventory of Reservation Waters Fish Rearing Feasibility Study and a Review of the History and Status of Anadromous Fishery Resources of the Klamath River Basin. March 15, 1979. Arcata, CA. 134pp.

United States Fish and Wildlife Service (USFWS). 1999. Juvenile Salmonid Monitoring on the Mainstem Klamath River at Big Bar and Mainstem Trinity River at Willow Creek 1996. Klamath River Fisheries Assessment Program. Arcata, CA.

United States Fish and Wildlife Service (USFWS). 2001. Juvenile Salmonid Monitoring on the Mainstem Klamath River at Big Bar and Mainstem Trinity River at Willow

Creek 1997-2000. Klamath River Fisheries Assessment Program. Arcata, CA. 106pp.

United States Fish and Wildlife Service (USFWS). 2003a. Klamath River Fish Die-off, September 2002, Causative Factors of Mortality. Arcata Fish and Wildlife office. Arcata, CA. Report Number AFWO-F-02-03. 115pp.

United States Fish and Wildlife Service (USFWS). 2003b. Klamath River Fish Die-off, September 2002, Report on Estimate of Mortality. Arcata Fish and Wildlife office. Arcata, CA. Report Number AFWO- 01-03. 28pp.

United States Forest Service (USFS). 1996. Fish Theme Name: “Fish Species Range” (knf_fish). Survey data courtesy of USDA Forest Service, Klamath National Forest, KNF Supervisor’s Office. Yreka, CA. Data downloaded on August 24, 2005.

United States Forest Service (USFS). 2006. Review comments, Klamath TMDL Report-Fish Population Distribution Map. Letter Dated July 7, 2006. Klamath National Forest. 2pp.

West, J.R. 1991. A Proposed Strategy to Recover Endemic Spring-Run Chinook Salmon Populations and Their Habitats in the Klamath River Basin. USDA-Forest Service. Klamath National Forest. 26pp.

APPENDIX 6

Model Configuration and Results

Klamath River Model for TMDL Development

Fourth Revision: December 2009
Third Revision: June 2009
Second Revision: September 2008
First Revision: September 2007
Original: September 2005

Prepared for:
U.S. Environmental Protection Agency Region 9
U.S. Environmental Protection Agency Region 10
North Coast Regional Water Quality Control Board
Oregon Department of Environmental Quality

Prepared by:
Tetra Tech, Inc.

Contents

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Steve Kirk	Oregon Department of Environmental Quality
David Leland	North Coast Regional Water Quality Control Board
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1.0 INTRODUCTION

The Klamath River watershed traverses the states of Oregon and California, encompassing an area of approximately 15,722 square miles. The headwaters of the Klamath River originate in the Cascade Mountains and the river flows to the southwest from Oregon into northern California toward its confluence with the Pacific Ocean (Figure 1-1). Major tributaries to the Klamath River include the Lost River Diversion Channel and the Shasta, Scott, Salmon, and Trinity Rivers.

The watershed includes portions of Jackson, Josephine, Klamath, and Lake Counties in Oregon, and Del Norte, Humboldt, Modoc, Siskiyou, and Trinity Counties in California. Nearly 63 percent of the watershed (approximately 9,933 square miles) lies in California, while 37 percent (5,727 square miles) is in Oregon. The Klamath River watershed includes twelve U.S. Geological Survey (USGS) 8-digit hydrologic cataloging units, numbers 18010201 through 18010212.

The Oregon Department of Environmental Quality (ODEQ) and California's North Coast Regional Water Quality Control Board (NCRWQCB) have both included the Klamath River on their corresponding Clean Water Act section 303(d) lists as a result of observed water quality criteria exceedances. Impairments include dissolved oxygen (DO), chlorophyll *a*, temperature, pH, and ammonia for various portions of the Klamath River and its tributaries in Oregon and nutrients, temperature, and organic enrichment/low DO for segments of the river and its tributaries in California.

The states are required to develop total maximum daily loads (TMDLs) for applicable water quality parameters. The TMDL process identifies the maximum load of a pollutant a waterbody is able to assimilate and still fully support its designated uses. The TMDL process also allocates portions of the allowable load to all sources, identifies the necessary controls that may be implemented voluntarily or through regulatory means, and describes a monitoring plan and associated corrective feedback loop to ensure that uses are fully supported. Watershed and water quality modeling is often used during the development of TMDLs to help with one or more of these tasks. Modeling is a quantitative approach to better understand complex environmental processes and relationships. Models can be used to help fill in gaps in observed water quality data, estimate existing pollutant sources throughout a watershed, calculate allowable loads, and assess the potential effectiveness of various control options.

The first steps in the TMDL development process were previously conducted, including compiling available data; evaluating monitoring data to identify the extent, location, and timing of water quality impairments; and developing a technical approach to analyze the relationship between source pollutant loading contributions and in-stream response. These steps were detailed in *Data Review and Modeling Approach—Klamath and Lost Rivers TMDL Development* (Tetra Tech, Inc. 2004). Subsequent steps include model configuration, model testing (calibration), and scenario analysis. This document discusses the configuration of the Klamath River model and presents modeling results for the Klamath River from Upper Klamath Lake (UKL) to the river's outlet at the Pacific Ocean for the river and reservoir segments (2000 and 2002) and estuarine segment (2004).

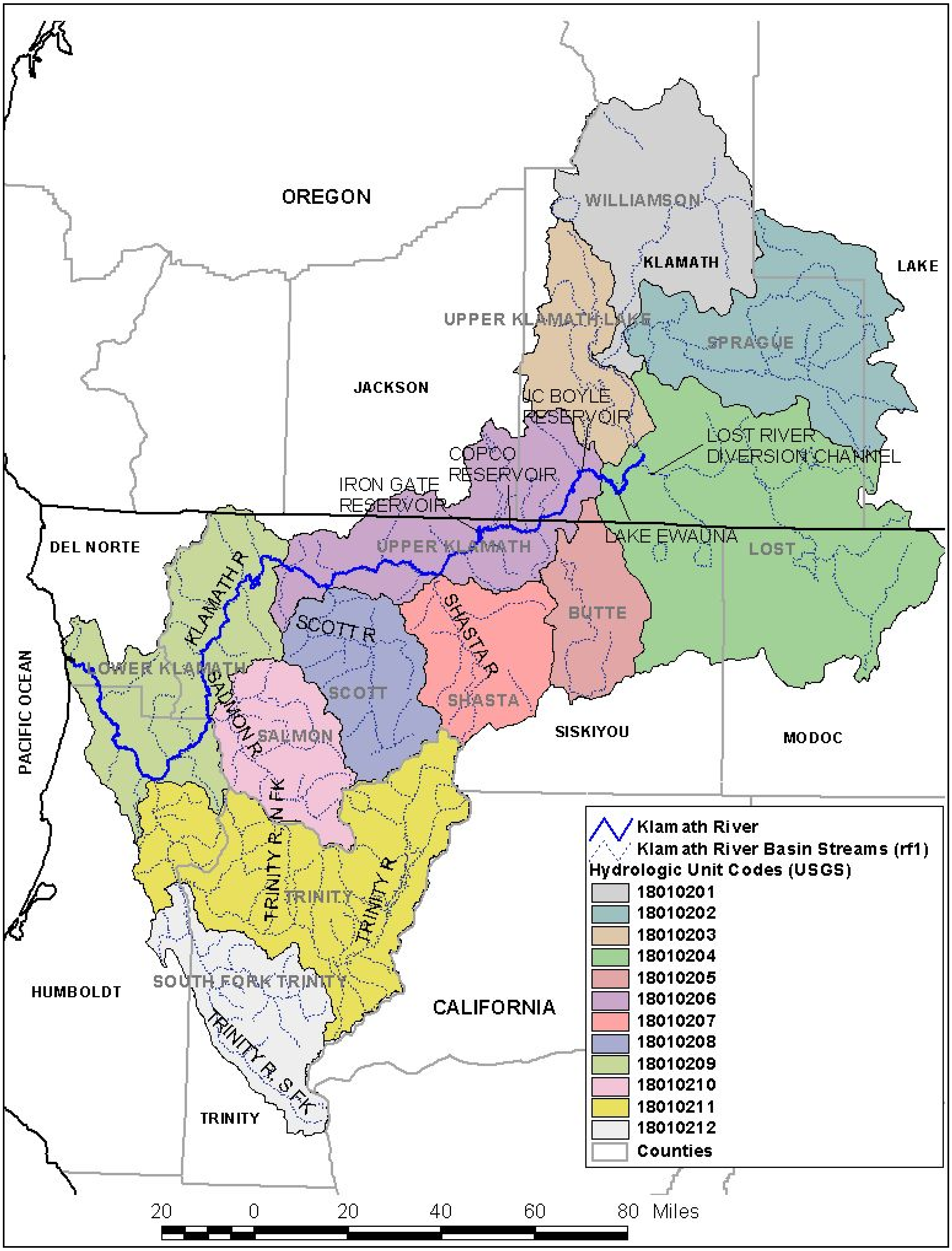

Figure 1-1. Extent of the Klamath River watershed

2.0 MODELING APPROACH

2.1 Model Selection

To support TMDL development for the Klamath River system, the need for an integrated receiving water hydrodynamic and water quality modeling system was identified. The following model capabilities were identified as being necessary to support TMDL development. The model must be

- Capable of predicting hydrodynamics, nutrient cycles, DO, temperature, pH, and other parameters and processes pertinent to the TMDL development effort;
- Capable of simulating the multiple flow control structures along the length of the Klamath River;
- Dynamic (time-variable) and thus capable of representing the highly variable flow and water quality conditions within years and between years;
- Capable of considering the steep channel slope of the Klamath River; and
- Capable of representing conditions in the Klamath Estuary.

A model for the Klamath River had already been developed by PacifiCorp to support studies for the Federal Energy Regulatory Commission Hydropower relicensing process (Watercourse Engineering, Inc. 2004) when this project began. The version of the model available in 2004 is hereafter referred to as the *PacifiCorp Model*. The PacifiCorp Model and other models, including the operational models MODSIM and CALSIM, were evaluated for applicability to Klamath River TMDL development (Tetra Tech, Inc. 2004). NCRWQCB, ODEQ, and the U.S. Environmental Protection Agency (EPA) determined that the existing PacifiCorp Model would provide the optimal basis, after making some enhancements, for TMDL model development. Section 2.2 provides a description of the enhancements made to the PacifiCorp Model. It should be noted that PacifiCorp has since updated the model after receiving comments from reviewers (PacifiCorp 2005).

The original PacifiCorp Model consisted of Resource Management Associates (RMA) RMA-2 and RMA-11 models and the CE-QUAL-W2 model. Specifically, the RMA-2 and RMA-11 models were applied for Link River (which is the stretch of the Klamath River from UKL to Keno Dam), Keno Dam to J.C. Boyle Reservoir, Bypass/Peaking Reach (hereafter referred to as the Bypass/Full Flow Reach), and Iron Gate Dam to Turwar. RMA-2 simulates hydrodynamics, while RMA-11 represents water quality processes. The CE-QUAL-W2 model was applied for Lake Ewauna-Keno Dam, J.C. Boyle Reservoir, Copco Reservoir, and Iron Gate Reservoir. In addition to addressing the model needs identified above, the PacifiCorp Model

- Uses hydrodynamic and water quality models with a proven track record in the environmental arena, including historical application to the Klamath River;
- Has already been reviewed by most stakeholders in the watershed;
- Can be directly compared to ODEQ, NCRWQCB and tribal water quality criteria;
- Has been preliminarily calibrated for the Klamath River and its applicability demonstrated; and
- Uses the public domain model CE-QUAL-W2 and a version of RMA that can be distributed to the public for purposes of TMDL application.

Because the estuarine portion of the Klamath River (Turwar to the Pacific Ocean) was not included in the original PacifiCorp Model, it was necessary to identify a model appropriate for modeling that portion of the river. After reviewing a 2004 bathymetric survey and grab, multiprobe, and cross-sectional profile data, it was determined that a laterally averaged 2-D model, such as CE-QUAL-W2, was not the ideal choice for modeling the estuarine portion of the Klamath River.

Hydrodynamics and water quality within the estuary are highly variable spatially and throughout the year and are greatly influenced by time of year, river flow, tidal cycle, and location of the estuary mouth (which changes because of sand bar movement). Additionally, transect temperature and salinity data in the lower estuary showed significant lateral variability, as did DO to a lesser extent. The Environmental Fluid Dynamics Code (EFDC), which is a full 3-D hydrodynamic and water quality model, was selected to model the complex estuarine environment instead.

EFDC is an EPA-endorsed and widely applied 3-D model (particularly for TMDL development). EFDC allows for representing the complex geometry of the Klamath Estuary with a boundary-fitted, curvilinear grid. The model is capable of simulating important physical processes and features, such as the circulation pattern near the funnel-shaped mouth and islands. The mouth of the estuary is very wide; however, it does not open to the Pacific Ocean completely because of the presence of a sand bar. As a result, the estuary can communicate with the ocean only through a very narrow opening in the sand bar. Configuring a CE-QUAL-W2 grid for this portion of the system would likely result in a very wide segment at the downstream end of the river. The wide segment would be linked to a very narrow segment representing the opening in the sand bar. This configuration runs the risk of resulting in computational error because of the sudden change in segment width at the most dynamic portion of the system (Cole and Wells, 2003). Although it is impossible to simulate the evolution of the existing sand bar at the estuary mouth with available technology, EFDC can potentially be used to efficiently evaluate the implications of mouth locations on hydrodynamics and water quality.

Hydrodynamics and water quality in the estuary are also highly variable throughout the year and are greatly influenced by time of year, river flow, tidal cycle, and location of the mouth. Hydrodynamic data also show significant lateral variability, as does DO to a lesser extent. It is desirable to apply a model that has the potential to represent this variability and EFDC is capable.

Additional factors leading to the choice of EFDC for modeling the estuary include the following:

- EFDC is capable of predicting hydrodynamics, nutrient cycles, DO, temperature, and other parameters and processes pertinent to the TMDL development effort for the estuarine section.
- The EFDC model is dynamic (time-variable) and thus capable of representing the highly variable flow and water quality conditions within years and between years.
- EFDC has a proven track record in the environmental arena—particularly with regard to TMDLs.
- Model results can be directly compared to ODEQ, NCRWQCB and tribal water quality criteria.
- EFDC is EPA-endorsed and supported and is included in the EPA TMDL Modeling Toolbox. It is a public domain model, fully transparent (i.e., model code), and is available free of charge. EPA also provides training and support on the application free of charge.

- EFDC has a function for blocking flows between computational cells, and this allows for efficiently evaluating the effect of the location and size of the sand bar opening, with a single grid configuration.
- The EFDC water quality module possesses a fully numerical sediment diagenesis module to predict sediment oxygen demand (SOD) and benthic nutrient flux based on organic loading to the waterbody. This improves the reliability of the model for DO and nutrient TMDLs. Although this component was not used in this study because of time and data limitations, it can be implemented in the future using the existing framework when sufficient data become available.

The combination of the enhanced PacifiCorp Model (RMA and CE-QUAL-W2) and EFDC resulted in the Klamath River model used for TMDL development. Table 2-1 identifies the modeling elements applied to each river segment.

Table 2-1. Model components applied to each Klamath River segment

Modeling segment	Segment type	Model(s)	Dimensions
Link River	River	RMA-2/RMA-11	1-D
Lake Ewauna-Keno Dam	Reservoir	CE-QUAL-W2	2-D
Keno Dam to J.C. Boyle Reservoir	River	RMA-2/RMA-11	1-D
J.C. Boyle Reservoir	Reservoir	CE-QUAL-W2	2-D
Bypass/Full Flow Reach	River	RMA-2/RMA-11	1-D
Copco Reservoir	Reservoir	CE-QUAL-W2	2-D
Iron Gate Reservoir	Reservoir	CE-QUAL-W2	2-D
Iron Gate Dam to Turwar	River	RMA-2/RMA-11	1-D
Turwar to Pacific Ocean	Estuary	EFDC	3-D

The linkages between the riverine and reservoir/estuary models identified in Table 2-1 were made by transferring time-variable flow and water quality from one model to the next (e.g., output from the Link River model became input for the Lake Ewauna-Keno Dam model). This modeling framework is consistent with available models appropriate for application to riverine/reservoir systems and is based on the PacifiCorp Model's existing modeling approach for the river system.

Each model type included (RMA, CE-QUAL-W2, and EFDC) is discussed in more detail below.

RMA

The hydrodynamic component of the RMA modeling suite, RMA-2, is a model specifically designed to assess flow response in complex river systems (Deas 2000). RMA-2 solves the full-flow equations, known as the St. Venant Equations. These equations use all terms of the conservation of momentum formulation and provide a complete description of dynamic flow conditions. The model has been widely applied (it is one of the most used full hydrodynamic models in the United States) to a variety of river and estuary systems in the United States as well as internationally.

The water quality component, RMA-11, is a general-purpose water quality model, compatible in geometry with the configuration of the RMA-2 hydrodynamic model. The model simulates advective heat transport and air-water heat exchange processes, as well as fate and transport of water quality parameters (e.g., nutrients), to produce dynamic descriptions of temperature and constituent concentration along the river reach. Input requirements include temperatures and quality of boundary flows, and meteorological data defining atmospheric conditions governing heat exchange at the air-water interface. Model output is in the form of longitudinal profiles of temperature and water quality parameters along river reaches, or time series at fixed locations.

CE-QUAL-W2

The U.S. Army Corps of Engineers' CE-QUAL-W2 is a 2-D, longitudinal/vertical (laterally averaged), hydrodynamic and water quality model (Cole and Wells, 2003). The model allows for application to streams, reservoirs, and estuaries with variable grid spacing, time-variable boundary conditions, and multiple inflows and outflows from point/nonpoint sources and precipitation.

The two major components of the model include hydrodynamics and water quality kinetics, which simulate changes in constituent concentrations. Both of these components are coupled (i.e., the hydrodynamic output is used to drive the water quality at every timestep). The hydrodynamic portion of the model predicts water surface elevations, velocities, and temperature. The ULTIMATE-QUICKEST numerical scheme used in the CE-QUAL-W2 model is designed to reduce the numerical diffusion in the vertical direction to a minimum and in areas of high gradients, reduce the undershoots and overshoots that could produce small negative concentrations. The water quality kinetics portion can simulate 21 water quality parameters including DO, nutrients, phytoplankton interactions, and pH.

EFDC

EFDC is a general purpose modeling package for simulating 1-D, 2-D, and 3-D flow, transport, and biogeochemical processes in surface water systems including rivers, lakes, estuaries, reservoirs, wetlands, and coastal regions. The EFDC model was originally developed at the Virginia Institute of Marine Science for estuarine and coastal applications. This model is now being supported by EPA and has been used extensively to support TMDL development throughout the country. In addition to hydrodynamic, salinity, and temperature transport simulation capabilities, EFDC is capable of simulating cohesive and non-cohesive sediment transport, near-field and far-field discharge dilution from multiple sources, eutrophication processes, the transport and fate of toxic contaminants in the water and sediment phases, and the transport and fate of various life stages of finfish and shellfish. Cohesive sediment refers to silt and clay particles while non-cohesive refers to anything larger than silt (e.g., sand, gravel). The EFDC model has been extensively tested, documented, and applied to environmental studies worldwide by universities, governmental agencies, and environmental consulting firms.

The structure of the EFDC model includes four major modules: (1) a hydrodynamic model, (2) a water quality model, (3) a sediment transport model, and (4) a toxics model. The water quality portion of the model simulates the spatial and temporal distributions of 22 water quality parameters including DO, suspended algae (3 groups), attached algae, various components of carbon, nitrogen, phosphorus and silica cycles, and fecal coliform bacteria. Salinity, water temperature, and total suspended solids are needed for computation of the 22 water quality parameters, and they are simulated by the hydrodynamic model.

EFDC's water quality model also includes a sediment process model, which uses a slightly modified version of the Chesapeake Bay 3-D model (Park et al. 1995). Upon receiving the particulate organic matter (OM) deposited from the overlying water column, it simulates its diagenesis and the resulting fluxes of inorganic substances (ammonium, nitrate, phosphate and silica) and SOD back to the water column. The coupling of the sediment process model with the water quality model not only enhances the model's predictive capability of water quality parameters, but also enables it to simulate the long-term changes in water quality conditions in response to changes in nutrient loads.

2.2 Model Enhancements

Although the original PacifiCorp Model (Watercourse Engineering, Inc. 2004) is capable of addressing the identified water quality issues, a number of enhancements to the model were necessary to expedite and strengthen the model for the rigors of TMDL development for the Klamath River.

Selected algorithms in the PacifiCorp Model were considered for augmentation of the modeling framework to address specific processes and support TMDL development. Enhancements were made in the following areas:

- BOD/OM unification
- Two-state algae transformation algorithm in Lake Ewauna
- Monod-type continuous SOD and OM decay
- pH simulation in RMA
- OM-dependent light extinction simulation in RMA
- Reaeration formulations
- Dynamic OM partitioning
- Periphyton carrying capacity
- Additional shading in RMA
- Second order polynomial spillway representation

2.2.1 BOD/OM Unification

It was determined that biochemical oxygen demand (BOD) should not be modeled in addition to OM because BOD itself is a surrogate for OM. The BOD compartment in the modeling system was eliminated for both the riverine (RMA model component) and reservoir (CE-QUAL-W2 model component) sections. To maintain consistency between the new version of the model and the original version in terms of organic loading, the BOD concentration in the original version was converted to an OM component by using a stoichiometric ratio of BOD:OM = 1.4. This stoichiometric coefficient was derived on the basis of the original RMA-11 model and is also consistent with representation in the CE-QUAL-W2 model. This converted OM was combined with the OM in the original version to form the total OM in the new version. This conversion allowed the model to represent consistent amounts of OM in the original and new versions.

Additionally, in the original CE-QUAL-W2 models for the reservoirs, particulate OM was not included in the tributary boundary condition files. This is expected to result in an underestimation of particulate OM into the system. Therefore, for the major tributaries that are highly productive, such as the Lost River Diversion Channel, particulate OM loading was represented on the basis of data and appropriate assumptions. Concentration boundary condition files were modified using a labile particulate OM (LPOM) to labile dissolved OM (LDOM) ratio of 4.0 (LPOM:LDOM = 0.8:0.2), which is same as for the Link River boundary condition. Labile OM refers to the portion that is decomposed relatively quickly. The state variable slots in the CE-QUAL-W2 models for labile OM (i.e., LDOM and LPOM) were used to represent all dissolved OM and particulate OM, respectively. Therefore, even though the terms “LDOM” and “LPOM” are used when referring to model results, the values essentially represent all OM, without differentiating between labile and refractory components.

2.2.2 Two-state Algae Transformation Algorithm in Lake Ewauna

Very low levels of phytoplankton were observed in lower Lake Ewauna, as shown in the year 2000 monitoring data for the Highway (Hwy) 66 station. Phytoplankton biomass in Lake Ewauna also shows significant variability from upstream (Miller Island water quality station) to downstream (Hwy 66 water quality station). In addition, observed data show that there was a sharp drop in algae concentration at the Miller Island station during the summer. These phenomena were not predicted by the existing PacifiCorp Model, although it is configured to simulate all algae-DO-nutrient interactions represented in the W2 model code.

Simulated algae biomass in the existing PacifiCorp Model is similar at both locations, and algae concentrations remained high throughout the summer period. This is due to the dominant upstream inflow (from UKL) that causes water to flow quickly from upstream to downstream. The inability to accurately predict the temporal and spatial distribution of phytoplankton has significant implications on the water quality dynamics. Therefore, model refinement was needed to better represent the algae dynamics in this lake.

It appears that with the existing kinetic structure in the model, it is not possible to reproduce this type of spatial distribution of algae biomass. During the model testing process, which is described later in this report, the algae growth and mortality parameters were varied significantly in an attempt to reproduce the observed spatial algae pattern in Lake Ewauna. Regardless of the parameter combinations used, the model predicted similar algae magnitudes and patterns at the Miller Island and Hwy 66 stations (due in large part to the rapid transport of algae in Lake Ewauna). It is believed that the summer hypoxia/anoxia in the lake influences the spatial variability of algae biomass in Lake Ewauna. Data show that sometimes during the summer, the entire Lake Ewauna water column becomes hypoxic (exhibiting very low DO concentrations), and even anoxic (exhibiting DO concentrations near zero). Figure 2-1 shows the observed DO data, along with chlorophyll *a*, at the Miller Island and Hwy 66 locations for 2000 (at approximately 1 meter from the surface). Algal mortality has been causally linked with low DO in UKL (National Research Council 2004) and found to be related to anoxic conditions in other systems (Baric et al. 2003). Available data show no other explanation for the observed phenomenon.

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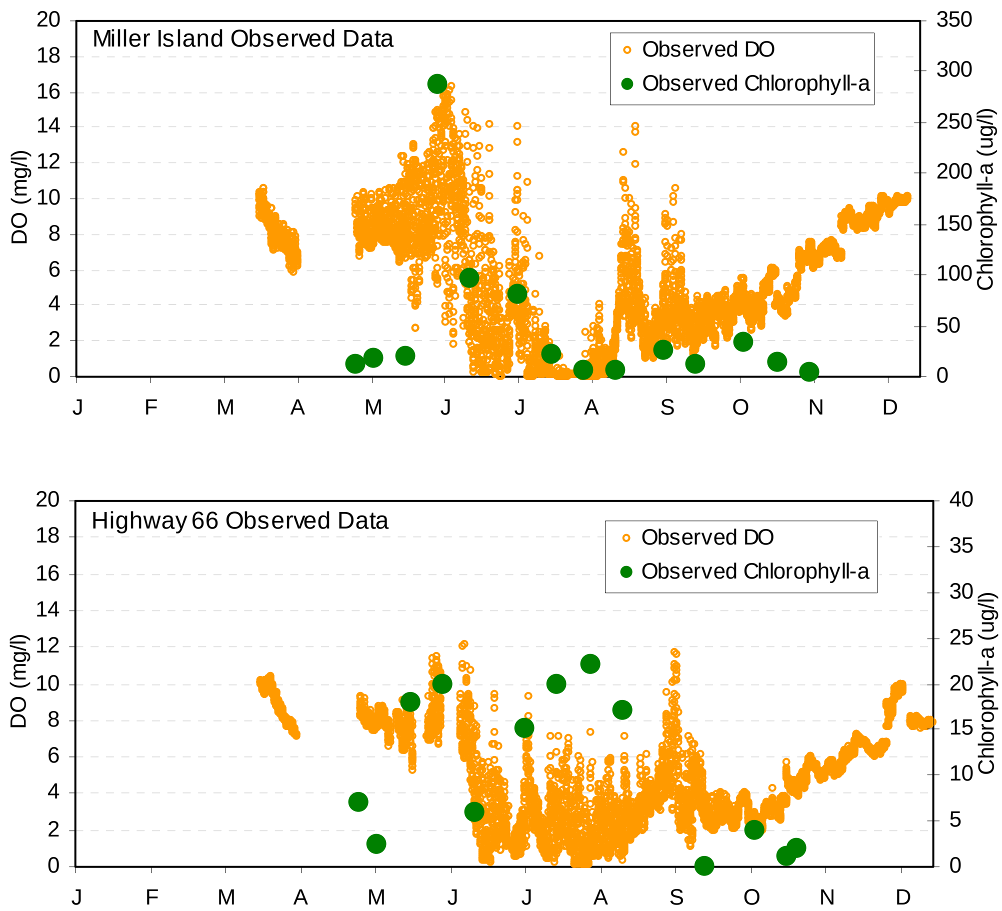

Figure 2-1. Observed DO and Algae at sites in Lake Ewauna (2000)

Algae need oxygen to respire. Thus, when oxygen levels become low or depleted, algae metabolism might be affected. Growth is likely to be slowed down, and death/excretion is likely to increase. In addition to directly affecting algae metabolism, the hypoxia/anoxic condition from top to bottom in the lake can result in excessive concentration of undesirable chemicals such as H2S in the water column, which is highly toxic to phytoplankton. Previous scientific investigations do not indicate whether DO or other undesirable chemicals directly cause the observed pattern, however the impacts of all these factors (since they are manifested under low DO conditions) can be mathematically represented through DO concentration alone. Therefore, DO-dependent algae kinetics representation was deemed the most appropriate approach for representing the phenomenon.

The major assumptions associated with the DO-dependent algae kinetics are the following:

- Low DO concentrations can restrict algae growth and enhance algae death due to either the directly effect on metabolism or indirect effect through chemical toxicity.
- The longer algae are exposed to hypoxia/anoxia or toxic water environment associated with these conditions, the more the algae mortality is enhanced.

Using these assumptions, a model capable of simulating the impact of hypoxic/anoxic conditions on algae dynamics not only needs to represent the dependence of algae on DO concentrations, but it needs to track the duration of exposure of algae to these conditions. For example, a cluster of algae in Link River (before entering hypoxic Lake Ewauna) is free of the effects of low DO concentrations. However, after this cluster enters Lake Ewauna, it is subjected to local hypoxic conditions (while being transported downstream). The effect of the hypoxic/anoxic conditions on the algae becomes more severe with distance downstream because the exposure time to these conditions increases. This exposure time is hereby referred to as *ET*, and it is not the same as the time that the DO is hypoxic/anoxic at a specific location, which is referred to as *THA*.

CE-QUAL-W2, like most numerical hydrodynamic and water quality models, is based on the Eulerian system that does not track the history of travel of particles. Therefore, it is very difficult to directly track the ET of a specific cluster of algae. The PacifiCorp Model was unable to reproduce the sharp algae decline from upstream to downstream in Lake Ewauna, in part because it was unable to consider exposure time. In this study, a two-state algae transformation approach was applied to the model as a surrogate for representing the effect of the ET. The approach involves defining two states of algae, where one state represents the *healthy* group which is free of the hypoxic/anoxic impact and the other state represents the *unhealthy* group (for which the physiological condition is severely disturbed because of hypoxia/anoxia). The healthy group is represented using typical algae growth and respiration rates; however, the unhealthy algae growth and respiration rates are very low or 0.0 (because of the hypoxic/anoxic condition's effect on the algae's physiology).

The ET is indirectly represented through conversion of healthy algae to unhealthy algae using a first-order transformation mechanism when the algae are in the presence of low-DO conditions. The longer the algae are exposed to hypoxia/anoxia, the higher the fraction of algae transformed into the unhealthy state becomes. Thus, the overall growth and respiration rate of the entire algae cluster is reduced because of the larger amount of unhealthy algae. In the following equations, *A* denotes the healthy group and *B* denotes the unhealthy group:

$$\frac{dC_A}{dt} = L_A - K_1 C_A + K_2 C_B \qquad (1)$$

$$\frac{dC_B}{dt} = L_B + K_1 C_A - K_2 C_B \qquad (2)$$

where

C_A = concentration of algae group A
C_B = concentration of algae group B
L_A = total sources and sinks including kinetics for algae group A as represented in the original model
L_B = total sources and sinks including kinetics for algae group B as represented in the original model
K_1 = transformation rate from algae group A to B
K_2 = recovering rate from algae group B to A

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The effect of low DO on the kinetic parameters K_1 and K_2 is represented as:

$$K_1 = K_{1(0)} \frac{HDO_1}{HDO_1 + DO} \quad (3)$$

$$K_2 = K_{2(0)} \frac{DO}{HDO_2 + DO} \quad (4)$$

where

$K_{1(0)}$ = the base transformation rate from algae group A to B
$K_{2(0)}$ = the base recovering rate from algae group B to A
DO = the DO concentration in the water column
HDO_1 = the half saturation coefficient in mg oxygen /L for K_1
HDO_2 = the half saturation coefficient in mg oxygen/L for K_2

The mechanisms described in Equations (1) through (4) were incorporated into the CE-QUAL-CE-QUAL-W2 source code. The model was then run for Lake Ewauna, and the results indicated that the model was capable of explaining the observed algae patterns reasonably well. It should be noted that the assumptions, mathematical formulations, and code development for algae kinetics are based on general scientific knowledge of algae metabolism. It is recommended that further research be conducted to investigate the impact and response relationships among DO, water chemistry changes, and algae metabolism to better understand this complex phenomenon.

2.2.3 Monod-Type SOD and OM Decay

The PacifiCorp Model used the CE-QUAL-W2 code, which represents SOD and OM decay as a delta function. With the delta function, the SOD and OM decay are activated when DO is greater than a pre-specified value (generally close to zero), and deactivated when DO is lower than the value. This leads to abruptly turning SOD and OM decay on and off when DO is low or fluctuates around the pre-specified value. A Monod-type continuous SOD and OM decay formulation was thus incorporated into the CE-QUAL-W2 code to represent a smoother transition of SOD and OM decay effects when DO is low.

$$SOD = \frac{DO}{DO + HDO} SOD_s$$

$$Kd = \frac{DO}{DO + HDM} Kd_s$$

where

SOD = effective SOD (g O_2/m^2/day)
DO = DO concentration in the water column for Kd, or in the bottom water for SOD (milligrams per liter [mg/L])
HDO = half saturation DO concentration (mg/L)
SOD_s = SOD before being adjusted by the water column DO (g O_2/m^2/day)

Kd = effective OM decay rate (1/day)
HDM = half saturation DO concentration for OM decay rate adjustment (mg/L)
Kd_s = OM decay rate before DO adjustment (1/day)

2.2.4 pH Simulation Module in RMA

The standard RMA modeling framework does not have the capability of simulating interactions among nutrients, phytoplankton/benthic algae, and pH. Because pH is a key water quality target for Klamath TMDL development, the modeling framework was enhanced to dynamically simulate pH dynamics.

A pH simulation module was developed and incorporated into the RMA framework to simulate the pH in the river, considering the impact of boundary conditions, phytoplankton, periphyton, benthic sources, and atmospheric-water exchange. The state variables for the pH module include Total Inorganic Carbon (TIC) and Alkalinity (Alk). Their transport is simulated using the same algorithms used for transporting other dissolved constituents in RMA. While Alk is assumed to be conservative in the water column, TIC changes due to several physical (water-air interface exchange), chemical (OM decay and benthic sources), and biological (phytoplankton and benthic algae metabolism) factors. The mathematical equations for the pH module are based on those described in Chapter 39 of Chapra (1997), and are detailed in Appendix A.

2.2.5 OM-dependent Light Extinction Formulation in RMA

The existing RMA model does not have the capability of representing the effect of OM on light conditions. Thus, it can inaccurately predict periphyton or phytoplankton growth in the presence of OM. OM can reduce sunlight and limit aquatic vegetation growth. An OM-dependent light extinction formulation was developed using the same formulation in the CE-QUAL-W2 model and incorporated into the RMA code to provide a more realistic representation of the system:

$$Ke = Ke' + OM \times KEOM$$

where

Ke = effective light extinction coefficient
Ke' = light extinction coefficient before OM adjustment
OM = OM concentration
KEOM = light extinction coefficient adjustment factor related to OM concentration

2.2.6 Reaeration Formulation Modification

In the existing RMA-11 model, the flow velocity used for reaeration calculation was forced to be greater than or equal to 0.5 meters per second (m/s). This resulted in excessive reaeration when the flow velocity was actually slower (e.g., during low-flow conditions). A modification was made to this formulation to set the lower bound of the velocity to 0.03 m/s based on Chapra (1997). This modification results in more reasonable DO predictions under low flow, critical conditions.

A scaling factor was also introduced into the RMA-11 model to enhance reaeration just downstream of Iron Gate Dam. At this location, the observed summer DO concentration is much higher than what can be predicted by RMA-11 using the available empirical formulas. In the model, the DO concentration of water exiting Iron Gate Reservoir during the summer is low due to vertical stratification in the reservoir (and thus low DO concentrations at depths from which water is drawn). Significant reaeration is necessary over a very short distance to increase the low DO concentrations to the significantly higher observed concentrations. The RMA-11 formulas, however, are unable to replicate this phenomenon, which is caused by the presence of significant turbulence downstream of Iron Gate Dam. To account for this observed phenomenon, a scaling factor (or multiplier) was introduced into the RMA-11 model. After multiple iterations during model testing, a value of 100.0 was selected. Application of this scaling factor results in a significantly higher coefficient than what is typically used with the RMA-11 formulas, however, it is necessary (and justifiable) to simulate the observed DO concentrations.

2.2.7 Dynamic OM Partitioning

Key updates were made to the original PacifiCorp Model to transfer model results between segments represented using CE-QUAL-W2 and those represented using RMA. Originally, the upstream boundary conditions for a CE-QUAL-W2 reservoir model were based on model results from the upstream riverine RMA model. In RMA all the OM is represented as a lumped parameter, while in W2 they are partitioned into four different components: LPOM, RPOM, LDOM, and RDOM. Therefore, when transferring the RMA OM results to W2, the OM output must be partitioned into the four components for W2. In the existing PacifiCorp Model, a static partitioning ratio of 0.8:0.2 was used to partition the OM into LPOM and LDOM, respectively. This static conversion factor does not account for the change in OM composition that occurs throughout the system. Therefore, a dynamic OM partitioning scheme was implemented that calculates and tracks the time-variable partitioning ratio in the reservoir models and applies the ratios to downstream segments. Using this approach, different ratios are implemented for J.C. Boyle and Copco reservoirs. For J.C. Boyle Reservoir, the OM in the upstream river flow is partitioned in such a way that, on average, LDOM accounts for 62 percent, LPOM 36 percent, RDOM 1 percent, and RPOM 1 percent. For Copco Reservoir, the corresponding values are: 67 percent, 30 percent, 2 percent, and 1 percent. These values demonstrate that the fraction of dissolved OM increases with downstream distance, while the fraction of particulate OM decreases (because of the effect of settling). The percentages noted above are not fixed for all simulations.

2.2.8 Periphyton Carrying Capacity

In the RMA-11 model code used in the PacifiCorp Model, the carrying capacity of periphyton biomass was implemented such that when the simulated periphyton biomass exceeds a prescribed maximum value, the simulated biomass is set to that value. This method of handling the periphyton carrying capacity results in unbalanced nutrient representation in the system. When the simulated biomass exceeds the prescribed maximum value, additional nutrients are not utilized by the periphyton biomass (as they would be should no maximum be set). The PacifiCorp Model predicts that the periphyton biomass remains constant for an extended period of time during the summer. Not only is this unrealistic, but it is equivalent to artificially removing nutrients from the system.

A more reasonable way of reflecting the growth limitation when the simulated periphyton approaches the carrying capacity is to relate the growth rate to the biomass itself. Thus growth is depressed when biomass is high, but it has no impact when biomass is low. The formula is:

$G_e = Gx(1 - C/Cmax)$

where

G_e = effective growth rate of periphyton (day^{-1})
G = growth rate before adjusting for carrying capacity (self-limiting) effects
C = periphyton biomass (g/m^2)
C_{max} = periphyton carrying capacity (g/m^2)

When the periphyton biomass increases, the corresponding effective growth rate decreases. When the biomass reaches the carrying capacity, the effective growth rate becomes 0.0. Since nutrient uptake is coupled with periphyton growth in water quality models, formulating the effect of carrying capacity in this manner guarantees a balanced nutrient budget in the system.

2.2.9 Additional Shading in RMA

Temperature simulated by the PacifiCorp Model for the Bypass/Full Flow Reach downstream of J.C. Boyle Reservoir was significantly higher than the observed data. Therefore, during the model testing process one of the most influential factors, the representation of solar radiation, was explored. RMA-11 uses empirical equations to internally calculate solar radiation for the thermal and bio-chemical simulations. These equations are based on longitude, altitude, sunrise and sunset time, and cloud condition. To evaluate whether or not RMA-11 was appropriately estimating solar radiation in this area, the RMA-11-estimated solar radiation was compared to the solar radiation data used in the Copco Reservoir CE-QUAL-W2 model. It was found that the solar radiation estimated using RMA-11 is approximately 20% higher than that used in the Copco Reservoir CE-QUAL-W2 model. This apparent over-estimation of solar radiation likely caused the overprediction of temperature noted above. To account for this discrepancy and to reduce the solar radiation calculated by RMA-11, additional shading was configured in the model. A value of 20% was selected based on the comparison made. To maintain consistency among all the RMA-11 models used for the Klamath River, this 20% additional shading was applied to all RMA-11 models. No changes were necessary for the CE-QUAL-W2 or EFDC models since solar radiation is handled differently for those models and because temperature predictions were not uniformly over- or under-estimated.

2.2.10 Second Order Polynomial Spillway Representation

To support TMDL development, The Klamath River model will not only be used to represent the current condition, but it will be used to represent conditions prior to the creation of Keno Dam. Based on information provided by the U.S. Bureau of Reclamation (USBR), a version of the CE-QUAL-W2 model for Lake Ewauna-Keno Dam was developed to represent the historical presence of Keno Reef (McGlashan and Dean 1913). The approach taken to represent the reef required modification of the CE-QUAL-W2 model code. Specifically, Keno Reef was represented in the model using a second-order spillway equation derived by USBR from historical data. The formulation of the spillway equation is:

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$$Q=101.265(H-1244.5)^2-15.030(H-1244.5)+12.35$$

where

Q = flow rate over Keno Reef (cms)
H = water surface elevation (m)
1244.5 = the Keno Reef datum (m).

2.3 Model Configuration

Model configuration involved setting up the model computational grid (bathymetry) using available geometric data, designating the model's state variables, setting boundary conditions, and setting initial conditions. This section describes briefly the configuration process and key components of the model in greater detail.

2.3.1 Segmentation/Computational Grid Setup

The computational grid setup defines the process of segmenting the entire Klamath River into smaller computational segments for application of the model. In general, bathymetry is the most critical component in developing the grid for the system.

The Klamath River model includes the entire Klamath River from Link Dam (at the outlet of the UKL) to the Pacific Ocean. The river is impounded by five dams along its length: Keno, J.C. Boyle, Copco, Copco 2, and Iron Gate Dam. For this modeling study, the Klamath River was divided into nine waterbodies (or Model Segments). Figures 2-2 and 2-3 show each of the waterbodies from upstream to downstream. Note that distances for each waterbody are approximate. Appendix B presents an excerpt (verbatim) from *Klamath River Water Quality Model Implementation, Calibration, and Validation* (PacifiCorp 2005) that summarizes geometric information for all waterbodies. Each of these waterbodies was represented using unique geometric and hydrological characteristics in the model and is detailed in subsequent sections.

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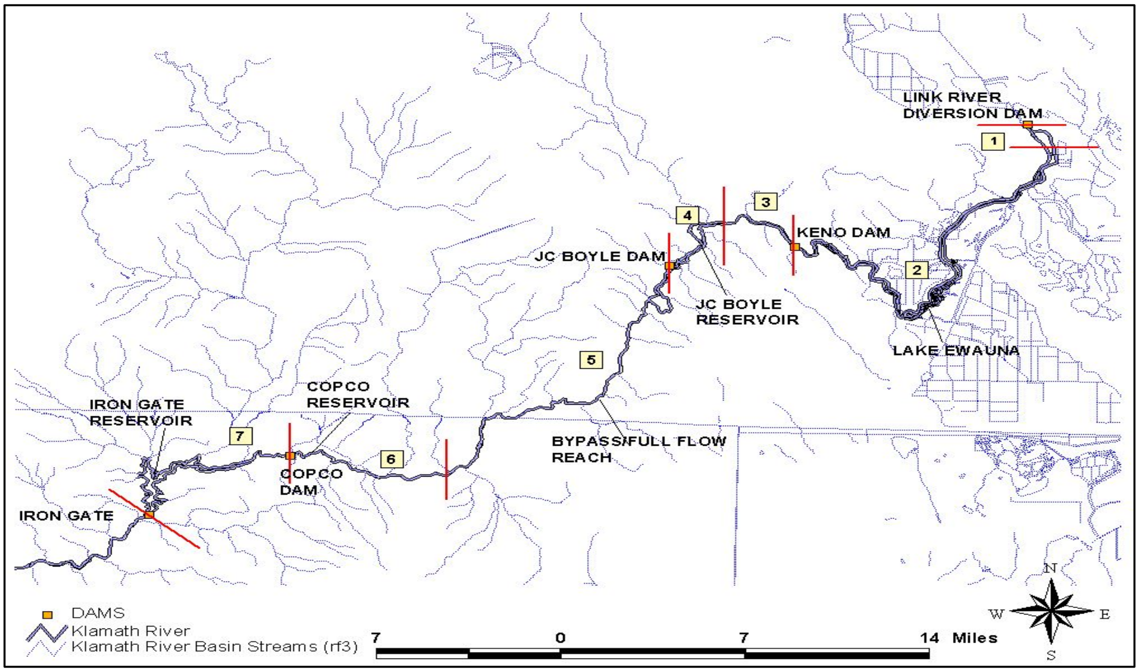


Figure 2-2. Location of waterbodies 1 through 7 along the Klamath River

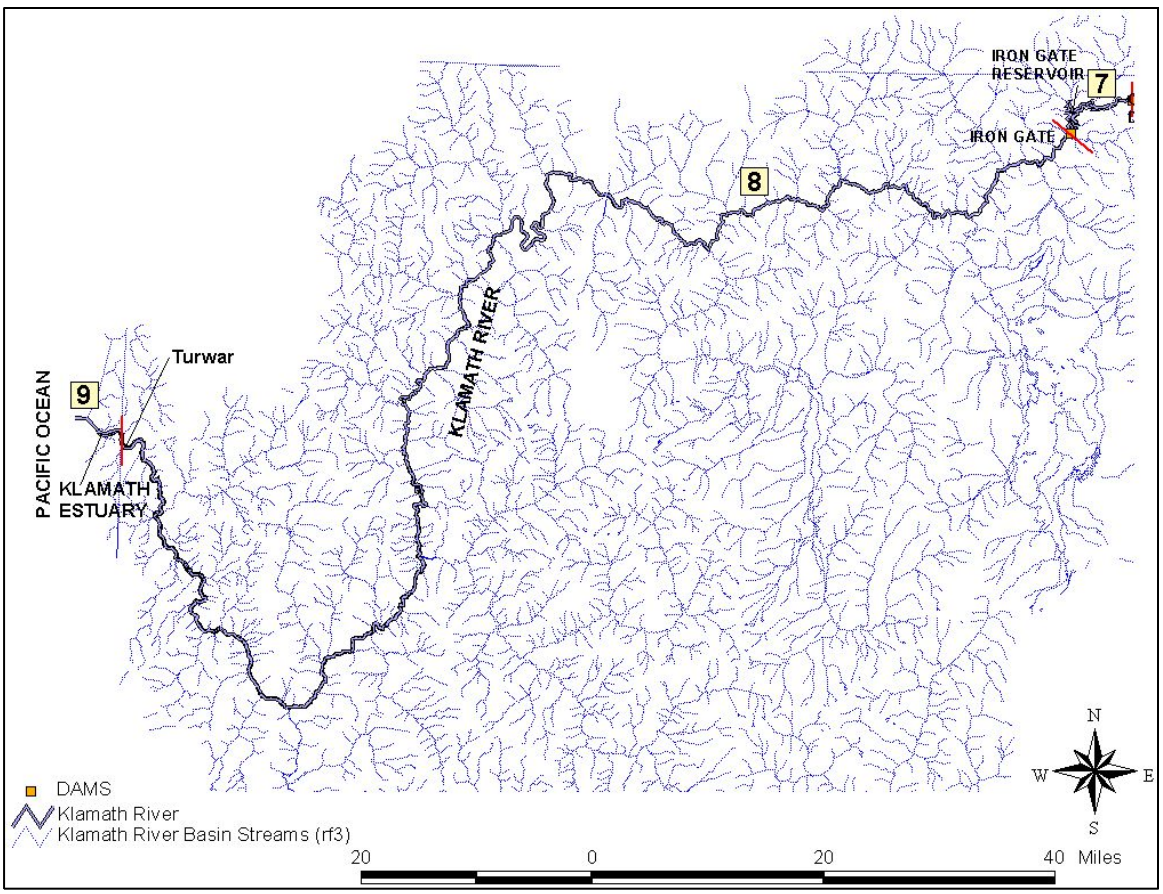


Figure 2-3. Location of waterbodies 7 through 9 along the Klamath River

2.3.1.1 Segmentation of River and Reservoir Segments

Within each of these separate Model Segments (excluding the Klamath Estuary) the primary waterbody (either a Klamath River section or a reservoir) was subdivided into higher resolution elements for greater detail in modeling. The TMDL modeling framework components were segmented similarly to the existing PacifiCorp Model. For the reservoir/lake models in the existing PacifiCorp Model (Lake Ewauna, J.C. Boyle Reservoir, Copco Reservoir, and Iron Gate Reservoir), the corresponding CE-QUAL-W2 models have layer thicknesses (depths) ranging from 0.61 to 1.0 meters and segment lengths ranging from 37 to 714 meters. For the riverine reaches (Link River, Keno reach, Bypass/Full Flow Reach downstream of J.C. Boyle Reservoir, and Klamath River from Iron Gate Dam to Turwar), the corresponding finite element model RMA has node distances ranging from 75 to approximately 300 meters (and are assumed to be homogeneous in the vertical direction). For greater detail on model segmentation in the river and reservoir segments of the Klamath River model, see Section 2.3 of the *PacifiCorp Report.*

Only the mainstem Klamath River and its reservoirs were simulated with the Klamath River model. All tributaries to the river were represented as boundary conditions (i.e., they were not explicitly modeled). More detailed information regarding the specific tributaries to be included or inflows to the model are included in Section 2.3.3 of this report.

2.3.1.2 Segmentation of the Klamath Estuary Segment

The tidal portion of the Klamath River from Turwar to the Pacific Ocean, which was not included in the existing PacifiCorp Model, was modeled using EFDC. The first step to configure EFDC was to discretize the waterbody into a computational grid. A boundary-fit curvilinear grid was developed to accurately represent the shape of the river. Significant hydraulic features (channels, shorelines, and major bathymetric variability) and their locations were considered in preparation of the grid. The grid consists of 138 curvilinear grid cells, with widths ranging from 99 to 209 meters and lengths from 192 to 1590 meters. Within the modeling domain, each cell is represented by four vertical layer(s), therefore a 3-D spatial representation represents the estuary portion.

The open boundary at the downstream end of the estuary was extended into the Pacific Ocean to reduce the effect of boundary reflection. This would likely occur if the open boundary was set directly at the opening of the sand bar. Appendix C presents the computational grid for the Klamath Estuary EFDC model. The bold red line in Appendix C represents the impermeable barriers added to the EFDC grid. The barriers allow for the water to flow through the outlet, as seen in the 2004 bathymetry data. These barriers may be reconfigured in the future, if needed, to simulate the sandbar opening at a different location. It should be noted that this grid was developed and refined through an iterative process wherein model resolution, accuracy, and simulation time were optimized. The number of layers was determined by configuring a model with eight vertical layers in addition to the version with four vertical layers and comparing predictions. The comparison indicated that refining the vertical resolution beyond four vertical layers would not lead to significantly improved model predictions with regard to vertical variability in salinity and water quality. The four layer representation reduced computational time without compromising model accuracy.

Bathymetry data for the Klamath Estuary were obtained from the NCRWQCB and represent bathymetric conditions in the year 2004. These data contain xyz format coordinate elevation data relative to North American Datum of 1988 (NAVD88) and were directly incorporated into the grid generation process. Bathymetry data were available from the outlet of the Klamath at the

Pacific Ocean upstream to the Rt. 101 Bridge (Hwy 101 @ Klamath). No bathymetry data were available from the Rt. 101 Bridge upstream to the USGS Klamath River near Klamath station (USGS 11530500) (a distance of approximately 3,300 meters). To address this data gap, a constant bed slope similar to the upstream portion of the bathymetry data (where the bathymetry was measured) was assumed. This slope was refined until tidal impacts were properly represented (i.e., no tidal effect was observed at Turwar).

River bank boundaries for the grid were defined using digital orthophotography obtained from the California Spatial Information Library (CaSIL) (http://gis.ca.gov/). Orthophotography was used instead of USGS quadrangle images due to the age of the USGS quadrangles. For example, the Requa, CA USGS quadrangle was last revised in 1966, while Requa orthophotography represents conditions in 1998. The images were georeferenced to a Universal Transverse Mercator (UTM) Zone 10 projection, using a NAD 1927 horizontal datum. This coordinate system was then used to develop the horizontal dimensions of the grid and calculate the dimensions of the computational cells.

2.3.2 State Variables

Selection of appropriate model state variables to represent water quality processes of concern is a critical factor in model configuration. For this study, state variables were selected to most accurately predict TMDL impairments and related physical, chemical, and biological processes. State variables varied for each model type in the Klamath River model (RMA, CE-QUAL-W2, and EFDC). Note that pH is not a state variable. It is computed from alkalinity and TIC. Alkalinity and TIC are transported by the model and are thus state variables. In addition, TDS was inherited from the PacifiCorp model. No effort was made to remove it since it has no impact on the water quality simulation. The following state variables were configured for the riverine segments of the Klamath River model (for the RMA portions of the model):

1. Arbitrary Constituent (configured as a tracer to evaluate the mass balance)
2. DO
3. Organic matter (OM)
4. Orthophosphorus (PO_4)
5. Ammonium (NH_4)
6. Nitrite (NO_2)
7. Nitrate (NO_3)
8. Phytoplankton
9. Temperature
10. Periphyton
11. Total inorganic carbon (TIC)
12. Alkalinity (Alk)

The reservoir segments of the Klamath River, where the CE-QUAL-W2 model was applied, were configured using the following active state variables:

1. Labile dissolved organic matter (LDOM)
2. Refractory dissolved organic matter (RDOM)
3. Labile particulate organic matter (LPOM)
4. Refractory particulate organic matter (RPOM)
5. Inorganic Suspended Solids (ISS)
6. PO_4
7. NH_4

8. NO_2/NO_3
9. DO
10. Phytoplankton
11. Alk
12. TIC
13. Temperature
14. Tracer
15. TDS
16. Age (to track detention time at different locations)
17. Coliform bacteria

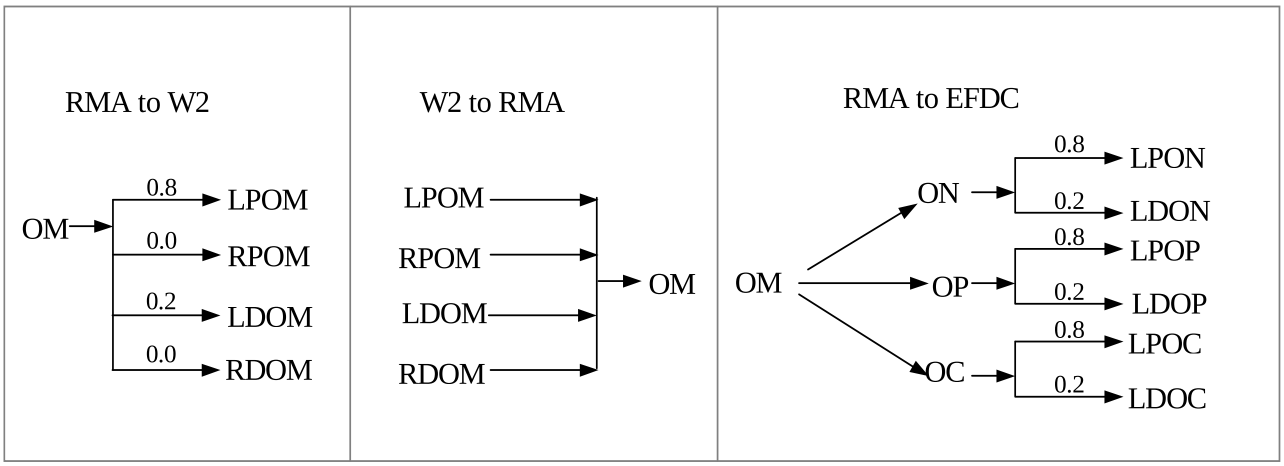
The estuarine portion of the Klamath River, which was modeled using EFDC, was configured with the following constituents as state variables:

1. Phytoplankton
2. Labile particulate organic carbon (LPOC)
3. Labile dissolved organic carbon (LDOC)
4. Labile particulate organic phosphorous (LPOP)
5. Labile dissolved organic phosphorous (LDOP)
6. PO_4
7. Labile particulate organic nitrogen (LPON)
8. Labile dissolved organic nitrogen (LDON)
9. NH_4
10. NO_2/NO_3
11. DO
12. Temperature
13. Salinity
14. Periphyton

The RMA model considers a single, lumped OM constituent while the CE-QUAL-W2 model contains four compartments (LDOM, RDOM, LPOM, and RPOM). Because available data are insufficient to accurately partition between labile and refractory components and because RMA only considers lumped OM, all the OM boundary conditions configured for the reservoir models were partitioned between only dissolved and particulate components. Further partitioning between labile and refractory components was not implemented. It's important to note that the state variable slots in the CE-QUAL-W2 models for labile OM (i.e., LDOM and LPOM) were used to represent the all dissolved OM and particulate OM, respectively. Therefore, even though the terms "LDOM" and "LPOM" are used when referring to model results, the values essentially represent all OM, without differentiating between labile and refractory components. Because average values are used in the model to represent characteristics such as decay rate, the model can be considered to inherently include some amount of both fast- and slow-decaying OM material (i.e., some amount of labile and refractory material). The model was configured such that a small amount of true refractory OM can be generated through algal metabolism, however, this amount is typically negligible. For the EFDC model of the estuary, the organic nutrients were not partitioned between labile and refractory components either. Rather ,they were lumped together and represented using the labile state variable slots.

The schematic below (Figure 2-4) shows the flow of OM to and from each of the models. The 0.8:0.2 ratio for partitioning OM was used in the existing PacifiCorp Model and was based on the CE-QUAL-W2 algae partition coefficient (APOM = 0.8). The RMA to W2 conversion shown in Figure 2-4 does not apply to the upstream boundary conditions for J.C. Boyle and Copco reservoirs, because dynamic OM partitioning was implemented (as previously discussed). For Link River, where no upstream dynamic reservoir model was available, the static partitioning shown in Figure 2-4 was implemented.

For model calibration, the EFDC upstream boundary condition was derived using 2004 monitoring data. Therefore, no OM conversion from the upstream RMA model was necessary. When modeling scenarios were run (which are not addressed in this report), the upstream RMA model representing Irongate to Turwar was linked to the estuary EFDC model. For this case, OM from the RMA model was converted into organic nitrogen (ON), organic phosphorous (OP), and organic carbon (OC) components for the EFDC model. This conversion is based on the stoichiometric ratio used in the upstream W2 and RMA models, where OM multipliers are the following: ON = 0.07, OP = 0.0055, and OC = 0.45 (Cole and Wells 2003). To further partition the ON, OP, and OC into particulate/dissolved components, the ratios presented in Figure 2-4 were used.



Note: The RMA to W2 conversion shown above does not apply to the upstream boundary conditions for J.C. Boyle and Copco reservoirs, where dynamic OM partitioning was applied. The RMA to EFDC representation does not reflect calibration conditions, rather it summarizes transfer used during scenario analysis.

Figure 2-4. Schematic showing the transfer of OM between models

2.3.3 Boundary Conditions

To run the Klamath River model, external forcing factors known as boundary conditions must be specified for the system. These forcing factors are a critical component in the modeling process and have direct implications on the quality of the model's predictions. External forcing factors include a wide range of dynamic information:

- Upstream Inflow Boundary Conditions: Upstream external inflows, temperature, and constituent boundary conditions
- Tributary (or Lateral) Inflow Boundary Conditions: Tributary inflows, temperature, and constituent boundary conditions
- Withdrawal Boundary Conditions
- Surface Boundary Conditions: Atmospheric conditions (including wind, air temperature, solar radiation)

Upstream external inflows essentially represent the inflow at the model's *starting* point. Tributary inflows represent the major tributaries that feed into the Klamath River. All water removed from the system is combined within the withdrawals category.

The surface boundary conditions are determined by the meteorological or atmospheric conditions and include air temperature, dew point temperature, wind speed, wind direction, and cloud cover. The meteorological file from the original PacifiCorp Model was maintained since it was based on real data and was intensively reviewed. Data obtained from station KFLO near Klamath Falls were used to represent the conditions from Link Dam to J.C. Boyle Dam. Data from Brazie Ranch represent the boundary conditions from J.C. Boyle Dam to Seiad Valley. For the reach from Seiad Valley to Turwar, the weather data from Hoopa and Somes Bar were used to represent the meteorological boundary conditions. Data from the Arcata Eureka Airport were applied to the estuarine portion of the Klamath River (Turwar to the Pacific Ocean), as described later in Section 2.3.3.9.

The following subsections provide a detailed description of the boundary conditions used to represent each modeled segment. The descriptions begin upstream at the Link River segment and continue downstream to the Klamath Estuary segment. In the existing PacifiCorp Model, boundary conditions were set as time series at each location on the basis of observed data or other assumptions where data were not available. For periods when no data were available, the model internally estimates the boundary on the basis of linearly interpolating the time series provided in the boundary condition files. In some situations, boundary conditions were updated using more recently acquired monitoring data. Both types of modification are further described in this section.

The upper and middle segments of the model (Model Segments 1 through 8) were tested (calibrated) using data from the year 2000. In addition, the calibration of the upper segments (Model Segments 1 through 5) was further corroborated (validated) with observed data for 2002. The estuarine portion (Model Segment 9), which was modeled with EFDC, was calibrated using data from the year 2004. As described in Section 3.0, these periods were selected because of data availability. In subsequent discussions, boundary condition descriptions are first described for the year 2000. Any deviations from the year 2000 representation for the year 2002 are then noted.

2.3.3.1 Model Segment 1: Link River

The Link River segment begins at the outlet of UKL (Link Dam) and ends at Lake Ewauna. Four types of boundary conditions were included in this model segment: upstream inflow boundary conditions, tributary boundary conditions, downstream stage-discharge boundary conditions, and surface boundary conditions (discussed above).

<u>Upstream Inflow Boundary Conditions:</u> The inflow to Link River is from UKL through releases from Link Dam. Since there were no observed data available at the head of Link River for 2000, observed water quality data at Pelican Marina (in UKL) were used as the basis for upstream boundary conditions. This representation is different than that in the existing PacifiCorp Model which used multiple year composite data for Link River at Fremont Bridge as the basis of boundary condition. Considering the significant inter-year variability in water quality in UKL, it is preferable to use data collected during the modeling year rather than other years to represent the external forces at boundaries. Monitoring data for NH_4, NO_2/NO_3, phytoplankton, DO, and temperature were directly applied to the boundary conditions using a linear interpolation method

to obtain daily values for dates without data. OM boundary conditions were derived using observed total phosphorus (TP), dissolved PO_4, and chlorophyll *a* data and following these steps:

Step 1: derive algal P as: $OP_{alg} = Chla \times CCHA / AGP$
Step 2: derive non-algal P as: $OP_{non\text{-}alg} = TP$ – dissolved $PO_4 - OP_{alg}$
Step 3: derive OM as: $OM = OP_{non\text{-}alg} \times OMP$

where

Chla = observed chlorophyll *a* concentration (µg/L)
CCHA = 0.067 (mg-algae per µg-chlorophyll *a*); derivation: Algae = Chla × 67 × (1 mg/1000 ug), where 67 represents the Algae:Chla ratio defined as 30/0.45 (on the basis of the WASP model default ratio of 30 for Algae-C:Chla and the CE-QUAL-W2 model default ratio of 0.45 for Algae-C:Algae)
AGP = algal P content coefficient (mg-algae / mg-P)
OMP = organic matter P content coefficient (mg-OM / mg-P)

OMP was determined to be 180.0 based on 2002 data for Link River at Fremont Bridge (where the average organic carbon:organic phosphorus ratio is 81, and thus the OM:OP ratio is 81 / 0.45 = 180.0). AGP was assumed to be the same as OMP because phytoplankton is the major source of OM in UKL. BOD was not configured for the model because all OM are represented using a single state variable (as previously noted).

Initially, the total PO_4 boundary condition was represented using the dissolved PO_4 monitoring data at Pelican Marina. It was found, however, that setting the PO_4 boundary concentration at Link River to the observed dissolved PO_4 value resulted in a significant underprediction of PO_4 concentration at Miller Island, in Lake Ewauna. Because Link River flow is dominant in upper Lake Ewauna, the PO_4 concentration at Miller Island should be similar in magnitude and pattern to that at the head of Link River. Several model sensitivity analyses confirmed this. The difference between the dissolved PO_4 data at Pelican Marina and the PO_4 data at Miller Island suggests that the dissolved PO_4 at Pelican Marina is likely not a good representation of conditions at the head of Link River. Therefore, the observed PO_4 data at Miller Island were used as the basis for configuring the PO_4 boundary condition at Link Dam.

The alkalinity boundary condition was configured on the basis of alkalinity monitoring data at Link River and Miller Island. In 2000 there was a limited amount of alkalinity data at Link River (on seven discrete dates). These data were insufficient to accurately predict alkalinity concentrations at Miller Island. Therefore, Miller Island data were used to supplement the Link River data in constructing the boundary condition. The first step in doing this was to compare the flow from Link River and the Lost River Diversion Channel to determine the period during which Link River flow was dominant. For this period the alkalinity at Miller Island would be similar in magnitude to that at Link River. Therefore, data at Miller Island were incorporated into the Link River data to form an expanded data set. The upstream boundary condition for alkalinity was then configured using this expanded data set. There were no data available for TIC; therefore, the TIC boundary condition was obtained through the pH calibration process for Miller Island. Initially, TIC at the Link River boundary was derived on the basis of pH at Miller Island and alkalinity at Link River. These estimates were refined to achieve a better calibration of pH at Miller Island in Lake Ewauna.

The upstream boundary condition for the 2002 model was derived using a method similar to that used for 2000. Available data at both the head of Link River (Fremont Bridge) and at Pelican

Marina were combined to form a composite data set for 2002 boundary condition derivation. Monitoring data for PO_4, NH_4, NO_2/NO_3, phytoplankton, DO, and temperature were directly applied to the boundary conditions using a linear interpolation method to obtain daily values for dates without data. The OM boundary condition was derived using the same approach used for the 2000 model. The alkalinity boundary condition was derived on the basis of monitoring data at Fremont Bridge. And the TIC boundary condition was derived on the basis of alkalinity data and pH data at the same location.

Tributary Boundary Conditions: There are two diversions from UKL at Link Dam. These diversions are two powerhouses that discharge water from UKL into the Link River segment (East Side and West Side). USGS gage 11507500 (Link River at Klamath Falls, Oregon) is between the powerhouse discharges.

The constituent concentrations for the tributary boundary conditions were set to be the same as the upstream boundary conditions because the powerhouses have the same water source as the upstream boundary (UKL).

Downstream Boundary Conditions: Downstream boundary conditions were configured using a stage-discharge relationship. Although this type of boundary condition does not allow for representation of the backflow condition that occasionally occur at the mouth of Link River, it is a better predictive tool than using the Lake Ewauna elevation as the downstream boundary condition. The backflow condition does not have a significant impact on the loading rate from Link River to Lake Ewauna, thus, it does not significantly impact the water quality in the lake.

2.3.3.2 Model Segment 2: Lake Ewauna to Keno Dam

This segment extends from the point where Link River enters Lake Ewauna to the outlet at Keno Dam. Five types of boundary conditions were included in the Klamath River model for the Lake Ewauna segment. They are upstream inflow boundary conditions, tributary boundary conditions, withdrawal boundary conditions, downstream outflow boundary conditions, and surface boundary conditions.

Upstream Inflow Boundary Conditions: The upstream boundary condition was defined as the water flowing into Lake Ewauna from Link River (Model Segment 1). Link River’s flow was determined by using the observed flows at USGS flow gage 11507500 plus the flow from the PacifiCorp West Turbine (powerhouse) gage, which is downstream of the USGS gage.

The upstream boundary conditions for water quality constituent concentrations were based on the model results in the downstream region of the Link River Model Segment. PO_4, NH_4, NO_2/NO_3, DO, phytoplankton, Alk, TIC, and temperature were directly transferred from the RMA-11 model (from Link River) to the CE-QUAL-W2 input data file for Lake Ewauna. Output for OM from Link River was applied to the Lake Ewauna segment and partitioned into four components: LDOM, RDOM, LPOM, and RPOM with partition ratios as 0.2, 0.0, 0.8, and 0.0, respectively. These ratios were based on the CE-QUAL-W2 ALPOM value and the decision not to further partition OM between labile and refractory components. These assumptions were justified because the majority of the organic matter from UKL are likely generated by phytoplankton blooms and metabolism. Therefore, the CE-QUAL-W2 ALPOM value can be used to represent partitioning. In reality significant spatial and temporal variability associated with organic matter composition may exist, however insufficient data are available to more accurately represent the organic matter boundary conditions. In addition, CE-QUAL-W2 isn't capable of representing seasonal variability of OM composition for the boundary conditions.

Tributary Boundary Conditions: There are 18 definable tributary discharges in the Lake Ewauna to Keno Dam river segment. These discharges include 11 stormwater locations, Columbia Plywood discharge, Klamath Falls Wastewater Treatment Plant, South Suburban Sanitation District, two discharges at Collins Forest Products, Lost River Diversion Channel, and Klamath Straits Drain (KSD).

The inflow from the stormwater locations was calculated as an average percentage of total stormwater runoff. The flow from Columbia Plywood was calculated from the discharger's monthly monitoring reports as an average of 0.01 cubic feet per second (cfs). Variable daily flows were used for the Klamath Falls Wastewater Treatment Plant and ranged from approximately 4 to 12 cfs. Variable daily flows were also used for South Suburban Sanitation District and generally ranged from 1 to 4 cfs. The two discharges at Collins Forest Products had average daily flows of approximately 1.4 cfs and 0.1 cfs. Daily flows from Lost River Diversion Channel and KSD into Lake Ewauna were obtained from USBR's flow gages at these locations.

The water quality constituent concentrations of the tributary boundary conditions were set to be the same as in the previous PacifiCorp Model except for the major tributaries and point sources, including KSD, Klamath Falls Wastewater Treatment Plant, and South Suburban Sanitation District. For these major tributaries and point sources, available data for 2000 and 2002 were used to update the boundary conditions. The details of updating these boundary conditions are summarized as follows:

a) KSD

The concentration boundary condition at KSD was represented using data at station Pump F in the KSD. The formulas used to convert observed data to model boundary conditions are listed below. For each constituent notation, the one on the left-hand side corresponds to the model boundary condition, while the one on the right-hand side corresponds to observed data. For parameters not listed, observed values were used directly.

- Algae [mg/L] = Chlorophyll *a* [µg/L] × 0.067, where 0.067 was derived similarly to CCHA for the UKL boundary condition (previously described)
- LDOM [mg/L] = (TP [mg/L] – PO_4 [mg/L]) × 180.0 × 0.7, where 180.0 was derived similarly to OMP for the UKL boundary condition (previously described), and 0.7 was derived on the basis of 2002 data at KSD (Dissolved TP / TP)
- RDOM [mg/L] = 0.0
- LPOM [mg/L] = (TP – PO_4) × 180.0 × 0.3, where the ratio 0.3 was derived from (1.0–0.7, where 0.7 represents LDOM).
- RPOM [mg/L] = 0.0
- ISS [mg/L] = TSS [mg/L]
- TIC [mg/L] = *f*(Alk, temperature, pH), where *f* represents the functional form relating TIC to Alkalinity [mg/L], temperature [^oC], and pH. Detailed equations can be found in Chapra 1997.

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b) Klamath Falls Wastewater Treatment Plant and South Suburban Sanitation District

The water quality constituent concentrations for both the Klamath Falls Wastewater Treatment Plant and South Suburban Sanitation District were set to be the same as in the previous PacifiCorp Model, except for where more recent facility discharge monitoring report data were available. The formulas used to derive the boundary conditions based on data are as follows:

- BODu [mg/L] = BOD5 [mg/L] × 3.386, where the ratio 3.386 is based on the assumption that the treatment plants provide secondary treatment, thus the BOD has a decay rate around 0.07/day (Chapra, 1997)
- LDOM [mg/L] = BODu / 1.4 × 0.2, where the ratio 1.4 is based on the W2 stoichiometric ratio, and 0.2 is the same as that used for the UKL boundary condition
- LPOM [mg/L] = BODu / 1.4 × 0.8, where the ratio 1.4 is based on the W2 stoichiometric ratio, and 0.8 is the same as that used for the UKL boundary condition
- OM [mg/L] = LPOM + LDOM, which is based on the conservative assumption that all OM are labile for boundary inputs
- ISS [mg/L] = TSS [mg/L]
- PO_4 [mg/L] = TP [mg/L] – BODu / 1.4 / 180.0
- Org-P [mg/L] = OM × 0.0055, where the coefficient 0.0055 is the stoichiometric ratio used in the model
- TP [mg/L] = Org-P + PO_4
- Org-N [mg/L] = OM × 0.07 where the coefficient 0.07 is the stoichiometric ratio used in the model
- TN [mg/L] = Org-N + NH4 [mg/L] + NO2/NO3 [mg/L]

The 2000 boundary conditions for LDOM, LPOM, and DO at the Klamath Falls Wastewater Treatment Plant were updated using data from 2000. No data were available for ISS, PO_4, or NH4 for 2000, therefore data from 2002 were used for the 2000 model. For the 2002 model, LDOM, LPOM, DO, ISS, PO_4 and NH4 were all based on the 2002 data.

The 2000 and 2002 boundary conditions for LDOM, LPOM, DO, ISS, PO_4, and NH4 at South Suburban Sanitation District were configured based on data available for the corresponding year. For dates when PO_4 data were not available and thus could not be directly applied, PO_4 was derived based on the TP and BOD data using the formulas listed above.

<u>Withdrawal Boundary Conditions:</u> Three withdrawals in this segment are explicitly represented, including the Lost River, North Canal, and ADY Canal. Daily flows at all three of these withdrawals are gaged by USBR.

There is a lack of available daily withdrawal rates for a few non-USBR irrigation diversions, therefore they are not explicitly represented. Water diversion is grossly represented in the distributed flow, which was derived through a flow balance analysis.

The hourly flow rate at Keno Dam was available from USGS gage 11509500 (Klamath River near Keno, Oregon). The flows ranged from less than 500 cfs to more than 4,000 cfs. All these boundary conditions were kept the same as in the previous PacifiCorp Model.

<u>Downstream Outflow Boundary Conditions:</u> For Lake Ewauna, the downstream boundary condition was set as the outflow at the point before entering Keno Reach (Keno Dam to J.C.

Boyle Reservoir). The downstream boundary condition was set to be outflow; therefore, no water quality concentration boundary condition was needed.

2.3.3.3 Model Segment 3: Keno Dam to J.C. Boyle Reservoir (Keno Reach)

There were three types of boundary conditions included in this section of the model: upstream inflow boundary conditions, downstream outflow boundary conditions, and surface boundary conditions.

Upstream Inflow Boundary Conditions: The upstream inflow to this reach for the 2000 and 2002 models is based on the outflow from Lake Ewauna for the corresponding year. This segment was dominated by upstream water quality, therefore the simulated loading time series for phytoplankton, temperature, PO_4, NH_4, NO_2/NO_3, DO, TIC, and Alk from the Lake Ewauna to Keno Dam segment were applied. The four OM constituents predicted by the CE-QUAL-W2 model were combined into one OM constituent and applied to the boundary conditions (as previously discussed).

Downstream Outflow Boundary Conditions: Hydrodynamic downstream boundary condition was set as a stage-discharge relationship, which represents the downstream flow as only outflow; therefore, no concentration boundary condition was needed.

2.3.3.4 Model Segment 4: J.C. Boyle Reservoir

The J.C. Boyle Reservoir extends from the J.C. Boyle headwaters (Keno Reach to J.C Boyle Reservoir) to the J.C. Boyle Dam. There were four types of boundary conditions included in this portion of the model. They are upstream inflow boundary conditions, tributary boundary conditions, downstream outflow boundary conditions, and surface boundary conditions.

Upstream Inflow Boundary Conditions: Klamath River inflow for the 2000 and 2002 models to J.C. Boyle dam is represented by discharge from the Keno Reach during the corresponding year. The upstream boundary conditions for water quality constituents were based on the model results at the downstream node of the Keno Reach portion of the model for the corresponding year. PO_4, NH_4, NO_2/NO_3, DO, phytoplankton, temperature, TIC, and Alk were directly transferred from the RMA-11 model results for Keno Reach to the CE-QUAL-W2 input data file for J.C. Boyle Reservoir. Output for OM from the Keno Reach model was applied to the J.C. Boyle Reservoir (see Section 2.2.1) and was partitioned into four components: LDOM, RDOM, LPOM, and RPOM. The aforementioned dynamic partitioning scheme was applied. This scheme uses the LDOM, RDOM, LPOM, and RPOM fractions derived from model results from the last segment of Keno Reservoir to partition the OM into the four components.

Tributary Boundary Conditions: There is one tributary to J.C. Boyle Reservoir, Spencer Creek. Spencer Creek has very limited inflow information. Therefore, it is not configured as a separate tributary in this model. The minor contribution of flow from Spencer Creek is lumped into the upstream headwater in the original PacifiCorp Model, and directly adopted in the TMDL model. The net reservoir accretion/depletion was calculated through a flow balance process aiming to reproduce the observed surface water elevation in the reservoir. This accretion/depletion was configured as a distributed tributary boundary condition in the model. The concentration of the tributary inflow was set to be the same as in the upstream boundary condition.

Downstream Outflow Boundary Conditions: The outflow from the reservoir was calculated as the sum of all recorded releases to the four outlets in the reservoir (powerhouse canal, dam spillway, bypass releases, and fish ladder releases).

The downstream boundary condition was set to be outflow; therefore, no concentration boundary condition was needed.

2.3.3.5 Model Segment 5: Bypass/Full Flow Reach

The Bypass/Full Flow Reach extends from the J.C. Boyle Dam to the headwaters of Copco Reservoir. There were four types of boundary conditions included in this portion of the model: upstream inflow boundary conditions, tributary boundary conditions, downstream outflow boundary conditions, and surface boundary conditions.

Upstream Inflow Boundary Conditions: There are two inflows to the Bypass/Full Flow Reach. They are releases from J.C. Boyle Dam directly to the Klamath River and the J.C. Boyle Powerhouse tailrace. Measured releases from the dam for 2000 and 2002 were obtained from PacifiCorp and used to represent both inflows for the model for the corresponding years.

For the upstream water quality constituent concentration boundary conditions, the simulated loading time series for phytoplankton, temperature, PO_4, NH_4, NO_2/NO_3, and DO from the J.C. Boyle Reservoir were applied. The four OM constituents predicted by the CE-QUAL-W2 model were combined into one OM constituent as applied in the Keno Reach boundary condition.

Tributary Boundary Conditions: There are no major tributaries, but there are three springs represented by a constant flow of 75 cfs each. The flow rate, temperature, DO, and phytoplankton boundary conditions for the springs were the same as in the original PacifiCorp Model, while the concentrations for the major nutrients (i.e., PO_4, NH_4, and NO_2/NO_3) were derived through model calibration. After several iterations, the concentrations for NH_4, NO_2/NO_3, and PO_4 were determined to be 0.029 mg/L, 0.25 mg/L, and 0.066 mg/L, respectively. OM concentrations were assumed to be a small value of 0.5 mg/L considering the springs are mainly groundwater. These concentrations were applied to both the 2000 and 2002 models for this reach.

Downstream Outflow Boundary Conditions: The downstream boundary condition for the Bypass/Full Flow Reach was configured as a stage-discharge relationship. No concentration boundary condition was needed for the downstream boundary conditions because only outflow exists there.

2.3.3.6 Model Segment 6: Copco Reservoir

The Copco Reservoir model segment extends from Copco Reservoir's headwaters to Copco Dam. Four types of boundary conditions were included in the portion of the model for Copco Reservoir. They are upstream inflow boundary conditions, tributary boundary conditions, downstream outflow boundary conditions, and surface boundary conditions.

Upstream Inflow Boundary Conditions: The inflow for Copco Reservoir was represented as the sum of the inflow into the reservoir and the estimated accretion/depletion for the reservoir. The flows from Bypass/Full Flow Reach were used as inflow to the Copco Reservoir because there are no flow data available at the headwaters of Copco Reservoir. The daily accretion/depletion was the sum of the daily change in storage in the Copco reservoir and the daily average outflow from the reservoir (minus the daily average inflows from Bypass/Full Flow Reach) as derived in the original PacifiCorp Model.

The upstream water quality constituent concentration boundary conditions were based on the model results at the downstream node of the Bypass/Full Flow Reach portion of the model. PO_4, NH_4, NO_2/NO_3, DO, phytoplankton, and temperature were directly transferred from the RMA-11 model results for Bypass/Full Flow Reach to the CE-QUAL-W2 input data file for Copco Reservoir. Output for OM from the Bypass/Full Flow Reach portion of the model was applied to Copco Reservoir (see Section 2.2.1) and is partitioned into four components: LDOM, RDOM, LPOM, and RPOM using the dynamic-partitioning approach as described above.

Tributary Boundary Conditions: The concentrations of the distributed tributary boundary conditions were set to be the same as the upstream concentration boundary condition in the same manner as in the original model.

Downstream Outflow Boundary Conditions: The two main outlets for the Copco Dam are a spillway and two waterway intakes at the Copco powerhouse (treated as a single outlet). Hourly outflow data for the powerhouse and the spillway were available from PacifiCorp and used as reservoir outflow flows.

The downstream boundary condition was set to be outflow; therefore, no concentration boundary condition was needed.

2.3.3.7 Model Segment 7: Iron Gate Reservoir

The Iron Gate Reservoir model segment extends from the headwaters of the Iron Gate Reservoir to Iron Gate Dam. Five types of boundary conditions were included in the portion of the model for Iron Gate Reservoir. They are upstream inflow boundary conditions, tributary boundary conditions, withdrawal boundary conditions, downstream outflow boundary conditions, and surface boundary conditions.

Upstream Inflow Boundary Conditions: There is no gage to measure inflow to Iron Gate Reservoir; therefore, the flows from the Copco Reservoir were used to represent inflow.

Simulated water quality outflow values from Copco Reservoir were applied as the Iron Gate Reservoir inflow water quality constituent concentration boundary conditions, and they were the same configuration as for Lake Ewauna.

Tributary Boundary Conditions: There are three tributaries to the Iron Gate Reservoir. They are Camp Creek, Jenny Creek, and Fall Creek. Limited flow information was available for these creeks. The hourly accretion/depletion for the reservoir was calculated as the sum of the daily inflow, outflow, and change in storage in Iron Gate Reservoir. Jenny Creek was represented by this accretion/depletion, as in the original PacifiCorp Model. Neither Camp Creek nor Fall Creek were explicitly configured with contributions in the model. Tributary boundary conditions were not changed from the original PacifiCorp Model. Since Jenny Creek is represented as an accretion/depletion flow, its water quality is represented using the upstream inflow concentrations. This follows the same assumptions as for the upstream reservoirs.

Withdrawal Boundary Conditions: The dam's spillway was modeled as a withdrawal because it draws water to the side of the dam, not over or through the dam. Representing the spillway as a withdrawal more accurately represents the system. If the spillway were represented as a spillway in W2, water would flow to the end of the reservoir instead of the side, and this can affect the hydrodynamic simulation.

Downstream Outflow Boundary Conditions: The Iron Gate dam has four primary outlets: a spillway, penstock, and two fish hatchery intakes. Outflow from the reservoir was based on the outflow in the original PacifiCorp Model. Outflow was determined from PacifiCorp daily flow records for the Powerhouse release and spill and estimates of fish hatchery releases (50 cfs for lower hatchery release and 0 cfs for upper hatchery release).

The downstream boundary condition was set to be outflow; therefore, no concentration boundary condition was needed.

2.3.3.8 Model Segment 8: Iron Gate Dam to Turwar

Four types of boundary conditions were included in the portion of the model for Iron Gate Dam to Turwar. They are upstream inflow boundary conditions, tributary boundary conditions, downstream outflow boundary conditions, and surface boundary conditions.

Upstream Inflow Boundary Conditions: The upstream inflow boundary conditions for Iron Gate Dam to Turwar were based on PacifiCorp's original model, which used PacifiCorp's measured releases from Iron Gate Dam during 2000.

Upstream water quality constituent boundary conditions were the simulated outflow values from the Iron Gate reservoir.

Tributary Boundary Conditions: There are 23 tributaries to this segment of the Klamath River, including four major tributaries (Shasta, Scott, Salmon, and Trinity rivers). Five tributaries to this reach are actively gauged, including the Shasta, Scott, Salmon, and Trinity rivers, and Indian Creek. Inflows for minor tributaries were defined and quantified as daily accretion/depletions, as in the original PacifiCorp Model.

The Scott and Trinity rivers were assigned by summing USGS-gaged flows and daily accretion/depletions. The daily accretion/depletions were determined on the basis of a USGS methodology. Monthly average values were used to determine accretions and depletions for each river segment on the basis of differences in gage readings, and these accretions and depletions were then assigned to individual tributaries according to the estimated basin area. Appendix D presents the USGS methodology for estimating these flows for tributaries (PacifiCorp 2004). Model node and element numbers and type of flow record employed for each tributary are summarized in Table 2-2.

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Table 2-2. Element flow information for the Iron Gate to Turwar simulation

Location	Node	Element	Flow Type
Bogus Creek	7	4	7 day average
Willow Creek	55	28	7 day average
Cottonwood Creek	86	43	7 day average
Shasta River	144	72	Daily measured
Humbug Creek	204	102	7 day average
Beaver Creek	319	160	7 day average
Horse Creek	468	234	7 day average
Scott River	513	257	Daily measured + A/D Ft. Jones to Klamath
Grider Creek	656	328	7 day average (A/D Scott to Seiad)
Thompson Creek	735	368	7 day average
Indian Creek	906	453	Daily measured
Elk Creek	925	463	7 day average
Clear Creek	1000	500	7 day average
Ukonom Creek	1098	549	7 day average
Dillon Creek	1162	581	7 day average
Salmon River	1357	679	Daily measured
Camp Creek	1466	733	7 day average
Red Cap Creek	1511	756	7 day average
Bluff Creek	1547	774	7 day average
Trinity River	1609	805	Daily measured + A/D Hoopa to Klamath
Pine Creek	1644	822	7 day average
Tectah Creek	1850	925	7 day average
Blue Creek	1908	954	7 day average

Shasta River daily flows were taken from USGS Gage 11517500 (Shasta River near Yreka). Scott River daily flows were calculated from USGS Gage 11519500 (Scott River near Ft Jones) and accretion/depletions. Daily Indian Creek flows were taken from USGS Gage 11521500 (Indian Creek near Happy Camp). Salmon River daily flows were from USGS Gage 11522500 (Salmon River at Somes Bar). Trinity River daily flows were calculated from USGS Gage 11530000 (Trinity River at Hoopa) and accretion/depletions.

Water quality constituent concentrations in the tributaries for all parameters except DO were based on U.S. Fish and Wildlife Service (USFWS), USBR, EPA, USGS, California Department of Water Resources (CDWR), NCRWQCB Surface Water Ambient Monitoring Program, and Yurok Tribe Environmental Program (YTEP) data.

Temperature data for the tributaries were very limited, therefore the temperature boundary conditions for all the tributaries were configured on the basis of USGS-estimated temperature for 2002 (Flint, L.E. and Flint, A. L. 2008). It was found that by directly using the USGS-estimated temperatures in these tributaries, the model reproduced observe temperatures in the Klamath River quite well. This is not surprising since the USGS study did show that there is no significant inter-year variation in the predicted in-stream temperature.

There were very little to no water quality data available for most tributaries. The only tributaries with sufficient data to represent seasonal variations for 2000 were the Shasta and Scott Rivers (USBR 2003 data). For the other two major rivers, Salmon and Trinity, NCRWQCB derived representative data to approximate the boundary conditions for 2000, based on statistical analysis of historical tributary data. Several historical datasets (1960s to 1980s) with water quality data from CDWR, STORET, USBR, and USGS were supplemented with more recent data (2000 to 2006) from USFWS, USBR, EPA, USGS, CDWR, NCRWQCB, and YTEP. The data were split into two seasonal periods – Wet (November – April) and Dry (May – October), and years which had similar hydrologic conditions to the year 2000 were selected based on statistical measures. The median water quality values for the two seasonal periods were used for boundary conditions.

In addition to the USBR data, the NCRWQCB compiled nutrient data for several minor tributaries including Beaver Creek, Bluff Creek, Clear Creek, Dillon Creek, Elk Creek, Red Cap Creek, Indian Creek, and Bogus Creek for the period from 2001 to 2006. These data were divided into two categories. The first was data for Bogus Creek that were used to derive the boundary condition for Bogus Creek. Bogus Creek exhibits significantly higher nutrient concentrations than the other tributaries. The second was data for all other minor tributaries, which were combined to derive values representing all the minor tributaries. Because of a lack of sufficient data to characterize temporal variability, it was deemed appropriate to use an annual average value to represent the boundary conditions from the minor tributaries.

DO in all minor tributaries was estimated using 90 percent saturated conditions, except for the Shasta and Scott rivers, where DO data were available. DO saturation concentrations were based on the temperature data and atmospheric pressure corrected for elevation. A detailed description of the boundary conditions for each of the tributaries is provided in Table 2-3.

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Table 2-3. Description of Boundary Conditions for Tributaries within the Irongate to Turwar Segment

Tributary name	Temperature	Nutrients	DO	TIC/ALK
Bogus Creek	Based on USGS estimated data	Based on NCRWQCB data	90 % saturation value	Based on the data in the Scott River
Willow Creek	Based on USGS estimated data	Based on NCRWQCB estimated data	90% saturation value	Based on the data in the Scott River
Cottonwood Creek	Based on USGS estimated data	Based on NCRWQCB estimated data	90% saturation value	Based on the data in the Scott River
Shasta River	Based on 2000 data	Nutrients were set based on USFWS data at the mouth of the Shasta River	DO was based on observed data, except for the period without monitoring data, which was set to be 90% of the saturation value.	Based on the data at the Shasta River mouth
Humbug Creek	Based on USGS estimated data	Based on NCRWQCB estimated data	90% saturation value	Based on the data in the Scott River
Beaver Creek	Based on USGS estimated data	Based on NCRWQCB data	90% saturation value	Based on the data in the Scott River, except for August and September, when limited data were available for 2006. For August and September, the data were used directly.
Horse Creek	Based on USGS estimated data	Based on NCRWQCB estimated data	90% saturation value	Set to be the same as in the Beaver Creek boundary condition
Scott River	Based on 2000 data	Based on USFWS data at the mouth of the Scott River	Based on USFWS data at the mouth of the Scott River. Periods without data were set at 90% saturation value	Based on USFWS data at the mouth of the Scott River
Grider Creek	Based on USGS estimated data	Based on NCRWQCB estimated data	90% saturation value	Set based on the observed data at the mouth of Salmon River
Thompson Creek	Based on USGS estimated data	Based on NCRWQCB estimated data	90% saturation value	Set based on the observed data at the mouth of Salmon River
Indian Creek	Based on USGS estimated data	Based on NCRWQCB data	90% saturation value	Based on the observed data at the mouth of the Salmon River, except for August and September, when 2006 data were available at Indian Creek. For this

Tributary name	Temperature	Nutrients	DO	TIC/ALK
				period, the data were used directly.
Elk Creek	Based on USGS estimated data	Based on NCRWQCB data	90% saturation value	Based on the observed data at the mouth of the Salmon River except for August and September, when 2006 data were available at Elk Creek. For this period, the data were used directly.
Clear Creek	Based on USGS estimated data	Based on NCRWQCB data	90% saturation value	Based on the observed data at the mouth of the Salmon River, except for August and September, when 2006 data were available at Clear Creek. For this period, the data were used directly.
Ukonom Creek	Based on USGS estimated data	Based on NCRWQCB estimated data	90% saturation value	Based on the observed data at the mouth of the Salmon River
Dillon Creek	Based on USGS estimated data	Based on NCRWQCB data	90% saturation value	Based on the observed data at the mouth of the Salmon River, except for August and September, when 2006 data were available at Dillon Creek. For this period, the data were used directly.
Salmon River	Based on 2000 data	Based on USFWS data	90% saturation value	Based on the observed data at the mouth of the Salmon River
Camp Creek	Based on USGS estimated data	Based on NCRWQCB estimated data	90% saturation value	Based on the observed data at the mouth of the Trinity River
Red Cap Creek	Based on USGS estimated data	Based on NCRWQCB data	90% saturation value	Based on the observed data at the mouth of the Trinity River, except for August and September, when 2006 data were available. For this period, the data were used directly.
Bluff Creek	Based on USGS estimated data	Based on NCRWQCB data	90% saturation value	Based on the observed data at the mouth of the Trinity River, except for August and September, when 2006 data were available. For this period, the data were used directly.

Tributary name	Temperature	Nutrients	DO	TIC/ALK
Trinity River	Based on 2000 data	Based on USFWS data	90% saturation value	Based on the observed data in the Trinity River
Pine Creek	Based on USGS estimated data	Based on NCRWQCB estimated data	90% saturation value	Based on the observed data at the mouth of the Trinity River
Tectah Creek	Based on USGS estimated data	Based on NCRWQCB estimated data	90% saturation value	Based on the observed data at the mouth of the Trinity River
Blue Creek	Based on USGS estimated data	Based on NCRWQCB estimated data	90% saturation value	Based on the observed data at the mouth of the Trinity River

Downstream Outflow Boundary Conditions: The downstream boundary condition for this section is a stage-discharge condition. No water quality boundary condition is needed because only outflow is represented at the downstream.

2.3.3.9 Model Segment 9: Klamath Estuary (Turwar to the Pacific Ocean)

The estuarine portion of the Klamath River (Turwar to the Pacific Ocean) was modeled using EFDC and was not included in the original PacifiCorp Model. This model segment was ultimately calibrated using data from the year 2004 because it had the most available data for all parameters. Insufficient data were available to calibrate for the year 2000 in the estuarine portion of the Klamath River. Boundary conditions were thus prepared using monitoring data at Turwar. Three types of boundary conditions were included in the Klamath Estuary portion of the model. They are upstream inflow boundary conditions, downstream open boundary conditions, and surface boundary conditions.

Upstream Inflow Boundary Conditions: The portion of the Klamath River represented by EFDC was delineated from the USGS 11530500 streamflow gage at Klamath to the Klamath River's intersection with the Pacific Ocean (Appendix C). Streamflow data from the Klamath River at Klamath USGS gage (11530500) were used as the upstream inflow boundary for model calibration (described in Section 3.0). Model results from the Iron Gate Dam to Turwar portion of the model are used as input for the modeling scenarios.

The upstream boundary condition for water quality was configured using the USFWS/Yurok's 2004 water quality monitoring data at Turwar (for model calibration). The USFWS station was sampled five times from June to September 2004. A time series was generated for water quality using linear interpolation of the five available data points. The following constituents were configured as state variables in the upstream boundary water quality input file using the Turwar data:

1. Phytoplankton
2. LPOC
3. LDOC
4. LPOP
5. LDOP
6. PO_4
7. LPON

8. LDON
9. NH_4
10. NO_3/NO_2
11. DO

Not all data were available to be directly used in the EFDC water quality input file. The following assumptions were made to derive parameters to create the water quality input file:

- The particulate to dissolved OM ratio was assumed to be 0.8:0.2. This ratio was also used to derive the particulate and dissolved components of phosphorus, nitrogen and carbon. It maintains consistency with upstream segments.
- Due to a lack of data to further partition OM between labile and refractory components, labile and refractory components were not considered separately.
- Organic phosphorous was derived by subtracting PO_4 from total phosphorous.
- The ON:OM and OP:OM ratios were assumed to be the same as in upstream reaches, which are ON:OM=0.07, and OP:OM=0.0055. These ratios were used to derive ON from OP data.
- The algae biomass to chlorophyll ratio was assumed to be 0.067 mg algae/ug Chla, which is the same as those in the upstream reaches.

Diel DO and temperature data were not readily available at the Turwar gage for 2004 when this model was developed. Thus, daily average values were computed on the basis of the diel data for the Upper Estuary monitoring site (at Hwy 101) and specified as the upstream boundary condition at Turwar. The model can be updated to reflect additional monitoring data as these data become available.

For modeling scenarios, model output from the Iron Gate Dam to Turwar segment are used. OM conversion from the RMA model to EFDC is presented in Figure 2-4 of Section 2.3.2.

Two tributaries to the Klamath Estuary, Hunter Creek and Salt Creek, were also initially considered as part of the boundary conditions but were later eliminated. Flow estimates were available for Hunter Creek, based on drainage area for the period May 1 through September 30, and were found to be relatively insignificant (median value of 5.9 cfs in 2004) in comparison to the Klamath River flows. Salt Creek flows were smaller than those for Hunter Creek.

Downstream Open Boundary Conditions: The outlet of the Klamath River at the Pacific Ocean is characterized by a widening of approximately 1,400 meters. Depending on the conditions, the outlet may be largely closed off by a transient sand bar. The opening through this sand bar was set to approximately 200 meters in width for the model, based on measured 2004 bathymetry data. To reduce the influence of boundary reflection, the downstream open boundary of the model was set well into the Pacific Ocean, beyond the physical opening in the sand bar (Appendix C). To allow for flexibility in evaluating the effect of different locations of the sand bar opening, the sand bar is included in the grid system as a column of active cells. It has an internal barrier that blocks the water from penetrating all cells except those representing the opening.

Tidal data from the National Oceanic and Atmospheric Administration (NOAA) gage at Crescent City (9419750) were used to represent the tidal boundary of the model. Tidal elevation data from the Crescent City gage are referenced to a mean lower low water (MLLW) vertical datum, while bathymetry data obtained from the NCRWQCB use the NAVD88. The difference between the two data at this location is approximately 0.38 feet, or 0.116 meters. Tidal elevation data from the Crescent City gage station were adjusted to correspond to the bathymetry datum obtained for the lower portion of the Klamath River.

Surface Boundary Conditions: The surface boundary conditions are based on meteorological conditions. The meteorological data required by the EFDC model are specified in two separate files (*aser.inp* and *wser.inp*). The *aser.inp* file is used to specify the atmospheric pressure, air temperature, relative humidity, precipitation, evaporation, solar radiation and cloud cover. The *wser.inp* file is used to specify the wind speed and direction. Meteorological data from the Arcata Eureka Airport (WBAN 24283), approximately 35 miles downstream of the estuary along the Pacific coastline, were used. Hourly, unedited local meteorological data (atmospheric pressure, air temperature, relative humidity, precipitation, cloud cover, wind speed and direction) were available from this NOAA-NCDC station and were used in creation of the *aser.inp* and *wser.inp* files for the estuary model. These data provided the most complete data set of required surface airways parameters for the EFDC model meteorological file. Solar radiation data were not available. Clear sky solar radiation was computed on the basis of the latitude and longitude and corrected using cloud cover to generate the solar radiation data.

2.3.4 Initial Conditions

The Klamath River model requires specifying initial conditions in the input files. The initial conditions from the original PacifiCorp Model (Model Segments 1 through 8) were maintained for all segments, except BOD was eliminated from the initial condition setting for Link River, Keno Reach, and Bypass/Full Flow Reach (see Section 2.2.1). Where field data were unavailable, the conditions of the first day of available field data were applied. In general, the impact of the initial conditions was insignificant and lasted for less than 10 days in the winter period. The initial condition for Model Segment 9 was set to values similar in magnitude as observed data. Because of the relatively large flow from the Klamath River, however, the impact of initial conditions is noticeable only for a very short (insignificant) time period.

2.4 Modeling Assumptions, Limitations, and Sources of Uncertainty

2.4.1 Assumptions

The major underlying assumptions associated with Klamath River model development are as follows:

- The initial condition and the boundary conditions set for the winter and early spring period do not have a significant effect on the simulated water quality during the critical summer and early fall periods. This assumption permits assigning the initial conditions and winter/early spring boundary conditions using best professional judgment, without impairing the model performance for the critical period.
- Time series flow data were not available for all tributaries and withdrawals. Reliable time series flow data were also not available for many monitoring locations along the length of the Klamath River. In light of the limitations, it was assumed that tributary flows could be reasonably represented through interpolation on the basis of limited flow measurements.

- One phytoplankton species and one periphyton species were assumed to be sufficient for representing the overall primary production and nutrient interactions in the system given no data is available to support multiple species modeling.
- Alkalinity is conservative (as stated in CE-QUAL-W2 manual). Therefore, no internal sources or sinks were considered.
- All the OM in the water column (and that from other sources) has the same stoichiometric ratio unless data are available to derive site-specific ratio.
- The effect of zooplankton and benthic creatures do not have a significant impact on the algal/periphyton dynamics and nutrient recycling.
- A stage-discharge relationship was applied at the Link River boundary to enable predictive simulation downstream. This adjustment was made on the basis of previous peer review comments for the Klamath River Model. Although this configuration does not explicitly simulate backwater effects, it was deemed suitable for TMDL development scenarios. The magnitude of the Link River flow is significant. And because Link River is fairly steep, flow velocities into Lake Ewauna are relatively high. If backwater flow exists, it would not have a significant effect on the nutrient budget downstream.
- The OM in the boundary conditions is lumped (and thus not partitioned between labile and refractory components) due to lack of sufficient data for accurate OM partitioning.
- Denitrification in the riverine sections is not simulated due to the fact that the majority of the river bed is rocky and DO in the water column is high. Neither of these conditions are favorable for denitrification bacteria and corresponding denitrification processes. This assumption may potentially cause overprediction of NO_2/NO_3 in the riverine sections, however the impact is expected to be minimal.
- The sand bar opening at the mouth of the Klamath Estuary has relatively constant dimensions and physical characteristics for a period of time; thus, a fixed grid configuration can be used for a simulation.
- The impact of sediment transport and siltation on channel geometry is not significant; therefore, the same bathymetric configuration can be used for different scenario simulations. Additionally, insufficient data are available to dynamically simulate the time-dependent effect of sediment transport on bathymetry.

2.4.2 Limitations

Potential limitations that have been identified include the following:

- The model's capabilities are constrained by the limited availability and quality of monitoring data. This is particularly the case for boundary conditions to the model, but it is also the case for in-stream model calibration data. The Klamath River model is not expected to be able to mimic the exact timing and location of all water quality conditions. The model can be used to represent the overall water quality trends in response to external loading and internal system dynamics.
- While the multi-model framework might be efficient for calibration, it is also cumbersome in terms of data management and transfer between models. Additionally, because of differences in algorithms and state parameters for RMA, CE-QUAL-W2, and EFDC (e.g., for organic components), conversion of pollutant loads between models could result in slight inaccuracies.

- The model does not simulate multiple species of phytoplankton and periphyton. Therefore, this model is currently not suitable for evaluating competition among multiple species or evolution of the aquatic algal communities and their interaction with nutrients.
- Because of the lack of a direct linkage between OM loading and SOD and benthic nutrient flux, the model in its present stage cannot fully evaluate the long-term effect of load reductions on SOD.
- Neither zooplankton nor benthic animals are simulated in the model; therefore, there could be some uncertainty in the simulation of algal dynamics and nutrient cycling.
- In the estuarine portion of the model, the sand bar opening is fixed. Although this is a reasonable assumption, it can introduce uncertainty in simulating the dynamic features of the system, particularly over an extended period of time.
- Because of a lack of data and the seasonal variability in sand bar location, it is infeasible to configure a long-term simulation model for the estuary. Therefore, the sediment diagenesis model is not activated in EFDC for predicting the sediment-water interaction.
- Algae are represented as one lumped state variable, thus interspecies differences are not simulated. The nitrogen fixing process was not explicitly represented in the model. In general, nitrogen concentrations are high in the water column. Under these circumstances, N-fixing algae tend to uptake dissolved nitrogen directly from the water column as opposed to the air since nitrogen fixation is a highly energy-demanding process.
- Denitrification is not included in the riverine models. This might result in slight overprediction of nitrogen in the water column.
- Some fine scale nutrient patterns might not be accurately represented due to limitations in model formulations related to nutrient-periphyton interaction. RMA-11, for example, assumes periphyton uptakes only inorganic nitrogen and phosphorus and releases only organic nitrogen and phosphorus through respiration. In reality, both the uptake and release processes may involve both the inorganic and organic forms.
- OM for boundary conditions is not partitioned between labile and refractory forms. Therefore, detailed kinetic variability related to OM decay is not fully represented in the reservoirs.

2.4.3 Sources of Uncertainty

As with virtually every hydrodynamic and water quality model, uncertainty is present with regard to various aspects of the Klamath River Model. These uncertainties were minimized to the extent possible in this effort, and thus the model reproduces general trends in the observed data both temporally and spatially. Further reduction of uncertainty is possible through collection of more systematic and accurate data within and external to the system and a more in-depth scientific understanding of the physical, chemical, and biological processes occurring in this unique system.

Some of the major sources of uncertainty include the following:

- *Uncertainty Associated with Boundary Conditions.* Boundary conditions for the Klamath River Model include time series flow, temperature, water quality, and atmospheric conditions. They provide the driving force for the hydrodynamic and water quality simulations. Therefore, accurate definition of boundary conditions is critical to reducing uncertainty. In developing the Klamath River Model, boundary conditions were defined using available monitoring data or were derived using different techniques (e.g., interpolation). Unfortunately, data are not available for all boundary conditions, and where data are available, they generally do not represent high temporal resolution (i.e., every point in time). Although techniques such as interpolation are a reasonable way to represent general trends in a system, precise prediction of water quality at every single point in time and every location is not possible.

- *Uncertainty in Spatial Representation.* The governing partial differential equations of hydrodynamic and water quality models are solved using the finite difference method (FDM) in CE-QUAL-W2 and finite element method (FEM) in RMA-2 and RMA-11. For both FDM and FEM, the waterbodies need to be discretized into different computational cells or nodes on the basis of topographical data. The accuracy in representing the true bathymetry of a waterbody has a significant effect on model performance. Thus, any uncertainty associated with the data sets used to discretize the waterbodies in the Klamath River has a direct effect on the model's predictive capabilities. Additionally, all the impoundments are represented using a laterally averaged system. This inherently assumes that lateral variability is insignificant, though this might not be the case. Also, all rivers are represented in a single, longitudinal dimension.
- *Uncertainty in Process Representation.* Water quality prediction for the Klamath River involves representing numerous dynamic interactions (including many physical, chemical, and biological processes). Mathematical models offer a simplified representation of these processes. Although the current state of knowledge with respect to fully understanding all the detailed interactions in the Klamath River is somewhat limited, the Klamath River modeling effort takes full advantage of all information amassed and understood to date. Major simplifications associated with the Klamath River Model that introduce uncertainty include representing the entire phytoplankton community as a single algae group, representing the entire periphyton community as a single periphyton group, representing SOD using a zero-order formulation, and representing OM with only four components based on solubility and degradability.
- *Uncertainty in Kinetic Structures.* Both CE-QUAL-W2 and RMA-11 represent major water quality decay and transformation with first-order kinetics. These kinetics are widely tested and accepted with regard to reasonably representing the dynamic interaction between water quality constituents. There is, however, uncertainty introduced in using these formulations because these processes are of higher order in reality.

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3.0 MODEL TESTING

Once the Klamath River model was configured, a calibration was performed at multiple locations throughout the system. Calibration refers to the adjustment or fine-tuning of modeling parameters to produce an adequate fit of the simulated output to the field observations. The sequence of calibration for the Klamath River model involved calibrating flow and water surface elevation first and then calibrating water quality using available monitoring data. Since the original PacifiCorp Model was already calibrated for hydrodynamics (see Section 3.2), this section of the report mainly focuses on the hydrodynamic calibration of the EFDC portion of the model and the water quality calibration of the entire model.

The upper Klamath River model (Model Segments 1 through 8) was calibrated using data from the year 2000. This year was selected for calibration because relatively good boundary condition data and in-stream data were available in the upper portion of the system (particularly for Lake Ewauna). Data were available, but not to the same extent, for the lower portion of the system (particularly downstream of Iron Gate Dam). Selection of this year was deemed appropriate because water quality conditions in the upper portion of the system drive the response downstream. To improve confidence in model predictions, the model was also corroborated (validated) using data from the year 2002 for Model Segments 1 through 5. Again, considerably more data were available for the upper portion of the system in 2002 than for other years. The estuarine portion (Model Segment 9) was calibrated using data from the year 2004, because bathymetric data and data for key water quality parameters were available. Water quality data were collected as part of an intensive monitoring effort. Insufficient data were available to calibrate for the year 2000 or 2002 in the estuarine portion of the Klamath River.

Hydrodynamic and water quality model calibration is typically guided by visual comparison between simulated and observed data and/or error statistics. Klamath River Model calibration was primarily guided by the former approach. Comparing time series plots of modeled versus observed data provides more insight into the nature of the system and is more useful, particularly for water quality calibration, than a statistical comparison. Trends in the observed data and cause-effect relationships between various parameters can be replicated with a model, although precise values at each and every point in time may not be. As long as the trends, relationships, and magnitudes are well-represented, and thus the underlying physics and kinetics are also being represented, a model can be confidently applied to scenario analysis, such as for TMDL development. Previous studies, such as Arhonditsis and Brett (2004), have indicated a reliance on visual comparison as opposed to error statistics for aquatic bio-chemical modeling. In the 153 papers surveyed by Arhonditsis and Brett during the 1992 to 2002 period, only 30% quantified error statistics while the majority (70%) relied only on visual comparison to evaluate model performance.

Although error statistics are often used in evaluating model calibration, they are not recommended for evaluating Klamath River Model reliability due to the following reasons: (1) Due to data gaps associated with configuring the modeling framework, it’s unrealistic to assume that the model will be able to precisely predict each and every condition. (2) Most of the available data for calibration were not continuous. Point data only permits comparison during a snapshot in time, and this snapshot is representative of only a single condition. Although multiple water quality data are available, they are not necessarily representative of all conditions (which are, in fact, simulated by the model because it is continuous). (3) Making a “point-by-point” comparison (i.e. a comparison of a water quality observation for a given date and time versus the modeled value for the same date and time) may result in poor statistical results, because the precise timing of all physical, chemical, and biological phenomenon are likely not perfect in a model. Although calibration was guided by visual analysis, error statistics were calculated. Mean Error (ME) and Absolute Mean Error (AME) were computed for several locations characterized by a relative abundance of monitoring data. These statistics are presented in Appendix E for Miller Island and Hwy 66, and Appendix H for Shovel Creek and Stateline.

Theoretically, model reliability can be improved by modeling a longer period of time. This is one reason the model was calibrated and corroborated for separate years (2000 and 2002, respectively). The ability to readily expand the time period modeled using the Klamath River model is severely limited by a number of factors. Boundary conditions for the Klamath River are quite variable over time, and insufficient monitoring data are available to fully characterize this variability. Additionally, the Klamath River is characterized by a very short retention time. As such, signals from major inflows have a significant impact on the in-stream water quality. Modeling multiple years therefore largely involves estimating/deriving/refining boundary conditions rather than adjusting internal model parameter values. Discrepancies between model predictions and observations may be due solely or primarily due to inaccurate boundary conditions as opposed to model settings. Model reliability was deemed sufficient based on the ability to represent the water quality trends and magnitudes for both the calibration and corroboration periods.

3.1 Monitoring Locations

The water quality monitoring stations with relevant data used for the 2000 model calibration are presented in Table 3-1, Figure 3-1, and Appendix C.

Table 3-1. Monitoring stations used for Klamath River model calibration (2000)

Station/Location	Site ID	Source
Klamath River at Miller Island boat ramp	KR24589/ KR24594	City of Klamath Falls/ODEQ/ USBR/PacifiCorp
Klamath River at Keno Bridge (Hwy 66)	KR23490	USBR/PacifiCorp/ODEQ
J.C. Boyle Reservoir at deepest point	KR22505	USBR/STORET/ODEQ/ BEAK
Klamath River u/s Shovel Creek	KR20642	NCRWQCB
Copco Lake near Copco	KR19874	USBR/STORET
Iron Gate Reservoir	KR19021	USBR/STORET
Klamath River below Iron Gate Dam	KR18952	USBR/STORET/SWAM/ KRIS/USGS
Klamath River above Shasta River	KR17608	USBR
Klamath River above Scott River	KR14260	USBR/USFWS
Klamath River near Seiad Valley	KR12858	USBR/STORET
Klamath River at Youngs Bar	KR04036	USBR
Upper Estuary	UE	NCRWQCB/Yurok Tribe
Middle Estuary	ME	NCRWQCB/Yurok Tribe
Lower Estuary	LE	NCRWQCB/Yurok Tribe

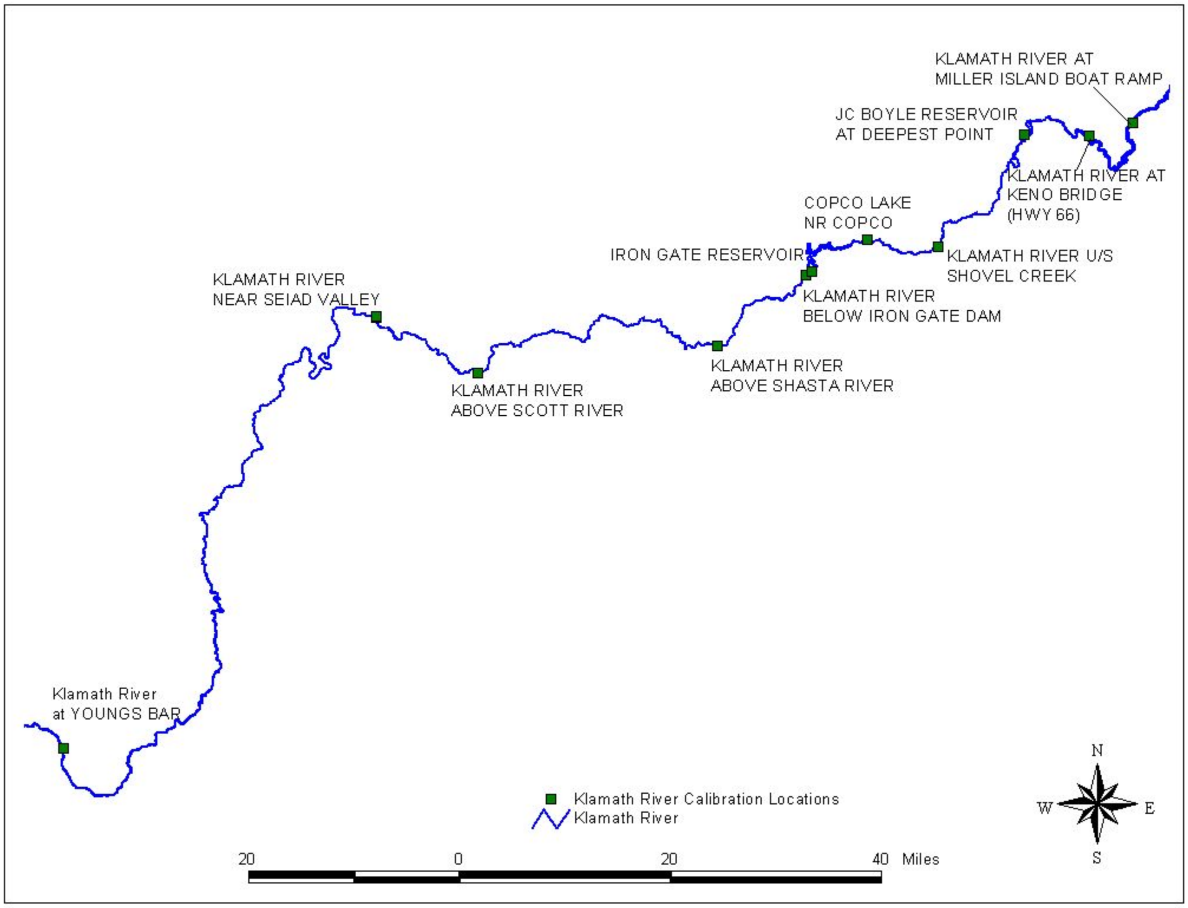

Figure 3-1. Calibration locations for Klamath River modeling (above the Klamath Estuary)

In 2002 data were collected at several additional stations in the upper portion of the river. Model results were therefore also evaluated at these stations (Table 3-2). Figure 3-2 shows the locations of the additional stations in the Lake Ewauna to Keno Dam modeling segment. Figure 3-3 shows the locations of the additional stations in the Keno Dam to J.C. Boyle modeling segment.

Table 3-2. Additional monitoring stations used for Klamath River model calibration (2002)

Station/Location	Site ID	Source
Lake Ewauna at Railroad Bridgespan	KR25173	City of Klamath Falls
Klamath River at South-Side Bypass Bridge	KR25079	City of Klamath Falls/ ODEQ/USBR/PacifiCorp
Lost River Diversion	LK	City of Klamath Falls/PacifiCorp
Klamath River at HWY 97 BR NE	KR24901	City of Klamath Falls
Klamath River below Boyle Dam	KR22129/KR22460	PacifiCorp
Klamath River u/s of Boyle Powerhouse Tailrace	KR22128	USFWS
Klamath River d/s of Boyle Powerhouse Tailrace	KR22127	ODEQ
J.C. Boyle Powerhouse Tailrace	BTR	USFWS
Klamath River near Stateline	KR20932	PacifiCorp/SWAMP

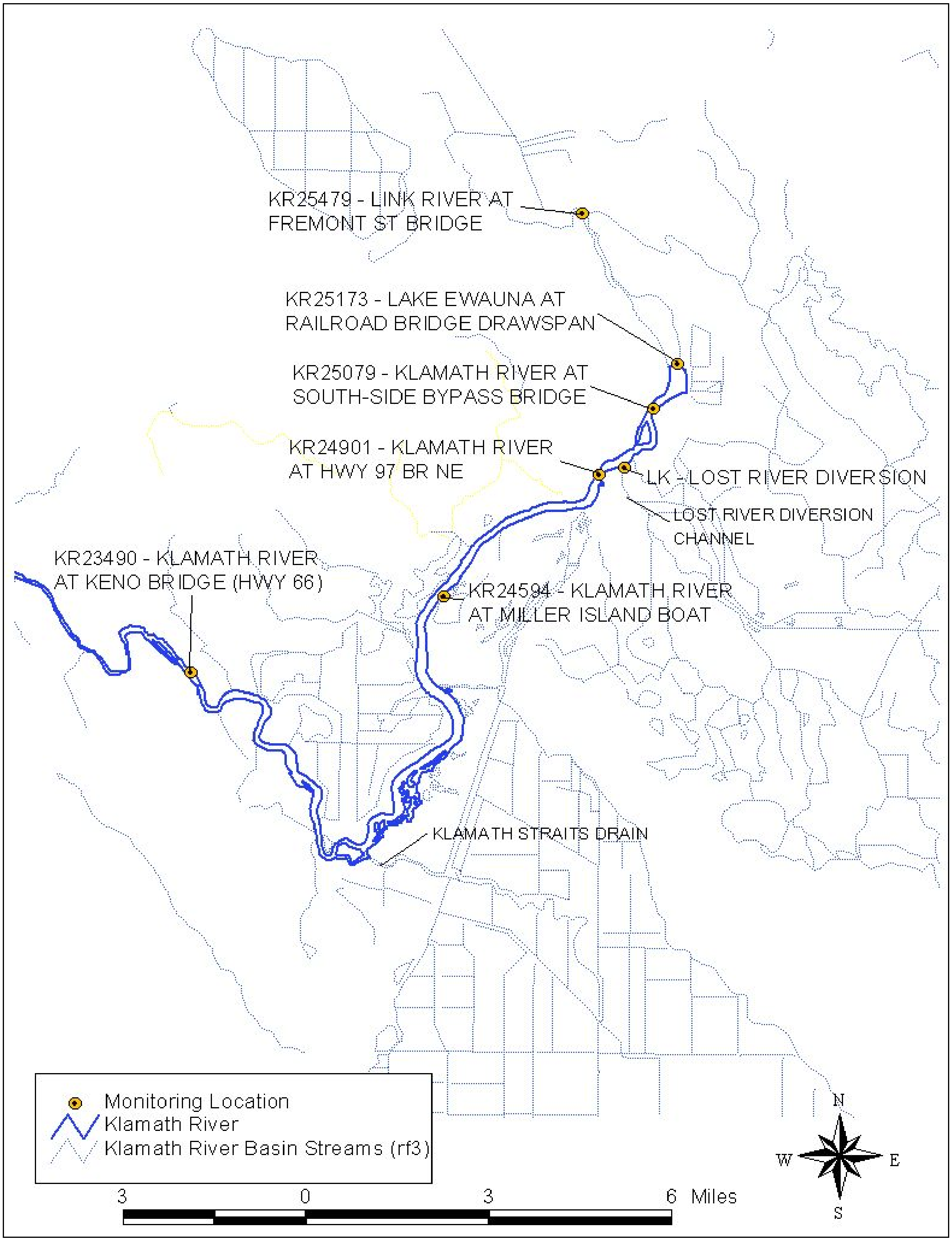

Figure 3-2. Additional calibration locations for Klamath River modeling—Lake Ewauna to Keno Dam modeling segment (2002)

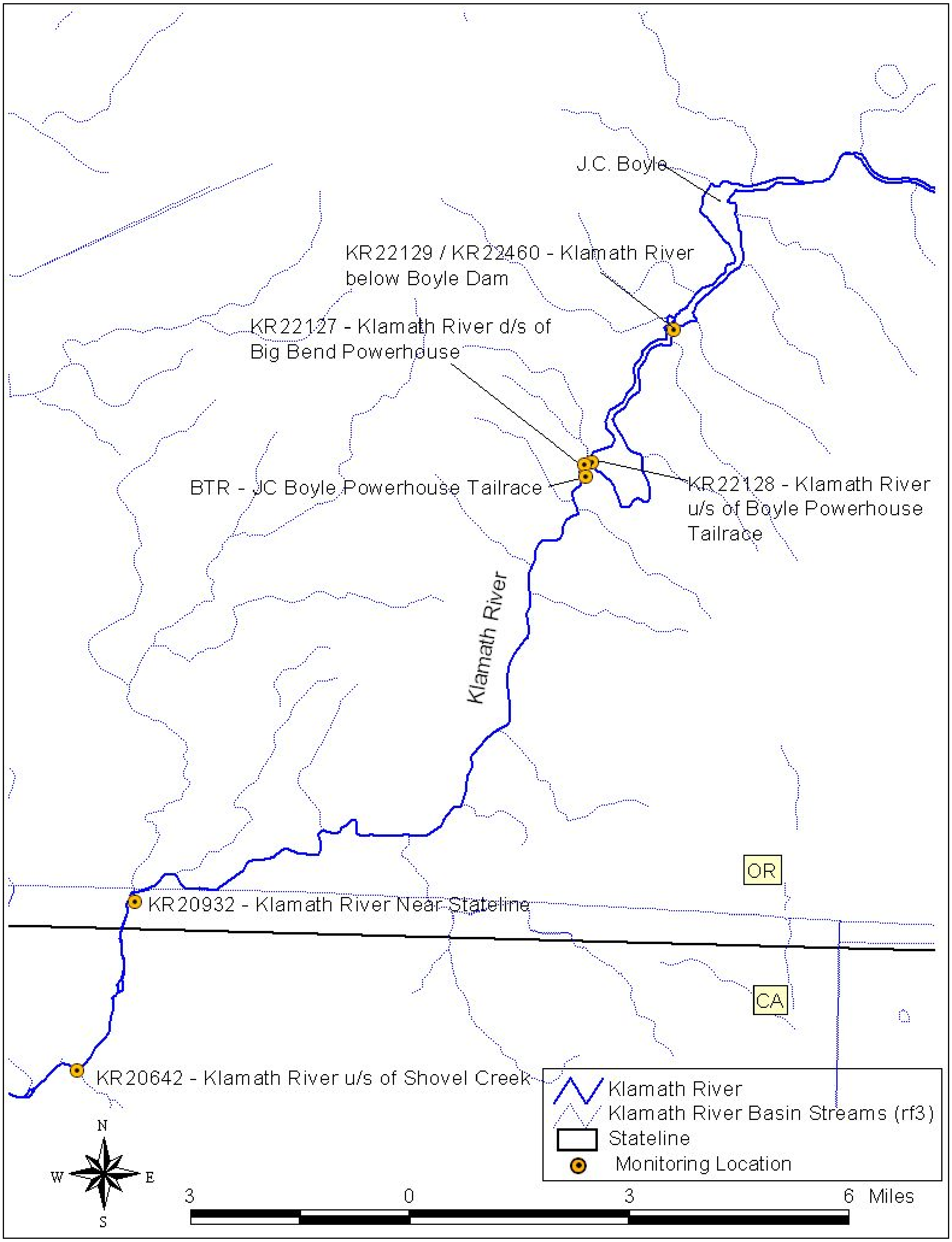

Figure 3-3. Additional calibration locations for Klamath River modeling—Keno Dam to J.C. Boyle modeling segment (2002)

3.2 Hydrodynamic Calibration

It was not necessary to perform additional hydrodynamic calibration for Klamath River Model Segments 1 through 8. The grid layout and hydrodynamic configuration and calibrations for the PacifiCorp Model were found to be reasonable, and no better information is available to further refine this component of the model. Therefore, there has been no additional effort to further refine the hydrodynamic model. Hydrodynamic calibration results (for temperature) are presented in Appendices E through K for Lake Ewauna through Turwar.

Hydrodynamic results for temperature and salinity in the estuarine portion of the Klamath River (Model Segment 9) are presented in Appendix L (Figures L-1 through L-6). Temperature and salinity sonde data collected at the surface and bottom were compared to model output for three separate locations. In general, the temperature calibration followed the observed data trend fairly well with the model underpredicting slightly at the Upper Estuary site. The model was able to simulate lower temperatures at the bottom and higher temperatures at the surface in the lower estuary where salinity and temperature stratification exist. It was able to capture the magnitude of peaks and trends and the spatial variability of salinity fairly well (i.e., high salinity at the Lower Estuary site and low salinity at the Upper Estuary site). Also, the model predicted high salinity at the bottom and lower salinity at the surface, which matches the observed salinity profile. The model also predicts significant temporal variability of salinity as a result of the complex interactions between upstream freshwater inflows and downstream tidal impact. Some disparity does exist between the simulated and observed salinity, and this can be explained by uncertainty in physical representation. For example, the exact dimensions of the sand bar opening for the simulated period are not known. Also, representation of downstream tidal characteristics is limited by available data. Overall, the model predicts the observed temperature and salinity trends and thus reasonably represents physical circulation and transport in the estuary.

3.3 Water Quality Calibration

The Klamath River modeling system was developed in a piecewise manner, where models for different sections of the river were linked by routing flow and constituent mass from upstream to downstream. The water quality calibration process involved first calibrating the upstream waterbodies and then using the resulting flow and predicted concentration time series (together with the watershed and other tributary inputs) to drive the downstream waterbody simulations.

Calibration of the water quality model was implemented by fine-tuning major kinetic parameters such as algal growth rate, death rate, nitrification/denitrification rates, OM decay rates, and SOD rates. The calibration process started with the existing PacifiCorp Model and continued with fine-tuning of parameter values after the major boundary conditions were set. This entailed comparison of model predictions to monitoring data and iterative adjustment of parameter values. The overall goal was to most accurately match observed data while maintaining consistency among all the waterbodies. In the following sections, the water quality calibration results at each station and in each modeled segment are presented. The major calibrated parameters in the CE-QUAL-W2 models are presented in Tables 3-3 and 3-4, and those for the RMA-11 models are presented in Table 3-5. Because the water quality parameters in all the riverine sections are the same, they are not listed by modeling segment.

It should be noted that while most CE-QUAL-W2 parameters were consistent from one model segment to the next, those associated with algae dynamics and OM dynamics differed somewhat. The algae parameters include growth rate, respiration rate, and death rate and are used to characterize the algae communities in each lake. In different waterbodies, algae communities can consist of different algae species, and each of these species exhibits different characteristics.

Additionally, a single algae species can exhibit different characteristics in different waterbodies because of a variety of factors. Since the model represents a single, lumped algae species and represents only the impacts of temperature, light, and nutrients on algae, algae-related parameters differ from one waterbody to the next. Although these parameter values differ, they are all within the range of literature values.

The OM parameters differ among model segments in that the decay rates for labile particulate and dissolved OM are higher in the upstream modeling segments than in the lower segments. This is because all the OM from the boundary conditions is lumped together and represented using the labile OM slots. An average decay rate is used to reflect the characteristics of the OM. Because an average value is used, it can be taken to mean that a combination of both extremely labile OM and refractory OM are considered. The decay rate of the OM decreases in a downstream manner since the more labile OM fraction is lost faster than the less labile fraction

Table 3-3. Nutrient input parameters used in the CE-QUAL-W2 Models

Parameter	Description	Units	Lake Ewauna-Keno Dam (Model Segment 2)	J.C. Boyle Reservoir (Model Segment 4)	Copco Reservoir (Model Segment 6)	Iron Gate Reservoir (Model Segment 7)	Typical literature values[a]
PO4R	Sediment release rate of phosphorus	fraction of SOD	0.01	0.01	0.01	0.01	0.001 to 0.03
ORGP	Fraction of phosphorus in OM	--	0.0055	0.0055	0.0055	0.0055	0.005 to 0.011
ORGN	Fraction of nitrogen in OM	--	0.07	0.07	0.07	0.07	0.08
NO3DK	Nitrate decay rate	day^{-1}	0.1	0.1	0.1	0.1	0.05 to 0.15
NO3T1	Lower temperature for nitrate decay	^oC	5	5	5	5	5
NO3T2	Upper temperature for nitrate decay	^oC	25	25	25	25	25
NO3K1	Lower temperature rate multiplier for nitrate decay	--	0.1	0.1	0.1	0.1	0.1
NO3K2	Upper temperature rate multiplier for nitrate decay	--	0.99	0.99	0.99	0.99	0.99
NH4DK	Ammonium decay rate	day^{-1}	0.10	0.1	0.1	0.1	0.00 to 0.80
NH4R	Sediment release rate of ammonium	fraction of SOD	0.05	0.05	0.05	0.05	0.00 to 0.40
NH4T1	Lower temperature for ammonium decay	^oC	5	5	5	5	5
NH4T2	Upper temperature for ammonium decay	^oC	25	25	25	25	25
NH4K1	Lower temperature rate multiplier for ammonium decay	--	0.1	0.1	0.1	0.1	0.1
NH4K2	Upper temperature rate multiplier for ammonium decay	--	0.99	0.99	0.99	0.99	0.99

Parameter	Description	Units	Lake Ewauna-Keno Dam (Model Segment 2)	J.C. Boyle Reservoir (Model Segment 4)	Copco Reservoir (Model Segment 6)	Iron Gate Reservoir (Model Segment 7)	Typical literature values[a]
LDOMDK	LDOM decay rate	day^{-1}	0.20	0.15	0.10	0.05	0.01 to 0.63
RDOMDK	RDOM decay rate	day^{-1}	0.001	0.001	0.001	0.001	0.001
LPOMDK	LPOM decay rate	day^{-1}	0.20	0.15	0.10	0.05	0.001 to 0.11
RPOMDK	RPOM decay rate	day^{-1}	0.001	0.001	0.001	0.001	0.001
SOD	Sediment oxygen demand	gram $O_2/m^2/day$	3.0	1.4	1.4	1.1	0.1 to 5.8

[a] Literature values are from the CE-QUAL-W2 Users Manual which compiled data from a range of sources. The only exception is the stoichiometric coefficient, which was derived from Chapra 1997.

Table 3-4. Phytoplankton input parameters used in the CE-QUAL-W2 Models

Parameter	Description	Units	Lake Ewauna-Keno Dam (Model Segment 2)	J.C. Boyle Reservoir (Model Segment 4)	Copco Reservoir (Model Segment 6)	Iron Gate Reservoir (Model Segment 7)	Typical literature values[a]
AG	Growth rate	day^{-1}	2.3	1.2	1.2	1.2	0.2 to 9.0
AR	Dark respiration rate	day^{-1}	0.18	0.1	0.1	0.1	0.01 to 0.92
AE	Excretion rate	day^{-1}	0.05	0.05	0.02	0.02	0.01 to 0.044
AM	Mortality rate	day^{-1}	0.15	0.06	0.06	0.07	0.03 to 0.30
AS	Settling rate	day^{-1}	0.3	0.3	0.3	0.3	0.001 to 13.20
AHSP	Phosphorous half-saturation coefficient	$g.m^{-3}$	0.003	0.003	0.003	0.003	0.001 to 1.520
AHSN	Nitrogen half-saturation coefficient	$g.m^{-3}$	0.014	0.014	0.014	0.014	0.01 to 4.32
ASAT	Light saturation	$W.m^{-3}$	75	75	75	100	10 to 150
AT1	Lower temperature for minimum algal rates	^oC	5	5	5	5	N/A
AT2	Lower temperature for maximum algal rates	^oC	17	17	17	14	N/A
AT3	Upper temperature for minimum algal rates	^oC	35	35	35	35	N/A
AT4	Upper temperature for maximum algal rates	^oC	45	45	45	45	N/A
AK1	Lower temperature rate multiplier for minimum algal rates	--	0.1	0.1	0.1	0.1	N/A
AK2	Lower temperature rate multiplier for maximum algal rates	--	0.99	0.99	0.99	0.99	N/A
AK3	Upper temperature rate multiplier for	--	0.99	0.99	0.99	0.99	N/A

Parameter	Description	Units	Lake Ewauna-Keno Dam (Model Segment 2)	J.C. Boyle Reservoir (Model Segment 4)	Copco Reservoir (Model Segment 6)	Iron Gate Reservoir (Model Segment 7)	Typical literature values[a]
	minimum algal rates						
AK4	Upper temperature rate multiplier for maximum algal rates	--	0.1	0.1	0.1	0.1	N/A
ALGP	Phosphorus to biomass ratio	--	0.0055	0.0055	0.0055	0.0055	0.005 to 0.08
ALGN	Nitrogen to biomass ratio	--	0.07	0.07	0.07	0.07	0.08
ALGC	Carbon to biomass ratio	--	0.45	0.45	0.45	0.45	0.45

[a] Literature values are from the CE-QUAL-W2 Users Manual Cole and Wells (2003); which compiled data from a range of sources. The only exception is the stoichiometric coefficient, which includes information derived from Chapra 1997.

Table 3-5. Parameters used in the RMA-11 Models

Variable	Description, units	Value	Typical literature values
ALP0	Chl a to algal biomass conversion factor, phytoplankton, mg Chl_a to mg-A	67	22 to 220
ALP1	Fraction of algal biomass that is nitrogen, phytoplankton, mg-N/mg A	0.07	0.08
ALP2	Fraction of algal biomass that is phosphorous, phytoplankton, mg-P/mg A	0.0055	0.005 to 0.08
MUMAX	Maximum specific growth rate, phytoplankton, 1/d	1.00	0.2 to 9.0
RESP	Local respiration algae, phytoplankton, 1/d	0.18	0.01 to 0.92
MORT	Local mortality rate of algae, phytoplankton, 1/d	0.05	0.03 to 0.30
KLIGHT	Half saturation coefficient for light, phytoplankton, KJ m-2 s-1	0.10	N/A
PREFN	Preference factor for NH3-N, phytoplankton	0.60	N/A
ABLP0	Chl a to algal biomass conversion factor, bed algae, mg Chl_a to mg-A	67	22 to 220
BMUMAX	Maximum specific growth rate, bed algae, 1/d	1.15	0.45 to 2.0
BRESP	Local respiration rate of algae, bed algae, 1/d	0.20	N/A
BMORT	Local mortality rate of algae, bed algae, 1/d	0.20	N/A
KBLIGHT	Half-saturation coefficient for light, bed algae, KJ m-2 s-1	0.05	N/a
PBREFN	Preference factor for NH3-N, bed algae	0.75	N/A

Variable	Description, units	Value	Typical literature values
BET1	Rate constant: biological oxidation NH3-N, 1/d	0.30	0.0 to 0.8
BET2	Rate constant: biological oxidation NO2-N, 1/d	0.50	N/A
BET3	Rate constant: hydrolysis OM to NH3-N, 1/d	0.20	0.001 to 0.63
KNITR	Michaelis-Menton half saturation constant: nitrogen, phytoplankton, mg/l	0.014	0.01 to 4.32
KPHOS	Michaelis-Menton half saturation constant: phosphorous, phytoplankton, mg/l	0.003	0.001 to 1.52
KBNITR	Half-saturation coefficient for nitrogen, bed algae, mg/lFraction of algal biomass that is phosphorus, bed algae, mg/l	0.014	N/A
KBPHOS	Half-saturation coefficient for phosphorus, bed algae, mg/lHalf-saturation coefficient for nitrogen, bed algae, mg/l	0.003	N/A
Peri_Carry	Carrying capacity half-saturation for periphyton (mg/m^2)	94.0	N/A
ALP3	Rate O2 production per unit of algal photosynthesis, phytoplankton, mg-O/mg-AHalf-saturation coefficient for phosphorus, bed algae, mg/l	1.40	1.40
ALP4	Rate O2 uptake per unit of algae respired, phytoplankton, mg-O/mg-ARate O2 production per unit of algal photosynthesis, phytoplankton, mg-O/mg-A	1.4	1.4
ALP5	Rate O2 uptake per unit NH3-N oxidation, mg-O/mg-NRate O2 uptake per unit of algae respired, bed algae, mg-O/mg-A	3.43	3.43

3.3.1 Link River (Model Segment 1)

Link River is a short, 1.31 mile segment that is characterized by a steep slope and rapid flow. With an average flow velocity at the end of Link River equivalent to approximately 0.9 m/s, it takes less than an hour for water to flow from Link Dam to Lake Ewauna (the next downstream segment). In this short time frame, significant water quality variation is not expected to occur. Model simulation results demonstrate this characteristic and show that the segment’s outflow water quality is nearly the same as the inflow conditions.

The Link River model was developed on the basis of the RMA-11 modeling framework. In the original PacifiCorp Model, nine water column constituents and one benthic constituent were simulated. The nine water column constituents include an arbitrary constituent, BOD, DO, OM, NH_4, NO_2/NO_3, PO_4, phytoplankton, and temperature. The benthic constituent is used to simulate benthic algae such as periphyton. In this system configuration, the simultaneous representation of the BOD and OM provide some redundancy because BOD essentially is a surrogate for OM. Therefore, BOD and OM were combined into one constituent (see Section 2.2.1).

The model was run for the period from January 1, 2000, to December 31, 2000 for the 2000 calibration run. I It was also run from January 1, 2002 to December 31, 2002 for the corroboration run. No data were available to calibrate the model for the reach.

3.3.2 Lake Ewauna-Keno Dam (Model Segment 2)

The Lake Ewauna segment was developed on the basis of the CE-QUAL-W2 modeling framework. In the original PacifiCorp Model, 18 water column constituents were simulated, which included four OM components and one BOD component. In the present study, BOD was eliminated from the active constituent list in the model input data file (see Section 2.2.1).

In the calibration run, the model was run for the period from January 1, 2000, to December 31, 2000. The model output was compared to observations at two water quality stations in Lake Ewauna: Klamath River at Miller Island boat ramp and Klamath River at Keno bridge (Hwy 66). As shown in Figures E-1 through E-16 in Appendix E, the model reproduced the observed water quality pattern reasonably well. The final calibrated parameters for Lake Ewauna are presented in Tables 3-3 and 3-4.

The model reproduces the supersaturation of DO in June well, as well as the extended anoxic period in July. The DO data show strong diurnal fluctuation and supersaturation conditions during May, however, it seems to contradict the phytoplankton data. Phytoplankton data exhibit low chlorophyll *a* concentrations during this period, and these concentrations are insufficient to generate the supersaturated DO concentrations observed in the water column. Since the May chlorophyll *a* data correspond with algae levels in UKL, it was assumed that the DO concentrations in May are not entirely reliable. Therefore, no attempt was made to reproduce the supersaturation in May. The model also was able to reproduce DO recovery in early August and the subsequent dip in late August and through September. It is worth noting that the data show low DO in late fall and winter while the model simulates relatively high DO concentrations. During this period, water temperature dropped rapidly, and algae and OM loading from UKL decreased. One would expect that these monitored phenomena would result in DO recovery from the summer anoxic conditions (as predicted by the model). Lake Ewauna, however, is a unique system that is highly dynamic and subject to tremendous OM loading from UKL. The lake also experiences an extended period of summer hypoxic/anoxic conditions which result in quick removal of algae and generation of extra OM. Therefore, it is highly likely that the lake’s late fall and winter DO concentrations do not respond similarly to most other impoundments.

One possible cause might be that the extremely high organic loading from both UKL and algae death during the summer result in a tremendous amount of OM being settled into the sediment layer during the summer (forming a highly enriched bed). During late fall and winter, even though OM and algae loadings cease, this highly enriched bed may provide significant oxygen consumption potential (preventing high DO concentrations). This could be the ultimate cause of the observed low DO during the late fall and winter. Without a predictive sediment diagenesis module, however, the existing CE-QUAL-W2 model is not capable of fully representing the dynamic interaction and feedback between the sediment and water column. This limitation is not expected to impact TMDL determination, because the critical, anoxic period occurs during the summer.

The predicted phytoplankton biomass matches the observed trends very well, especially the decline during the summer anoxic period and the difference in magnitude between Miller Island

and Hwy 66. The model does overpredict chlorophyll *a* during the month of June at both Miller Island and Hwy 66 due to the lack of temporally variable data in UKL to set the boundary condition. The boundary condition data for UKL shows a chlorophyll *a* peak during June, and this is transported quickly downstream, resulting in the peak in June at Miller Island and Hwy 66. In general, the model also predicts nutrients well, except for timing in some situations. This is likely because of limitations surrounding the definition of boundary conditions (i.e., the use of limited data to derive the boundaries). The model was able to predict relatively high NH_4 and PO_4 concentrations during the anoxic period likely due to a combination of multiple water quality processes including upstream and tributary loading, OM decay, algae die-off, and release from sediment.

It should be noted that simulated NO_2/NO_3 is relatively low compared with the observed values. The accuracy of these data, however, is unknown. Measurements made by different agencies during this time period were found to be significantly different (approximately an order of magnitude). It is suspected that the high NO_2/NO_3 measurements are incorrect. During the summer anoxic period, nitrification, which is the source of NO_2/NO_3, is inhibited by the low DO concentration. NO_2/NO_3 levels are expected to be high only if an external source is supplying a significant amount. This, however, is not supported by currently available data. The model predicts the trends exhibited by the lower level NO_2/NO_3 measurements. The model results also show good agreement between the simulated and observed pH at the two locations, indicating a reasonable representation of the fate and transport of pH related constituents and their interactions.

The Lake Ewauna to Keno Dam model segment was further tested using monitoring data in 2002. In 2002 the city of Klamath Falls collected a significant amount of data in this reach. Data were collected at six monitoring stations, including Lake Ewauna at Railroad Bridge Drawspan (LERBD), Klamath River at South Side Bypass Bridge (KRSSBB), Klamath River at Hwy 97 (KR97), Klamath River at Lost River Diversion Channel (KRLRDC), Klamath River at Miller Island (KRMI), and Klamath River at Hwy 66 (KR66). The simulated temperature, nutrients, DO, and algae biomass are plotted against the observed data at these locations in Figures E-17 to E-57. The model reproduces the observed water quality conditions and trends well. A disparity between observed and modeled DO does exist between March and June. During this period, the model tends to underpredict DO. This suggests that the estimated OM boundary condition at Link River might be too high for this period and results in excessive deoxygenation potential in the water column. More representative monitoring data characterizing this boundary would improve the model predictions. Fortunately this time period is outside the critical summer months of July and August. Another observation is that the model tends to overpredict chlorophyll *a* during the month of June. This might be due to uncertainty in the upstream boundary condition as well as possible inter-year variability in water column kinetic characteristics that cannot be accounted for by using the same parameter values as in the 2000 calibration model. Despite this minor disparity between model results and data, the 2002 model represents the chlorophyll *a* trends well.

Model results from 2000 can also be used to determine the significance of nutrient limiting effects on algae growth. Figure E-62 presents the simulated nutrient limiting condition at Hwy66 in 2000. Due to the high incoming nutrient loading from UKL, as well as significant contributions from LRDC and KSD, nutrient limiting factors for both nitrogen and phosphorus are very high (>0.9). This indicates that algae growth is not limited by nutrient availability. If either nutrient group (i.e., phosphorus or nitrogen) showed a significant divergence from a value of 1.0, nutrient availability would be limiting algae growth. In the spring, it appears that nitrogen might be slightly more limiting than phosphorus.

3.3.3 Keno Dam to J.C. Boyle Reservoir (Model Segment 3)

The portion of the water quality model for Keno Reach was developed using the RMA-11 modeling framework. In the original PacifiCorp Model, nine water column constituents and one benthic constituent were simulated as in the Link River model. In this river segment, BOD and OM were combined to form a unified constituent as was done for the Link River model segment.

The model was run for the period from January 1, 2000, to December 31, 2000. No data were available to calibrate the model for the year 2000. Data were available for the year 2002 at a location downstream of Keno Dam. Figures F-1 through F-7 in Appendix F show the calibration results for the year 2002. The model reproduces the observed nutrients and pH well. The model results for DO also match the observed magnitudes and trends well. It does, however, predict a lower DO than the data show during the summer (Figure F-2). One reason might be that the model is not representing sufficient reaeration downstream of the dam. This would result in slower recovery from the low DO conditions seen upstream of the dam. It should also be noted that only one monitoring point is available during this extended time period. A single DO sample is insufficient to reflect the likely range of DO levels that would occur over a day and throughout this critical time period.

3.3.4 J.C. Boyle Reservoir (Model Segment 4)

The J.C. Boyle Reservoir segment was developed using the CE-QUAL-W2 modeling framework. The model was run for the period from January 1, 2000, to December 21, 2000. The constituent configuration in this river segment is the same as the Lake Ewauna segment (Section 3.3.2).

For calibration, the model was run for the period from January 1, 2000, to December 31, 2000, and the simulated water quality is compared with observed profiles in the reservoir at water quality monitoring station J.C. Boyle Reservoir (at deepest point). Major parameters adjusted during the calibration process included algae growth rate, algae respiration rate, algae death rate, particulate OM settling velocity, OM decay rate, and suspended solids settling velocity. As shown in Figures G-1 through G-7 in Appendix G, the model reproduced the observed pattern reasonably well.

Although the model overpredicts NH_4 and NO_3 concentrations on some dates and underpredicts them on other dates, it predicts concentrations within the range of observed data. These differences are caused by uncertainty in boundary conditions. To more accurately represent such fine-scale variability (both temporally and on a depth basis), higher resolution data (i.e., temporally and spatially) are necessary to configure boundary conditions representing major tributaries and inflows. The final calibrated parameters for J.C. Boyle Reservoir are presented in Tables 3-3 and 3-4.

The J.C. Boyle model was further tested using the 2002 data. Only three constituents are available for 2002: temperature, pH, and DO. Model predictions for these constituents follow the overall trends well and suggest a reasonable calibration (Figures G-8 through G-10 in Appendix G).

3.3.5 Bypass/Full Flow Reach (Model Segment 5)

The Bypass/Full Flow Reach segment was developed using the RMA-11 modeling framework. In the original PacifiCorp Model, nine water column constituents and one benthic constituent were simulated as in the Link River model. In this study, BOD and OM are combined to form a unified constituent as was done for Link River model (see Section 2.2.1).

For calibration, the model was run for the period from January 1, 2000, to December 31, 2000. Data for temperature, nutrients, DO, Alkalinity, and pH were available to calibrate the model. Figures H-26 through H-33 in Appendix H show the comparison of model results versus observed data for the Klamath River upstream of Shovel Creek. The results indicate reasonable agreement between predictions and monitoring data. The overprediction of chlorophyll *a* during June is due to uncertainty in the UKL boundary condition. Similarly, the overprediction of NH4 during summer and fall can also be attributed to uncertainty in the upstream boundary conditions in Lake Ewauna. The model was further tested using data collected in 2002 and was run from January 1, 2002, through December 31, 2002. Figures H-34 through H-40 in Appendix H show the comparison of model results versus observed data for the Klamath River upstream of Shovel Creek.

In 2002 data were collected at more locations, including at the Klamath River downstream of J.C. Boyle Dam (KRJCB) (but upstream of the J.C. Boyle Powerhouse), Klamath River upstream of J.C. Boyle Powerhouse Tailrace (KRUPT), Klamath River downstream of Big Bend Powerhouse (KRBP), Klamath River at J.C. Boyle Powerhouse Tailrace (KRPT), and Klamath River near Stateline (KRS). The sampled constituents include temperature, DO, pH, and nutrients. The predicted results are plotted against the data in Appendix H (Figures H-1 to H-25).

As shown, the model accurately reproduces the general trends and magnitudes observed in the data. There are, however, some discrepancies between model results and data at various locations and times. For example, Figure H-1 shows that although the model has reproduced the seasonal variability and peaks of temperature downstream of J.C. Boyle, it underpredicts the diurnal fluctuation. This discrepancy may be due to local conditions not entirely captured by the model. Data collection could have occurred in a shallow region that exhibits a wider range of temperature variability while the model segment represents laterally and vertically averaged. This particular location is almost immediately downstream of J.C. Boyle, and thus a significant amount of water is always discharged from the dam (greater than 100 cfs). Under these conditions, the average temperature in this segment should be primarily controlled by the discharge temperature from the dam. The model reflects this condition while the data could actually represent a highly localized condition. The discrepancy between model results and DO data in Figure H-2 is likely also caused by this same condition. Figures H-7 and H-10 show that the model slightly overpredicts and underpredicts, respectively, the observed temperatures. This is likely due to differences between the modeled spring water flow and temperature and actual conditions in these portions of the river data. For example, the model represents the spring discharge in this area as three discrete tributaries with constant flow rates and temperatures. In reality, the spring discharge can be variable in quantity as well as temperature. The model's overprediction of chlorophyll *a* in Figure H-17 is likely caused by the overprediction of chlorophyll *a* in Lake Ewauna during the early summer, which propagate to this location in the system.

Neither nitrogen nor phosphorus appears to significantly limit algae growth in this portion of the river. Figure H-41 presents the simulated nutrient limiting factors on periphyton growth for both nutrient classes during 2000, at Stateline. Neither nutrient class diverges significantly from a value of 1.0. As with the Hwy66 location, nitrogen appears to be slightly more limiting than phosphorus in the spring.

3.3.6 Copco Reservoir (Model Segment 6)

The water quality model for Copco Reservoir was developed on the basis of the CE-QUAL-W2 modeling framework. The water quality constituent configuration in this segment is the same as for the Lake Ewauna segment.

The model was run for the period from January 1, 2000, to December 31, 2000. The simulated water quality output was compared with the observed profile data in the reservoir at water quality station Copco Lake near Copco. Key parameters that were changed through this calibration process include algae growth rate (AG), particulate organic matter settling velocity (POMS), labile dissolved organic matter decay rate (LDOMDK), and labile particulate organic matter decay rate (LPOMDK).

The final calibrated parameters for Copco Reservoir are presented in Tables 3-3 and 3-4. The model results are plotted against observed data at water quality station Copco Lake near Copco in Figures I-1 through I-7 in Appendix I. The model matched the monitoring data reasonably well. It overpredicts NH_4 and NO_3 concentrations on some dates and underpredicts them on other dates for Copco Reservoir. In general, however, it predicts concentrations within the range of observed data. Differences are likely caused by uncertainty in boundary conditions from limited data availability.

3.3.7 Iron Gate Reservoir (Model Segment 7)

The model was run for the period from January 1, 2000, to December 21, 2000. The simulated water quality output was compared with the observed profile data in the reservoir at the water quality station in Iron Gate Reservoir (Figures J-1 through J-7 in Appendix J).

The Iron Gate Reservoir portion of the model was updated using the new parameter values from Copco Reservoir. It was found that by changing the values of several kinetic parameters, including SOD, AG, LDOMDK, and LPOMDK (as shown in Table 3-3 and 3-4), the model was able to predict a reasonable water quality response for DO, phytoplankton, and nutrients. Additional parameters that were fine-tuned include sediment NH_4 release rate in proportion to SOD (NH4R), sediment PO_4 release rate in proportion to SOD (PO4R), algae death rate (AM). The detailed parameter values are listed in Tables 3-3 and 3-4. The model achieves a reasonable agreement with the data, indicating that the water quality dynamics in the reservoir are reasonably represented.

3.3.8 Iron Gate Dam to Turwar (Model Segment 8)

The water quality model for this segment was developed using the RMA-11 modeling framework, and the water quality constituent configuration is the same as for the upstream riverine RMA models.

The model was run for the period from January 1, 2000, to December 31, 2000. Data for only temperature and DO were available at five stations along this reach to calibrate the model. The five stations are the Klamath River downstream of Iron Gate Dam, Klamath River above Shasta

River, Klamath River above Scott River, Klamath River above Seiad Valley, and Klamath River at Youngs Bar. Model results are plotted against observed data in Appendix K. The model reproduces the observed temperature very well at these locations.

The model also reproduces DO concentrations. As noted earlier in this report, a scaling factor was introduced into the RMA-11 model to better represent reaeration just downstream of Iron Gate Dam. The scaling factor was determined through an inverse modeling process which involved estimating reaeration based on upstream and downstream DO concentrations. DO predictions further downstream generally also replicate monitoring data. The Klamath River is steep and is generally characterized by a large flow. This results in significant reaeration along the length of the river. Modeling results for this segment show that DO in the river increases to approximately saturation because of this reaeration effect. At monitoring locations farther downstream, e.g., above Seiad Valley and at Youngs Bar, data however do not show this expected trend. In fact, the model tends to overpredict DO. Observed DO can reach very low levels, e.g., 2.5 to 4.0 mg/L; however, the model tends to predict concentrations around 8.0 mg/L (close to saturation).

This disparity in results was investigated through a number of sensitivity analyses. The following adjustments to the model were made to determine their potential effect on in-stream DO concentrations:

- Tributary DO boundary conditions were reduced to 0.0 mg/L (for all incoming tributaries where monitoring data are available, except major rivers such as Shasta and Scott).
- SOD was increased to an extremely high value along the length of the river (to 5.0 g/m2/day). This represents a highly enriched substrate, although this is uncharacteristic of this region of the Klamath River.
- A very high OM concentration was set for all boundary conditions. The value used is equivalent to roughly 45.0 mg/L of CBOD.
- A series of different reaeration equations were used.

None of these adjustments was able to sufficiently lower the DO concentrations to the monitoring levels. It should also be noted that the low DO does not appear to be caused by biological activity (e.g., periphyton), based on the minimal observed diel DO fluctuation range. After running these sensitivity analyses, the quality of the DO monitoring data were further explored.

Upon further review, DO data for this time period were found to be inaccurate. The Klamath River Water Quality 2000 Monitoring Program—Project Report (Watercourse Engineering, Inc. 2003) indicated that biofouling of the DO membrane was an issue at nearly all monitoring locations (including the locations identified in this section for model calibration). Biofouling refers to the impact of biological activity on instrumentation, and it results in inaccurate DO measurements. It typically occurred within 24 to 96 hours of probe deployment and resulted in degradation (i.e., reduction) of DO concentrations. The extent of degradation in measurements is apparent from the DO monitoring data plotted in Appendix K. Sudden step increases of 2 to 3 mg/L occur multiple times over the course of the summer (e.g., beginning of August and September at the Youngs Bar station). These increases occur when a probe is removed, cleaned, and re-deployed. Subsequent to these increases, the DO concentrations again decline. Because of these inaccuracies, the model predictions should not (and do not) closely match the measured DO levels. The model predictions do tend to follow the trend in maximum DO concentrations measured for this period (where biofouling is not an issue).

In this stretch of the river, nutrient limitation is a more significant factor than at upstream locations. Figure K-26 suggests that nitrogen becomes a factor that can limit periphyton growth at Turwar during the late spring and summer. The limiting factor value for nitrogen falls to 0.4 while that for phosphorus remains close to 1.0. This significant divergence from 1.0 for nitrogen is more pronounced at this location than at Hwy66 or Stateline.

3.3.9 Klamath Estuary - Turwar to the Pacific Ocean (Model Segment 9)

EFDC was used to model this portion of the Klamath River. The simulated water quality output was compared with grab sample data and measured DO sonde data at three water quality stations in the lower, middle, and upper estuary for the year 2004 (Figures L-7 through L-9 in Appendix L).

Calibration data were available for 2004 because of an intensive monitoring effort conducted by the NCRWQCB and Yurok Tribe in June, July, August, and September. Data were collected as grab samples at the surface and bottom of the estuary for a suite of nutrients along with algae measurements and sonde data measurements for temperature, DO, and salinity. Continuous sonde data were collected each month for 4–5 days at the surface and bottom.

The water quality constituents evaluated for calibration include chlorophyll *a*, DO (surface and bottom), PO_4, NH_4, and NO_2/NO_3 at each of the three locations in the estuary. Although the grab sampling data provided a variety of data for calibration, all except one data point for PO_4, NH_4 and NO_2/NO_3 were reported as non-detects. It was noted that these samples were diluted, and that the reporting limit was raised on the basis of different dilutions (e.g., 5x, 10x and 20x) for different sampling days (because of matrix interference, possibly chloride). To consider this uncertainty in the data, error bars were provided in the calibration figures in Appendix L. These bars show the potential range of the laboratory measurements. The lower bound was estimated as half of the lowest report limit.

The water quality predictions follow the overall trends and magnitudes at the calibration locations fairly well. DO concentrations at the surface and bottom locations are replicated, and the model is able to predict low DO conditions during the summer period. The model also reproduces the observed diel fluctuation of DO in both the surface and bottom water. Since the model and observed data both show very low algae concentrations in the estuary, significant diel fluctuations of DO do not occur as a result of phytoplankton. Periphyton biomass, however, is predicted at high levels in the shallow regions of the estuary. This is likely a key contributor to diel DO fluctuation. Periphyton also influences diel fluctuation of nutrients. Table 3-6 presents the calibration parameter values for the EFDC model.

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Table 3-6. Calibrated parameter values for the Klamath Estuary

Parameter	Description	Value
PMc	Algae growth rate (1/day)	1.8
BMRc	Algae respiration rate (1/day)	0.1
PRRc	Algae mortality rate (1/day)	0.05
WSc	Algae settling velocity (m/day)	0.2
TMc1	Lower optimal temperature for algae growth (^oC)	20
TMc2	Upper optimal temperature for algae growth (^oC)	25
rNitM	Nitrification rate (1/day)	0.06
KLN	Minimum hydrolysis rate for LPON (1/day)	0.07
KDN	Minimum hydrolysis rate for LDON (1/day)	0.1
KLP	Minimum hydrolysis rate for LPOP (1/day)	0.07
KDP	Minimum hydrolysis rate for LDOP (1/day)	0.1
KLC	Minimum hydrolysis rate for LPOC (1/day)	0.07
KDC	Minimum hydrolysis rate for LDOC (1/day)	0.1
SOD	Sediment oxygen demand (g O_2/m^2/day)	2.0
FPO4	Benthic flux rate of PO4 (g/ m^2/day)	0.002
FNH4	Benthic flux rate of NH4 (g/m^2/day)	0.01
PMM	Periphyton growth rate (1/day)	1.5
BMRM	Periphyton respiration rate (1/day)	0.1
PRRM	Periphyton mortality rate (1/day)	0.05
TMM1	Lower optimal temperature for periphyton growth (^oC)	20
TMM2	Upper optimal temperature for periphyton growth (^oC)	25

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REFERENCES

Arhonditsis, G.B. and M.T. Brett. 2004. Evaluation of the current state of mechanistic aquatic biogeochemical modeling. *Marine Ecology Progress Series* 271: 13-26.

Baric, A., B. Grbec, G. Kuspilic, I. Marasovic, Z. Nincevic, and I. Grubelic. 2003. Mass Mortality Event in a Small Saline Lake (Lake Rogoznica) caused by Unusual Holomictic Conditions. *Scientia Marina* 67(2):129–141.

Cole, T.M. and S.A. Wells. 2003. *CE-QUAL-W2: A two-dimensional, laterally averaged, Hydrodynamic and Water Quality Model, Version 3.1*, Instruction Report EL-03-1, US Army Engineering and Research Development Center, Vicksburg, MS.

Chapra, S.C. 1997. *Surface Water-Quality Modeling*. McGraw-Hill, Inc., New York.

Deas, M. 2000. *Application of numerical water quality model in ecological assessment*. Ph.D. dissertation. University of California, Davis.

Flint, L.E. and Flint, A.L., 2008. A Basin-Scale Approach to Estimating Stream Temperatures of Tributaries to the Lower Klamath River, California. J Environ Qual 37:57-68.

McGlashan, H.D. and H.J. Dean. 1913. *Surface Water Supply of the United States 1913, Part XI, Pacific Slope Basins in California.* USGS Water Supply Paper 300. Washington: Government Printing Office.

National Research Council. 2004. *Endangered and Threatened Fishes in the Klamath Basin*. Committee on Endangered and Threatened Fishes in the Klamath River Basin, The National Academies Press, Washington, DC.

NCRWQCB. 2008. *Analysis of Klamath Tributary Data*. North Coast Regional Water Quality Control Board. July 2, 2008.

PacifiCorp. 2005. *Klamath River Water Quality Model Implementation, Calibration, and Validation.* Klamath Hydroelectric Project (FERC Project No. 2082) - Response to November 10, 2005, FERC AIR GN-2. December 16, 2005, FERC filing.

Park, K., A.Y. Kuo, J. Shen, and J.M. Hamrick. 1995. *A three-dimensional hydrodynamic-eutrophication model (HEM-3D): description of water quality and sediment process submodels*. Special Report in Applied Marine Science and Ocean Engineering No. 327. School of Marine Science Virginia Institute of Marine Science, College of William and Mary, January 1995.

Tetra Tech, Inc. 2004. *Data Review and Modeling Approach – Klamath and Lost Rivers TMDL Development*. Prepared for U.S. Environmental Protection Agency Region 10, U.S. Environmental Agency Region 9, Oregon Department of Environmental Quality, and North Coast Regional Water Quality Control Board.

Watercourse Engineering, Inc. 2003. *Klamath River Water Quality 2000 Monitoring Program - Project Report*. Prepared for U.S. Bureau of Reclamation with support from PacifiCorp. (January, 25, 2003).

Watercourse Engineering, Inc. 2004. *Klamath River Modeling Framework to Support the PacifiCorp Federal Energy Regulatory Commission Hydropower Relicensing Application* [DRAFT] Prepared for PacifiCorp (March 9, 2004).

APPENDIX 7

Modeling Scenarios

Klamath River Model for TMDL Development

December 2009

Prepared for:
U.S. Environmental Protection Agency Region 9
U.S. Environmental Protection Agency Region 10
North Coast Regional Water Quality Control Board
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Introduction

The approach, calibration results, and corroboration results for the Klamath River Model for TMDL development are described in "Model Configuration and Results - Klamath River Model for TMDL Development" (Tetra Tech, Inc., 2009). After the Klamath River Model was fully tested, it was applied to evaluate a series of scenarios to support TMDL development. This document summarizes how each scenario was configured, associated assumptions, and results. The simulated scenarios include:

- Natural conditions baseline scenario (T1BSR)
- Oregon allocation scenario (TOD2RN)
- California allocation scenario (TCD2RN)
- With-dams TMDL scenario (T4BSRN)

Natural Conditions Baseline Scenario (T1BSR)

The natural conditions baseline scenario (T1BSR) was run in order to estimate water quality conditions under natural conditions, because some water quality standards for both Oregon Department of Environmental Quality (ODEQ) and California North Coast Regional Water Quality Control Board (RWQCB) are based on natural conditions. T1BSR involved running a version of the Klamath River Model that includes no dams, with the exception of Link Dam at the upper boundary to the model. The Lake Ewauna portion of the system was modeled using CE-QUAL-W2 due to the historical presence of the Keno Reef. The portion of the system from Turwar to the Pacific Ocean was modeled using EFDC due to the tidal influence. And, the remainder of the river was modeled using RMA-2 and RMA-11. Table 1 presents the models applied for this scenario.

Table 1. Model components applied to each Klamath River segment

Modeling segment	Segment type	Model(s)	Dimensions
Link River	River	RMA-2/RMA-11	1-D
Lake Ewauna-Keno Reef	Reservoir	CE-QUAL-W2	2-D
Keno Reef to Turwar	River	RMA-2/RMA-11	1-D
Turwar to Pacific Ocean	Estuary	EFDC	3-D

The overall approach to T1BSR included setting boundary conditions at Upper Klamath Lake (UKL) based on the existing UKL Drainage TMDLs (ODEQ, 2002), removing point source inputs, keeping Lost River and Klamath Straits Drain flows but with water quality and temperature the same as at UKL, and assigning natural or TMDL conditions for tributaries (which vary by tributary). UKL flow was set to be the same as the calibrated Klamath River Model (Tetra Tech, Inc. 2009), but the water quality and temperature were based on 1995 UKL TMDL model conditions. 1995 represents the median condition occurring in UKL (based on implementation of the UKL TMDL). The boundary condition for pH analysis was set based on the alkalinity (ALK) in the Klamath River Model and the pH under the TMDL condition. The scenario was performed for the year 2000.

Assumptions and Configuration

The following list presents key assumptions associated with configuration of the T1BSR scenario:

- The phosphorus TMDL for UKL was used to configure the upstream boundary conditions for the Klamath River Model. The UKL Model output provided monthly average phosphorus values – total phosphorus (TP), algal P and non-algal P, as well as chlorophyll-a. The UKL model and Klamath River model use different ratios of chlorophyll-a to algal biomass. For the translation between the two models, algal biomass was conserved but not necessarily chlorophyll-a concentrations. Although the UKL TMDL was developed based on only TP, it is assumed that phosphorus reductions would also produce reductions in nitrogen (N) and carbon (C), because C, N, and P are tightly bound together as organic matter. Any management practice that reduces organic P is also expected to reduce organic C and N. Based on this assumption, the boundary conditions for Link River were derived as follows:
    - Average ratios for TN:TP, soluble reactive phosphorus (SRP):TP, nitrate-nitrite (NO3/2)-N:TN and ammonia (NH3)-N:TN were calculated based on Pelican Marina, UKL monitoring data, and were 11.895, 0.245, 0.027, and 0.253, respectively (with a sample size of 15).
    - Based on the non-algal P TMDL results and the above TN:TP ratio, non-algal TN was derived.
    - Based on the SRP:TP ratio, orthophosphorus (PO4) and Organic P concentrations were calculated using the non-algal P data.
    - Based on Organic P concentrations, the Organic Matter boundary conditions were calculated using a ratio of OM:OP=180.
    - Based on the NO3/2-N:TN ratio, the NO2/NO3 boundary conditions were derived.
    - Based on the ammonium (NH4):TN ratio, the NH4 boundary condition was derived.
    - The algae biomass was calculated from the UKL model algal P results. An algae-to-Algae P ratio of 180 was determined in the model calibration and is used here to derive the algae biomass.
    - Based on the temperature, saturated DO concentration was calculated and used as the boundary condition.
    - Under TMDL conditions, it was assumed that the majority of OM would likely exist as dissolved phase, therefore, the OM was partitioned such that 90% is dissolved and 10% is particulate (typical reported ratio for lakes as reported in Thurman 1985).
- All the point sources and derived accretion/depletion flows for flow balance in the existing model were removed. Over the course of the year, the accretion/depletion flows average to near zero, so they likely do not represent an ungaged groundwater input. On shorter time scales, the accretion flows can be significant enough to alter the instream concentrations depending on assumptions about their concentrations. Out of concern that the accretion flows might influence allocations to point and discrete nonpoint sources, they were removed in the scenarios.
- The downstream boundary condition was configured to represent the Keno Reef based on the rating curve information provided by the U.S. Bureau of Reclamation – Klamath Basin Area Office (USBR). The rating curve was derived by the USBR hydrologist using historical data:

  $$Q=101.265(H-1244.5)^2-15.030(H-1244.5)+12.35$$

  where Q is the flow rate over the Keno Reef (cms); H is the water surface elevation (m); and 1244.5 m is the Keno Reef datum.
- The flows from Lost River Diversion Channel (LRDC) and KSD were kept the same as in the Klamath River Model, while the water quality and temperature condition were set to be the same as at UKL. LRDC and KSD flows were kept the same as in the Klamath River Model to make it possible to evaluate dam impacts directly (i.e., by representing a similar flow condition between the with-dam and without-dam conditions).

- Other Oregon tributaries and accretions/depletions between Keno Dam and Iron Gate Dam were kept the same as in PacifiCorp's Without Project Facilities Model (PacifiCorp, 2005). The accretion/depletion (A/D) flows included in the model between Keno Dam and Iron Gate Dam were the A/D flow at Keno River, the three springs downstream of J.C. Boyle Reservoir, the A/D flow at the Peaking Reach, and the Jenny Creek A/D flow. For all these A/D flows except for the three springs, the water quality concentrations and temperatures were set equal to the mainstem concentrations. The concentrations of the three springs were not changed from the calibration. The flows were configured as time series in the hydrodynamic model input data file. Jenny Creek flow was updated from the PacifiCorp model using estimated natural A/D flow in the area.
- pH simulation was implemented by running the pH simulation module in the updated RMA-11 model.
- Below Iron Gate Dam, the boundary conditions for flow, temperature and nutrients were specified as shown in Table 2 and subsequently discussed.

Table 2. T1BSR Boundary Conditions for Flow, Temperature and Nutrients below Iron Gate

Stream(s)	Temperature	Flow	Nutrients
Trinity	0.5 deg C reduction from current conditions model depiction[1], June 1 to Oct 15, see Appendix A	2000 gauge records, see below	Unchanged from current conditions model depiction
Salmon	Unchanged from current conditions model depiction	Unchanged from current conditions model depiction	Unchanged from current conditions model depiction, see Appendix A
Scott	RWQCB estimation of natural temperature, see Appendix A	RWQCB estimation of natural flow, Appendix A	Unchanged from current conditions model depiction
Shasta	RWQCB estimation of natural temperature, see Appendix A	RWQCB estimation of natural flow, Appendix A	Calculated OM and NH4 based on nitrogenous biochemical oxygen demand (NBOD) TMDL; PO4 was based on NH4 data, and it resulted in a level lower than current conditions
Minor Tributaries	2.0 deg C reduction from Flints'[2] 2002 data, June 1 - Oct. 15	Unchanged from current conditions model depiction	Unchanged from current conditions model depiction

- For the Shasta River, nutrient concentrations were calculated based on TMDL results for NBOD from the 2002 Shasta River TMDL model. Since the RMA model requires OM, the NBOD was converted to OM based on stoichiometric ratios. The conversions used to extrapolate the OM from the NBOD are as follows:
    - Total Kjeldahl Nitrogen (TKN)/ON = 1.13; using existing data for Shasta (stations used SH00 - Shasta River at Mouth and SHUS - Shasta River at USGS Gage)

[1] The current conditions model depiction is the model calibration run for the year 2000, as reported in "Model Configuration and Results - Klamath River Model for TMDL Development" (Tetra Tech, Inc. 2009).
[2] Flint, L.E. and Flint, A.L., 2008

  - NBOD = 4.57 (TKN) (Chapra, 1997)
  - Convert NBOD to TKN
  - TKN=NBOD/4.57
  - Convert TKN to ON
  - ON = TKN/1.13
  - Convert ON to OM
  - OM = ON/0.07 (Cole and Wells, 2003)
  - Derive NH4 using
  - NH4=TKN-ON
  - PO4=3.22(NH4); based on existing data
  - NO3=1.333(NH4); based on existing data
- Sediment Oxygen Demand (SOD) for the section between Keno Dam and Turwar was set equal to that in the calibration model, which ranges from 1.0 to 1.5 gram O^2/m^2/day. For the reach from Link Dam to Keno Dam, the SOD was set based on the monitored value in Shasta River. The average SOD value of 1.42 gram O^2/m^2/day was used.
- All the kinetic parameters were set equal to the calibrated Klamath River Model riverine sections.
- The DO boundary conditions for the tributaries downstream of Iron Gate Dam was set based on the rules that 100% saturation values are used for all the minor tributaries and Trinity River, and 95% saturation for Shasta, Scott, and Salmon Rivers.

Model Simulation and Results

The T1BSR scenario was simulated in a piece-wise manner. The reach from Link to Keno was simulated first, and the output at the last node was used as the upstream boundary condition for the Keno to Iron Gate reach. Similarly, the output from the Keno to Iron Gate reach was used as the upstream boundary condition for the reach from Iron Gate to Turwar. Results for T1BSR are presented at 30 locations from UKL to the Lower Estuary (Figures 1 through 3).

1. Klamath Falls WWTP
2. South Suburban STP
3. Lost River Diversion Channel (LRDC) - Columbia Plywood
4. Miller Island
5. Klamath Straits Drain (KSD)
6. Keno Bridge (Hwy 66)
7. Keno Dam
8. Keno Dam Downstream USGS site
9. J. C. Boyle Dam Downstream
10. Oregon/California State Line
11. Copco Dam Downstream
12. Iron Gate Dam Upstream
13. Iron Gate Dam Downstream
14. Shasta Upstream
15. Shasta Downstream
16. Scott Upstream
17. Scott Downstream
18. Seiad Valley
19. Indian Upstream
20. Indian Downstream
21. Salmon Upstream

22. Salmon Downstream
23. Hoopa
24. Trinity Upstream
25. Trinity Downstream
26. Youngsbar
27. Turwar
28. Upper Estuary
29. Middle Estuary
30. Lower Estuary

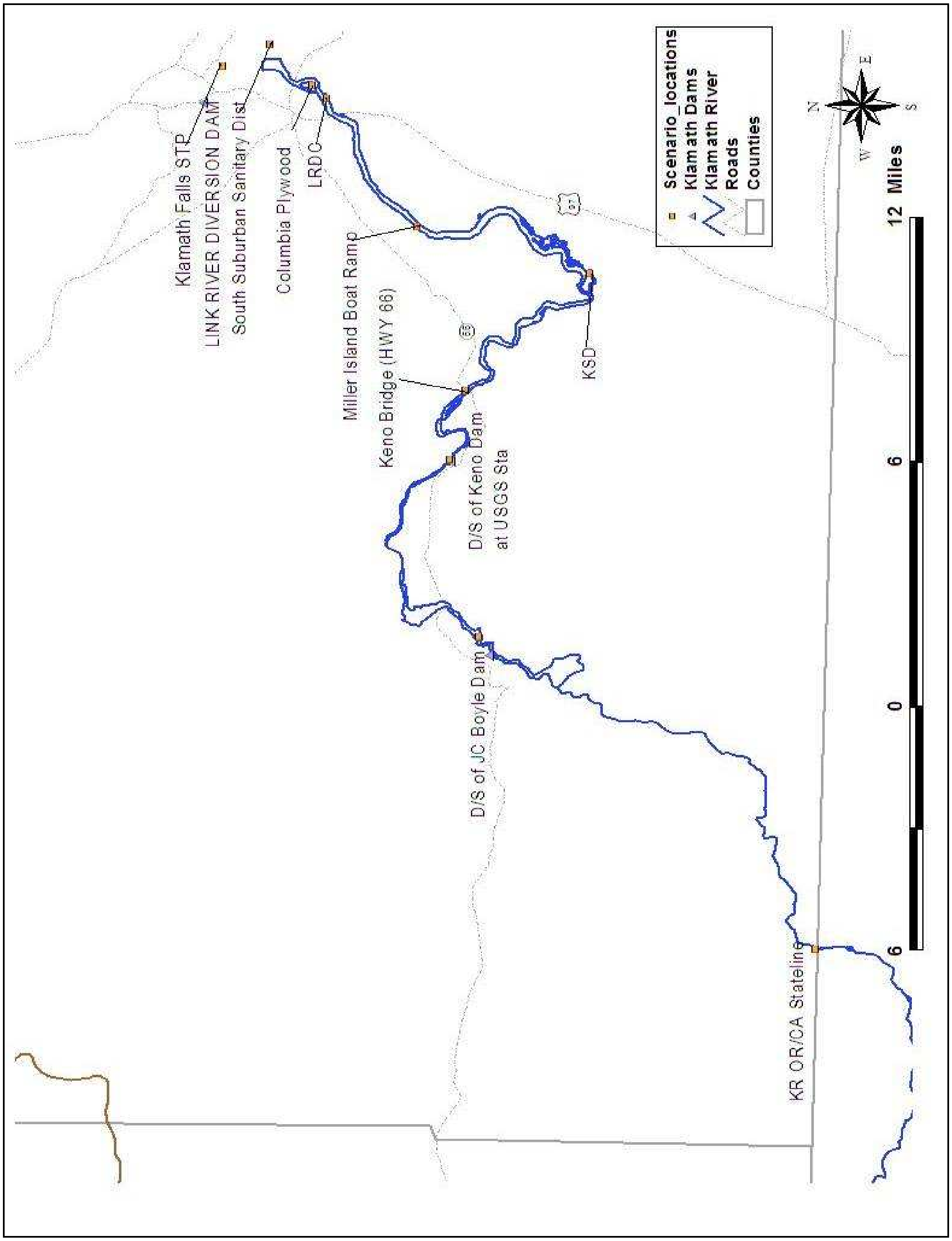


Figure 1. Model Output Locations from Link Dam to Stateline

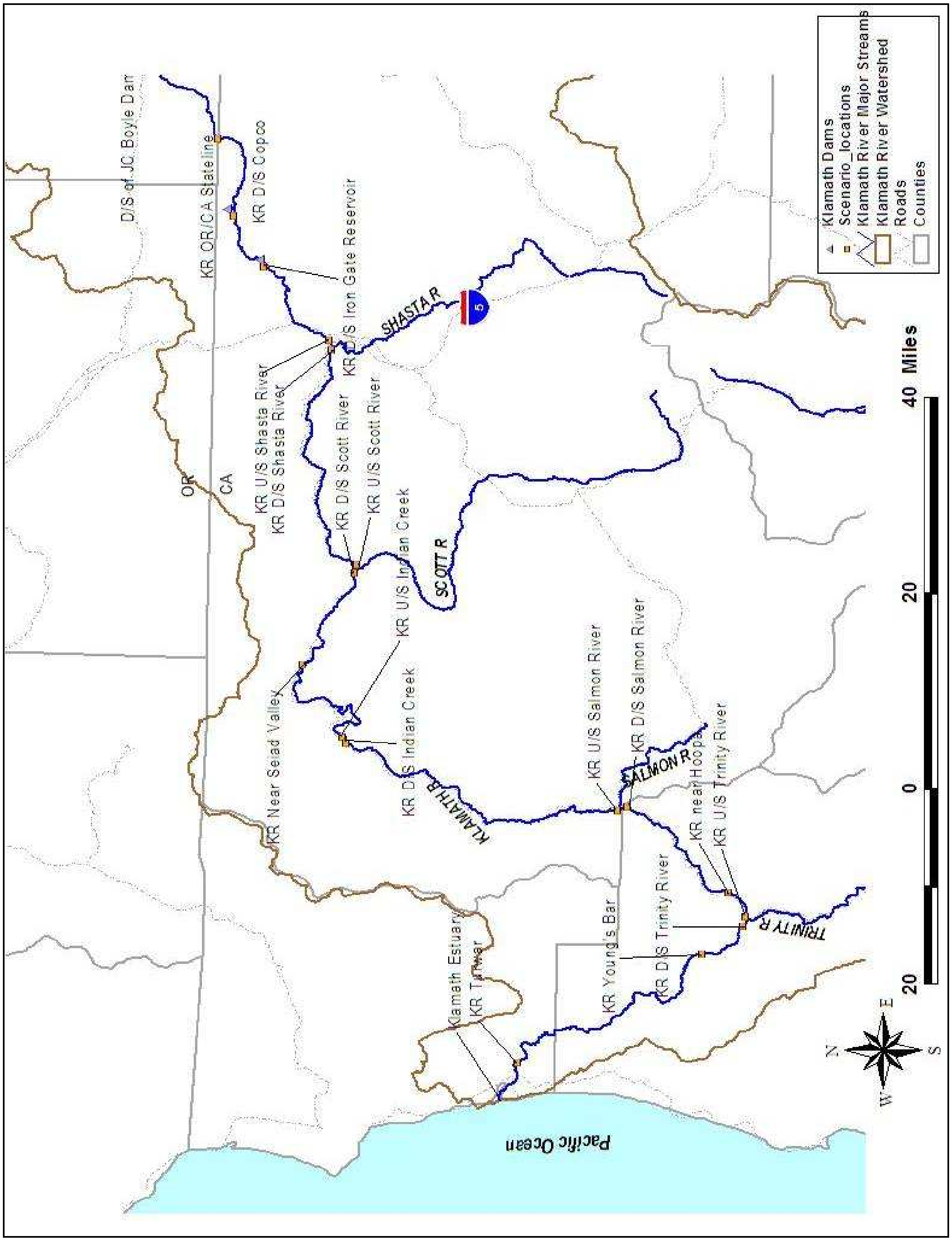


Figure 2. Model Output Locations from Stateline to Turwar

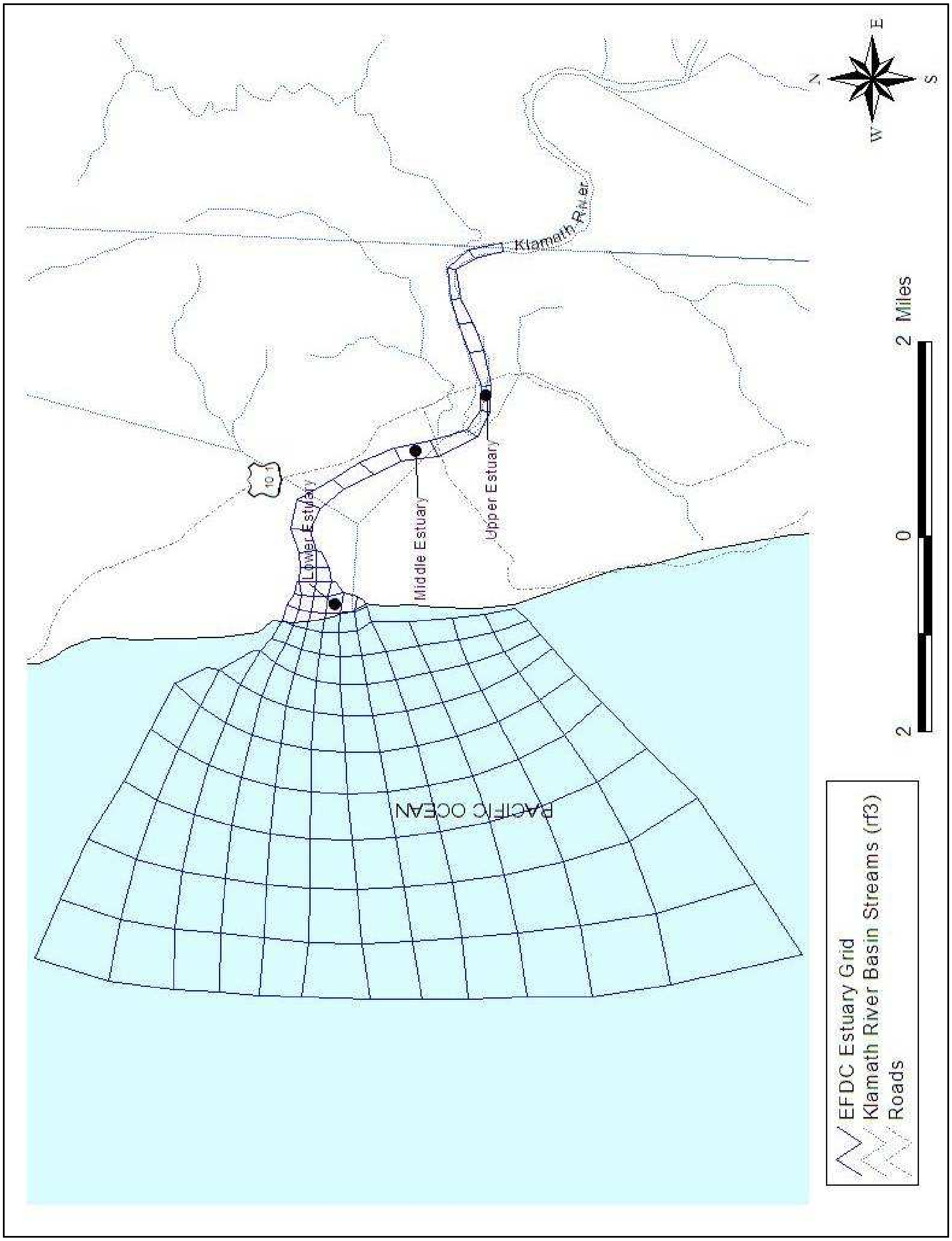


Figure 3. Model Output Locations in the Klamath Estuary

Appendix B shows the simulation results at the 30 locations from Link Dam to the Lower Estuary. Results are plotted together with the results of TOD2RN/TCD2RN, which are described below. Some general observations about the T1BSR results include:

- The simulated DO is higher than the Oregon instantaneous DO criterion of 4.0 mg/L and 7-day DO criterion of 5.0 mg/L for all the upstream locations above Keno Dam due to the relatively low organic matter loading from UKL under the median TMDL condition. The 30-day minimum mean DO criterion of 6.5 mg/L is slightly violated at downstream locations such as at the KSD and Hwy 66, and Keno Dam stations. Downstream of Keno Dam, the Oregon 30-day DO criterion of 8.0 mg/L is violated at all locations, while the instantaneous DO criterion of 6.0 mg/L is not violated at any locations. As for the 7-day DO criterion of 6.5 mg/L, it is only slightly violated at the upstream locations. DO tends to deteriorate with distance for the reach from Link Dam to Keno Dam, but this trend reverses for the reach from Keno Dam to Stateline, due to the accelerated flow velocity downstream of Keno Dam.
- The simulated pH generally meets the Oregon criterion, i.e., within the range of 6.5 to 9.0. The simulated pH, however, violates the California criterion of 8.5 consistently from upstream to downstream. The model results demonstrate that the diurnal fluctuation induced by periphyton activity is the major contributor to the pH violation.
- The ammonia toxicity criteria are satisfied at all the Oregon locations. The overall satisfaction of the ammonia toxicity standards is due to the significantly reduced ammonia loading from UKL under the median TMDL condition.
- The chlorophyll-a criterion of 15.0μg/L is violated at all locations upstream of the station D/S of Scott River due to the high concentration in the UKL boundary condition. With more dilution from tributaries, along with loss from respiration, die-off, and settling, phytoplankton concentration meets the criterion at locations downstream of the Scott River.
- Results indicate noncompliance with the Hoopa numeric criteria for DO, including a 8.0 mg/L moving weekly average of daily minima and 11.0 mg/L moving weekly average of daily minima during the spawning period. In addition, T1BSR indicates noncompliance with the 90% DO saturation criteria during the following months: June, July, August, September and October. July through September represent significant noncompliance."
- Simulated periphyton growth shows significant spatial variability. The simulated periphyton density can be close to zero at some locations but very high at other locations. The major reason for this spatial variability is likely the differences in nutrient concentrations, water depth, organic matter concentrations and phytoplankton concentrations.

Oregon and California Allocation Scenarios (TOD2RN/TCD2RN)

The Oregon and California allocation scenarios TOD2RN and TCD2RN represent compliance with water quality criteria in Oregon and California, respectively. The results of TOD2RN were applied as inputs to TCD2RN; therefore these scenarios are described as a single scenario. TOD2RN/TCD2RN involved running the Klamath River Model with no dams (except for Link Dam), as described above, setting boundary conditions at UKL based on the existing UKL TMDL, including point source inputs, keeping Lost River and Klamath Straits Drain flows but with higher nutrient concentrations and the same DO and temperature as UKL, and assigning natural or TMDL conditions for tributaries (which vary by tributary). UKL flow was set to be the same as the current condition, but the water quality and temperature were based on that of the natural baseline scenario T1BSR. The boundary condition for pH analysis is also set to be the same as that of the T1BSR. The modeling analysis was performed for the year 2000.

Criteria Interpretation

The following criteria were used in the evaluation:

- The numeric criteria for the reach upstream of Keno Dam that were used in this allocation analysis include the Oregon 30-day mean minimum and 7-day minimum mean criteria (6.50 mg/L and 5.0 mg/L, respectively). For the outfall of Keno Dam and the reach downstream of Keno Dam, these values change to 8.0 mg/L and 6.5 mg/L, respectively. There is also a DO resident trout spawning criteria of 11 mg/L or 95 % saturation that applies from January 1 to May 15, downstream of Keno Dam (not shown in graphics).
- The Upper Klamath Lake TMDL model predicts a range of conditions and the more extreme predicted water quality is not represented by T1BSR. Therefore, even when the natural condition baseline shows compliance with the numeric criteria, allocations are still calculated to protect against a quantified change from baseline conditions (i.e. a 0.2 mg/L digression).
- Upstream and downstream of Keno Dam, the cumulative point source and nonpoint source discharges should not cause a DO drop of greater than 0.20 mg/L (for the 7-day and 30-day criteria) during the entire year.
- In California, the DO must meet the proposed Site Specific Objectives (SSO) presented in Table 3.

Table 3. Proposed Site Specific Objectives (SSO) for DO in Mainstem Klamath River in California

Location	Percent DO Saturation	Time period
Stateline to Hoopa	90%	October 1 through March 31
	85%	April 1 through September 30
Hoopa to Turwar	85%	All year
Upper and Middle Estuary	80%	August 1 through August 31
	85%	September 1 through July 31
Lower Estuary	For the protection of estuarine habitat (EST), the dissolved oxygen content of enclosed bays and estuaries shall not be depressed to levels adversely affecting beneficial uses as a result of controllable water quality factors.	

Assumptions and Configuration

The following list presents key assumptions associated with configuration of the TOD2RN/TCD2RN scenario:

- The phosphorus TMDL for UKL was used to configure the upstream boundary conditions for the Klamath River Model as in the T1BSR scenario.
- A previous version of the model was used to develop the allocations through the process described below. These allocations were tested using the current version of model and found to achieve the DO and pH criteria.
- For the point sources, the configuration followed an iterative process:
    1. Initially, the 90^{th} percentile of the existing nutrient concentrations were calculated for each of the point sources (including the Columbia Plywood and Collins Forest Product dischargers). These values were used to represent the baseline condition for the point sources.

   a. For the two minor discharges, Columbia and Collins, their concentrations were unchanged in the allocation runs. Their contribution to the overall load was minor compared with the two treatment plants.
   b. For the two treatment plants, the nutrient and DO concentrations were set based on the principle that they should have the same concentration in the TMDL analysis. Temperature was set based on earlier sensitivity analyses which would not result in temperature rise of greater than 0.075 ^{o}C for each individual point source. See Table 4 for current and derived concentrations of the effluent from the treatment plants. DO concentrations were set to 5.0 mg/L.
2. The models were run in a piece-wise manner from UKL to Stateline. First, the model was run from Link Dam to Keno Dam, and reductions were made until criteria were met. Then, the model was run from Keno Dam to Iron Gate Dam to evaluate the compliance down to Stateline.
3. Compliance was evaluated at 9 locations:
   a. Klamath Falls STP discharge point
   b. South Suburban STP discharge point
   c. Miller Island
   d. LRDC
   e. KSD
   f. Keno Dam
   g. Downstream of Keno Dam at the USGS station
   h. Downstream of the J.C. Boyle Dam
   i. Stateline
4. Compliance was evaluated by subtracting the 7-day moving average of daily minimum DO and the 30-day moving average of daily average DO from the corresponding natural condition baseline estimates. This is essentially a time series of DO deficit. If the DO deficit was greater than 0.20 mg/L at any of the nine evaluation locations, the nutrients at the two major point source dischargers were reduced. pH compliance was determined with comparison to the 9.0 criteria.
5. The reduction of nutrients was made in the following order: PO4 was first reduced until the pH target was achieved. Organic matter and NH4 was then reduced to achieve the DO target. The nitrogen reduction was a lower priority than reducing phosphorus because a phosphorus limitation was desired for ultimate control of periphyton in the Klamath River system.
6. After multiple iterations, the DO criteria for the point source allocation were achieved (Table 4). Corresponding point source discharge concentrations were:
   - PO4: 0.3 mg/L (as opposed to the starting value of 4.0 mg/L)
   - OM: 9.8 mg/L (as opposed to the starting value of 40.0 mg/L of OM)
   - NH4: 7.8 mg/L (as opposed to the starting value of 14.6 mg/L)
   - NO2/NO3: 14.3 mg/L (equivalent to the starting value)
   - DO: 5.0 mg/L (equivalent to the starting value)

Table 4. Comparison of South Suburban (S. Suburban) and Klamath Falls (K. Falls) Treatment Plant Concentrations Using Metrics Commonly Measured on Discharge Monitoring Reports (DMRs) and Used in the Model

		DMR Metrics								CE-QUAL-W2 metrics							
Source	Scenario	Flow MGD	TKN mg/L	NH4 mgN/L	NO3 mgN/L	BOD5 mg/L	PO4 mg/L	TP mg/L	TN mg/L	Flow cms	PO4 mgP/L	NH4 mgN/L	NO3 mgN/L	LDOM mg/L	LPOM mg/L	TP mg/L	TN mg/L
S. Suburban	DMR average	2.7	12.5	7.3	2	27	3.1	3.6	14	0.12	3.1	7.3	2	6.2	24.7	3.2	11.0
S. Suburban	DMR 90th P	3.2	21.4	13.0	4	41	4.0	4.5	25	0.14	4.0	13.0	4	9.3	37.2	4.2	20.1
S. Suburban	2000 average	2.1	14.2	9.2	2.0	12	3.1	3.5	16	0.09	3.1	9.2	2.0	14.2	56.6	3.5	16.2
S. Suburban	2000 90th P	2.8	22.1	14.6	3.3	18	4.0	4.6	25	0.12	4.0	14.6	3.3	21.4	85.5	4.6	25.4
K. Falls	DMR average	3.3	5.4	7.8	8	9	3.5	5.1	14	0.14	5.1	7.8	8	1.9	7.8	5.1	16.6
K. Falls	DMR 90th P	4.4	13.2	11.5	14	15	5.1	10.3	28	0.19	10.2	11.5	14.3	3.4	13.7	10.3	27.0
K. Falls	2000 average	3.2	3.3	1.5	1.5	14	3.3	3.5	4.8	0.14	3.3	1.5	1.5	5.4	21.4	3.5	4.8
K. Falls	2000 90th P	4.1	6.1	3.3	1.5	23	5.6	5.8	7.6	0.18	5.6	3.3	1.5	8	32.0	5.8	7.6
Both	TOD2RN	3.2	8.5	7.8	14	18	0.30	0.35	22.8	0.14	0.30	7.8	14.3	1.9	7.8	0.4	22.8

Note: DMRs were examined between 1995 and 2005. “2000” represents the year 2000 calibration. Blue shading indicates derived values (i.e., measurements on DMRs were converted into W2 metrics). “90th P” = 90th percentile. TOD2RN concentrations are constant so no averages are needed.

- The most sensitive location point source loading for pH compliance was just downstream of South Suburban WWTP. The most sensitive location for DO compliance was just downstream of Klamath Falls WWTP. It is suspected that the bathymetry of historic Lake Ewauna creates this sensitive location for DO because of deep, slow moving water.
- The most sensitive time period for point source loading was mid-September when flows from Link River were greatly reduced (170 cfs as opposed to a median 736 cfs). However, this flow is still greater than the 7Q10 of 94 cfs. This is also the period in which there was earlier than usual flow into the Klamath River from Lost River Diversion Channel.
- Once point source allocations were determined, the discrete nonpoint sources (KSD and LRDC) were analyzed as follows:
    1. Due to the geographic separation from the point source discharges and KSD / LRDC, there was available DO and pH capacity for discrete nonpoint sources.
    2. All other Oregon tributaries, including Jenny Creek, and other accretion/depletions between Keno Dam and Iron Gate Dam were kept the same as in the T1BSR scenario. The downstream boundary condition was configured to represent the Keno Reef as in T1BSR.
    3. The flows and temperature from Lost River Diversion Channel (LRDC) and KSD were kept the same as in T1BSR. Nutrients were initially the same as in T1BSR but were iteratively scaled up until the cumulative DO impairment exceeded 0.20 mg/L at the most sensitive location for the combined impact (when compared to T1BSR). Nutrient ratios were kept constant. DO compliance required lower nutrient concentrations than pH compliance.
    4. The most sensitive locations for combined (discrete NPS and point source) DO compliance were at Miller Island (in late summer) and Keno Dam (in spring).
    5. The Oregon combined allocations achieved California criteria at the state line.
- Once the discrete nonpoint sources were allocated, the analysis proceeded into California. Below Iron Gate Dam, the boundary conditions for flow, temperature and nutrients were specified as shown in Table 5 and described below.

Table 5. TCD2RN Boundary Conditions for Flow, Temperature and Nutrients below Iron Gate

	TCD2RN (2000)		
Stream(s)	**Temperature**	**Flow**	**Nutrients**
Trinity	Unchanged from T1BSR	2000 flows recalculated to reflect the ROD	Unchanged from current conditions model depiction
Salmon	Unchanged from current model depiction	Unchanged from current model depiction	Unchanged from current conditions model depiction
Scott	0.8 °C reduction from current model depiction, June 1 to October 15[3]	Unchanged from current model depiction	Unchanged from current conditions model depiction
Shasta	1.6 °C reduction from current model depiction, June 1 to October 15, consistent with Shasta River Temperature TMDL[4]	Current flow plus 45 cfs from June 1 to October 15, consistent with Shasta River Temperature TMDL[5].	Unchanged from T1BSR
Minor Tributaries	Unchanged from T1BSR	Unchanged from current model depiction	Unchanged from current conditions model depiction[6]

- SOD was set to be the same as in the T1BSR scenario.
- All the kinetic parameters were set equal to the T1BSR scenario.
- The DO boundary conditions for the tributaries downstream of Iron Gate Dam were set based on the rules that 100% saturation values are used for all the minor tributaries and Trinity River, and 95% saturation for Shasta, Scott, and Salmon Rivers.

Model Simulation and Results

The TOD2RN/TCD2RN scenarios were simulated in the same piece-wise manner as for the T1BSR scenario, and results are presented at the same locations (Figures 1 through 3). Simulation results are presented in Appendix B, along with results for T1BSR.

[3] The TCD2RN temperatures at the mouth of Scott River were depicted by RWQCB staff using the Heat Source temperature model. This analysis built upon the Scott River Temperature TMDL analysis (RWQCB, 2005) by including the effects of colder tributaries in the Scott River canyon. A 2 °C reduction of mean temperatures in the Scott River tributaries downstream of Canyon Creek were assumed, based on the results of an analysis of potential temperature reductions of minor Klamath River tributaries (Wilder, 2007). The results of this Heat Source modeling analysis indicated that the average temperature at the mouth of the Scott River could be reduced by as much as 0.8 °C. This 0.8 °C reduction from current stream temperatures at the mouth of the Scott River is applied from June 1 to October 15 for TCD2RN.

[4] The Shasta River Temperature TMDL modeling estimated that average temperatures at the mouth of the Shasta River would be reduced by 1.6 °C under TMDL compliance conditions (site potential riparian shade, no net increase in stream temperature from irrigation return flows, and 45 cfs increase in dedicated cold water flow) (RWQCB, 2006). This 1.6 °C reduction from current stream temperatures at the mouth of the Shasta River is applied from June 1 to October 15 for TCD2RN.

[5] The Shasta River Temperature TMDL includes a goal to increase flows by 45 cfs (RWQCB, 2006)

Tables 6 through 9 present the exceedance statistics for the Oregon reaches. As shown in Table 6, the maximum DO deficit for the reach upstream of Keno Dan is always less than 0.2 mg/L, exhibiting 0% violation of the criteria. Although Table 7 shows slight exceedance of pH, it was deemed acceptable by ODEQ in the context of overall model uncertainty. The maximum frequency of excursion was less than 2%, and the excursion is relatively isolated spatially. Table 8 indicates that the spawning period criteria are met under the TOD2RN condition. Table 9 shows that the Oregon DO criteria are met at the reach downstream of Keno Dam. Although the maximum DO deficit is 0.205 mg/L, which is slightly higher than the threshold of 0.20 mg/L, it was deemed acceptable by ODEQ (due to overall uncertainty and the small magnitude of the excursion).

Table 6. DO Exceedance Statistics for Upstream of Keno Dam

LOCATION	Min 30-day DO (mg/L)					Min 7-day DO (mg/L)				
	Min 30-day DO (mg/L)		Criteria (mg/L)	TOD2RN-T1BSR		Min 7-day DO (mg/L)		Criteria (mg/L)	TOD2RN-T1BSR	
	TOD2RN	T1BSR		max DO deficit between TOD2RN & T1BSR	% time this deficit is < 0.2 mg/L	TOD2RN	T1BSR		max DO deficit between TOD2RN & T1BSR	% time this deficit is < 0.2 mg/L
KFALLS WWTP	7.08	7.03	6.50	-0.05	0.00%	5.91	5.89	5.00	-0.108	0.00%
SOUTH SUBURBAN SANITARY	7.37	7.38	6.50	-0.06	0.00%	7.09	7.07	5.00	-0.070	0.00%
LRDC	7.36	7.32	6.50	-0.05	0.00%	7.36	7.13	5.00	-0.061	0.00%
MILLER ISLAND	6.99	6.82	6.50	-0.07	0.00%	6.63	6.46	5.00	-0.075	0.00%
KSD	6.48	6.43	6.50	-0.06	0.00%	6.13	6.08	5.00	-0.069	0.00%
HWY 66	6.37	6.31	6.50	-0.06	0.00%	6.05	6.01	5.00	-0.068	0.00%
KENO DAM	6.25	6.20	6.50	-0.06	0.00%	5.88	5.83	5.00	-0.067	0.00%

Table 7. pH Exceedance Statistics Upstream of Stateline

LOCATION	Number of times (hours over the year) the pH is >9 at surface 1m layer		% Exceedance		Max pH	
	TIBSR	TOD2RN	TIBSR	TOD2RN	TIBSR	TOD2RN
KFALLS WWTP	18	44	0.21%	0.50%	9.03	9.05
SOUTH SUBURBAN SANITARY	30	174	0.34%	1.98%	9.04	9.11
LRDC	0	136	0.00%	1.55%	8.99	9.07
MILLER ISLAND	0	4	0.00%	0.05%	8.91	9.01
KSD	0	0	0.00%	0.00%	8.60	8.74
HWY 66	0	0	0.00%	0.00%	8.52	8.68
KENO DAM	0	0	0.00%	0.00%	8.51	8.64
USGS DS_KENO	0	0	0.00%	0.00%	8.58	8.71
DS_JCB DAM	0	0	0.00%	0.00%	8.76	8.76
US_POWERHOUSE	0	0	0.00%	0.00%	8.89	8.89
DS_POWERHOUSE	0	0	0.00%	0.00%	8.88	8.88
STATELINE	0	4	0.00%	0.05%	8.91	9.02

Table 8. Spawning Period DO Exceedance Statistics Downstream of Keno Dam in Oregon

Location			TOD2RN-T1BSR	
	Min DO during Spawning Period (Jan to May) (mg/L)	Criteria (mg/L)	max DO deficit between TOD2RN & T1BSR	% time this deficit is < 0.20 mg/L
DS Keno Reservoir	8.47	11.00	-0.096	0.00%
DS_J. C. Boyle Dam	8.50	11.00	-0.089	0.00%
STATELINE	8.66	11.00	-0.050	0.00%

Table 9. General DO Exceedance Statistics Downstream of Keno Dam in Oregon

Location	Min 30-day DO (mg/L)					Min 7-day DO (mg/L)				
	Min 30-day DO (mg/L)		Criteria (mg/L)	TOD2RN-T1BSR		Min 7-day DO (mg/L)		Criteria (mg/L)	TOD2RN-T1BSR	
	TOD2RN	T1BSR		max DO deficit between TOD2RN & T1BSR	% time this deficit is < 0.2 mg/L	TOD2RN	T1BSR		max DO deficit between TOD2RN & T1BSR	% time this deficit is < 0.2 mg/L
DS Keno Reservoir	6.65	6.63	8.00	-0.060	0.00%	6.44	6.43	6.5	-0.086	0.00%
DS_J. C. Boyle Dam	6.83	6.84	8.00	-0.052	0.00%	6.43	6.43	6.5	-0.072	0.00%
STATELINE	7.79	7.84	8.00	-0.055	0.00%	7.16	7.37	6.50	-0.205	1.67%

Tables 10 through 14 show the exceedance statistics for the California reaches of the Klamath River under the TCD2RN scenario. The proposed SSO are met at all locations (with minor violations). The predicted violations were deemed acceptable by RWQCB staff in the context of overall uncertainty.

The simulated DO was also compared with the Hoopa criteria. The Hoopa Tribe has three types of DO targets, including a COLD DO criterion of 8 mg/L, a 90% saturation criterion, and a SPAWN DO criterion of 11 mg/L. Table 13 indicates that while the first two criteria were exceeded 5.87% of the year for the COLD criterion and 7.83% for the 90% saturation criterion, the SPAWN criterion was exceeded over 50% of the year. The SPAWN criterion was exceeded for such a high frequency of time because during the period from March to June when the SPAWN criterion applies, the saturated DO falls below the criterion of 11 mg/L. This suggests that the SPAWN criterion cannot be met under natural conditions. Table 14 shows the exceedance statistics for DO with regard to the Yurok criteria. These criteria are met at all times.
.
In addition to the exceedance summaries, some general observations can be made based on the time series plots in Appendix B. Specifically:

- The simulated temperature in TOD2RN/TCD2RN is almost identical compared to T1BSR at locations from Lake Ewauna to upstream of Shasta River, indicating that the point sources have a negligible impact on the temperature. Downstream of Shasta River, the TCD2RN temperature differs slightly from the T1BSR temperature due to the different flow and temperature conditions assigned in the T1BSR and the TCD2RN scenarios. Overall, the difference in temperature is very minor. PO4 is generally slightly higher under TOD2RN than under T1BSR at the upper Klamath River locations due to the contributions from the point and nonpoint sources, but further downstream (such as at Iron Gate Dam), the PO4 becomes slightly lower under TCD2RN during the summer. This is due to the more intensive uptake by phytoplankton and periphyton. During the spring and winter, the PO4 under TCD2RN is still higher than under T1BSR at this location since biological activity of phytoplankton and periphyton is low during this period. The PO4, however, becomes lower in TCD2RN at locations further downstream for almost the entire year due to the influence of flow from the major tributaries. TP follows a similar trend.
- NH4 and NO3 are significantly higher at upstream locations due to the large loading from the point sources; however, this trend diminishes with distance downstream from the combined impact of phytoplankton and periphyton activity and the difference in flow from the major California tributaries. At the most downstream locations of the river, NH4 and NO3 are very similar between T1BSR and TCD2RN during the summer, although during the other seasons the TCD2RN concentrations are still considerably higher. TN follows a similar trend also.
- Chlorophyll-a is always higher under TOD2RN/TCD2RN than under T1BSR for all the locations, though the trend diminishes with distance downstream.
- In the upper riverine sections, such as D/S of Keno Dam and D/S of J.C. Boyle, due to severe P-limiting conditions, periphyton growth is highly depressed under both the TOD2RN and T1BSR conditions. Further downstream, due to the contribution of PO4 from the springs, the P-limiting condition is relieved and periphyton growth is stimulated. This results in higher periphyton biomass under TOD2RN/TCD2RN. This trend diminishes with distance, and finally at Seiad Valley, the peak periphyton biomass under T1BSR reaches a slightly higher level than under TCD2RN. TCD2RN also has a second peak which does not exist in the T1BSR scenario. From that point on, T1BSR tends to produce higher periphyton at most of the locations.

- In the upper Klamath River, e.g., in Lake Ewauna, the phytoplankton growth is generally P-limited under both T1BSR and TOD2RN, but further downstream, it appears that nitrogen can also become a co-limiting factor for periphyton growth.
- In the Klamath Estuary, the upstream water quality signal is reflected in the Upper Estuary location, but at the Lower Estuary location, the tidal impact becomes dominant such that the difference between T1BSR and TCD2RN becomes negligible.

Table 10. DO Exceedance Statistics for TCD2RN Based on Proposed California SSO – Stateline to Hoopa

Location	April 1 through September 30 (85% DO Saturation)	October 1 through March 31 (90% DO Saturation)
Stateline	0.00%	0.00%
DS_COPCO DAM	0.00%	0.00%
US_IG DAM	0.00%	0.00%
DS_IGDAM	0.49%	0.07%
US_SHASTA	0.00%	0.00%
DS_SHASTA	0.00%	0.83%
US_SCOTT	0.00%	0.07%
DS_SCOTT	0.00%	0.00%
SEIAD	0.00%	0.00%
US_INDIAN	0.00%	0.00%
DS_INDIAN	0.00%	0.00%
US_SALMON	0.00%	0.00%
DS_SALMON	0.00%	0.00%

Table 11. DO Exceedance Statistics for TCD2RN Based on Proposed California SSO – Hoopa to Turwar

Location	All year (85% DO Saturation)
US_TRINITY	0.00%
DS_TRINITY	0.00%
YOUNGSBAR	0.00%
TURWAR	0.00%

Table 12. DO Exceedance Statistics for TCD2RN Based on Proposed California SSO – Upper and Middle Estuary

Location	August 1 through August 31 (80% DO Saturation)	September 1 through July 31 (85% DO Saturation)
Upper Estuary	0.00%	0.11%
Middle Estuary - Top	0.00%	0.08%
Middle Estuary - Bottom	0.00%	0.04%

Table 13. Summary of Exceedance Frequency for Hoopa Tribe Standards

Location	% of time COLD Hoopa Tribe DO Criteria of *8 mg/L* is exceeded (year-round, based on 7-DAMin)	% of time *90%* of DO Saturation value is exceeded (year-round Hoopa Tribe Natural Conditions DO Criteria)	% of time SPAWN Hoopa Tribe DO Criteria of *11 mg/L* is exceeded (from September 14 to June 4, based on 7-DAMin)
HOOPA	5.87%	7.83%	52.14%

Table 14. Summary of Exceedance Frequency for Yurok Tribe Standards (year-round)

Location	% of time Absolute Minimum Yurok Tribe DO Criteria of *7 mg/L* is exceeded
DS_TRINITY	0.00%
YOUNGSBAR	0.00%
TURWAR	0.00%

Oregon and California With-Dams TMDL Scenario (T4BSRN)

This scenario involved running the Klamath River Model with all dams in place. Boundary water quality inputs were based on the final compliance scenarios for Oregon and California (TOD2RN and TCD2RN). The objective of the simulation was to provide a means of quantifying the impacts of the dams and appropriate allocations.

Assumptions and Configuration

The T4BSRN model was configured and implemented in a piece-wise manner from upstream to downstream. The existing condition model (S1), described in "Model Configuration and Results - Klamath River Model for TMDL Development," was used as the basis for T4BSRN in terms of physical configuration only (alternating CE-QUAL-W2 and RMA models for the reservoirs and riverine segments, along with EFDC for the estuary). Boundary water quality conditions were the same as the allocation scenarios (TOD2RN and TCD2RN) with the Keno Reef representation, as described above. Configuration details are as follows:

- All the dams are present, therefore the model is divided into 9 domains (4 reservoirs, 4 riverine reaches, and the estuary).
- For the UKL boundary condition, flow is the same as in the current conditions model depiction and TOD2RN. Water quality and temperature boundary conditions are the same as in TOD2RN.
- For the Lake Ewauna/Keno Reservoir segment, all inputs from TOD2RN are kept.
- Downstream of Keno Dam, all the tributary flow boundary conditions in Oregon are set the same as in TOD2RN. In California they are all set the same as in TCD2RN.
- SOD throughout the system is set the same as in the compliance runs, i.e., TOD2RN and TCD2RN. The only exception is when SOD for the existing condition is lower than in the compliance run (due to a change in the waterbody type).
- All other water quality parameters are consistent with the compliance runs.
- At the location immediately upstream of Copco Reservoir, the PO4 and OM concentrations were reducedI iteratively (that is, from the initially simulated T4BSRN condition – which itself was based on TOD2RN boundary conditions), in order to achieve a California summer mean chlorophyll-a target of 10 ug/L within Copco and Iron Gate Reservoirs. The chlorophyll-a concentration coming into Copco Reservoir was set at the target concentration of 10 ug/L, and the PO4 and OM were iteratively reduced until the summer mean chlorophyll-a concentration at the surface (1 m depth) in both Copco and Iron Gate Reservoirs at the location immediately upstream of the dams was equal to or below 10 ug/L. The scenario arrived at summer mean surface (1 m depth) chlorophyll-a concentrations of 9.8 ug/L for Copco and 6.7 ug/L for Iron Gate. The resulting PO4 and OM loads upstream of Copco Reservoir are 30% lower than those under the initially simulated T4BSRN condition [which was based on the TOD2RN boundary conditions].

Model Simulation and Results

Simulation results are presented for T4BSRN along with TOD2RN/TCD2RN in Appendix C. Some general observations can be made:

- At locations upstream of Keno Dam, the presence of the dam is predicted to cause slightly different average nutrient, DO, and chlorophyll-a concentrations than the without-dam condition. The main reason is that under the with-dam condition, the outflow was regulated by the dam but under the without-dam condition the outflow was controlled simply by the discharge rating curve at the reef. As a result, the water depth and retention time is different under T4BSRN than under TOD2RN. This causes different deoxygenation, nutrient transformation, and algal activity. Additionally, the there is a difference in the volume of water used in the vertical averaging process. In general, DO is lower under T4BSRN when Keno Dam is present.
- For all the locations upstream of Keno Dam, temperature is very similar between T4BSRN and TOD2RN, suggesting that the difference in summer water depth has an insignificant impact on temperature.
- Downstream of Keno Dam at the USGS station, the summer DO for T4BSRN is slightly lower than that for TOD2RN. Temperature is generally very similar between the two scenarios (with the dam present, the fluctuation in temperature during the summer is smaller). Chlorophyll-a is slightly lower when the dam is present, while PO4 is slightly higher. It is hard to judge whether the inorganic nitrogen is higher or lower with the presence of the dam, but a shift in time can be observed in the model results at this location.

- Due to the presence of J.C. Boyle Dam, the temperature downstream of the dam is smooth and shows much less diurnal fluctuation in T4BSRN than in TOD2RN. DO for T4BSRN becomes significantly lower than for TOD2RN due to the vertical stratification in J.C. Boyle Reservoir when the dam is present. Phytoplankton is slightly lower under T4BSRN downstream of J.C. Boyle Dam because of diminished phytoplankton in deep water in the reservoir. This reduces the overall biomass of phytoplankton in the outflow from J.C. Boyle Reservoir (since the outlet draws water from the full depth). PO4 and NO3 are slightly lower under T4BSRN than under TOD2RN at this location. This might be caused by the longer retention time in J.C. Boyle Reservoir that causes a loss of PO4 and NO3 from algal uptake while the benthic source is insufficient to compensate for this loss. NH4, however, appears to be slightly higher during the summer when J.C. Boyle Dam is present. This might be due to the benthic source.
- At Stateline, temperature is similar for T4BSRN and TOD2RN, although the temperature for T4BSRN shows a larger diurnal fluctuation due to the peaking operation. DO is lower for T4BSRN, and it shows more significant diurnal fluctuation due to the peaking operation. Overall, the most striking difference between T4BSRN and TOD2RN at the Stateline location is that for all the constituents except NH4 the concentration shows much more diurnal fluctuation under T4BSRN than under TOD2RN due to the peaking operation. NH4, however, has smaller diurnal fluctuation under T4BSRN due to the concentration from the springs.
- Downstream of Iron Gate Dam, a significant temporal shift is observed between the T4BSRN and TCD2RN results due to the change in retention time caused by the presence of the dams. In addition to the time shift, the temperature is much smoother under T4BSRN than under TCD2RN. DO and phytoplankton biomass are both significantly lower under T4BSRN than under TCD2RN due to vertical stratification in the upstream reservoirs when dams are present. In addition, the phytoplankton biomass is lower under T4BSRN because of the 30% reduction in PO4 and OM loading at the point entering Copco Reservoir.
- Downstream of Iron Gate Dam, the time shift in temperature becomes smaller, and finally becomes unidentifiable at the U/S Scott River location (and further downstream), because the signal from upstream has been dampened by solar radiation and air temperature impacts. Similarly, the difference in DO concentration also is reduced from upstream to downstream. Nutrient and phytoplankton differences also diminish with distance. The model results show that the periphyton dominant condition varies from site to site between T4BSRN and TCD2RN. At most locations, periphyton is higher under TCD2RN than under T4BSRN.
- In the Upper and Middle Estuary, a small but detectable difference between T4BSRN and TCD2RN is observed for the simulated nutrient and periphyton concentrations. DO and temperature, however, look almost identical in the Upper and Middle Estuary for T4BSRN and TCD2RN. In the Lower Estuary, the temperature and water quality parameters become even closer between T4BSRN and TCD2RN as the tidal signal dominates at this location.

References

Boyd, M. and B. Kasper. 2003. Analytical methods for dynamic open channel heat and mass transfer: Methodology for heat source model. Version 7.0.

Chapra, S.C. 1997. *Surface Water-Quality Modeling*. McGraw-Hill, Inc., New York.

Cole, T.M. and S.A. Wells. 2003. *CE-QUAL-W2: A two-dimensional, laterally averaged, Hydrodynamic and Water Quality Model, Version 3.1*, Instruction Report EL-03-1, US Army Engineering and Research Development Center, Vicksburg, MS.

Deas, M. and S. Null. 2007. Technical Memorandum: Year 2000 Unimpaired Shasta River Model Simulation for Flow and Water Temperature – Draft. Watercourse Engineering, Inc.

Flint, L.E. and Flint, A.L. 2008. A Basin-Scale Approach to Estimating Stream Temperatures of Tributaries to the Lower Klamath River, California. J Environ Qual 37:57-68.

Hauser, G.E. and G.A. Schohl. 2002. River Modeling System v4 - User Guide and Technical Reference. Report No. WR28-1-590-164. TVA River System Operations and Environment. Norris, Tennessee.

North Coast Regional Water Quality Control Board. 2005a. Staff Report for the Action Plan for the Scott River Watershed Sediment and Temperature Total Maximum Daily Loads.

North Coast Regional Water Quality Control Board. 2005b. Salmon River, Siskiyou County, California: Total Maximum Daily Load for Temperature and Implementation Plan.

North Coast Regional Water Quality Control Board. 2006. Staff Report for the Action Plan for the Shasta River Watershed Temperature and Dissolved Oxygen Total Maximum Daily Loads. May 3, 2006.

Oregon Department of Environmental Quality. 2002. Upper Klamath Lake Drainage Total Maximum Daily Load (TMDL) and Water Quality Management Plan.

PacifiCorp. 2005. *Klamath River Water Quality Model Implementation, Calibration, and Validation.* Klamath Hydroelectric Project (FERC Project No. 2082) - Response to November 10, 2005, FERC AIR GN-2. December 16, 2005, FERC filing.

Scott River Watershed Council (SRWC). 2004. Initial phase of the Scott River Watershed Council Strategic Action Plan.

State Water Resource Control Board (State Water Board). 1974. Report on Water Supply and Use of Water. Scott River Stream System. Scott River Adjudication. Siskiyou County, California. December 1974.

Tetra Tech, Inc. 2009. *Model Configuration and Results - Klamath River Model for TMDL Development*. Prepared for U.S. Environmental Protection Agency Region 9, U.S.

Environmental Agency Region 10, Oregon Department of Environmental Quality, and North Coast Regional Water Quality Control Board.

Thurman, E.M. 1985. *Organic Geochemistry of Natural Waters*. Nijhoff/Junk Publishers, Durdrecht, The Netherlands, 497p.

Wilder, C. 2007. Stream Temperature Analysis for the Select Tributaries of the Middle and Lower Klamath River. North Coast Regional Water Quality Control Board.

Zedonis, P. 2001. Empirical and Theoretical Influences of a Pulse Flow From Lewiston Dam on Water Temperature and Dissolved Oxygen of the Lower Klamath River. Draft Report #AFWO F2001-01.

Appendix A: RWQCB Estimates of California Tributary Natural Temperatures and Flows

RWQCB staff provided estimates of temperatures and flows for the tributaries in California for the natural conditions baseline scenario, as described here.

<u>Shasta River</u>
The Tennessee Valley Authority's River Modeling System model (Hauser and Schohl 2002) was applied to depict natural flows and associated temperatures at the mouth of the Shasta River (Deas and Null 2007), building upon modeling for development of the Shasta River Temperature TMDL (RWQCB 2006). The Shasta River temperature TMDL model scenario represented Shasta River temperatures associated with potential riparian shade on the tributaries and mainstem, absence of thermal load from irrigation tailwater return flows, and estimated natural flows and temperatures from Big Springs Creek, a major spring-fed tributary. The Shasta River natural conditions model scenario added to the Shasta River TMDL scenario by representing full natural flows and associated temperatures for the Shasta River and all tributaries (Deas and Null 2007). The Shasta River is fully appropriated from May 1 through October 31, according to a statutory adjudication established in 1932. Since 1934 the California Department of Water Resources (CDWR) Watermaster Service has managed the delivery of the adjudicated water rights. Estimates of natural Shasta River flows were developed based on CDWR Watermaster Service records from 1930-1955. The watermaster service records used in estimating natural flows were from headwater locations of the Shasta River and its major tributaries, at locations upstream of significant water rights. No accretions were assumed between the tributary headwaters and the confluence with the Shasta River. Shasta River accretions were calculated based on water balancecalculations. Natural flows at the mouth of the Shasta River were calculated as the sum of Shasta River and tributary headwater flow records plus the calculated mainstem accretion flows. Corresponding temperatures were predicted, as described by Deas and Null (2007).

<u>Scott River</u>
For T1BSR, Regional Water Board staff developed a depiction of potential natural temperatures of the Scott River at its mouth using the Heat Source temperature model (Boyd and Kasper 2003). Unimpaired flows were assumed to be equivalent to natural flows for this analysis. For this analysis, unimpaired flow refers to the flow of a stream without regulation, control, diversion, or artificial additions; natural flow is the same as unimpaired flow, but also incorporates changes in process, such as changes in transpiration due to more dense vegetation in the uplands, or changes in runoff resulting from soil compaction, for instance. This modeling exercise built on previous model scenarios implemented as part of the Scott River TMDL (RWQCB 2005). Further model scenarios were implemented to evaluate the combined effects of potential riparian shade (in both the tributaries and mainstem Scott River) and unimpaired flows on temperatures at the mouth of the Scott River. Neither the temperature effect of these tributaries, nor the effects of unimpaired flows on Scott River temperatures had been previously evaluated in this way. The effects of unimpaired discharges were not evaluated previously because estimates of unimpaired flows were unavailable. The effects of natural Scott River temperatures and flows were evaluated for two time periods in 2000: July 28 – August 1 and August 12 – September 25. These time periods overlap with time periods analyzed as part of the Scott River TMDL development process (July 28 – August 1 and August 27 – September 10). The August –September time period was extended 28 days for this analysis.

Regional Water Board staff used a range of unimpaired flow estimates representing possible natural flows, and meteorological data from 2000, to evaluate the thermal effects of natural Scott River flows on the Klamath River. A range of flows was evaluated due to the uncertainty associated with unimpaired Scott River flow estimates. The flow estimates were developed based on simple water balance assumptions and estimated rates of consumptive water use.

The hydrology of the Scott River is complicated by the high degree of groundwater-surface water interaction in Scott Valley. In most years, the Scott Valley aquifer is replenished by infiltration of precipitation and stream flows from November to May, generally speaking. Once the height of the Scott River drops below the height of the surrounding water table, water drains from the aquifer back to the river. In this way the Scott Valley aquifer acts as a large sponge soaking up water when it is plentiful, and releasing it when it is scarce. This process occurs to such a degree that the Scott Valley aquifer accounts for the majority of the Scott River water leaving Scott Valley in the summer months. For instance, on August 9, 1972, the Scott River was flowing just 5 ft^3/s near the upstream end of Scott Valley (river mile 50), but was flowing at 61 ft^3/s at the downstream end of the valley (river mile 22), despite the surface diversion of 28 ft^3/s and minimal tributary inflows in between (State Water Board 1974). Similarly, on August 27, 2003 Regional Water Board staff measured 11 ft^3/s at river mile 50 and 34 ft^3/s at river mile 19, and estimated surface diversions and tributary inflows as 17 ft^3/s and 2 ft^3/s, respectively (Regional Water Board 2005b).

Extraction of Scott Valley groundwater can reduce the amount of groundwater discharging to the Scott River when the drawdown (or pressure wave in a confined setting) associated with extraction intersects the river. If the effects of groundwater extraction don't reach the river before the next season's replenishment begins, the amount of extracted groundwater volume will be replenished and there will be no decrease in surface flows. Similarly, due to their geomorphology, many of the Scott River tributaries historically percolated into alluvial fans at times of low flow. A portion of surface water used for irrigation in Scott Valley is diverted from those creeks that historically percolated into alluvial fans. The amount of water diverted from these creeks that would have resurfaced in the Scott River in the same season is unknown. A reduction in stream flow percolation would result in a reduction in Scott River flow if percolating water would have reached the river before the next season's replenishment. Otherwise, if replenishment refills the aquifer prior to the time that the diverted stream flow would have otherwise reached the river, the diversion resulting in reduced stream flow would not affect Scott River flow.

Given these complexities and uncertainties associated with Scott River hydrology, using water use data to estimate unimpaired Scott River flows is difficult. As a starting point, Regional Water Board staff used the full unimpaired Scott River flows estimated by US Bureau of Reclamation for 2000 (Hicks 2006). The USBR method for estimating Scott River full unimpaired flows is summarized here. The entire estimated seasonal evapotranspiration of applied water (ETAW) for Scott Valley (71,010 acre-ft) was assumed equal to the seasonal flow impairment (ETAW is the loss of applied irrigation water to evaporation and transpiration). The ETAW value was then distributed through the irrigation season, by month, using estimates of monthly percentage impairment from

USBR's Irrigation Training and Research Center, resulting in estimates of monthly unimpaired flow. Regional Water Board staff then distributed the monthly unimpaired flow estimates as groundwater inputs throughout Scott Valley in proportion to rates of groundwater accretion measured by the State Water Board (1974).

The USBR analysis assumes that any water irrigated in a particular month would have otherwise flowed out of Scott Valley down the Scott River in the same month. This assumption implies no travel time between the points of diversion or extraction. While this approach is grounded in water use estimates, it also relies on a simple model of a complicated hydrologic system that likely results in overestimated flows. For instance, approximately 50% of water irrigated in Scott Valley is pumped groundwater. However, given the complex nature of the Scott Valley hydrology described above, it is unlikely that the entire amount of water lost due to evapotranspiration of extracted groundwater would have otherwise discharged to the Scott River in the same month, or even same season, in the absence of water use. Any extracted water that would not have reached the river should not be routed to the river in the same month or season.

Based on this assessment of USBR's analysis, Regional Water Board staff developed two simple alternative depictions of unimpaired 2000 Scott River flows. The first alternative depiction was developed by simply reducing the groundwater accretion calculated for the USBR estimate by 50%, and the second alternative depiction was developed by reducing the groundwater accretion calculated for the USBR estimate by 75%. The rates of groundwater accretion were reduced in these depictions because surface water inflows to Scott Valley account for a small fraction of the total outflow leaving Scott Valley in the summer months. This resulted in natural flow depictions based on 100%, 50%, and 25% of ETAW added to the measured flow of the Scott River. The estimated flows at the USGS Scott River flow gauge (located just downstream of Scott Valley) for these three natural flow scenarios are presented in Table A.1. Table A.1 also includes monthly average measured flows from August and September of 2000, as well as the mean of the August and September monthly average flows for the 1942-1976 time period, for comparison purposes. The 1942-1976 time period is significant because it represents a period prior to the extensive use of groundwater for irrigation in the Scott Valley (SRWC 2004).

The three estimates of natural Scott River flows span a broad range, but provide reasonable estimates of the upper and lower bounds, as well as an intermediate estimate.
Comparison of the data presented in Table A.1 indicates that the 25% ETAW scenario results in flows that are only slightly higher than the mean of the average August flow from 1942-1976, and slightly lower than the mean of the average September flow from 1942-1976. Given that the flows from 1942-1976 time period reflect a time of extensive water use, the true unimpaired flows must be higher than those estimated in the 25% ETAW scenario.

Table A.1: Estimated and measured flows at USGS' "Scott River near Fort Jones" gauge.

Source	Monthly average flow estimate, August (cfs)	Monthly average flow estimate, September (cfs)
USBR estimated unimpaired flow	**253**	**193**
Modeled flows, 100% ETAW	**277**	**188**
Modeled flows, 50% ETAW	**154**	**100**
Modeled flows, 25% ETAW	**94**	**59**
Mean of measured monthly average, 1942-1976	**77**	**62**
Measured monthly average, 2000	**19**	**24**

This analysis is further complicated, however, by the fact that Van Kirk and Naman (2008) estimate that July 1 – October 22 Scott River flows have declined approximately 13% due to changes in the regional-scale climate, on average, since the 1942-1976 time period, based on an analysis of nearby streams. Van Kirk and Naman also estimated a 20% decrease in stream flow from the 1942-1976 period that isn't explained by changes in climate.

Based on the analysis and reasoning described above, Regional Water Board staff used the flow conditions based on the 50% ETAW estimate to evaluate the potential for the Scott River to affect the temperature of the Klamath River or provide thermal refugia during the summer months. While the 50% ETAW estimate is not a definitive estimate of unimpaired flows, it does provide a reasonable estimate for use in evaluating the possible effects of water use on the temperatures of the Scott and Klamath Rivers for the purposes of this TMDL analysis.

A second component of the natural Scott River temperature and flow analysis was the estimation of natural Scott River tributary temperatures. Regional Water Board staff simulated two natural tributary scenarios. The first scenario assumed a reduction of 1°C in all tributaries from Kidder Creek (river mile 32) to the mouth of the Scott River. The second scenario assumed a 2°C reduction of mean temperatures in the Scott River tributaries from Kidder Creek to the mouth of the Scott River. The assumptions were based on the results of an analysis of potential temperature reductions of Klamath tributaries conducted by Regional Water Board staff for minor tributaries of the Klamath River.

The Heat Source stream temperature model (Boyd and Kasper 2003) was used to integrate the results of the two analysis components of the natural Scott River temperature and flow analysis (natural flows and natural tributary temperatures). The Heat Source model was previously implemented in the Scott River as part of the Scott River TMDL development process. The original model development, described in detail in the *Staff Report for the Action Plan for the Scott River Sediment and Temperature Total Maximum Daily Loads* (RWQCB 2005a), was based on:

- comprehensive mapping of the Scott River channel and nearby vegetation using high-resolution aerial imagery,
- substrate and width-to-depth data from habitat typing surveys,
- measured water temperatures at all 11 tributaries with surface connection to the Scott River,
- measured air temperatures at 6 sites distributed along the longitudinal axis of the Scott River,
- measured relative humidity data at 5 sites distributed along the longitudinal axis of the Scott River,
- measured wind speeds at 3 sites distributed along the longitudinal axis of the Scott River,
- periodic flow measurements at 10 sites distributed along the longitudinal axis of the Scott River and the continuous flow record at the "Scott River near Fort Jones" USGS gauge, and
- a thermal infrared survey covering the entire modeled reach (Watershed Sciences, 2004).

The model was calibrated for the August 27 - September 10, 2003, time period using hourly temperature data from 21 sites distributed along the longitudinal axis of the Scott River, and validated using temperature data at 18 sites during the July 28 - August 1, 2003, time period (three sites were not deployed until after August 1, 2003, and were unavailable for validation). The mean absolute error for the validation period at the 18 sites ranged from 0.5 to 2.4 °C (0.9 to 4.3 °F), and averaged 1.1 °C (2.0 °F). The mean absolute error 0.5 miles upstream of the mouth of Scott River was 0.75 °C (hourly data). Average bias of the daily average error for the validation period at 18 sites ranged from –1.9 to 2.1 °C (3.4 to 3.8 °F), and averaged -0.2 °C (-0.36 °F). The average bias of the Scott River daily average temperature near the mouth (river mile 0.5) was 0.2 °C (0.36 °F). For a further discussion of Scott River temperature TMDL model calibration, including charts of observed and predicted temperatures at all locations, see the *Staff Report for the Action Plan for the Scott River Sediment and Temperature Total Maximum Daily Loads* (RWQCB 2005a).

Salmon River

The results of the Salmon River Temperature TMDL analysis indicate that temperature improvements in the Salmon River watershed are unlikely to result in changes at the mouth of the Salmon River (RWQCB 2005b). That analysis indicates that a 10% increase in effective shade would decrease daily average temperatures at the mouth of the Salmon River by 0.1 ^{o}C (0.18 ^{o}F). Effective shade levels at the mouth of the Salmon River are unlikely to significantly change given the width of the river and TMDL shade allocations. Further, surface water diversions from the Salmon River are quite small. Therefore, no alterations of the current Salmon River hydrograph or temperature boundary conditions are made for the natural conditions baseline scenario.

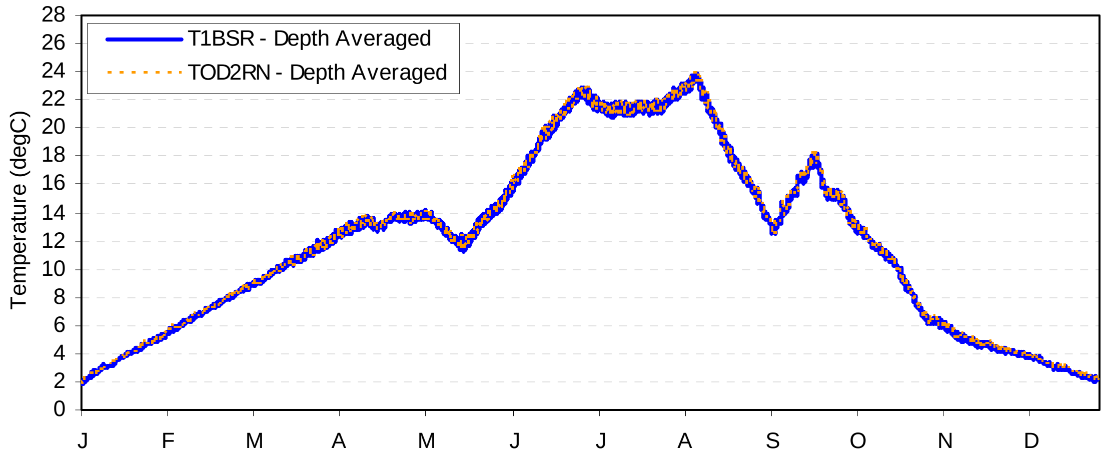
Trinity River

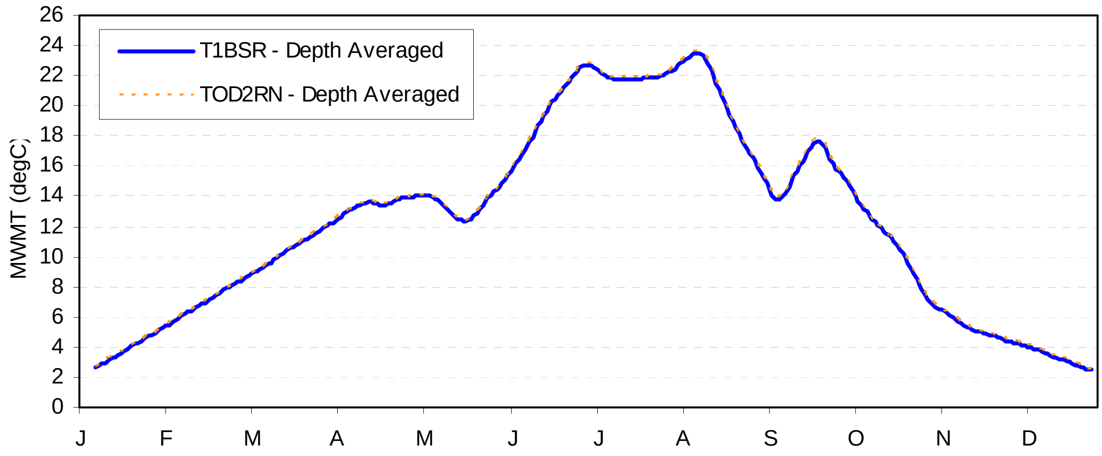
Regional Water Board staff developed estimates of natural Trinity River flows for 2000. The natural flow estimates are based on estimated full natural flows at Trinity Dam, gauged flows of Trinity River above Coffee Creek near Trinity Center (which is upstream of Clair Engle Lake), and gauged flows between Lewiston and Hoopa. The estimated full natural flows are based on a mass balance that takes into account inflows, outflows, diversions, evapotranspiration, and precipitation. The estimated full natural flows show great fluctuations during low flow conditions, therefore flows were estimated during this period by modifying gauged flows of Trinity River above Coffee Creek near Trinity Center. The Trinity River above Coffee Creek flows were multiplied by the ratio of the drainage area upstream of the gauge to the drainage area upstream of Lewiston. These data were used to represent natural flows at Lewiston for January 1 to January 10, and June 16 to December 31. The estimated full natural flows were used to represent natural flows at Lewiston for the January 11 – June 15 time period. The natural flow at the mouth of the Trinity River was estimated by adding the flow values discussed above to the difference in gauged flows between Hoopa and Lewiston. The accretion between Lewiston and Hoopa was added to the previous day's full natural flow at Trinity dam to account for time of travel between Lewiston and Hoopa (e.g. January 1st flow at Trinity Dam + January 2nd accretion = January 2 flow at Hoopa), based on Zedonis (2001).

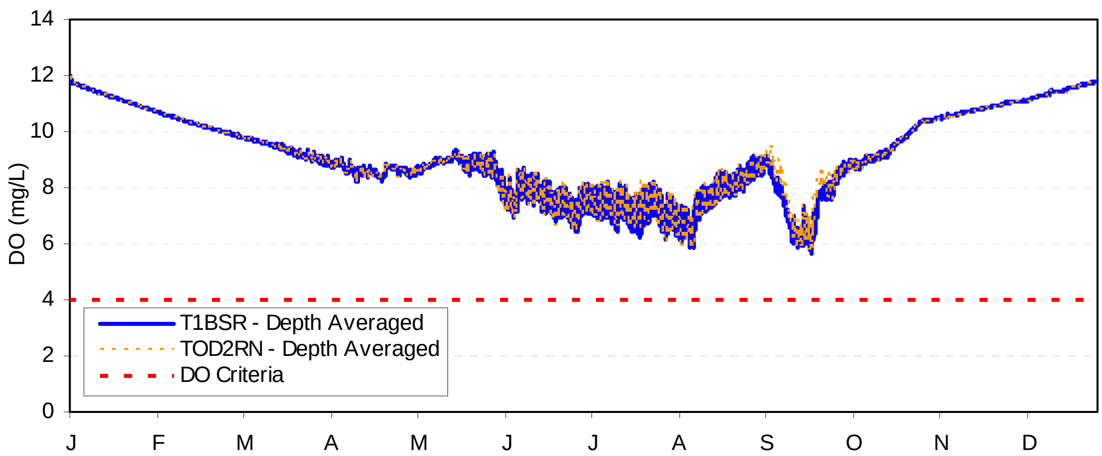
Corresponding temperatures at the mouth of the Trinity River under natural flows were estimated by Regional Water Board staff based on empirical analysis. The Trinity River Record of Decision (ROD) was implemented in 2005 and prescribes flows for a range of water year types, generally resulting in increased flows compared to pre-ROD flows. The expected change in temperature associated with increased flows (under natural conditions compared to current) was estimated by comparing the 2005 stream temperature and meteorological conditions with temperature and meteorological conditions of 2002-2004 (2005 was the first year of ROD flows). Regional Water Board staff also analyzed daily average Trinity River temperature data from the Hoopa gauge (RM 12.5) from both the 2000 and 2005 summer seasons to compare temperatures from two "normal" water year types with and without ROD flows (2005 and 2000, respectively). Neither of these comparisons indicated that a large temperature reduction at the mouth of the Trinity River would have occurred had ROD flows been implemented in 2000. Based on this comparison, Regional Water Board staff estimated stream temperatures would be reduced by 0.5 ^{o}C from June 1 to October 15 under natural conditions.

Appendix B: T1BSR and TOD2RN/TCD2RN Results

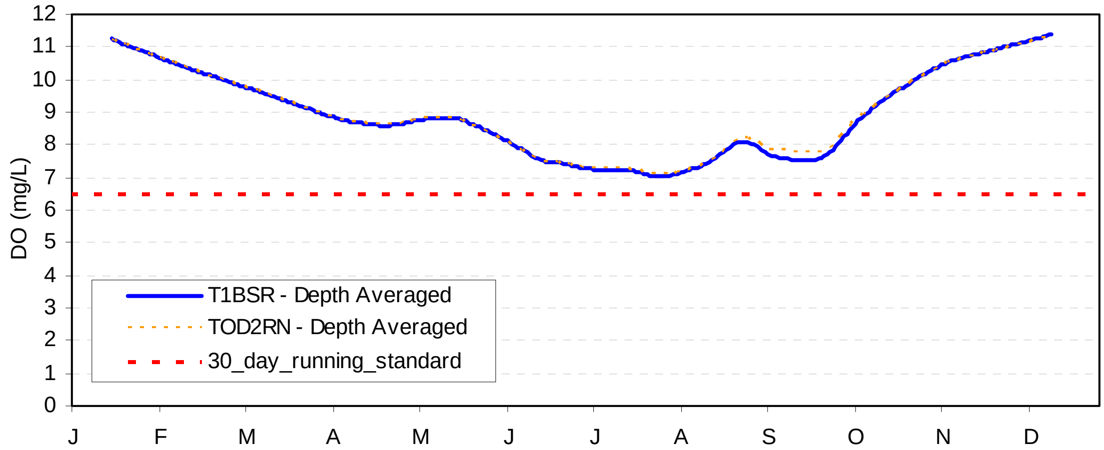
Klamath Falls STP

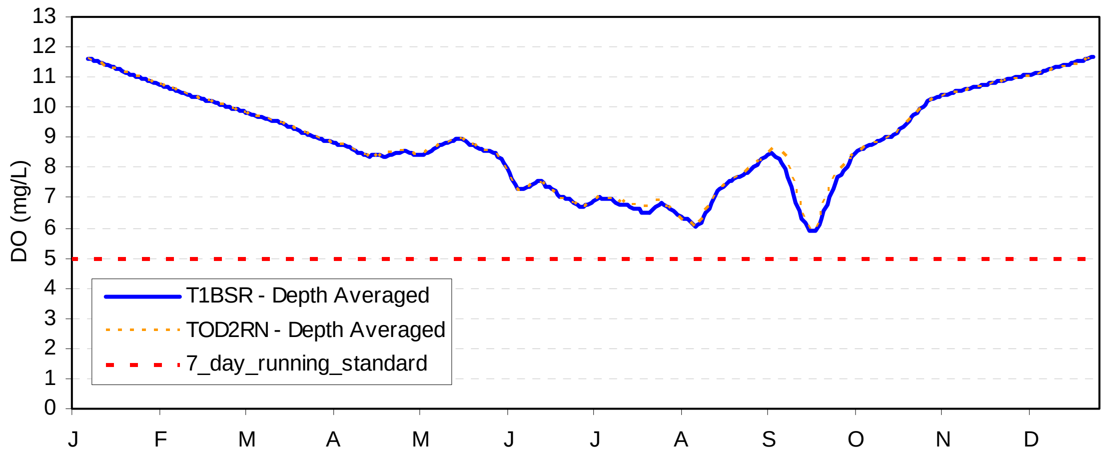


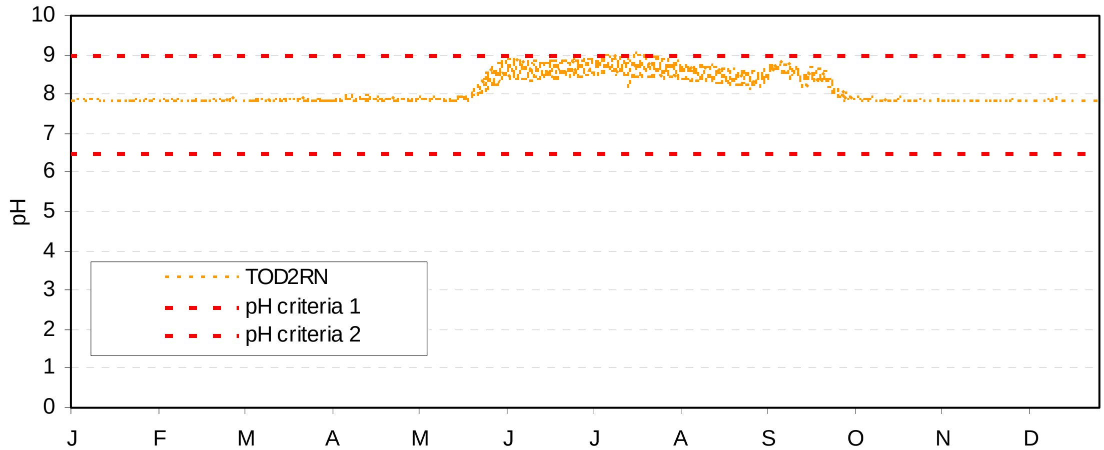




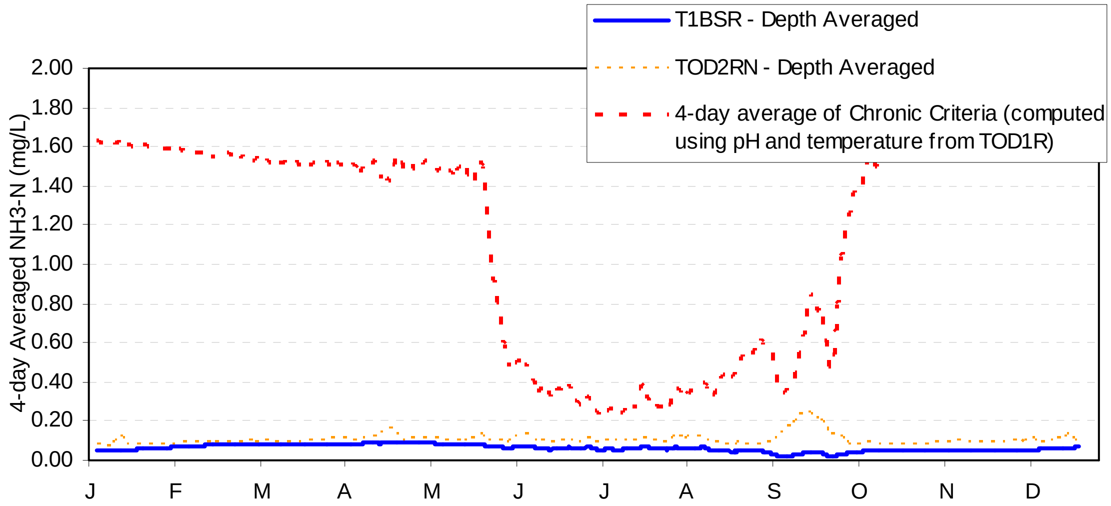
Klamath Falls STP

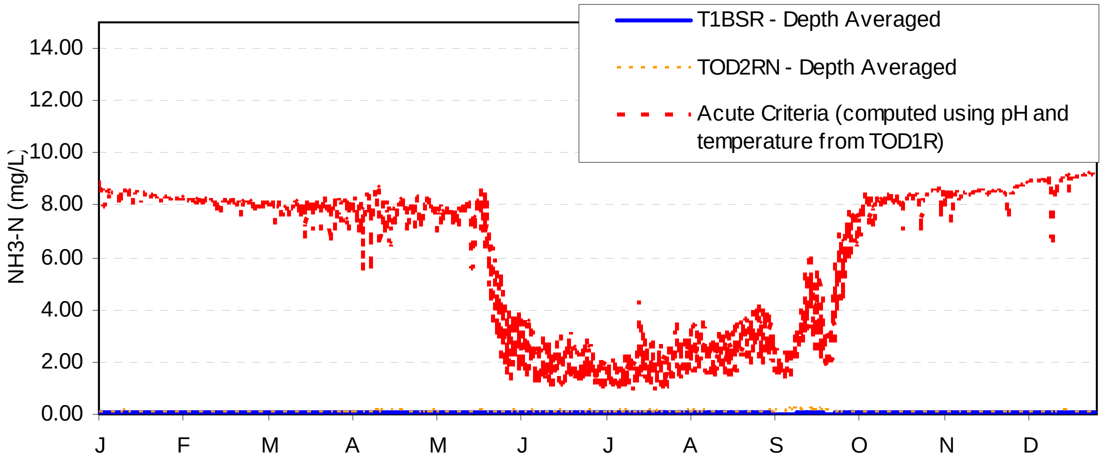


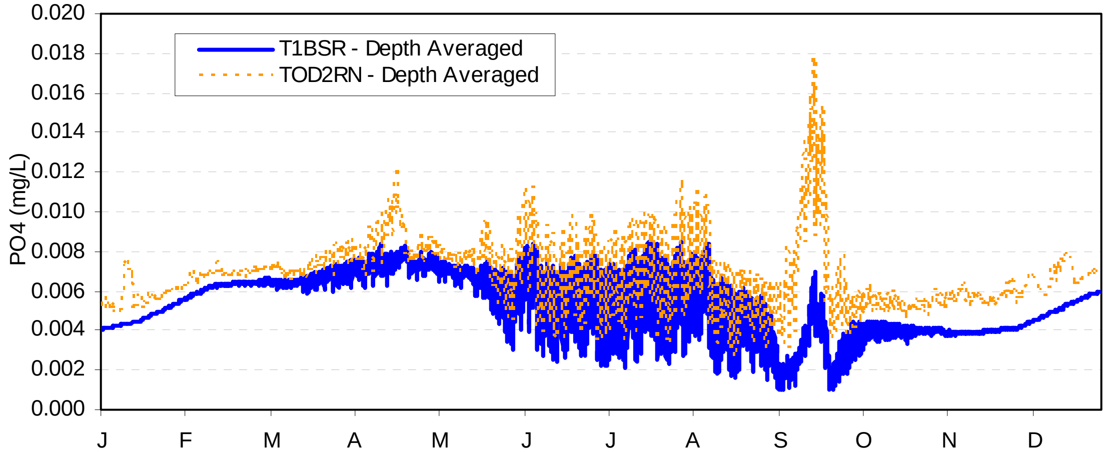




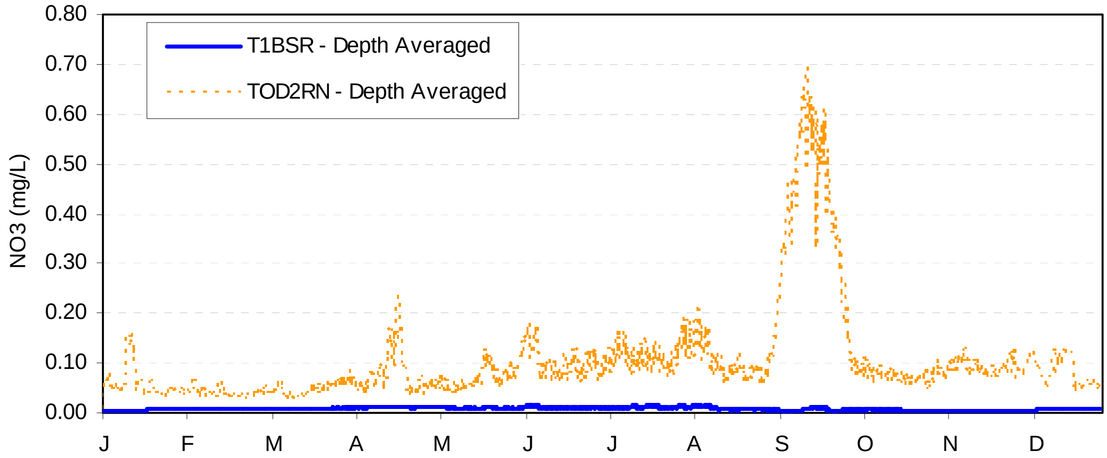
Klamath Falls STP

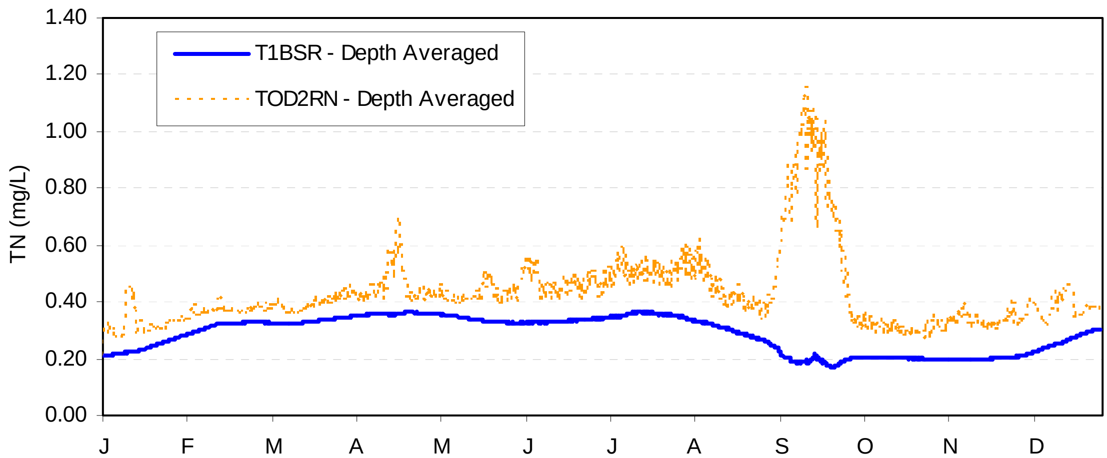


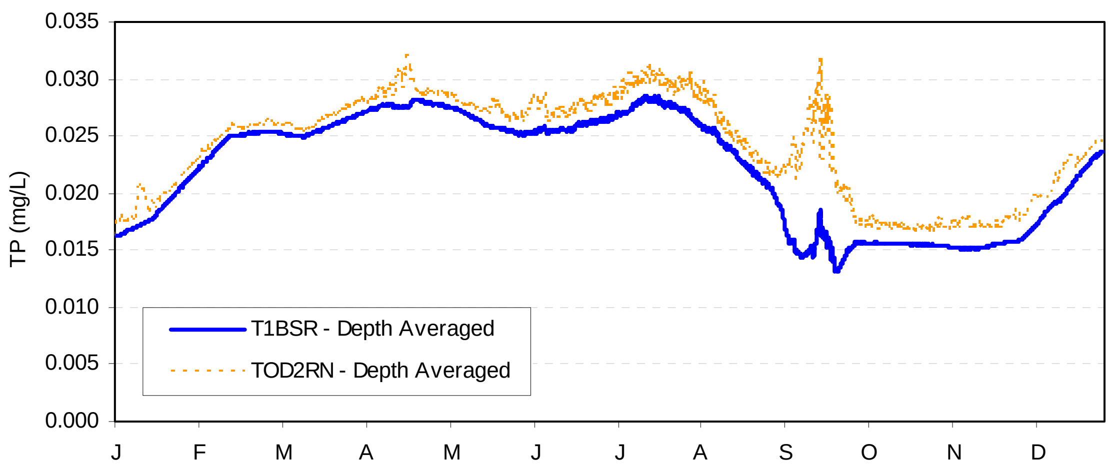




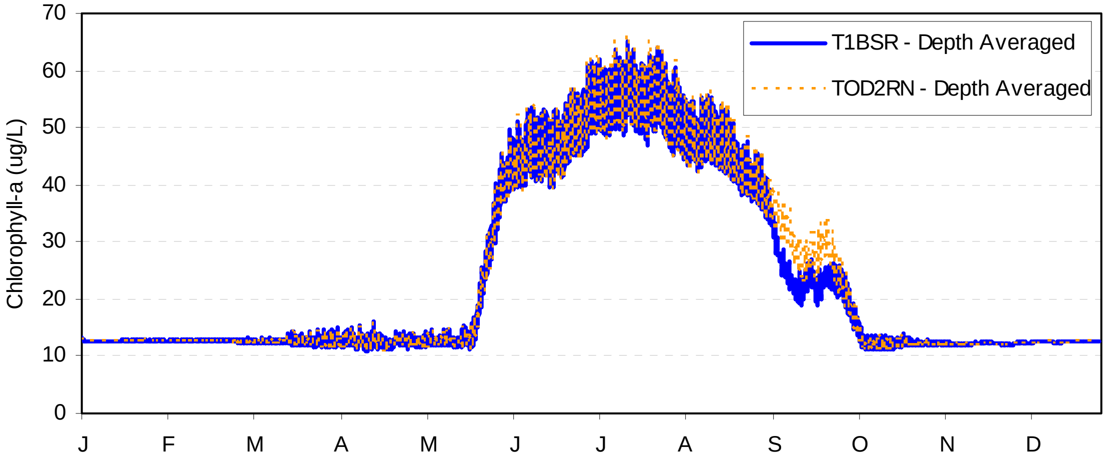
Klamath Falls STP

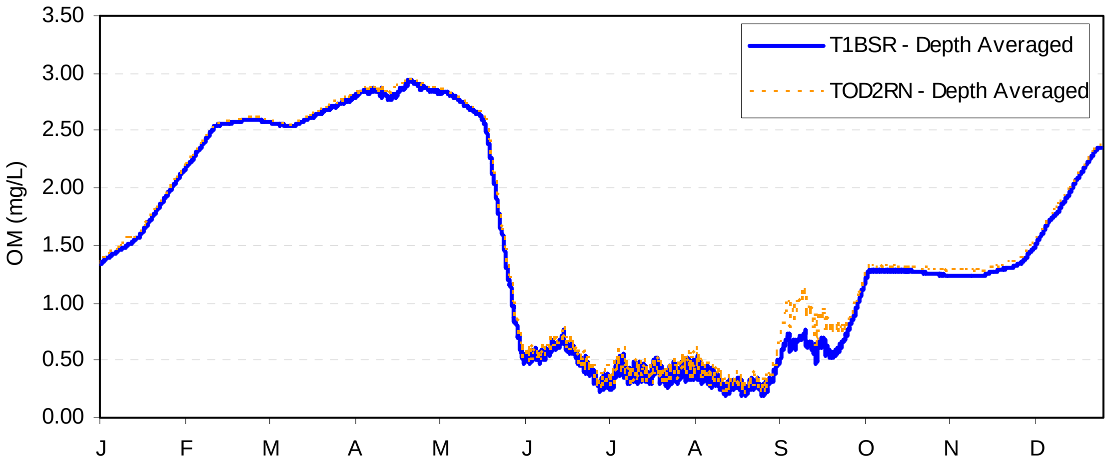




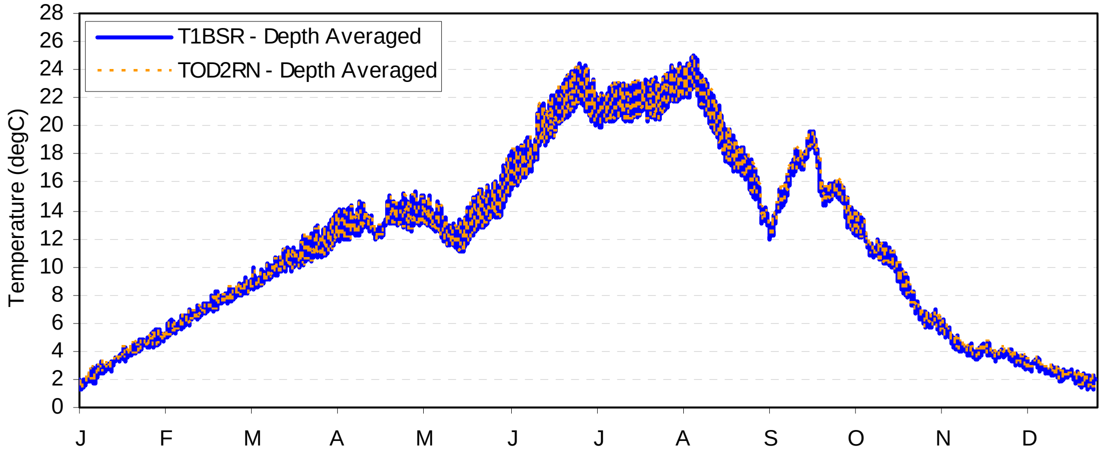


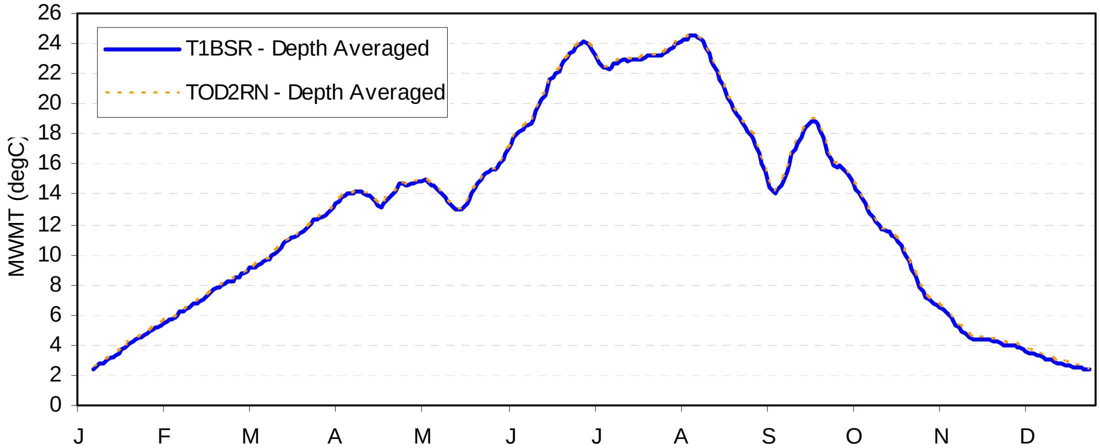
Klamath Falls STP

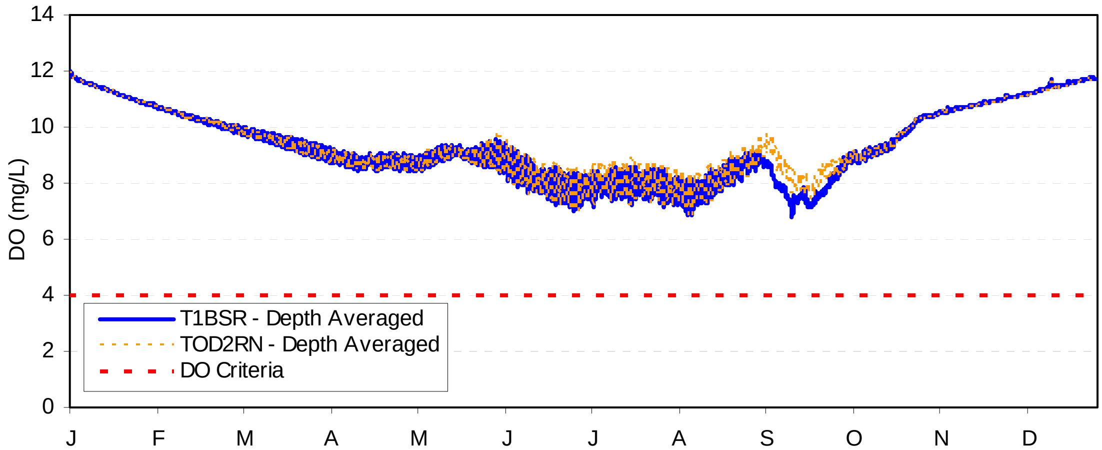




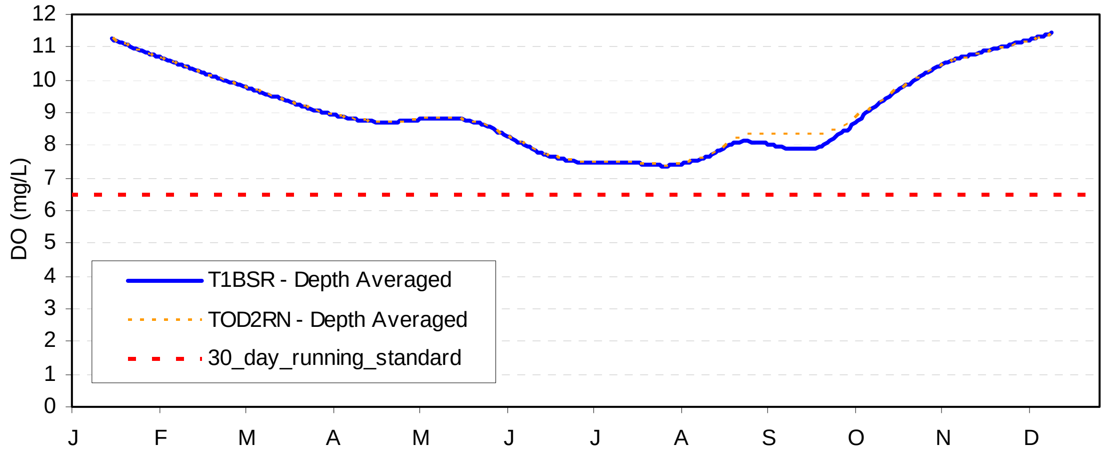
South Suburban Sanitary

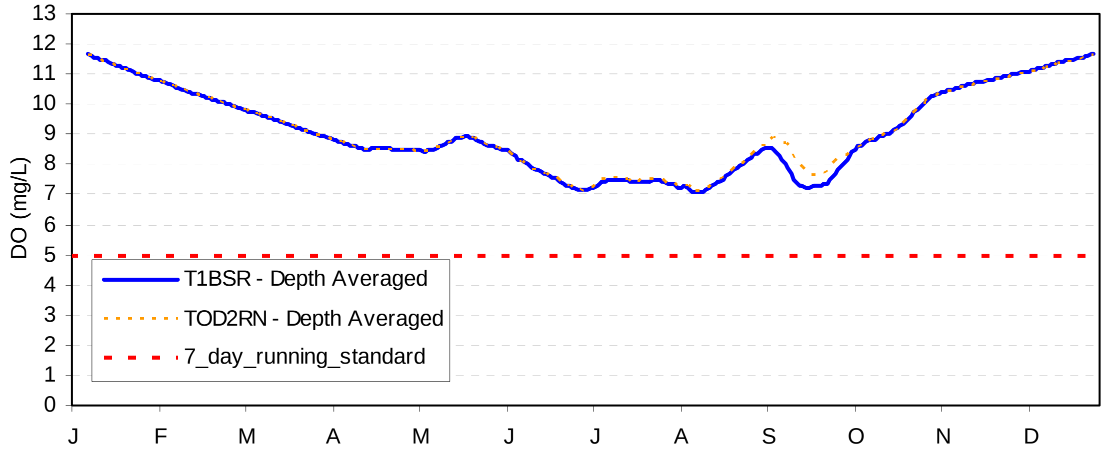


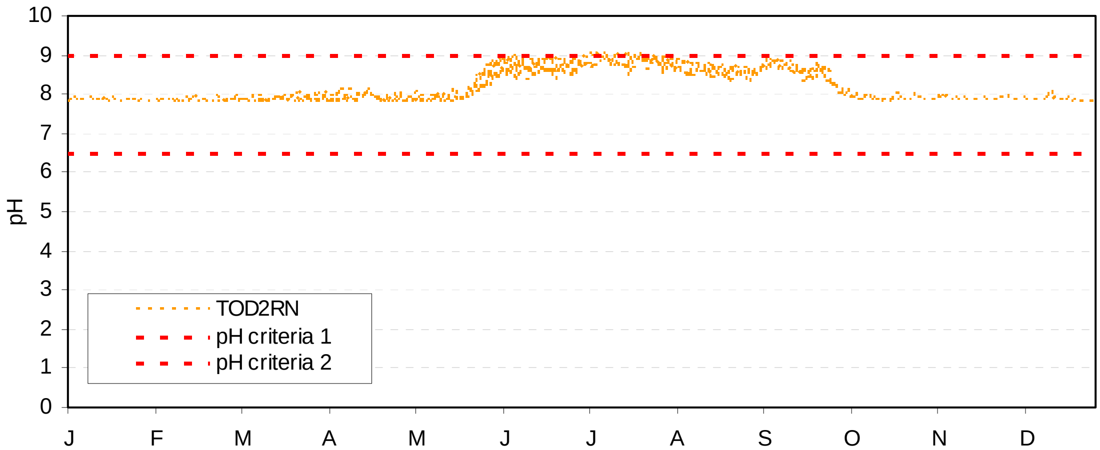




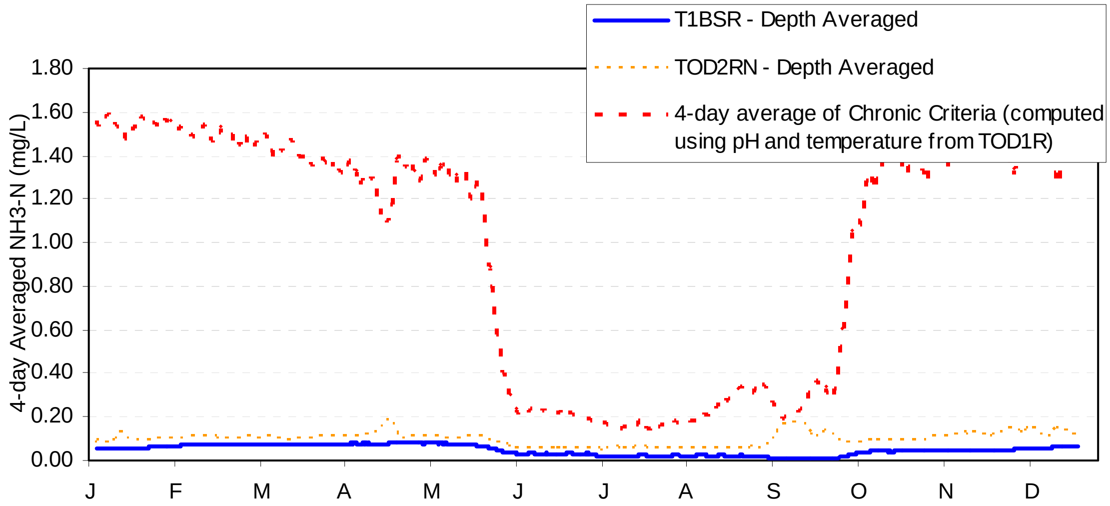
South Suburban Sanitary

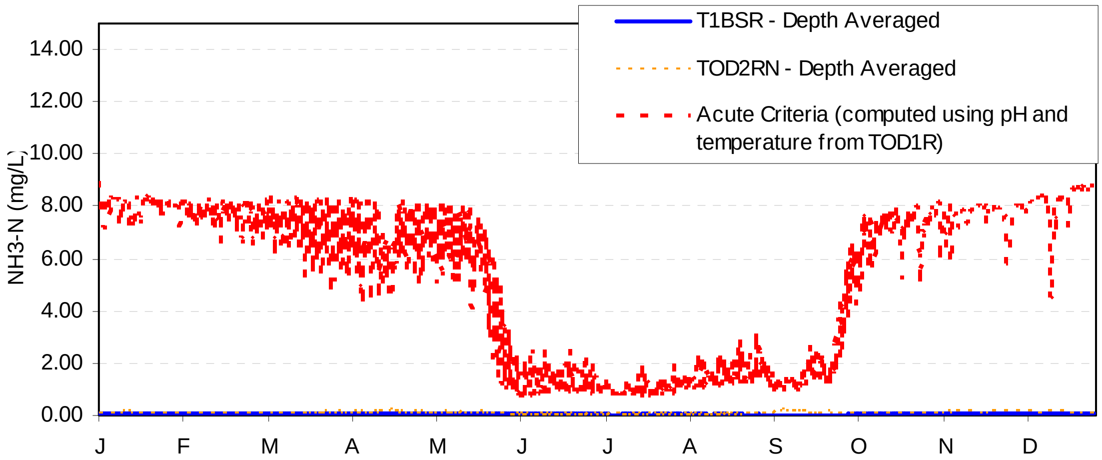


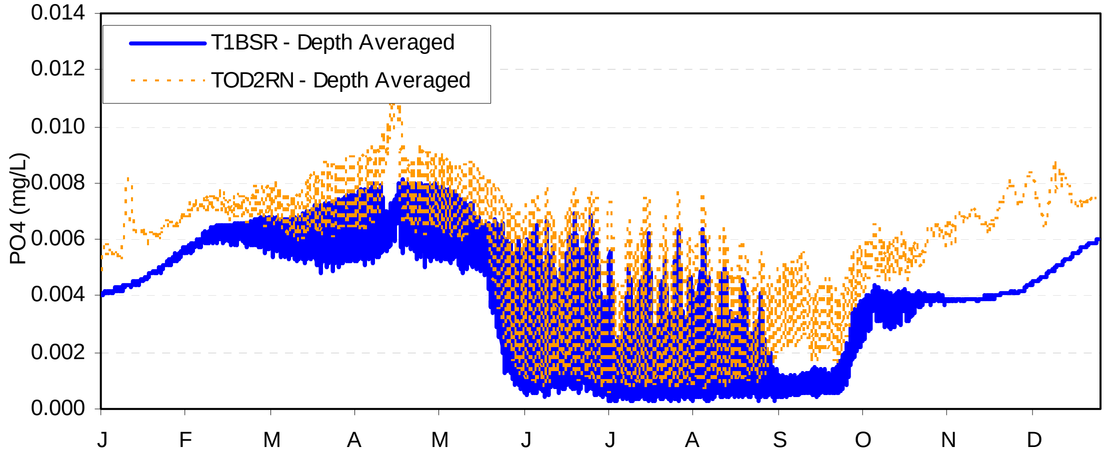




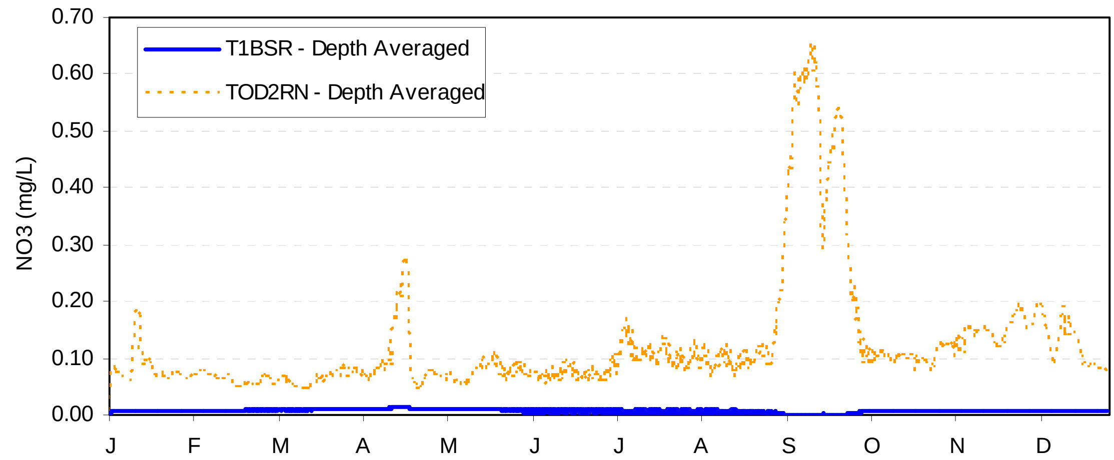
South Suburban Sanitary

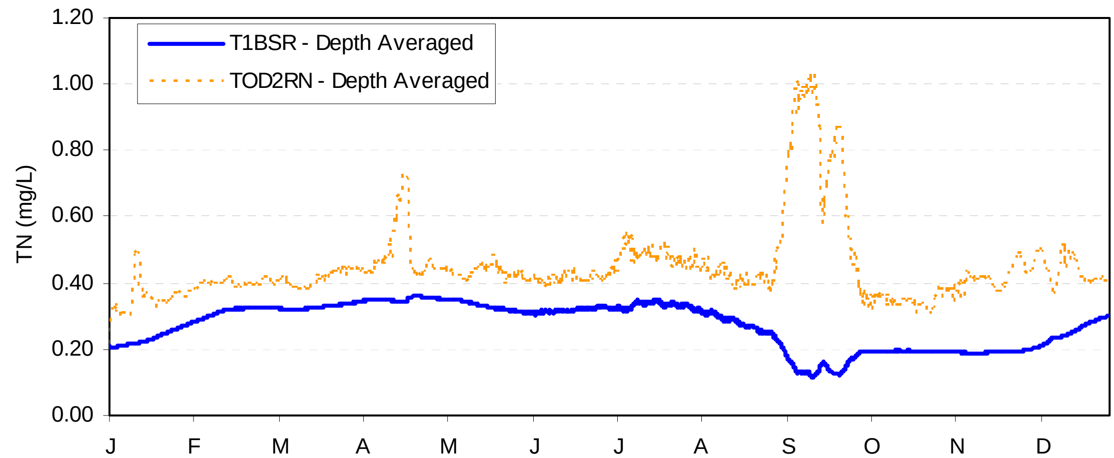


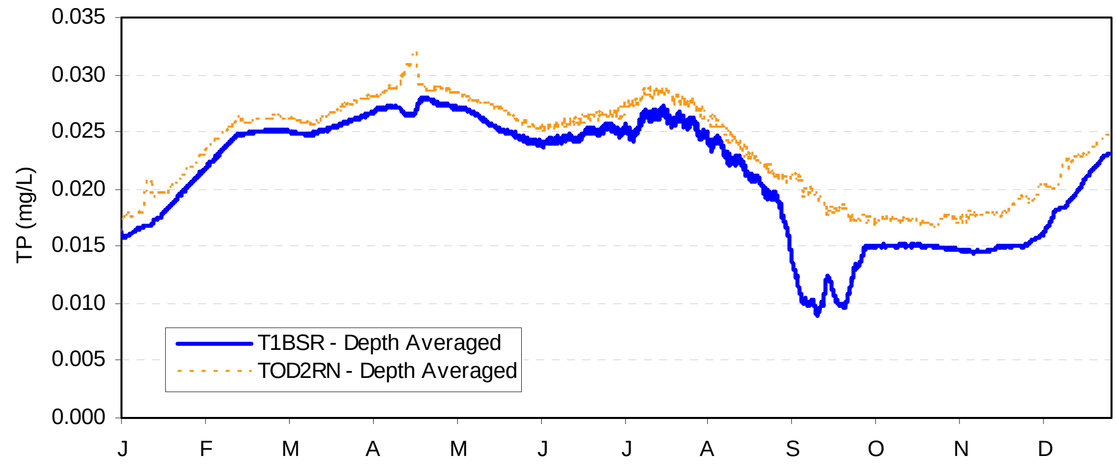




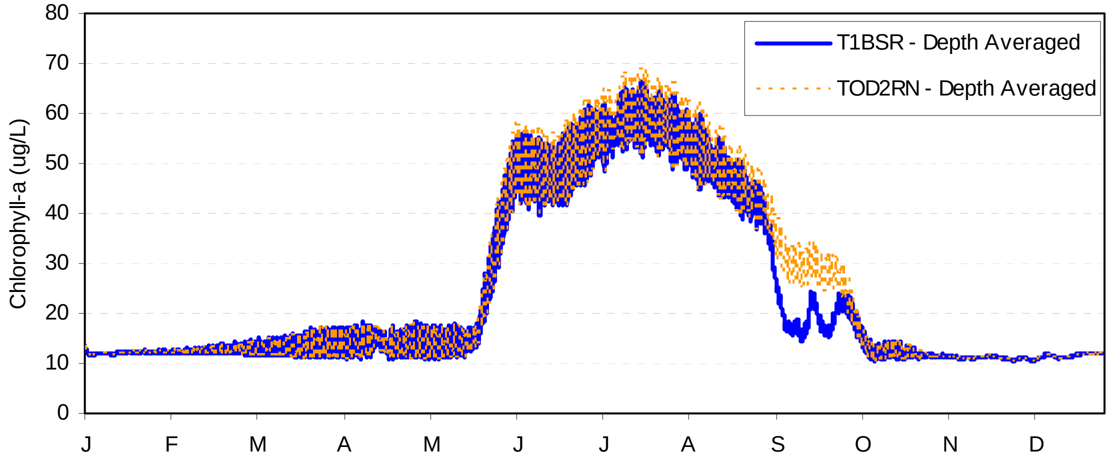
South Suburban Sanitary

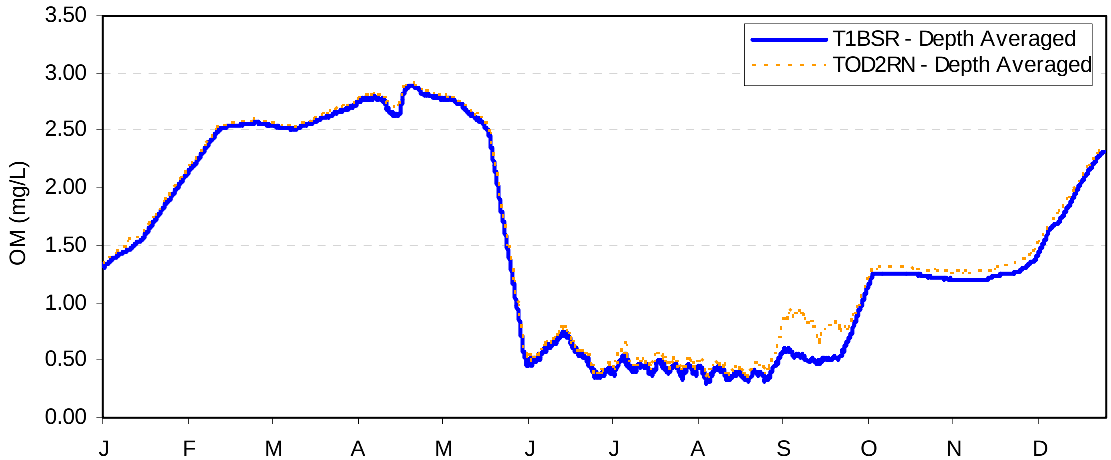




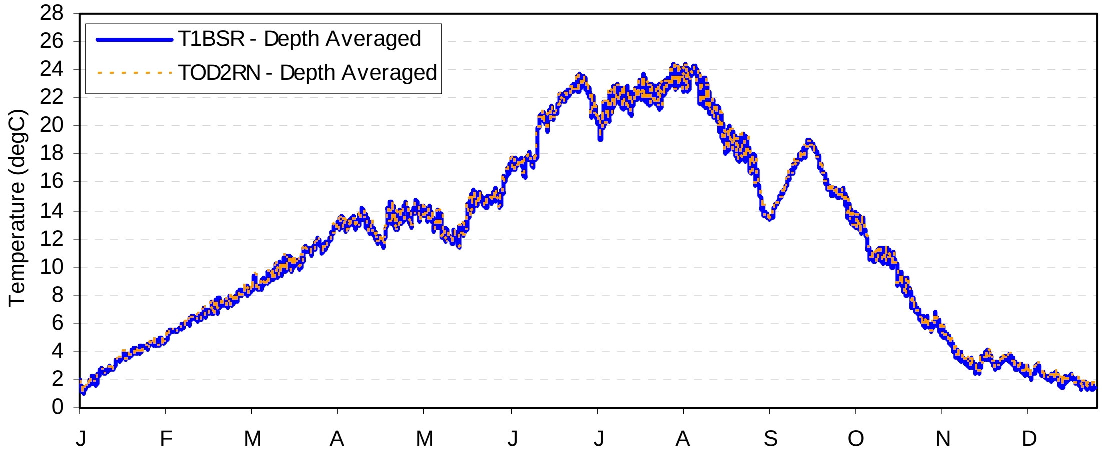


South Suburban Sanitary

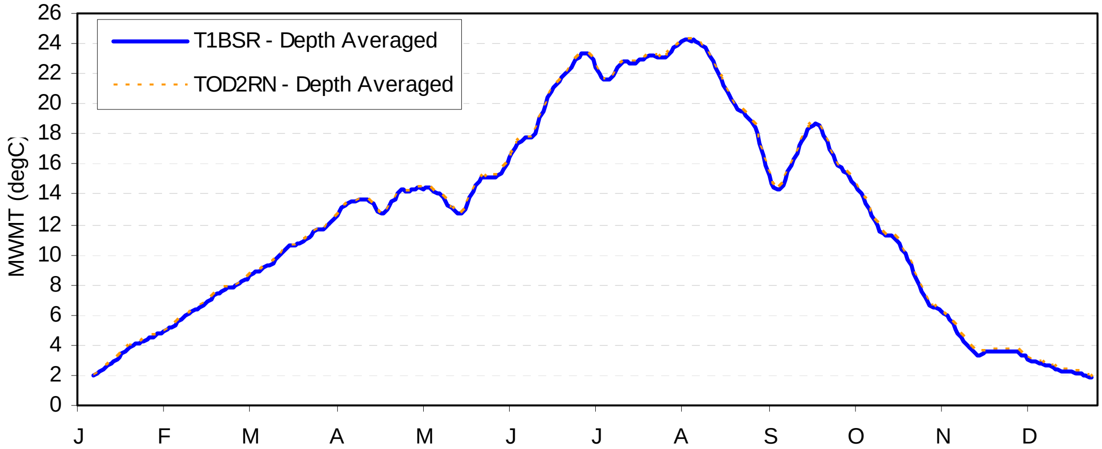




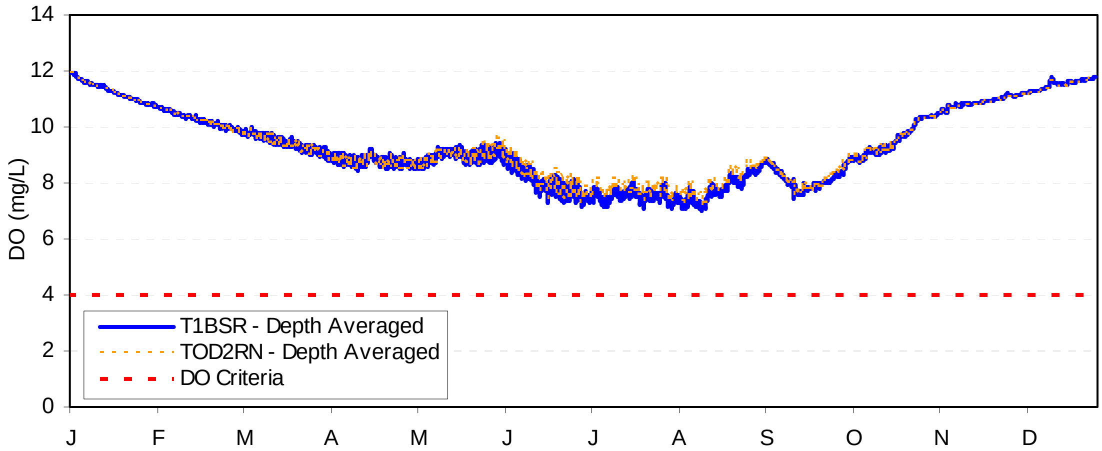
LRDC - CP



T1BSR - Depth Averaged
TOD2RN - Depth Averaged
Temperature (degC)
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
J
F
M
A
M
J
J
A
S
O
N
D

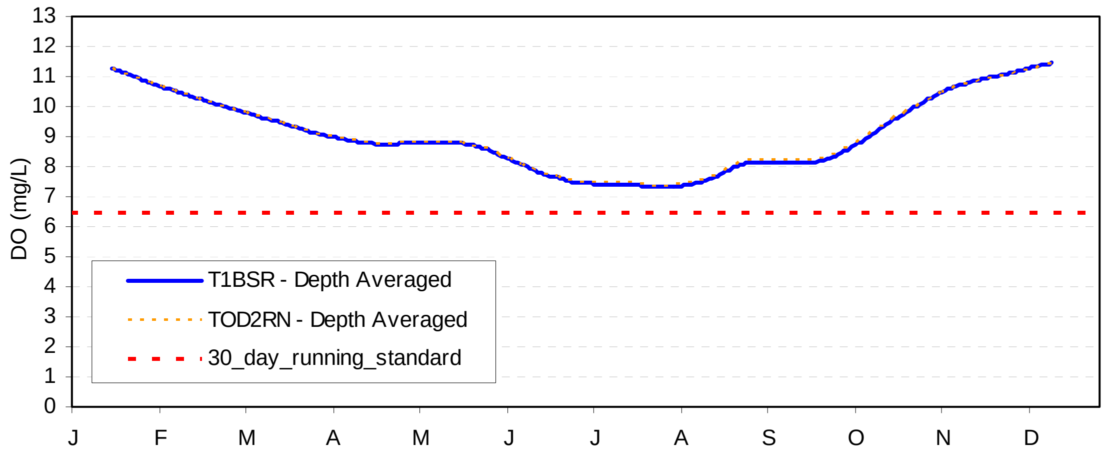


T1BSR - Depth Averaged
TOD2RN - Depth Averaged
MWMT (degC)
26
24
22
20
18
16
14
12
10
8
6
4
2
0
J
F
M
A
M
J
J
A
S
O
N
D

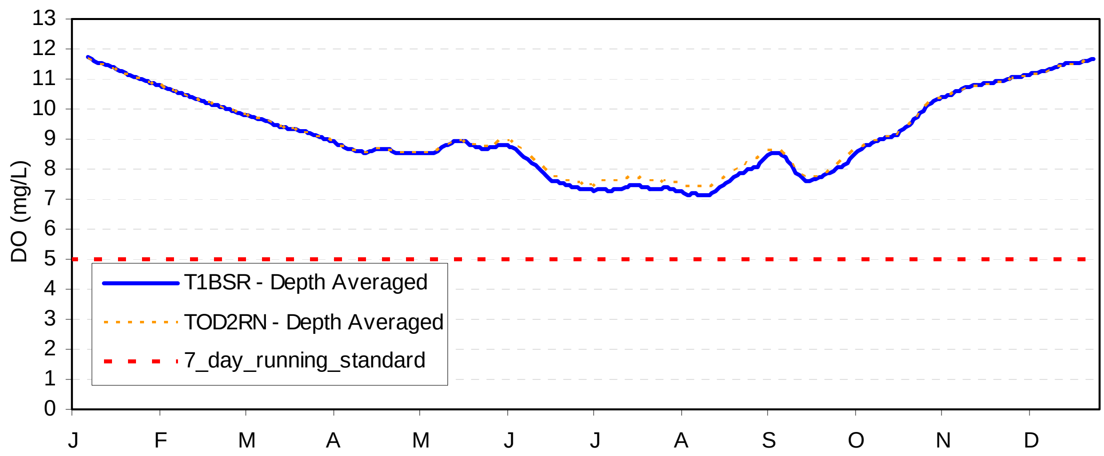


T1BSR - Depth Averaged
TOD2RN - Depth Averaged
DO Criteria
DO (mg/L)
14
12
10
8
6
4
2
0
J
F
M
A
M
J
J
A
S
O
N
D

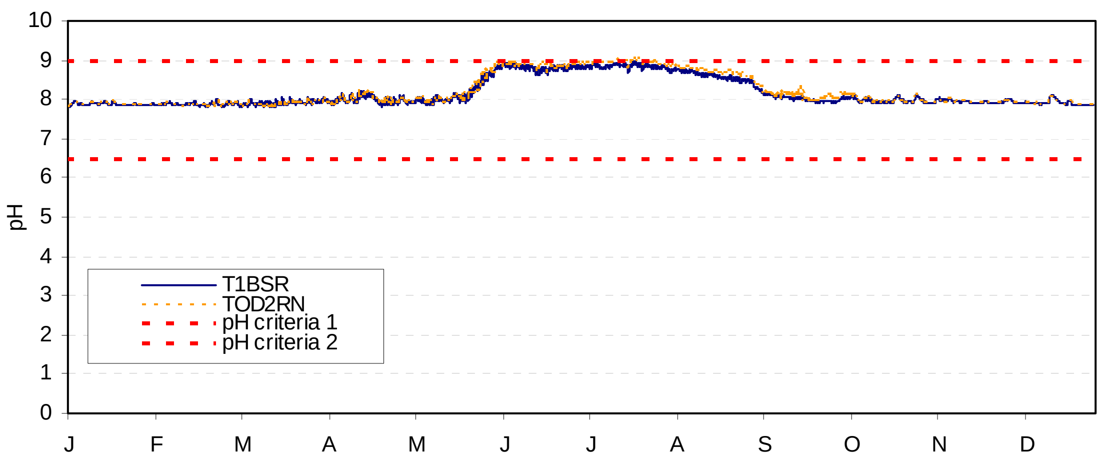
LRDC - CP



13
12
11
10
9
8
7
6
5
4
3
2
1
0
DO (mg/L)
T1BSR - Depth Averaged
TOD2RN - Depth Averaged
30_day_running_standard
J
F
M
A
M
J
J
A
S
O
N
D

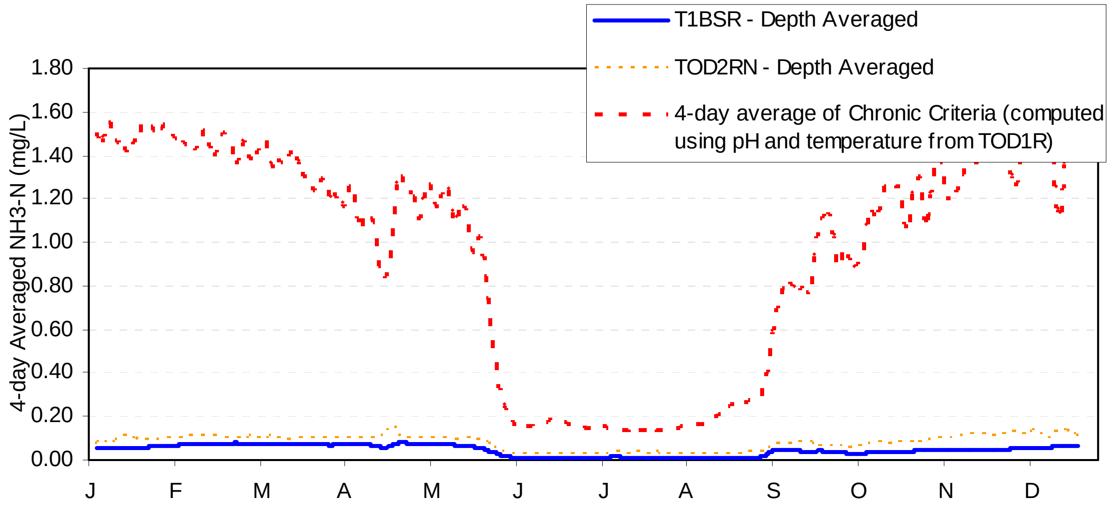


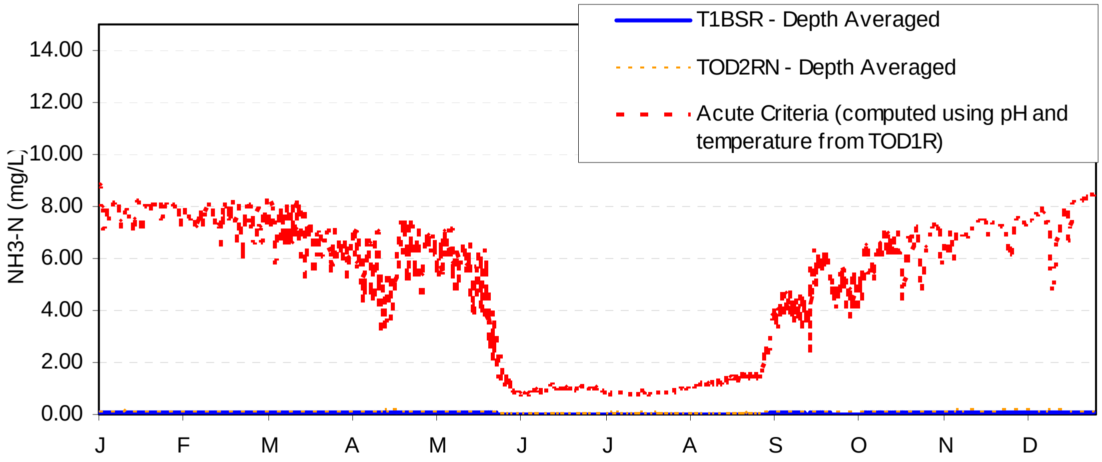
13
12
11
10
9
8
7
6
5
4
3
2
1
0
DO (mg/L)
T1BSR - Depth Averaged
TOD2RN - Depth Averaged
7_day_running_standard
J
F
M
A
M
J
J
A
S
O
N
D

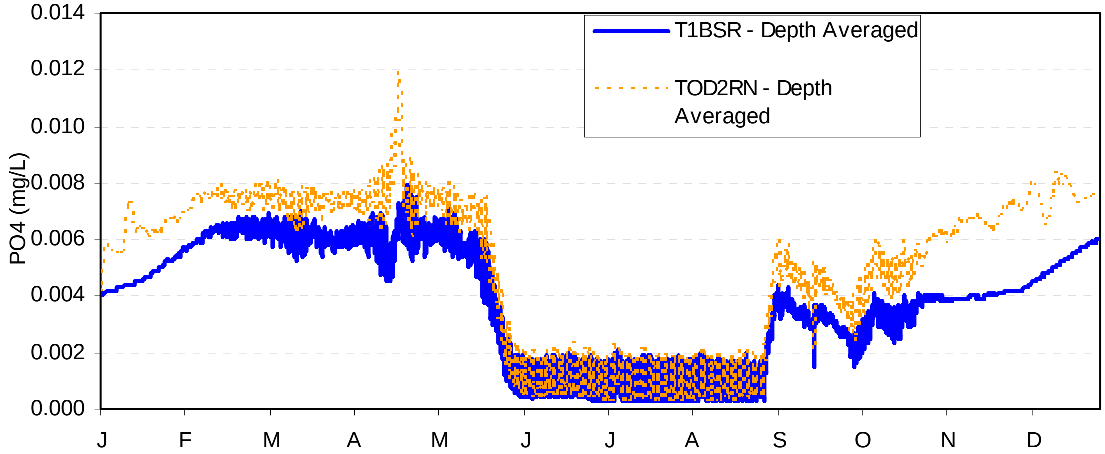


10
9
8
7
6
5
4
3
2
1
0
pH
T1BSR
TOD2RN
pH criteria 1
pH criteria 2
J
F
M
A
M
J
J
A
S
O
N
D

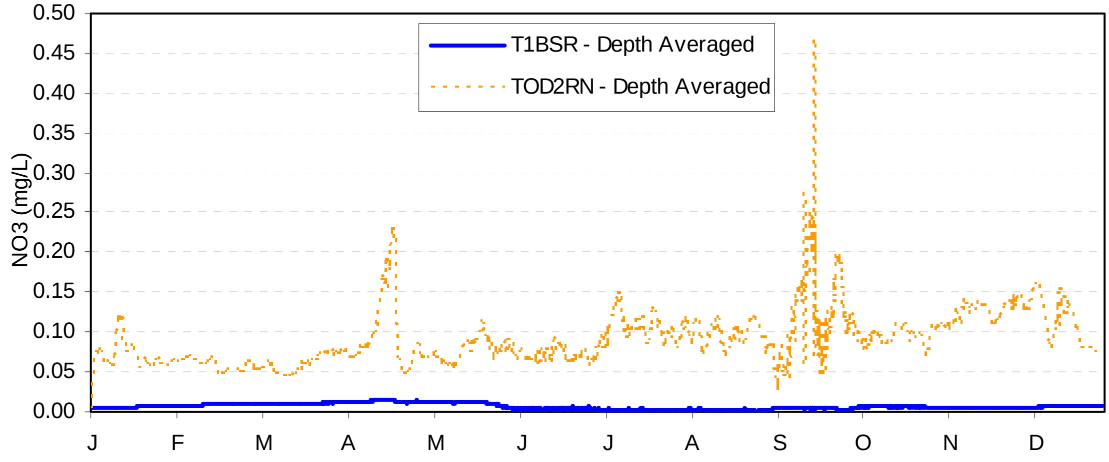
LRDC - CP


T1BSR - Depth Averaged
TOD2RN - Depth Averaged
4-day average of Chronic Criteria (computed using pH and temperature from TOD1R)
4-day Averaged NH3-N (mg/L)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
J F M A M J J A S O N D

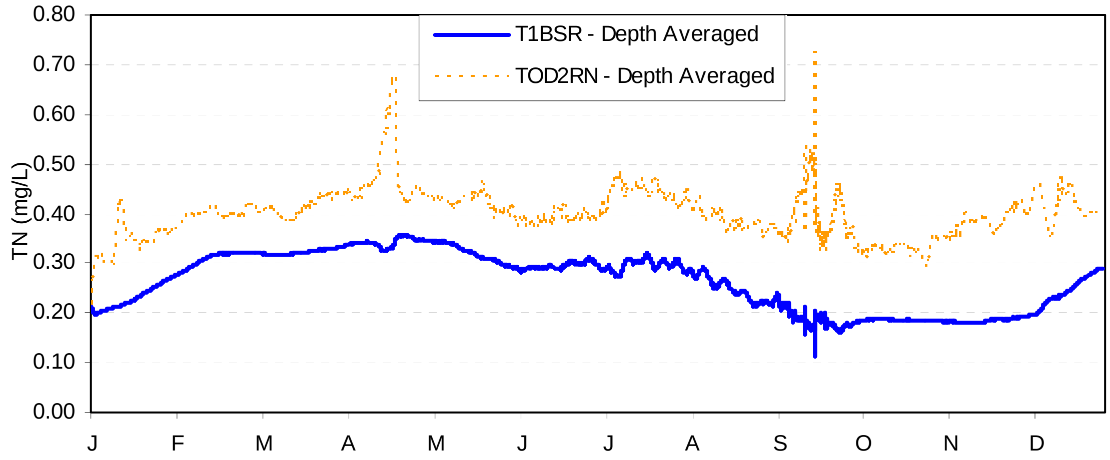

T1BSR - Depth Averaged
TOD2RN - Depth Averaged
Acute Criteria (computed using pH and temperature from TOD1R)
NH3-N (mg/L)
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
J F M A M J J A S O N D


T1BSR - Depth Averaged
TOD2RN - Depth Averaged
PO4 (mg/L)
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
J F M A M J J A S O N D

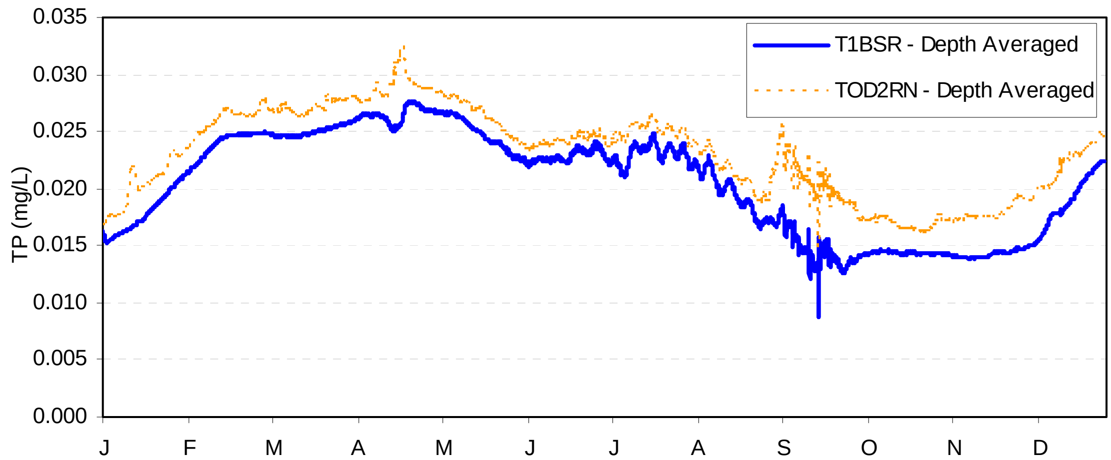
LRDC - CP



T1BSR - Depth Averaged
TOD2RN - Depth Averaged
NO3 (mg/L)
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
J F M A M J J A S O N D

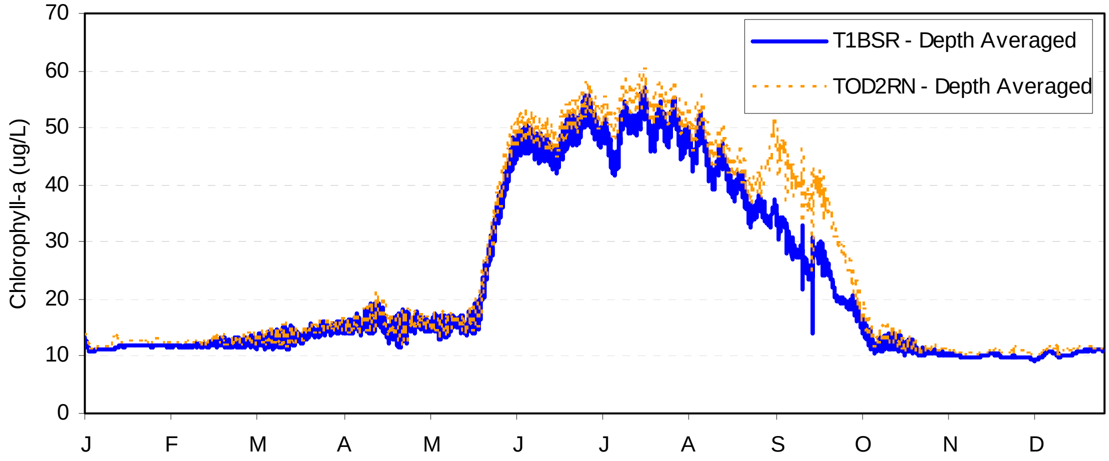


T1BSR - Depth Averaged
TOD2RN - Depth Averaged
TN (mg/L)
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
J F M A M J J A S O N D

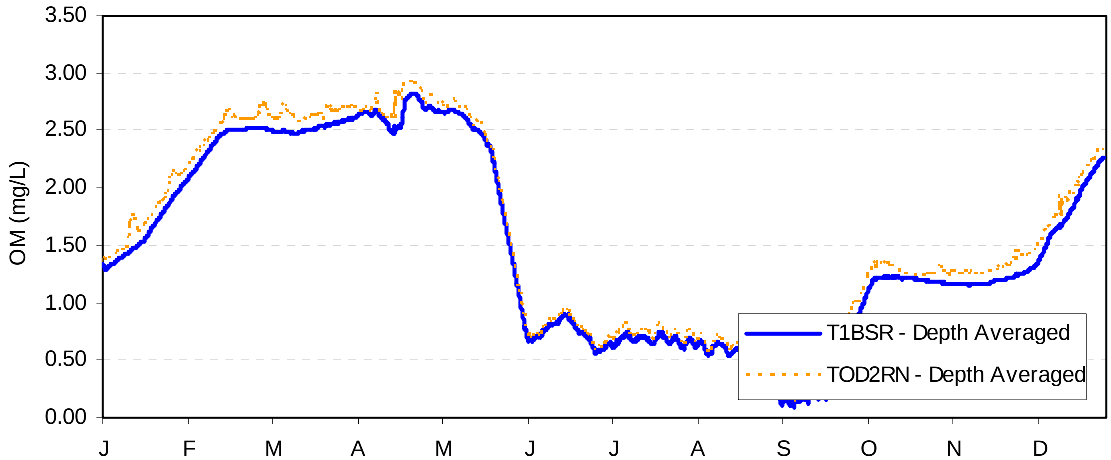


T1BSR - Depth Averaged
TOD2RN - Depth Averaged
TP (mg/L)
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
J F M A M J J A S O N D

LRDC - CP

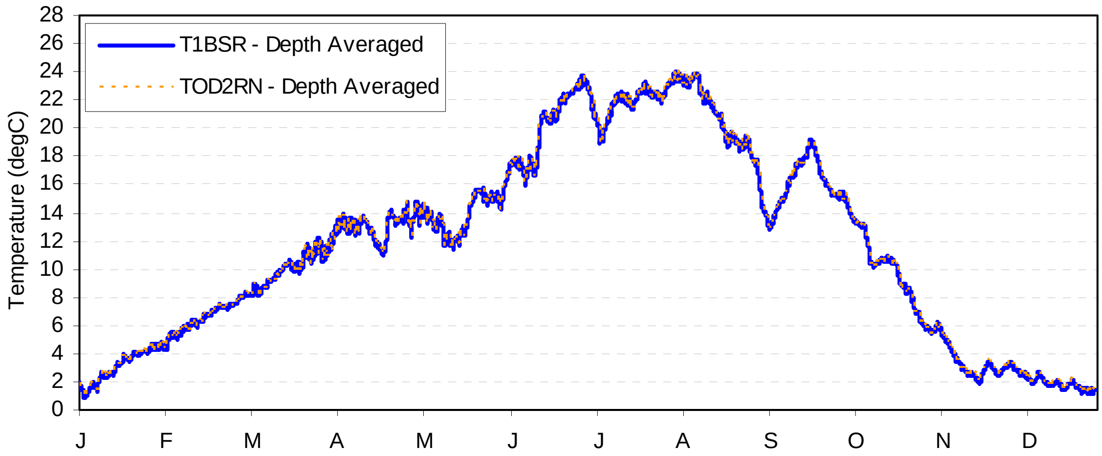


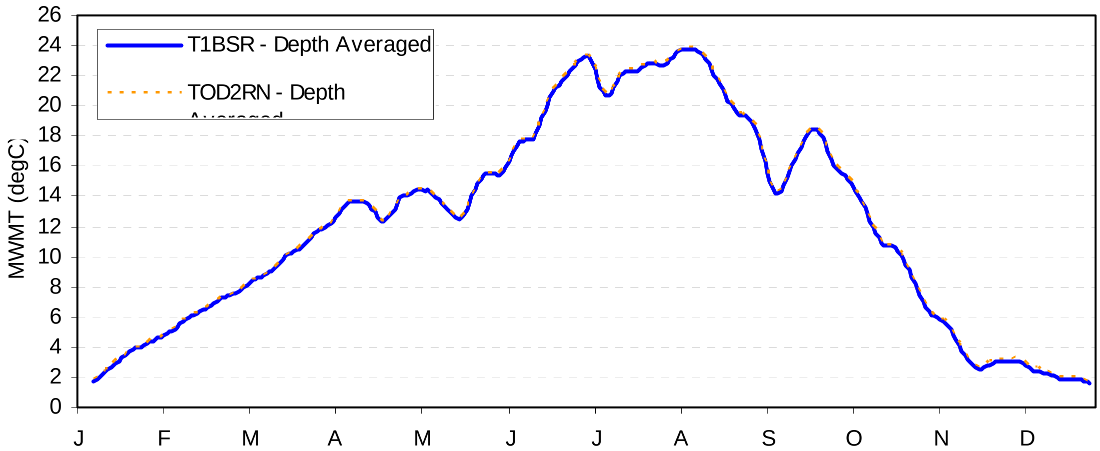
70
60
50
40
30
20
10
0
Chlorophyll-a (ug/L)
J
F
M
A
M
J
J
A
S
O
N
D
T1BSR - Depth Averaged
TOD2RN - Depth Averaged

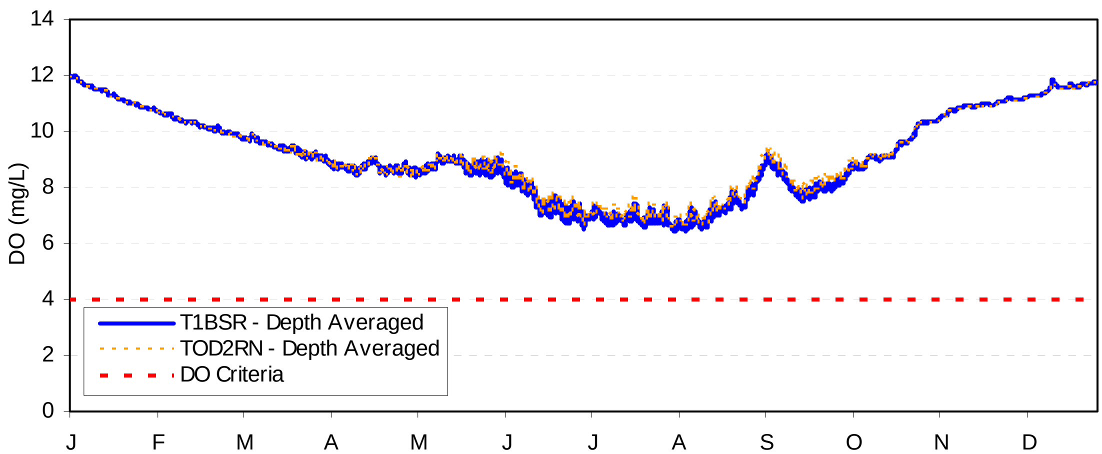


3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
OM (mg/L)
J
F
M
A
M
J
J
A
S
O
N
D
T1BSR - Depth Averaged
TOD2RN - Depth Averaged

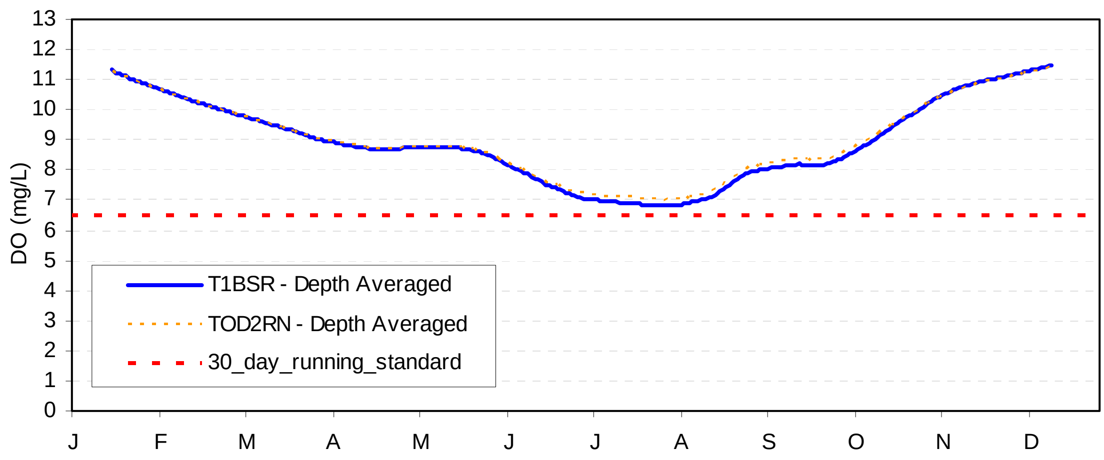
Miller Island

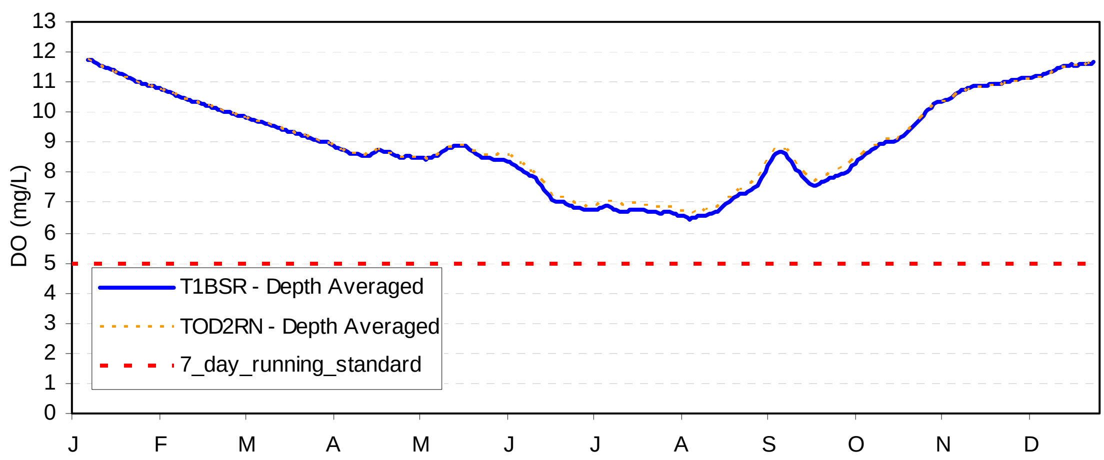


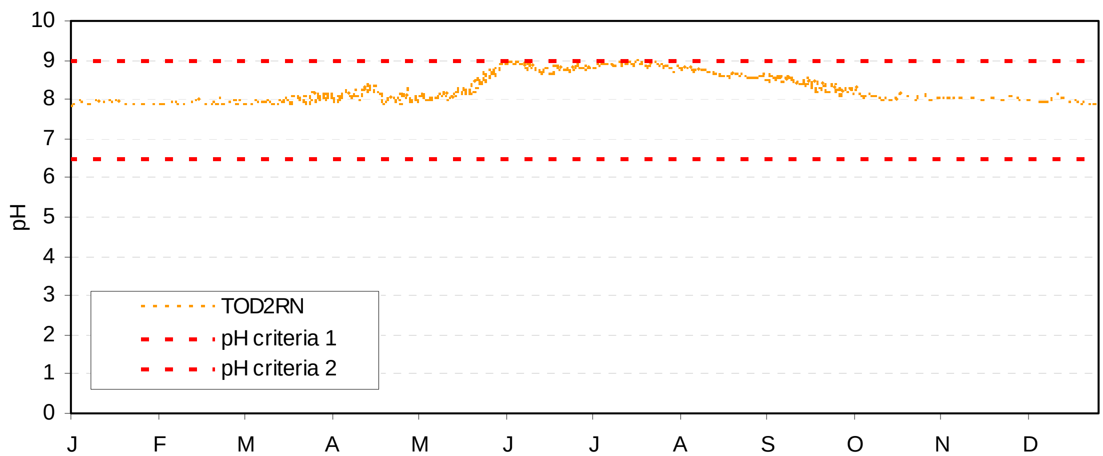




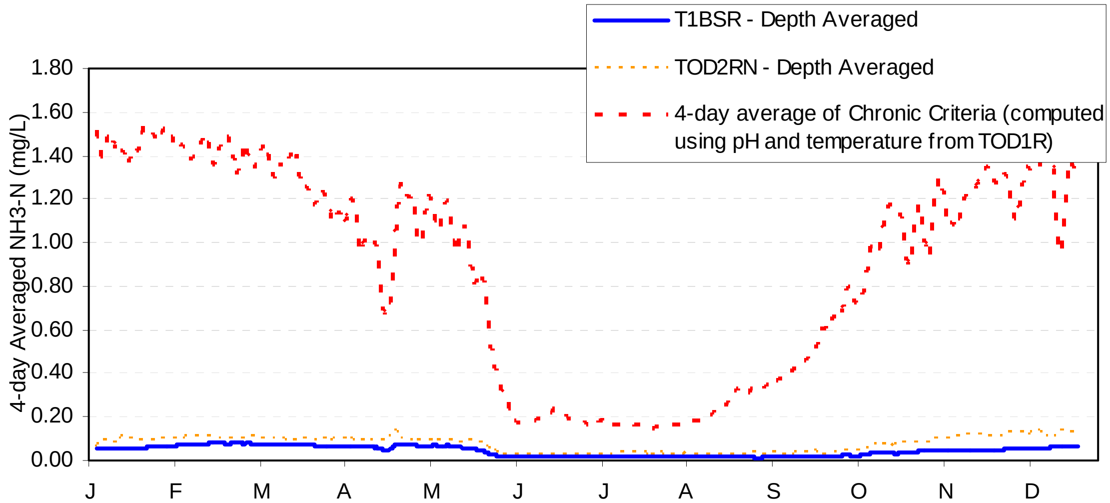
Miller Island

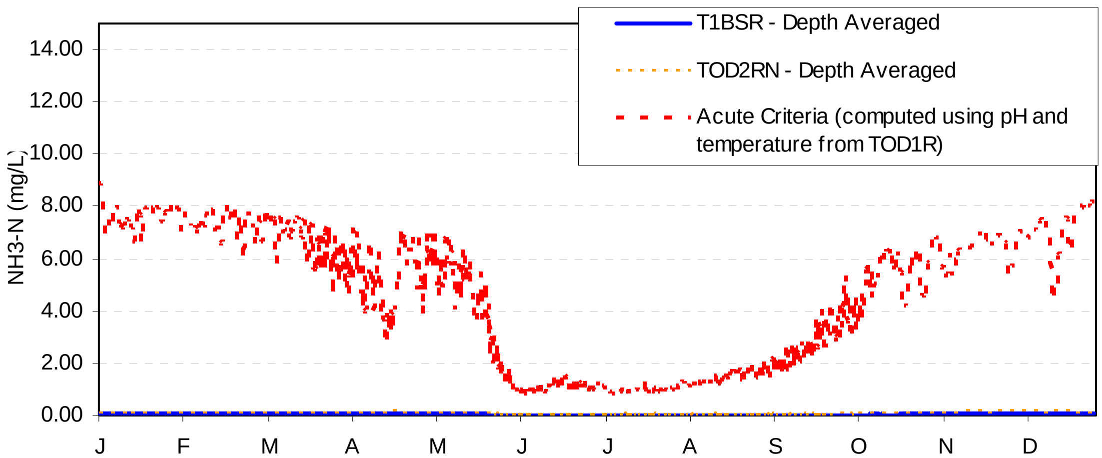


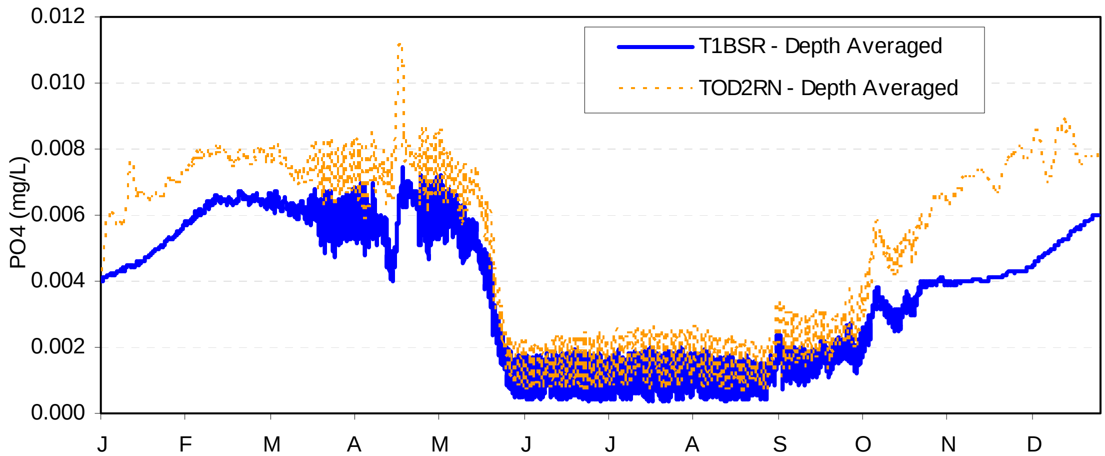




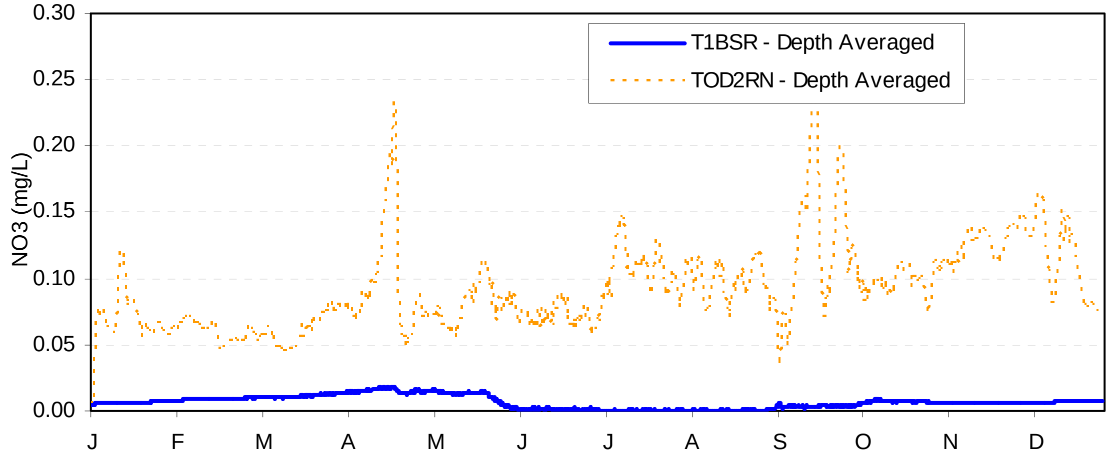
Miller Island

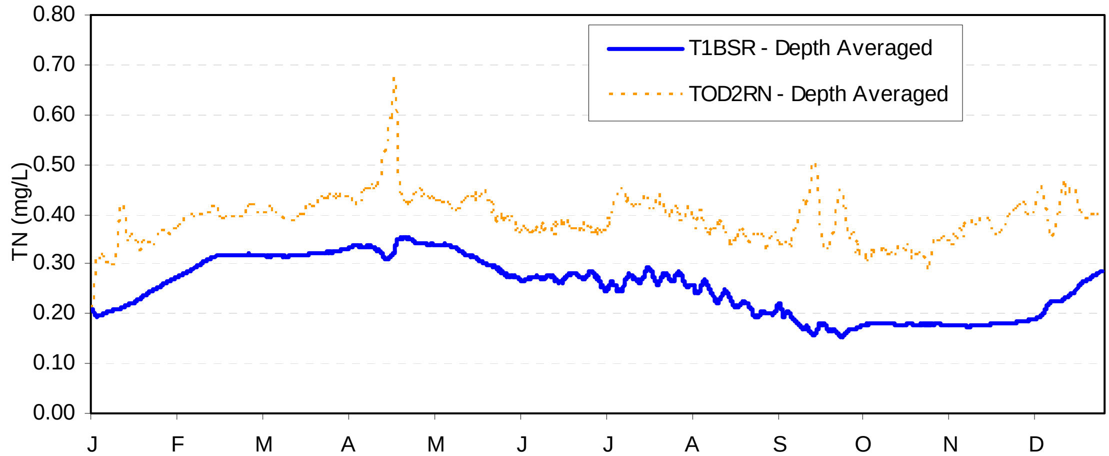


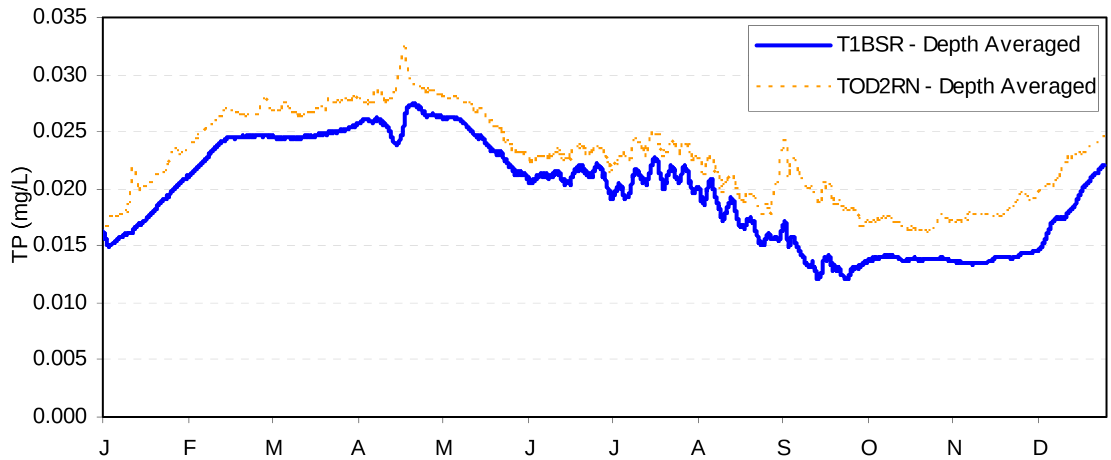




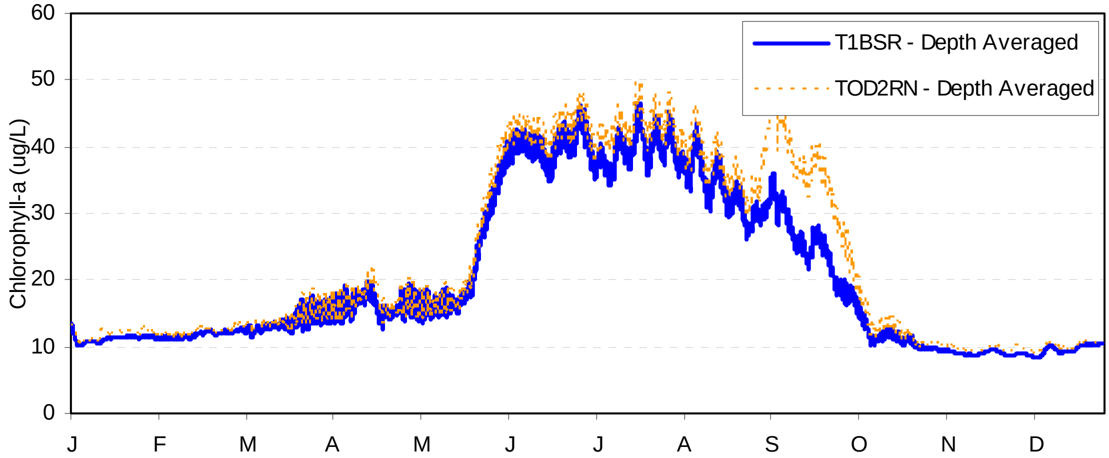
Miller Island

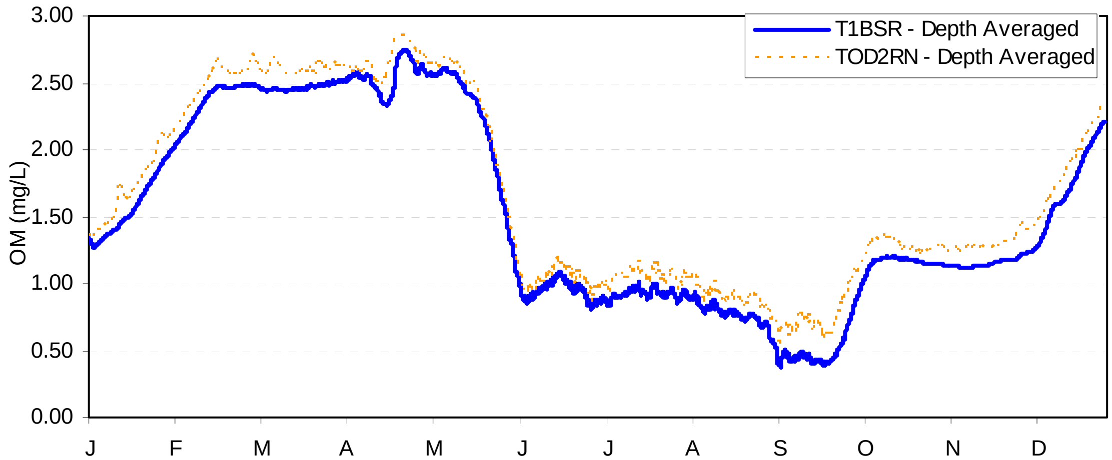




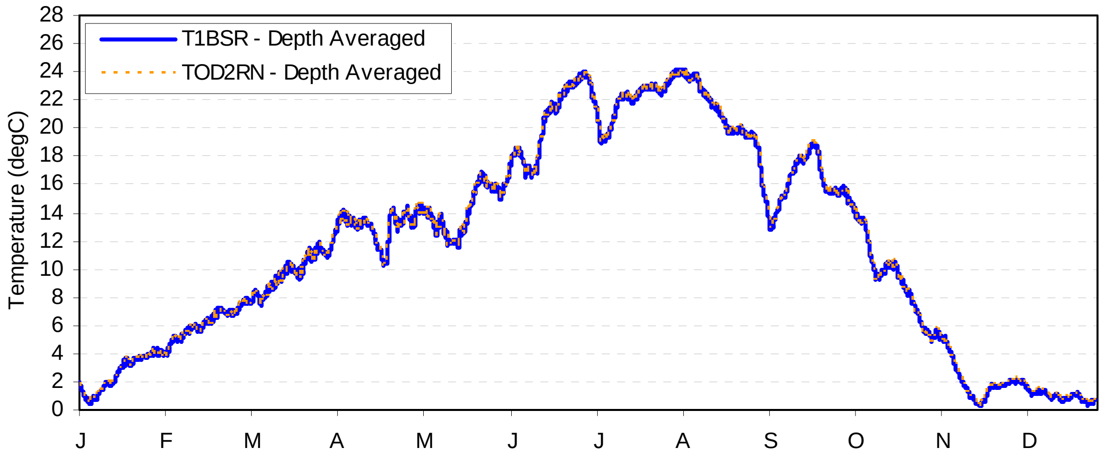


Miller Island

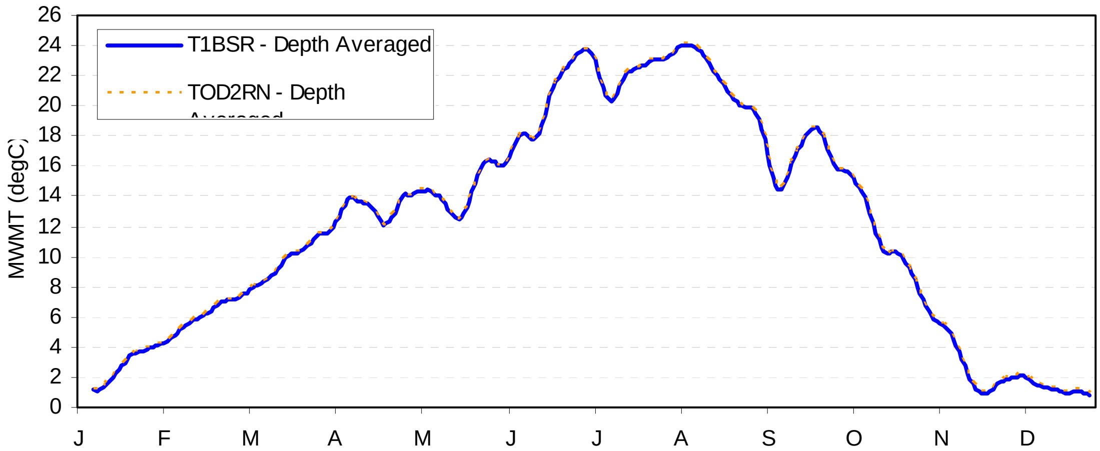




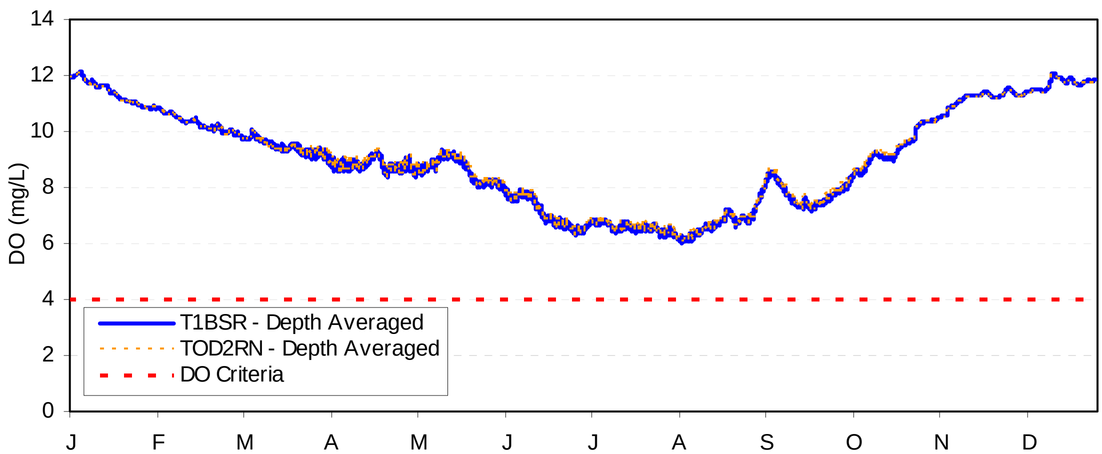
KSD



T1BSR - Depth Averaged
TOD2RN - Depth Averaged
Temperature (degC)
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
J
F
M
A
M
J
J
A
S
O
N
D

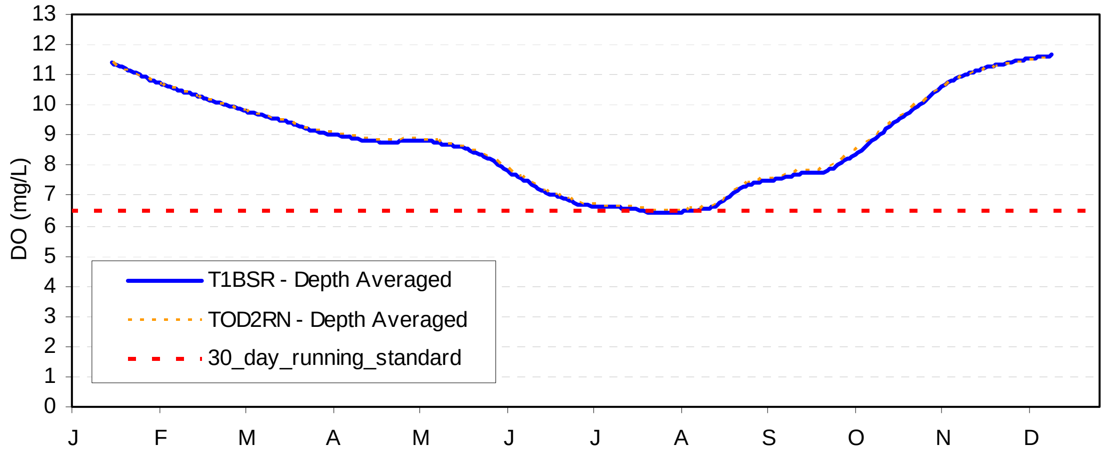


T1BSR - Depth Averaged
TOD2RN - Depth
MWMT (degC)
26
24
22
20
18
16
14
12
10
8
6
4
2
0
J
F
M
A
M
J
J
A
S
O
N
D

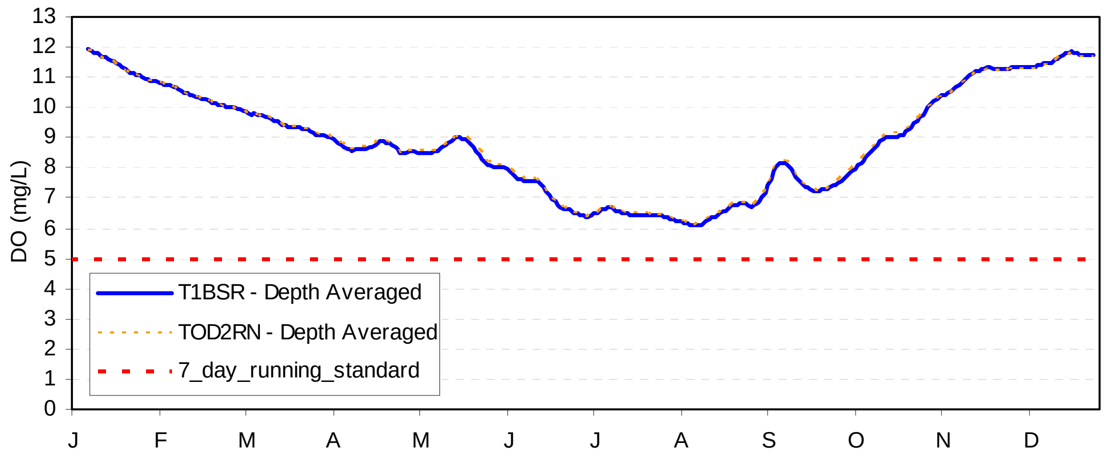


T1BSR - Depth Averaged
TOD2RN - Depth Averaged
DO Criteria
DO (mg/L)
14
12
10
8
6
4
2
0
J
F
M
A
M
J
J
A
S
O
N
D

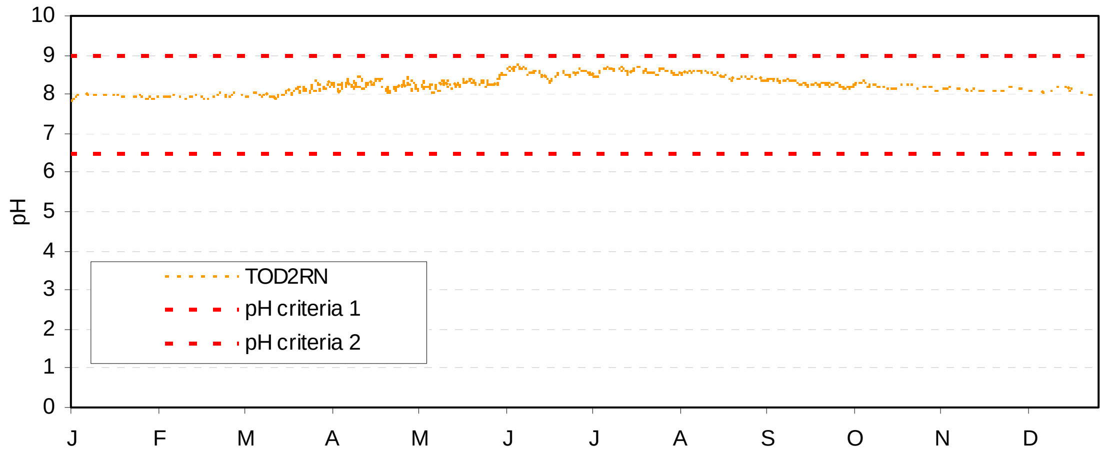
KSD



DO (mg/L)
13
12
11
10
9
8
7
6
5
4
3
2
1
0
T1BSR - Depth Averaged
TOD2RN - Depth Averaged
30_day_running_standard
J F M A M J J A S O N D

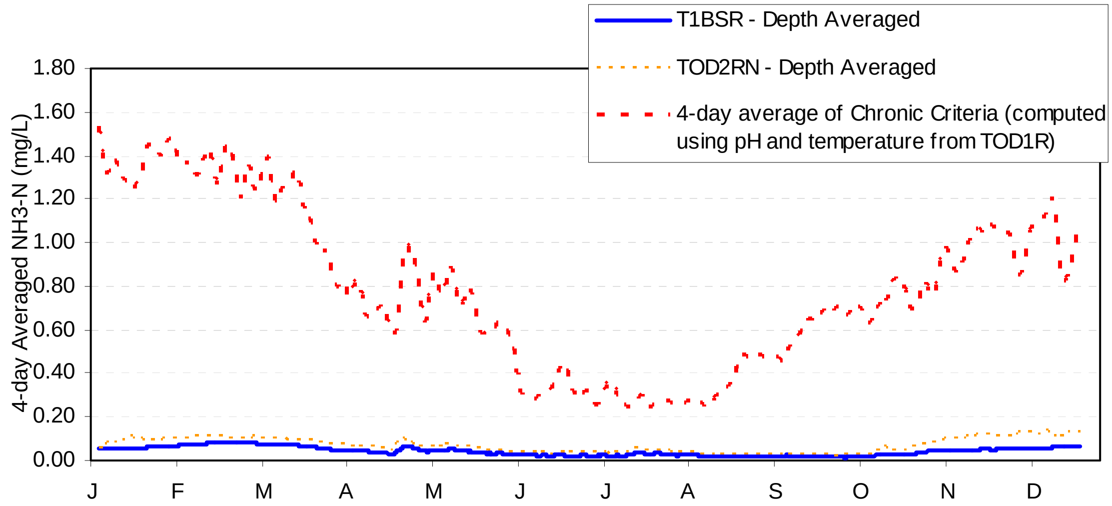


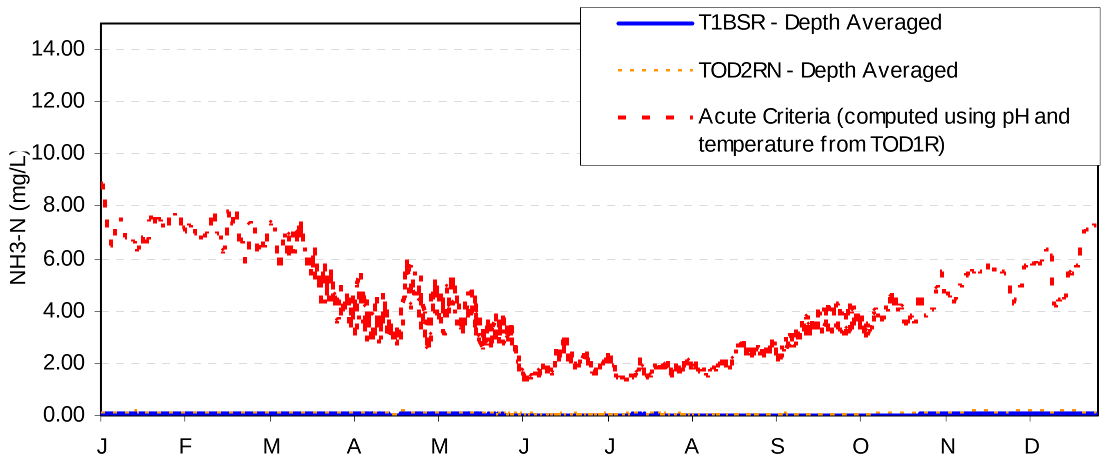
DO (mg/L)
13
12
11
10
9
8
7
6
5
4
3
2
1
0
T1BSR - Depth Averaged
TOD2RN - Depth Averaged
7_day_running_standard
J F M A M J J A S O N D

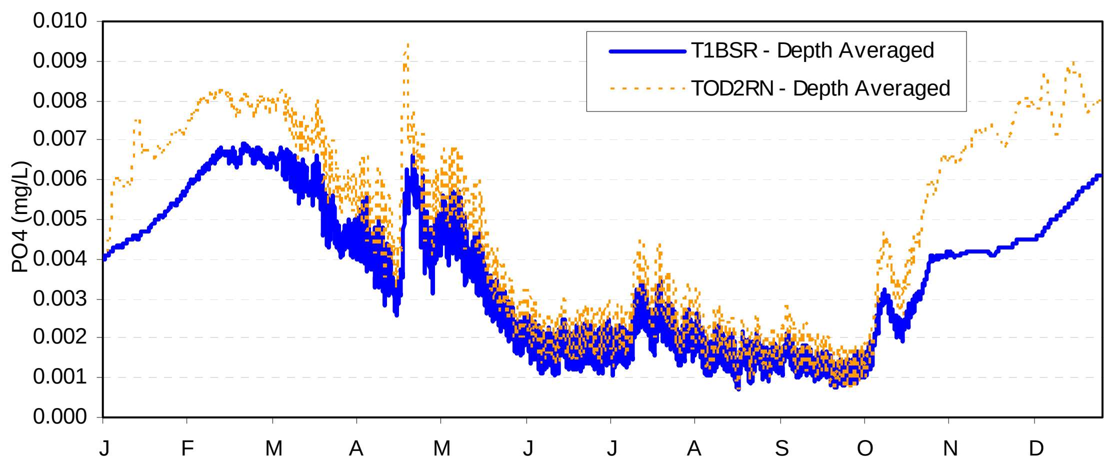


pH
10
9
8
7
6
5
4
3
2
1
0
TOD2RN
pH criteria 1
pH criteria 2
J F M A M J J A S O N D

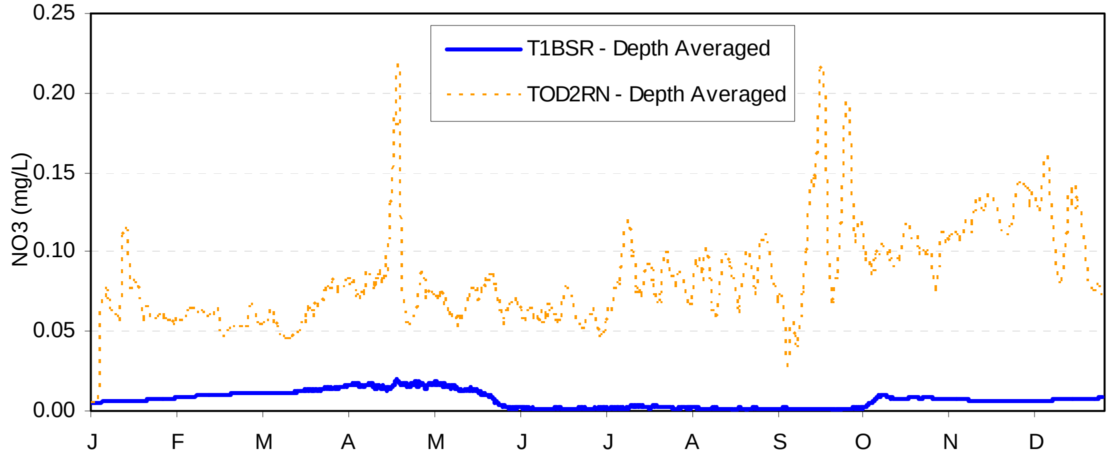
KSD


T1BSR - Depth Averaged
TOD2RN - Depth Averaged
4-day average of Chronic Criteria (computed using pH and temperature from TOD1R)
4-day Averaged NH3-N (mg/L)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
J F M A M J J A S O N D

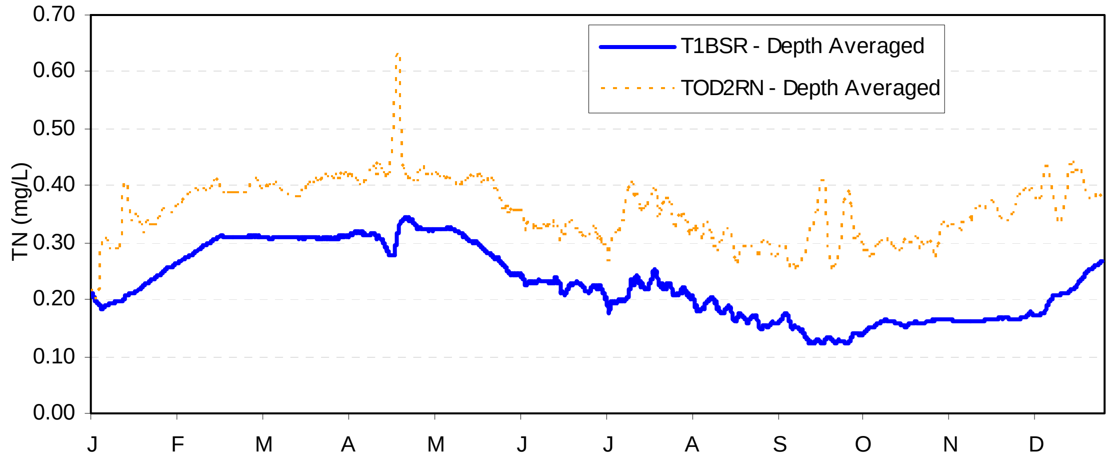

T1BSR - Depth Averaged
TOD2RN - Depth Averaged
Acute Criteria (computed using pH and temperature from TOD1R)
NH3-N (mg/L)
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
J F M A M J J A S O N D


T1BSR - Depth Averaged
TOD2RN - Depth Averaged
PO4 (mg/L)
0.010
0.009
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0.000
J F M A M J J A S O N D

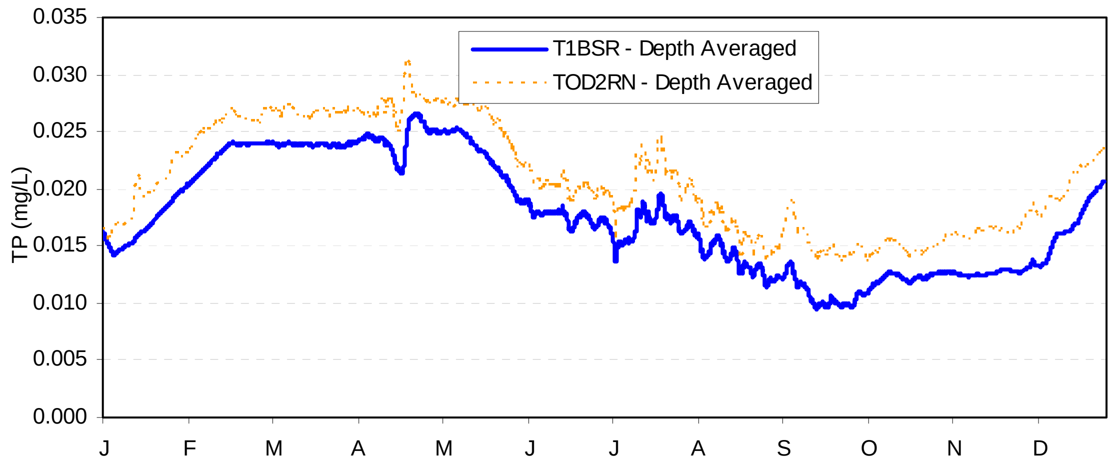
KSD



0.25
0.20
0.15
0.10
0.05
0.00
NO3 (mg/L)
T1BSR - Depth Averaged
TOD2RN - Depth Averaged
J F M A M J J A S O N D

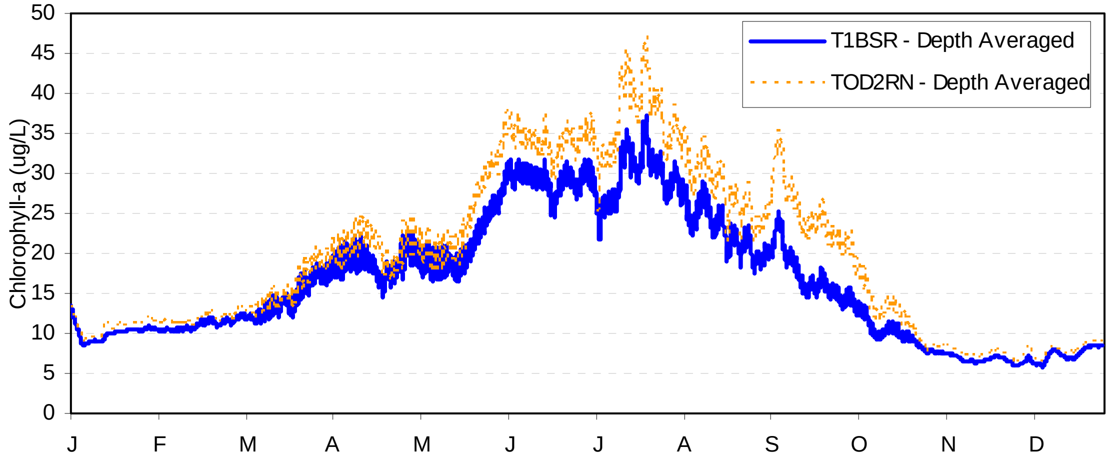


0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
TN (mg/L)
T1BSR - Depth Averaged
TOD2RN - Depth Averaged
J F M A M J J A S O N D

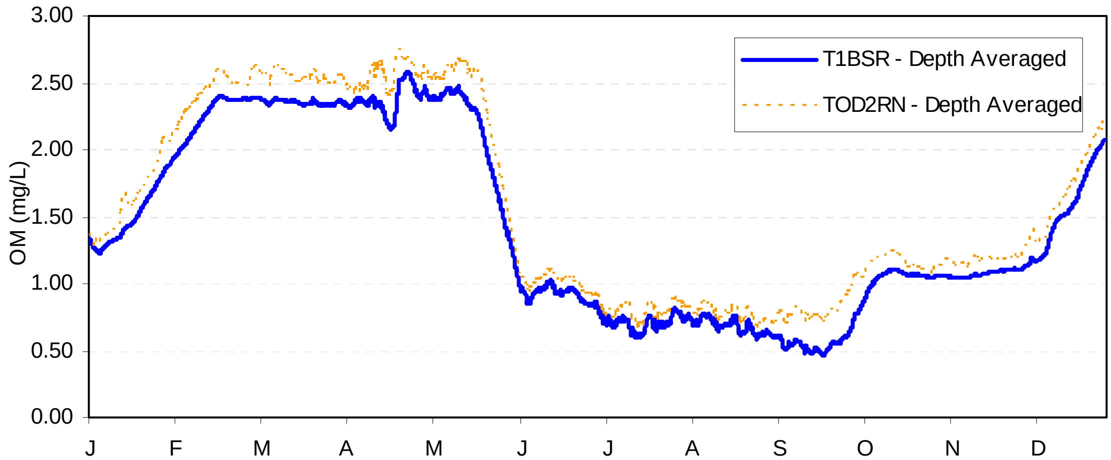


0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
TP (mg/L)
T1BSR - Depth Averaged
TOD2RN - Depth Averaged
J F M A M J J A S O N D

KSD

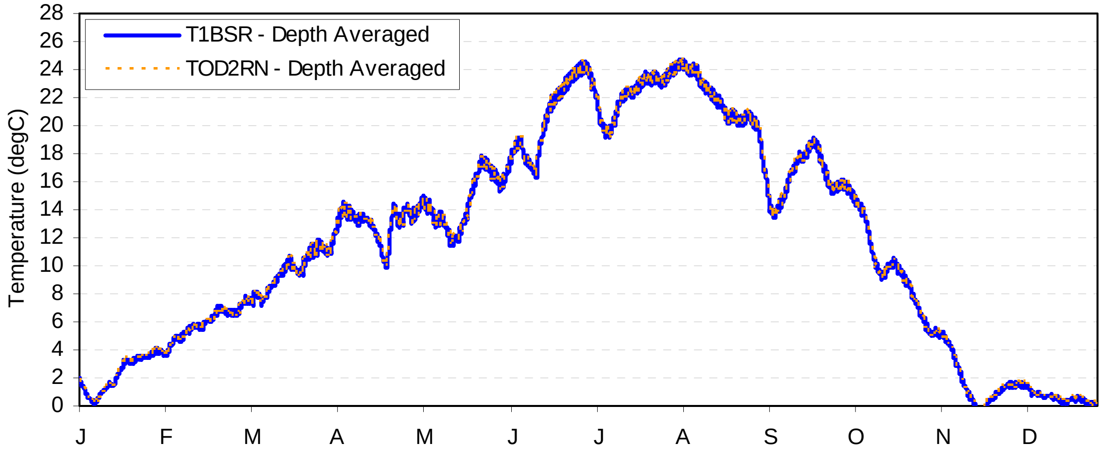


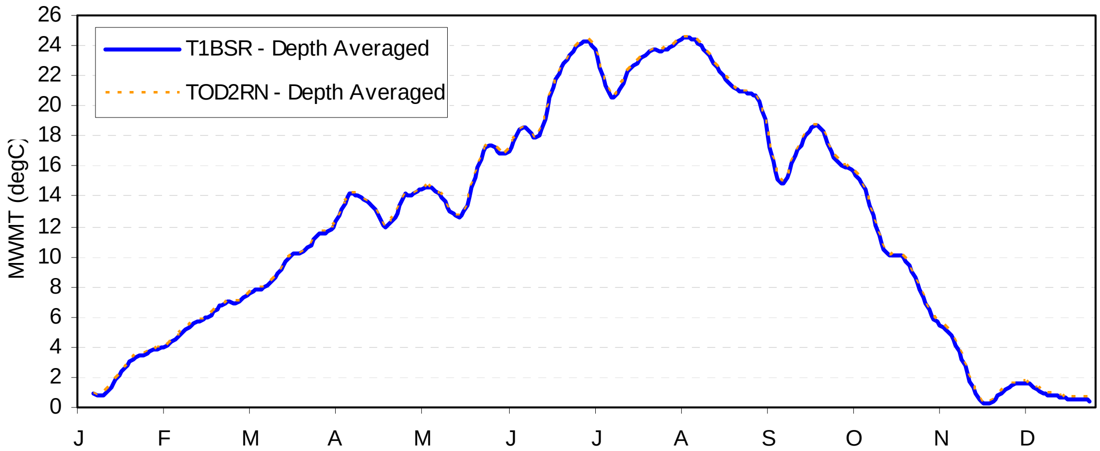
Chlorophyll-a (ug/L)
50
45
40
35
30
25
20
15
10
5
0
J
F
M
A
M
J
J
A
S
O
N
D
T1BSR - Depth Averaged
TOD2RN - Depth Averaged

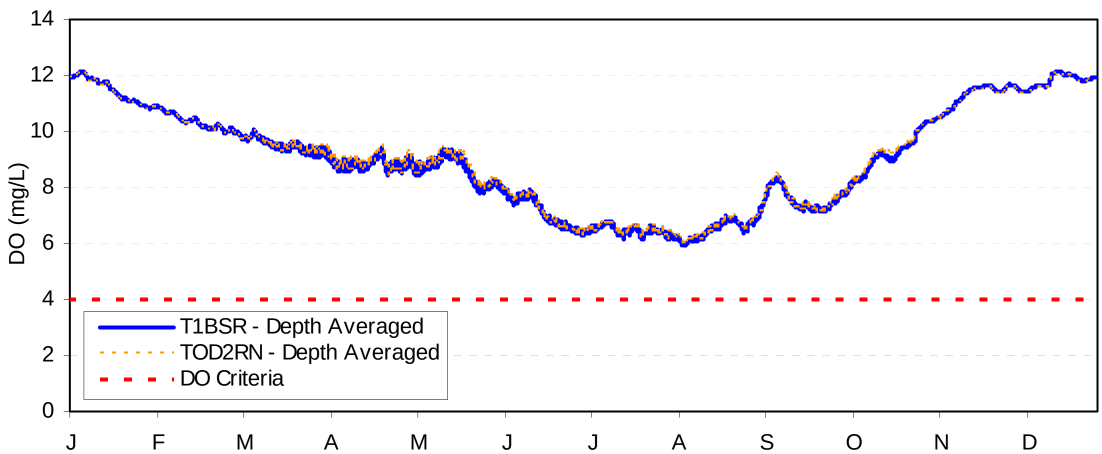


OM (mg/L)
3.00
2.50
2.00
1.50
1.00
0.50
0.00
J
F
M
A
M
J
J
A
S
O
N
D
T1BSR - Depth Averaged
TOD2RN - Depth Averaged

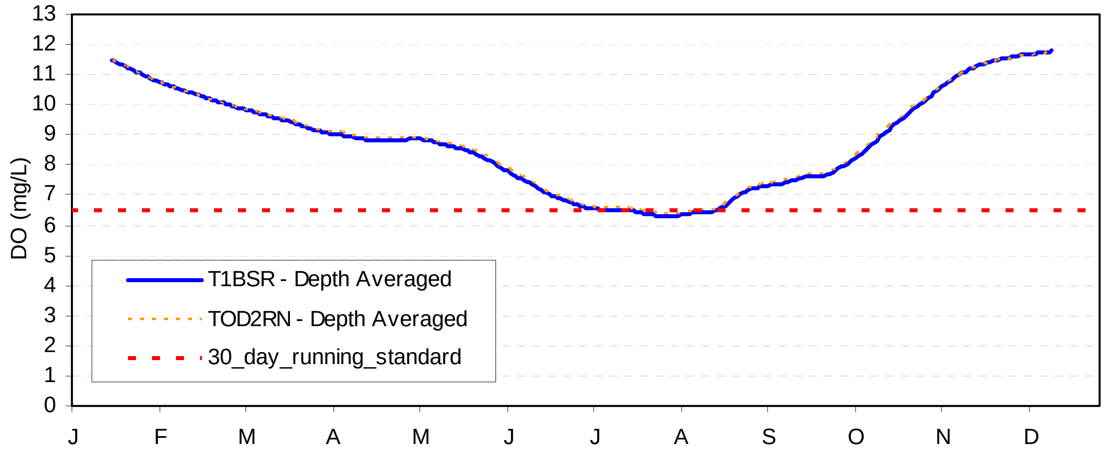
Hwy 66


Temperature (degC)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
T1BSR - Depth Averaged
TOD2RN - Depth Averaged
J F M A M J J A S O N D

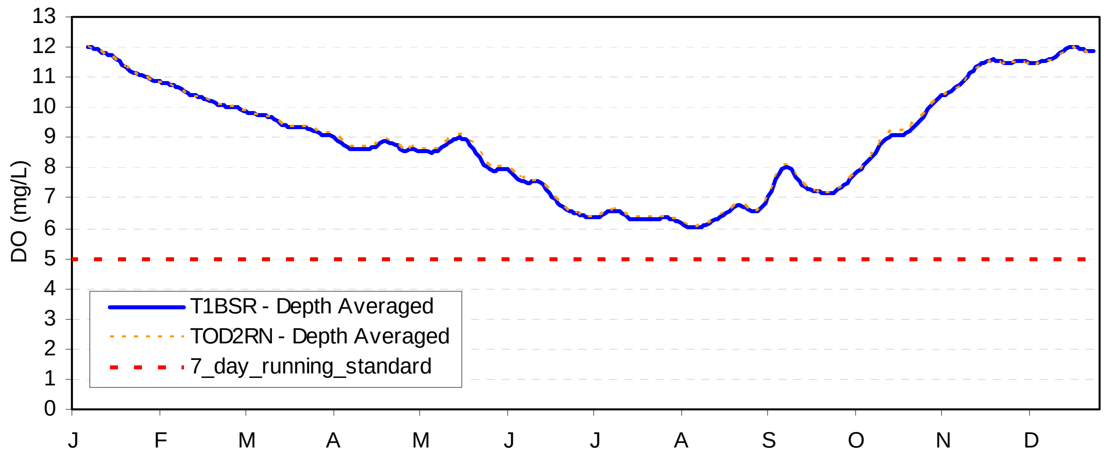

MWMT (degC)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
T1BSR - Depth Averaged
TOD2RN - Depth Averaged
J F M A M J J A S O N D


DO (mg/L)
0
2
4
6
8
10
12
14
T1BSR - Depth Averaged
TOD2RN - Depth Averaged
DO Criteria
J F M A M J J A S O N D

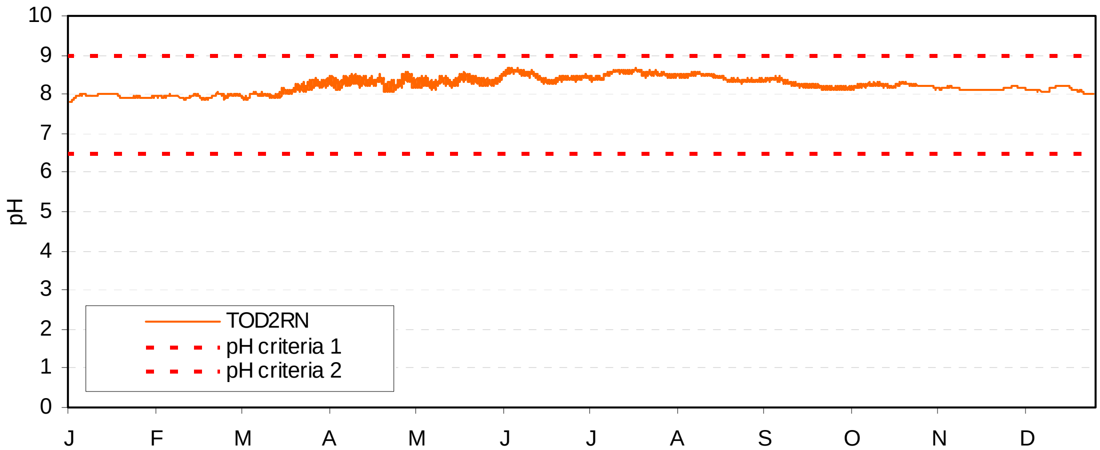
Hwy 66



DO (mg/L)
13
12
11
10
9
8
7
6
5
4
3
2
1
0
T1BSR - Depth Averaged
TOD2RN - Depth Averaged
30_day_running_standard
J
F
M
A
M
J
J
A
S
O
N
D

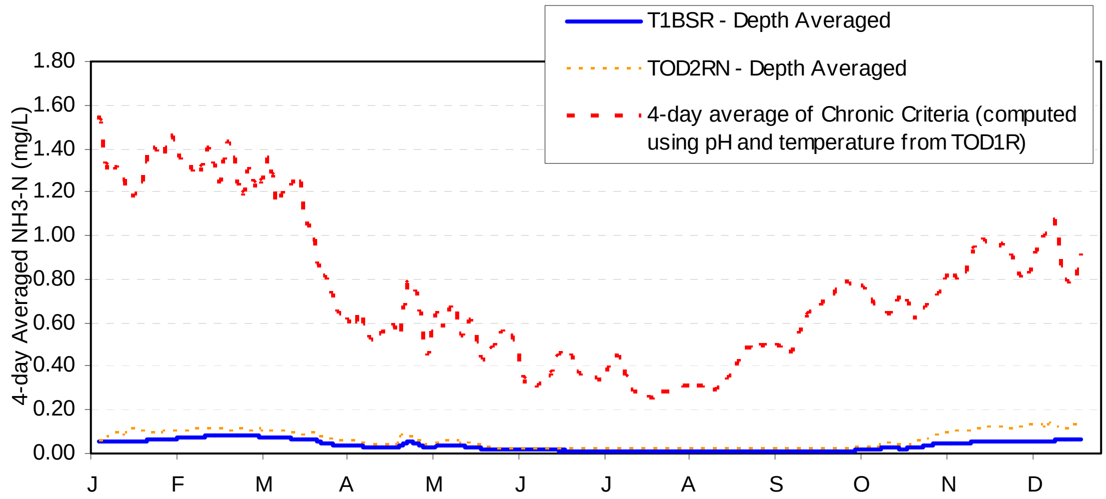


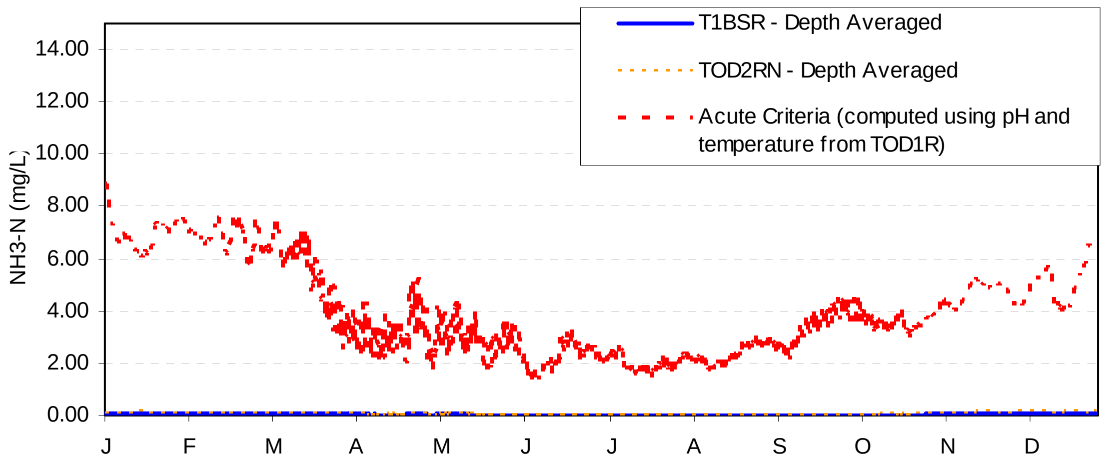
DO (mg/L)
13
12
11
10
9
8
7
6
5
4
3
2
1
0
T1BSR - Depth Averaged
TOD2RN - Depth Averaged
7_day_running_standard
J
F
M
A
M
J
J
A
S
O
N
D

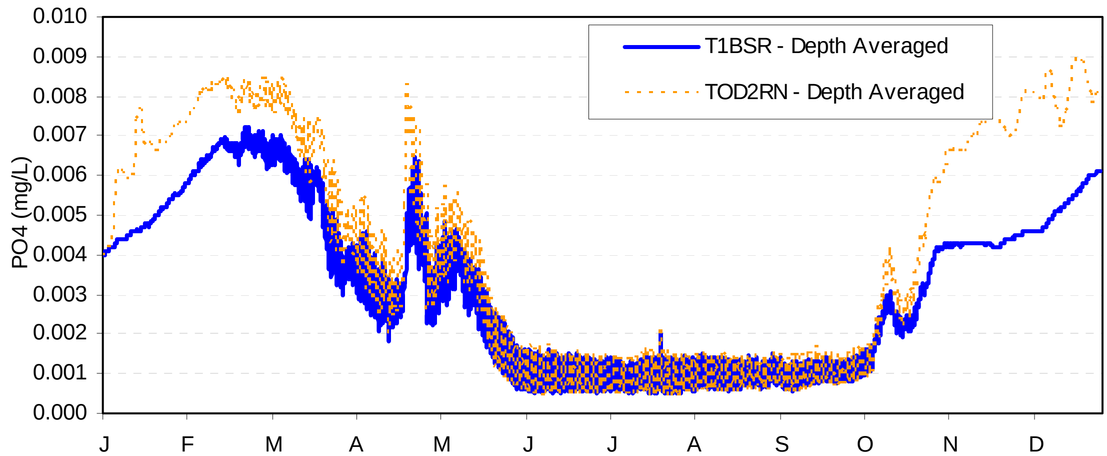


pH
10
9
8
7
6
5
4
3
2
1
0
TOD2RN
pH criteria 1
pH criteria 2
J
F
M
A
M
J
J
A
S
O
N
D

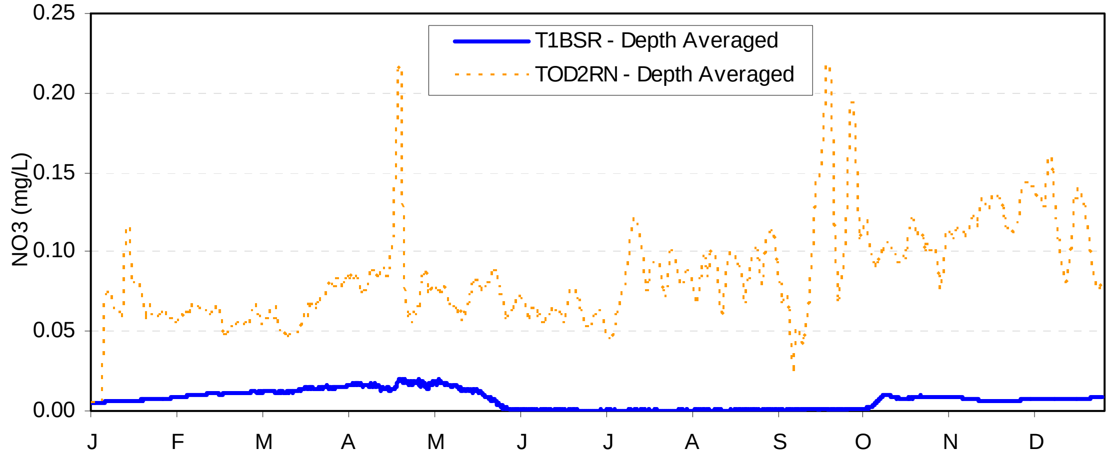
Hwy 66


T1BSR - Depth Averaged
TOD2RN - Depth Averaged
4-day average of Chronic Criteria (computed using pH and temperature from TOD1R)
4-day Averaged NH3-N (mg/L)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
J F M A M J J A S O N D

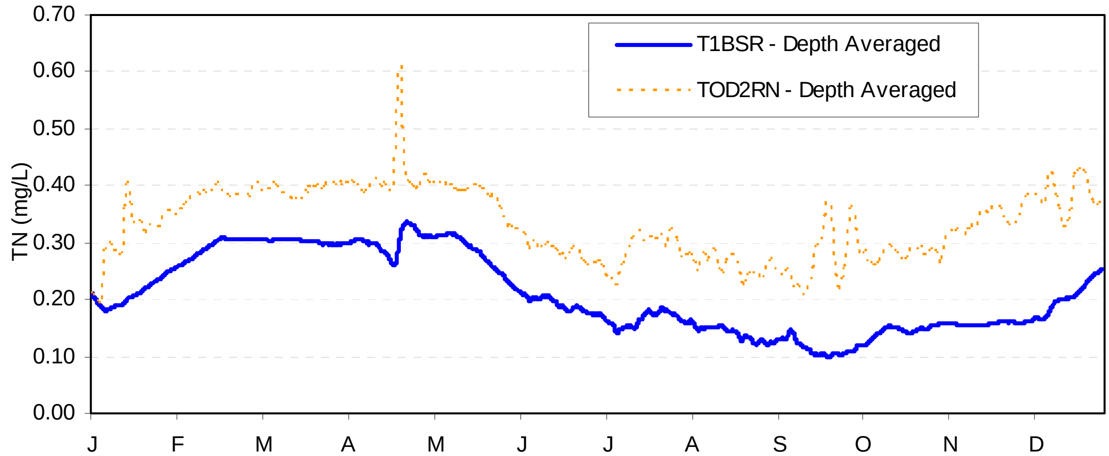

T1BSR - Depth Averaged
TOD2RN - Depth Averaged
Acute Criteria (computed using pH and temperature from TOD1R)
NH3-N (mg/L)
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
J F M A M J J A S O N D


T1BSR - Depth Averaged
TOD2RN - Depth Averaged
PO4 (mg/L)
0.010
0.009
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0.000
J F M A M J J A S O N D

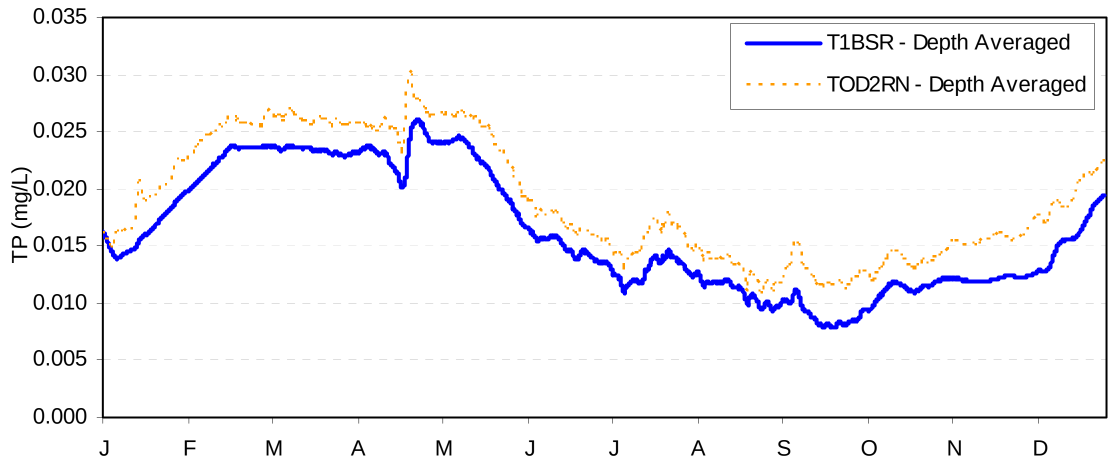
Hwy 66



NO3 (mg/L)
0.25
0.20
0.15
0.10
0.05
0.00
J
F
M
A
M
J
J
A
S
O
N
D
T1BSR - Depth Averaged
TOD2RN - Depth Averaged

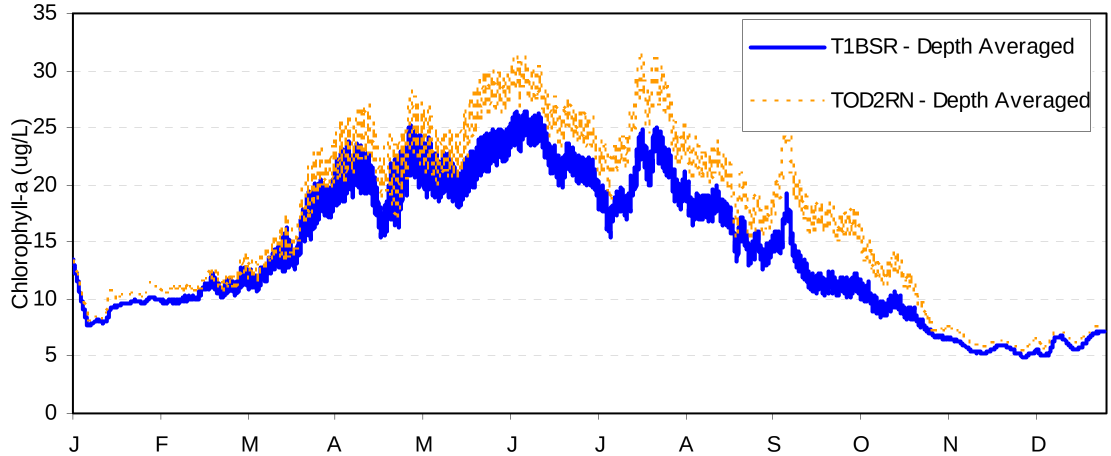


TN (mg/L)
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
J
F
M
A
M
J
J
A
S
O
N
D
T1BSR - Depth Averaged
TOD2RN - Depth Averaged

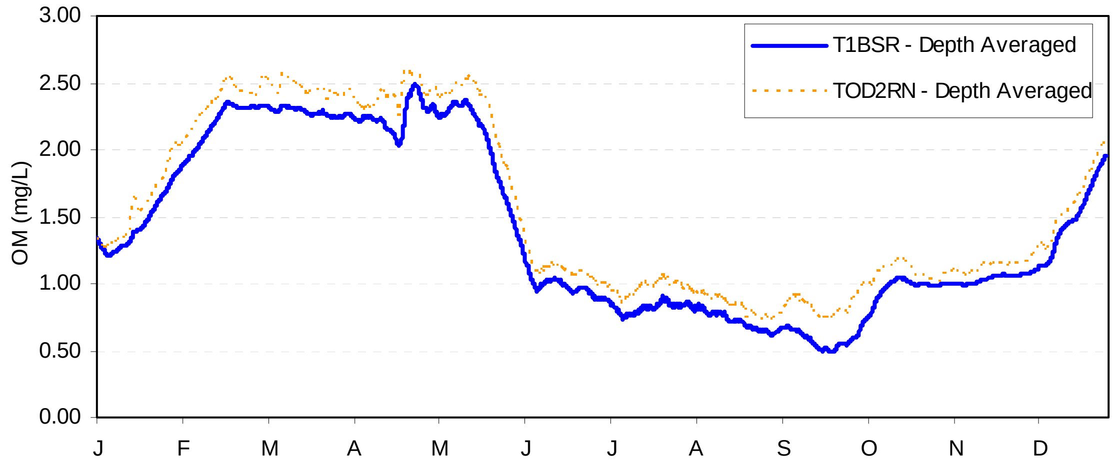


TP (mg/L)
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
J
F
M
A
M
J
J
A
S
O
N
D
T1BSR - Depth Averaged
TOD2RN - Depth Averaged

Hwy 66

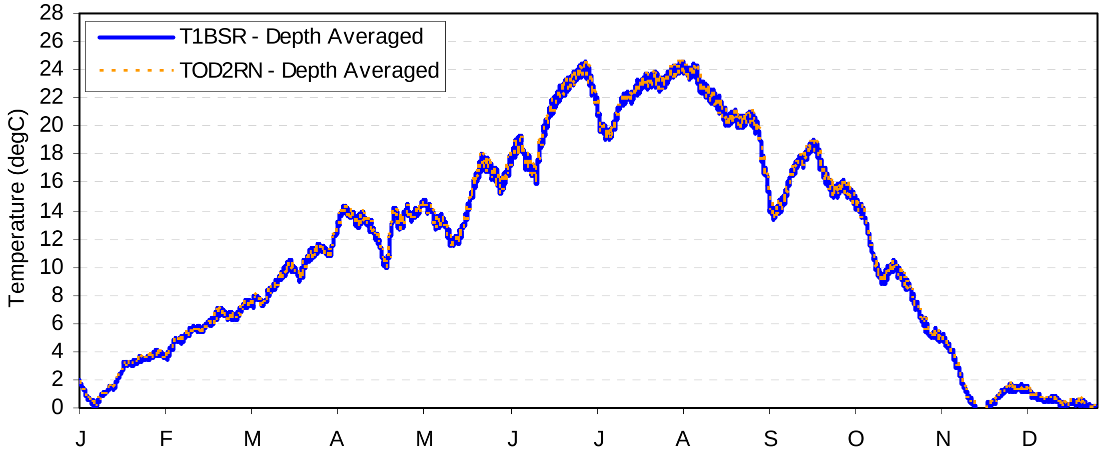


Chlorophyll-a (ug/L)
35
30
25
20
15
10
5
0
J
F
M
A
M
J
J
A
S
O
N
D
T1BSR - Depth Averaged
TOD2RN - Depth Averaged

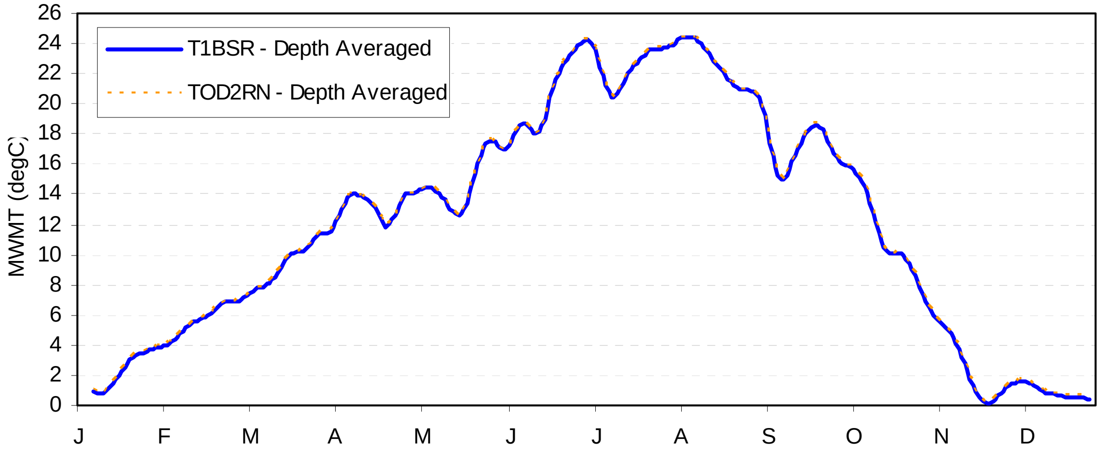


OM (mg/L)
3.00
2.50
2.00
1.50
1.00
0.50
0.00
J
F
M
A
M
J
J
A
S
O
N
D
T1BSR - Depth Averaged
TOD2RN - Depth Averaged

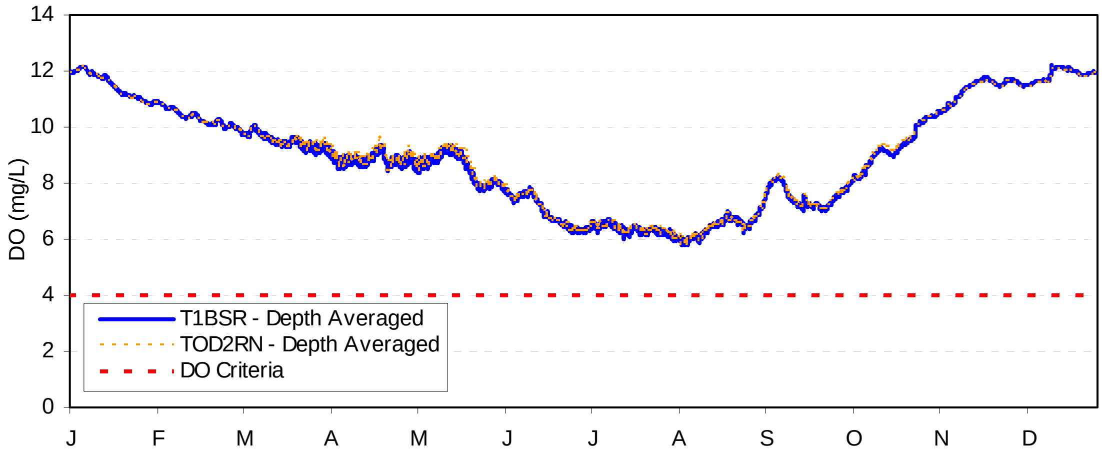
Keno Dam



T1BSR - Depth Averaged
TOD2RN - Depth Averaged
Temperature (degC)
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
J F M A M J J A S O N D

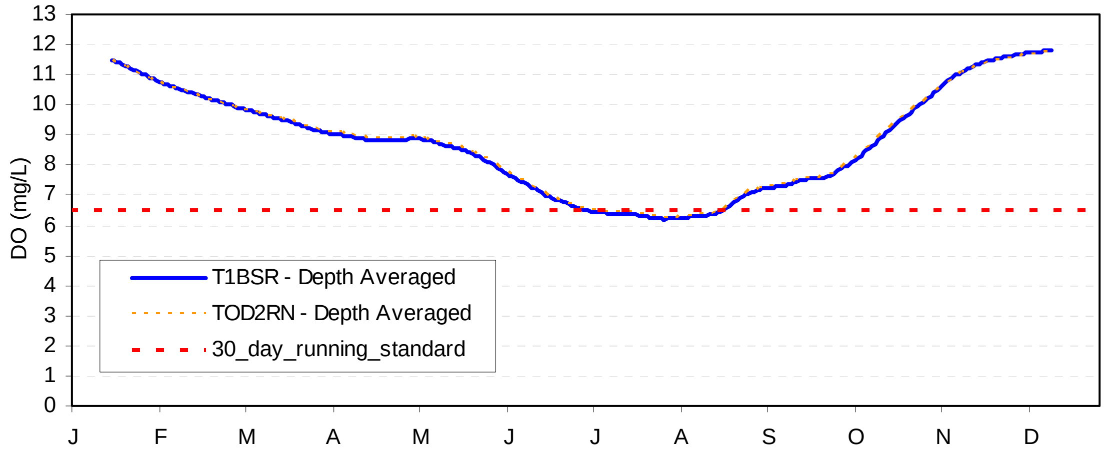


T1BSR - Depth Averaged
TOD2RN - Depth Averaged
MWMT (degC)
26
24
22
20
18
16
14
12
10
8
6
4
2
0
J F M A M J J A S O N D

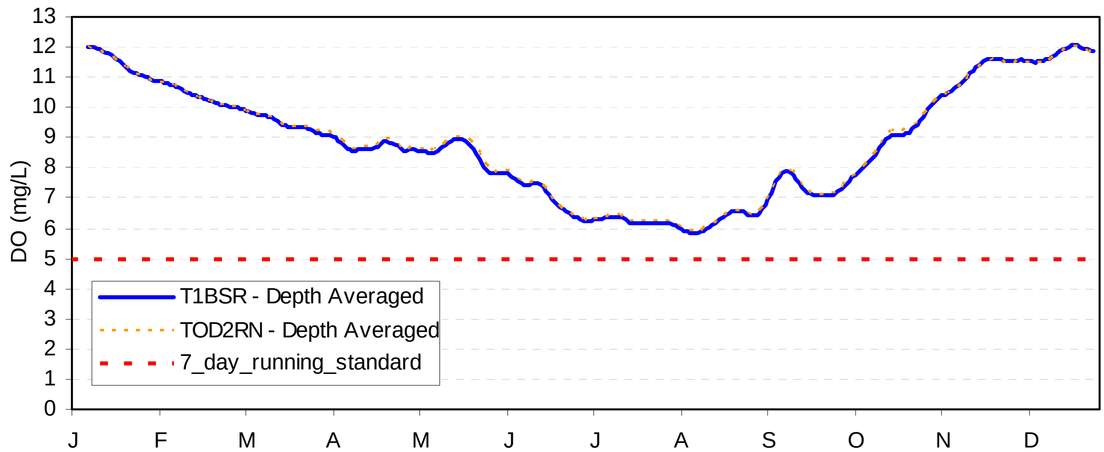


T1BSR - Depth Averaged
TOD2RN - Depth Averaged
DO Criteria
DO (mg/L)
14
12
10
8
6
4
2
0
J F M A M J J A S O N D

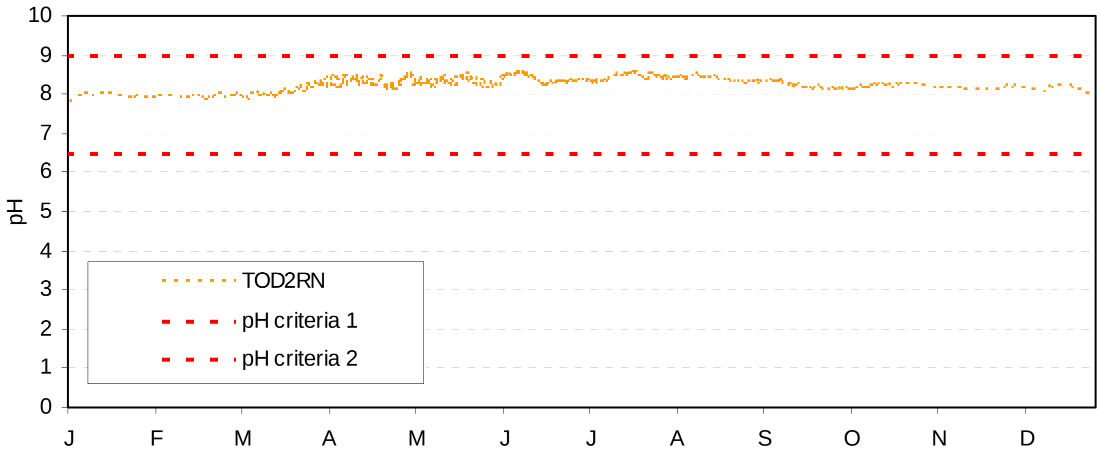
Keno Dam



DO (mg/L)
T1BSR - Depth Averaged
TOD2RN - Depth Averaged
30_day_running_standard
J F M A M J J A S O N D

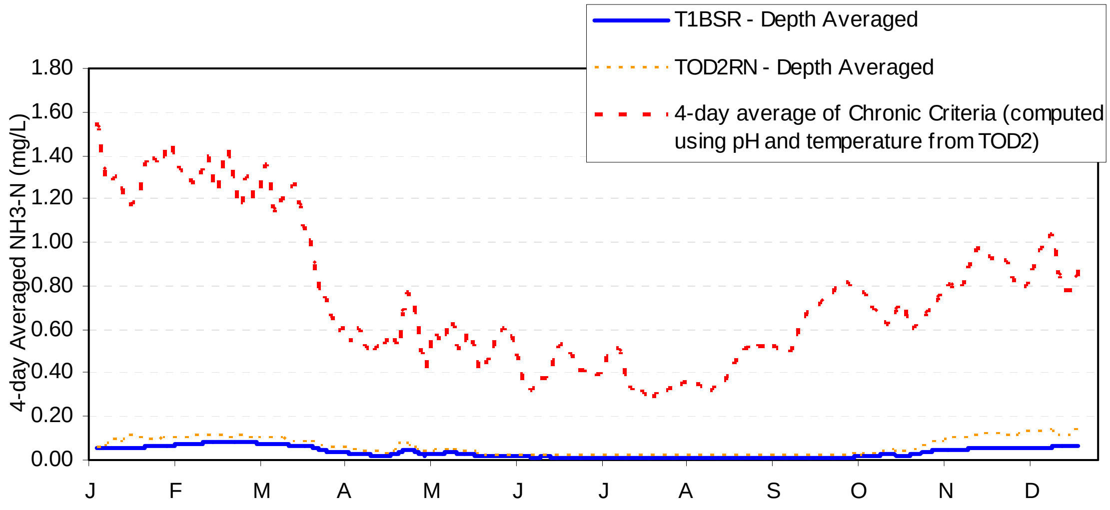


DO (mg/L)
T1BSR - Depth Averaged
TOD2RN - Depth Averaged
7_day_running_standard
J F M A M J J A S O N D

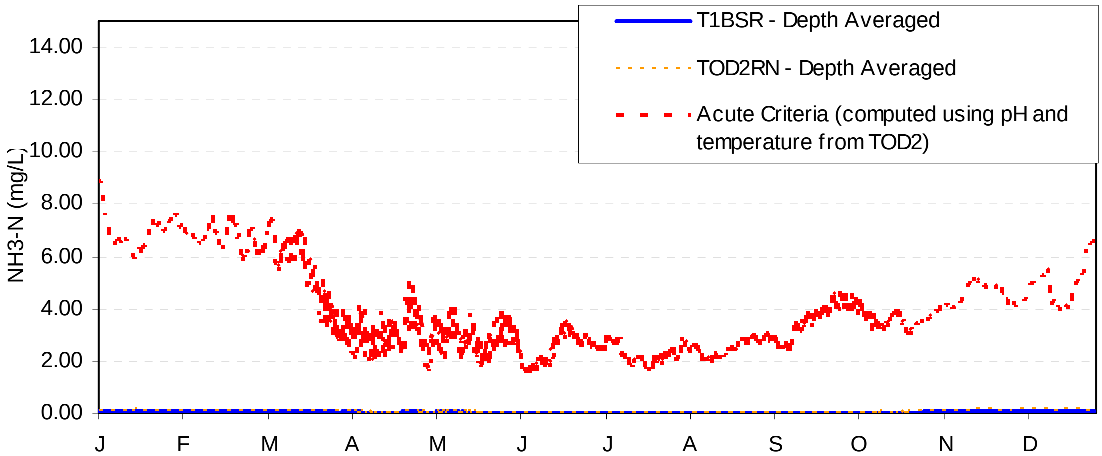


pH
TOD2RN
pH criteria 1
pH criteria 2
J F M A M J J A S O N D

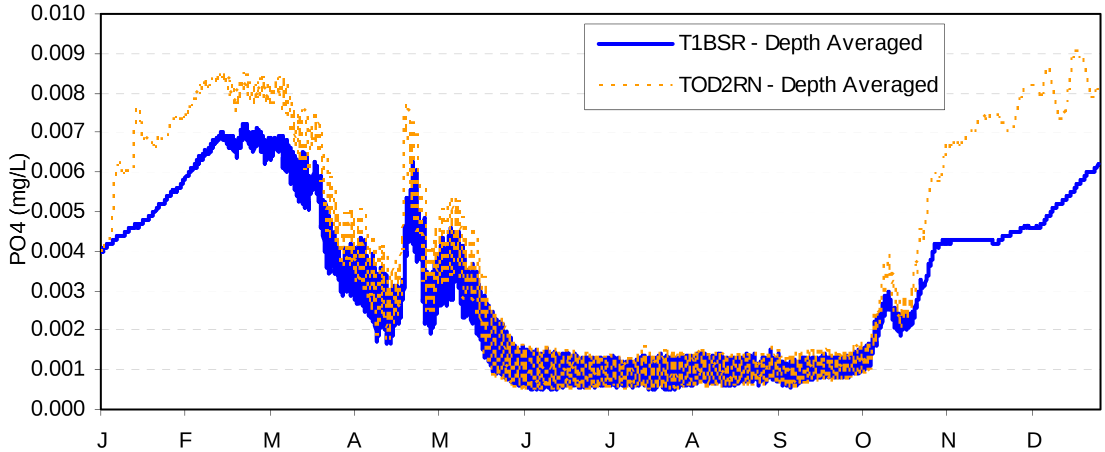
Keno Dam



T1BSR - Depth Averaged
TOD2RN - Depth Averaged
4-day average of Chronic Criteria (computed using pH and temperature from TOD2)
4-day Averaged NH3-N (mg/L)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
J F M A M J J A S O N D

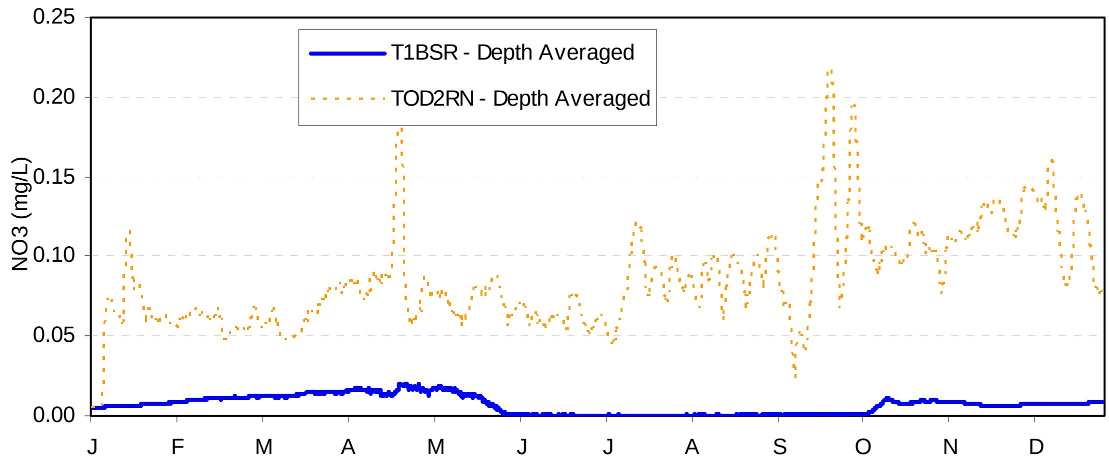


T1BSR - Depth Averaged
TOD2RN - Depth Averaged
Acute Criteria (computed using pH and temperature from TOD2)
NH3-N (mg/L)
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
J F M A M J J A S O N D

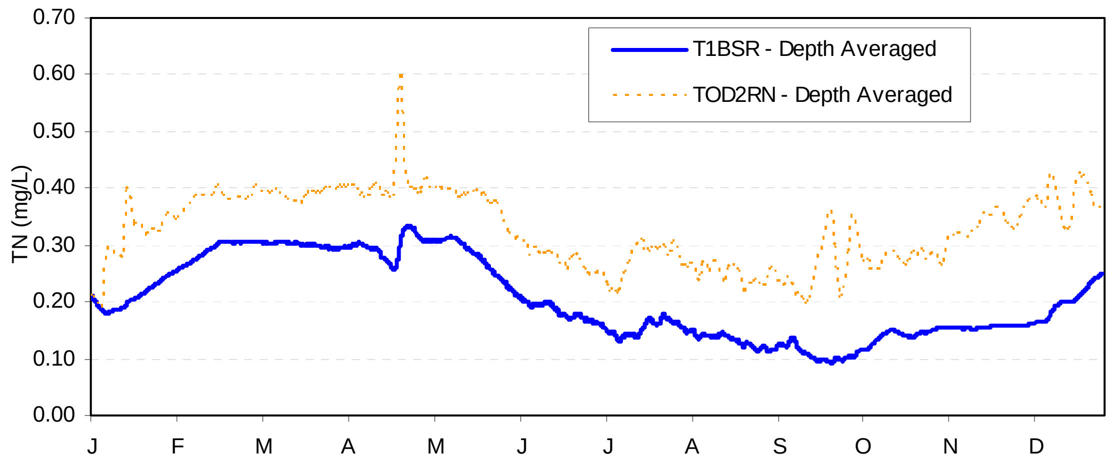


T1BSR - Depth Averaged
TOD2RN - Depth Averaged
PO4 (mg/L)
0.010
0.009
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0.000
J F M A M J J A S O N D

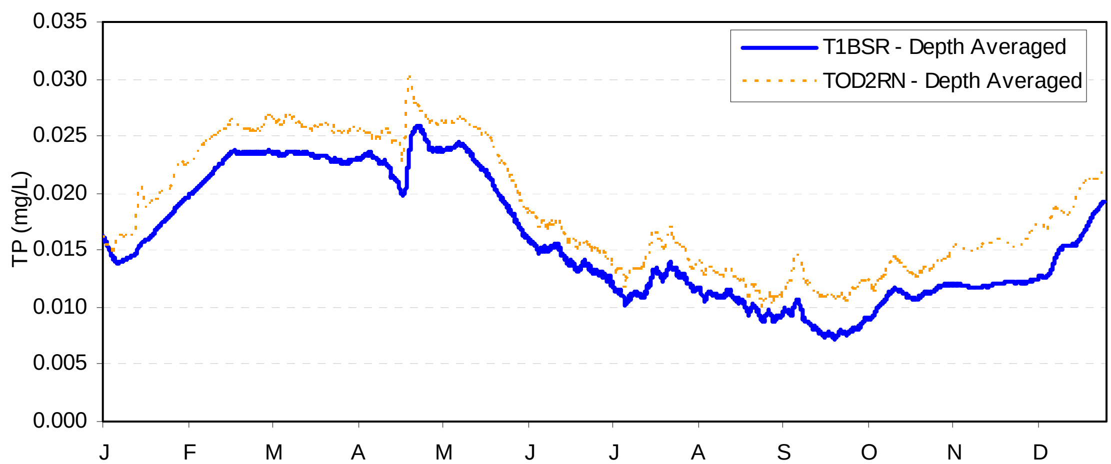
Keno Dam



0.25
0.20
0.15
0.10
0.05
0.00
NO3 (mg/L)
J
F
M
A
M
J
J
A
S
O
N
D
T1BSR - Depth Averaged
TOD2RN - Depth Averaged

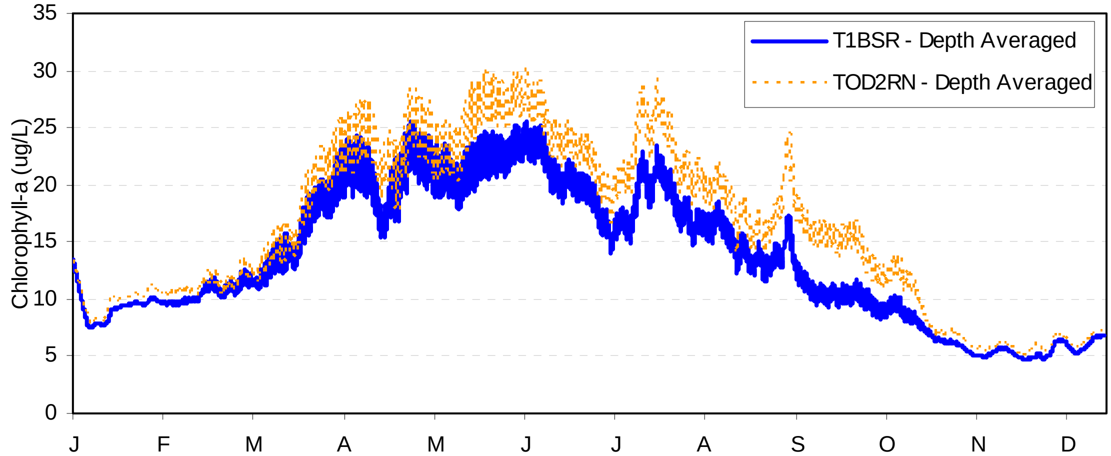


0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
TN (mg/L)
J
F
M
A
M
J
J
A
S
O
N
D
T1BSR - Depth Averaged
TOD2RN - Depth Averaged

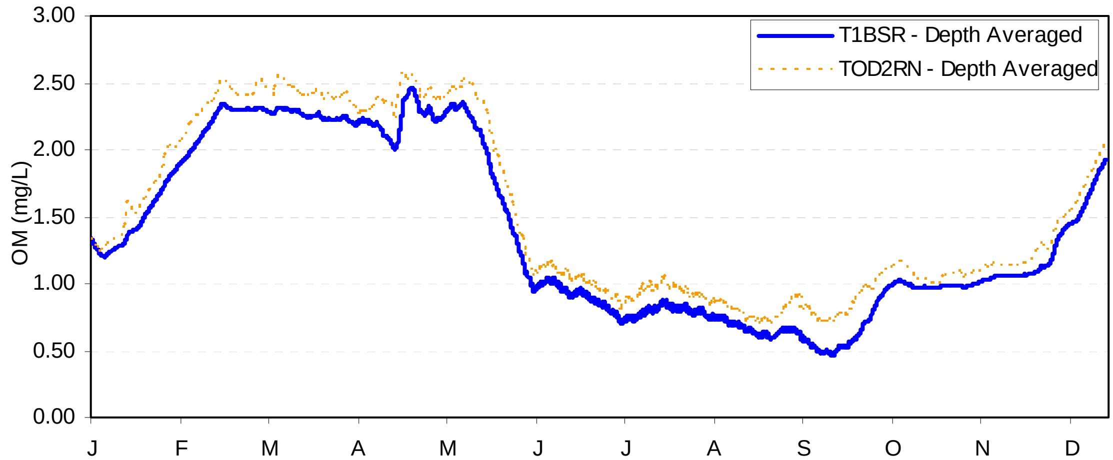


0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
TP (mg/L)
J
F
M
A
M
J
J
A
S
O
N
D
T1BSR - Depth Averaged
TOD2RN - Depth Averaged

Keno Dam

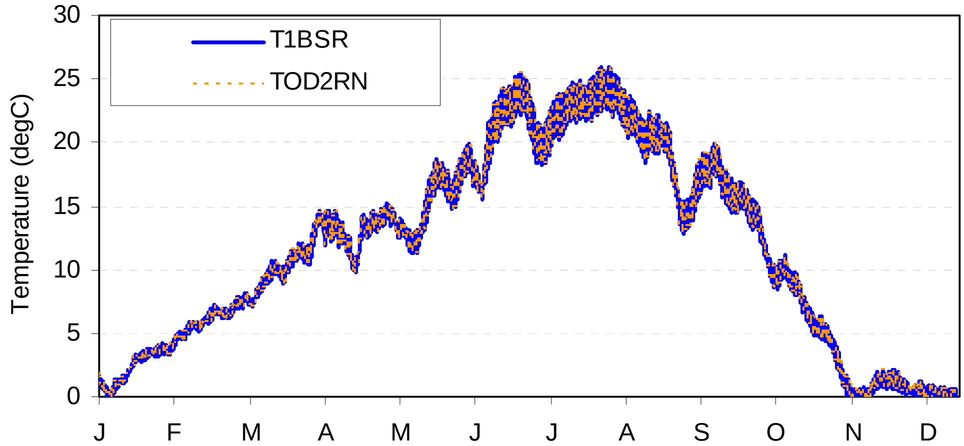


T1BSR - Depth Averaged
TOD2RN - Depth Averaged
Chlorophyll-a (ug/L)
35
30
25
20
15
10
5
0
J F M A M J J A S O N D

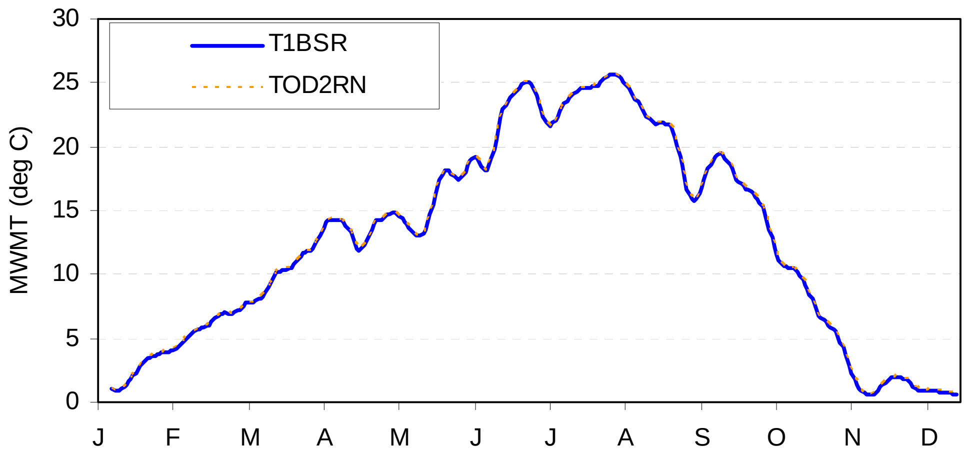


T1BSR - Depth Averaged
TOD2RN - Depth Averaged
OM (mg/L)
3.00
2.50
2.00
1.50
1.00
0.50
0.00
J F M A M J J A S O N D

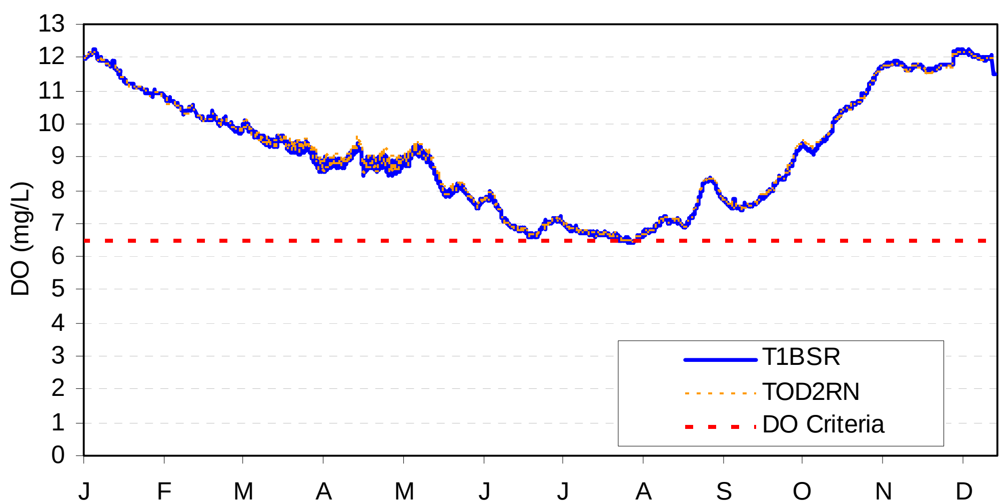
DS KENO USGS



T1BSR
TOD2RN
Temperature (degC)
30
25
20
15
10
5
0
J F M A M J J A S O N D

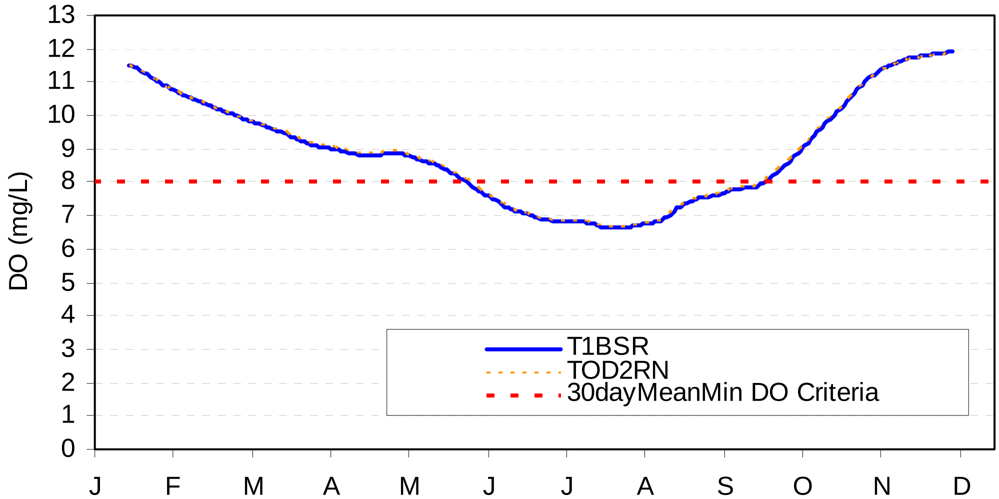


T1BSR
TOD2RN
MWMT (deg C)
30
25
20
15
10
5
0
J F M A M J J A S O N D

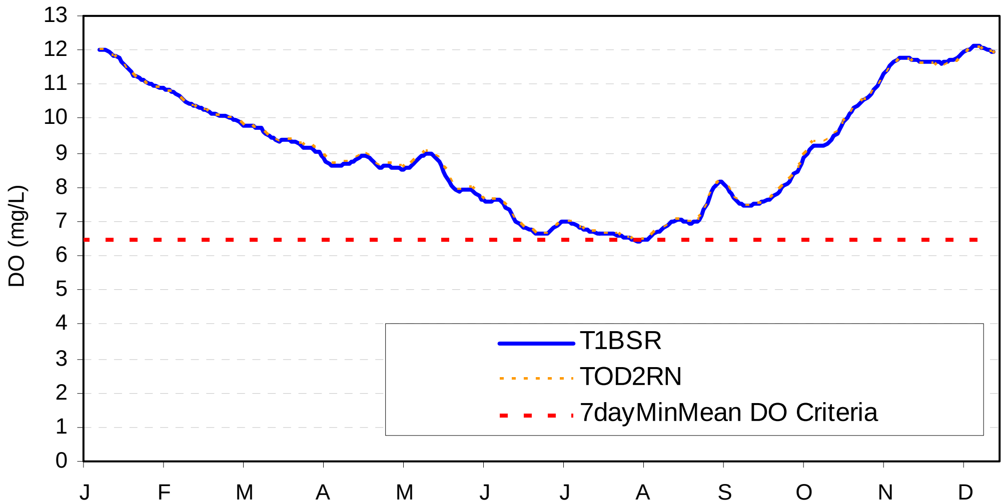


DO (mg/L)
13
12
11
10
9
8
7
6
5
4
3
2
1
0
T1BSR
TOD2RN
DO Criteria
J F M A M J J A S O N D

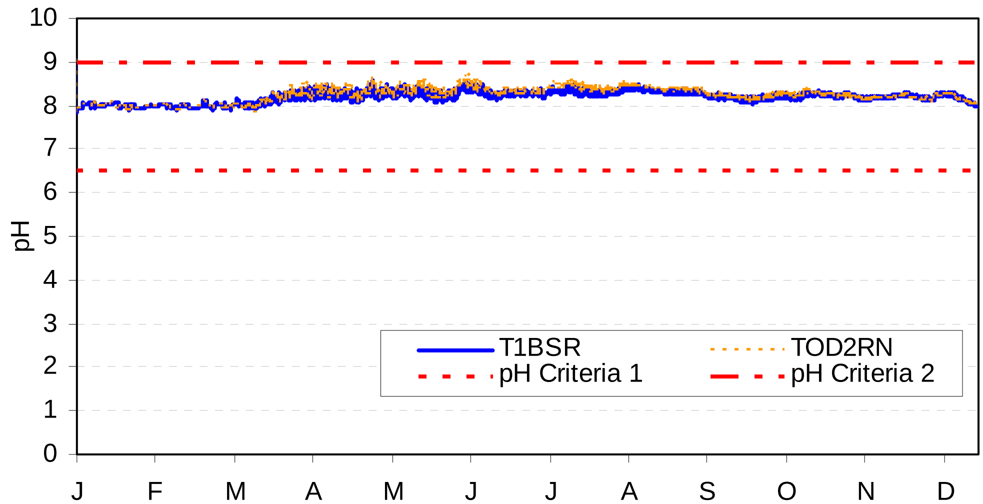
DS KENO USGS



DO (mg/L)
13
12
11
10
9
8
7
6
5
4
3
2
1
0
J F M A M J J A S O N D
T1BSR
TOD2RN
30dayMeanMin DO Criteria

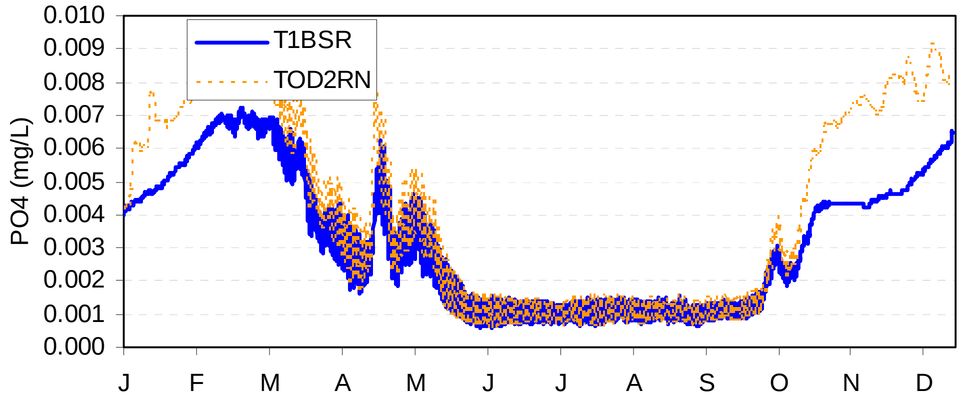


DO (mg/L)
13
12
11
10
9
8
7
6
5
4
3
2
1
0
J F M A M J J A S O N D
T1BSR
TOD2RN
7dayMinMean DO Criteria

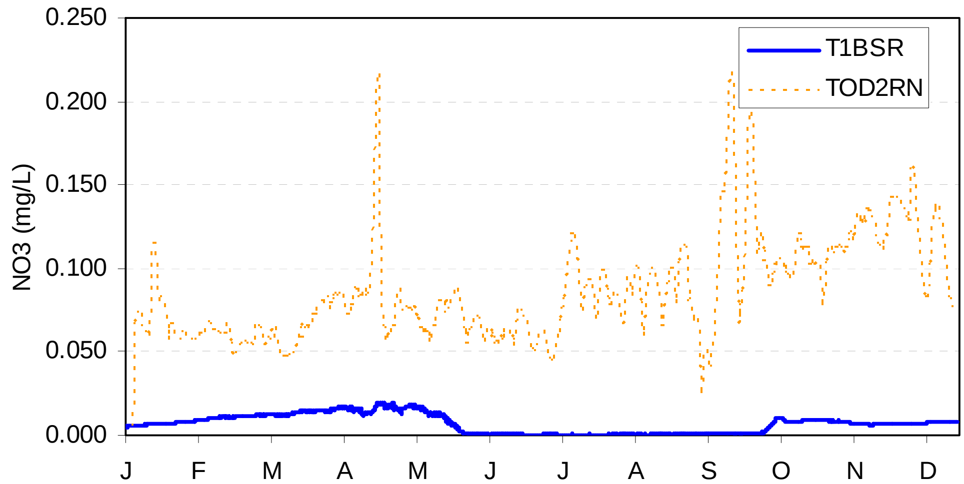


pH
10
9
8
7
6
5
4
3
2
1
0
J F M A M J J A S O N D
T1BSR
TOD2RN
pH Criteria 1
pH Criteria 2

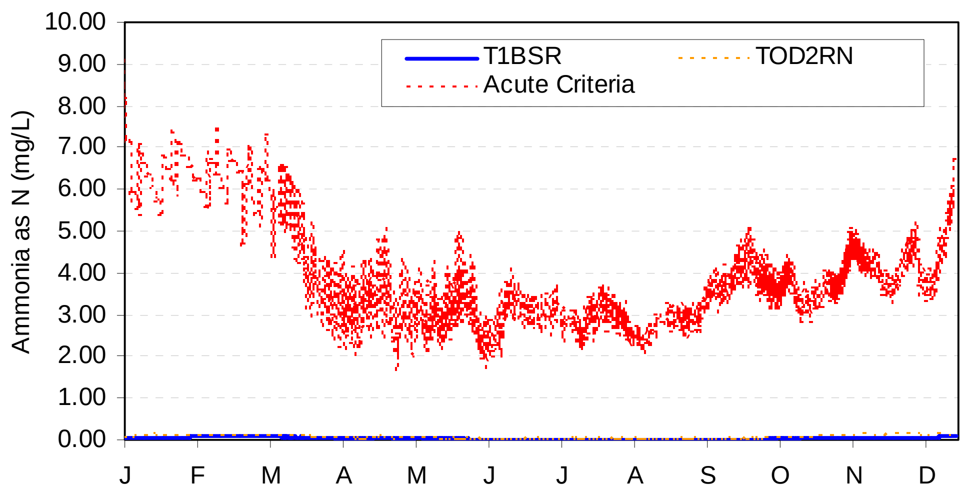
DS KENO USGS



PO4 (mg/L)
0.010
0.009
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0.000
T1BSR
TOD2RN
J F M A M J J A S O N D

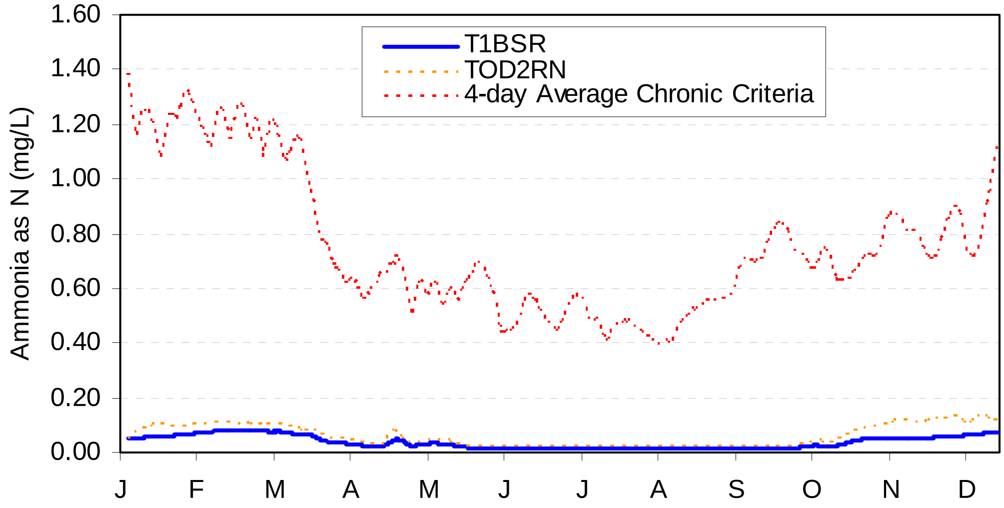


NO3 (mg/L)
0.250
0.200
0.150
0.100
0.050
0.000
T1BSR
TOD2RN
J F M A M J J A S O N D

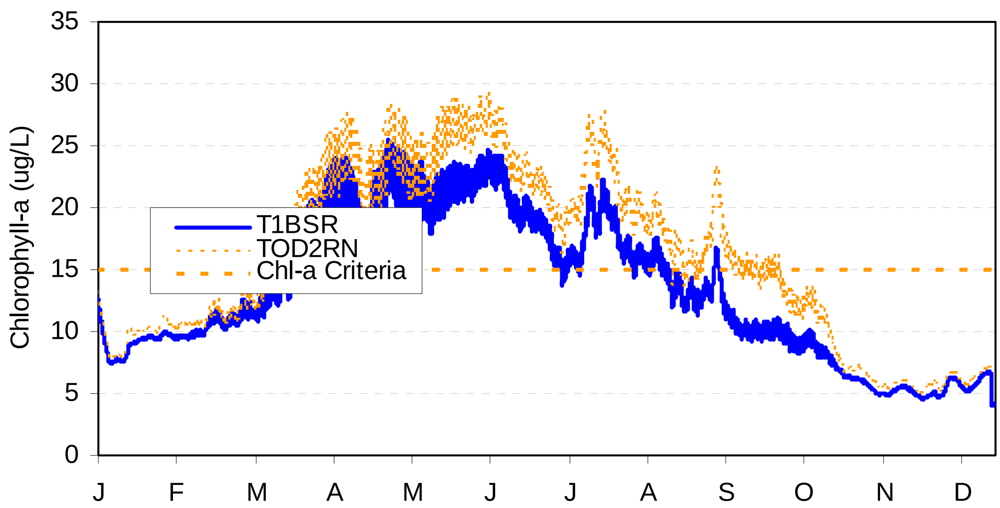


Ammonia as N (mg/L)
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
T1BSR
TOD2RN
Acute Criteria
J F M A M J J A S O N D

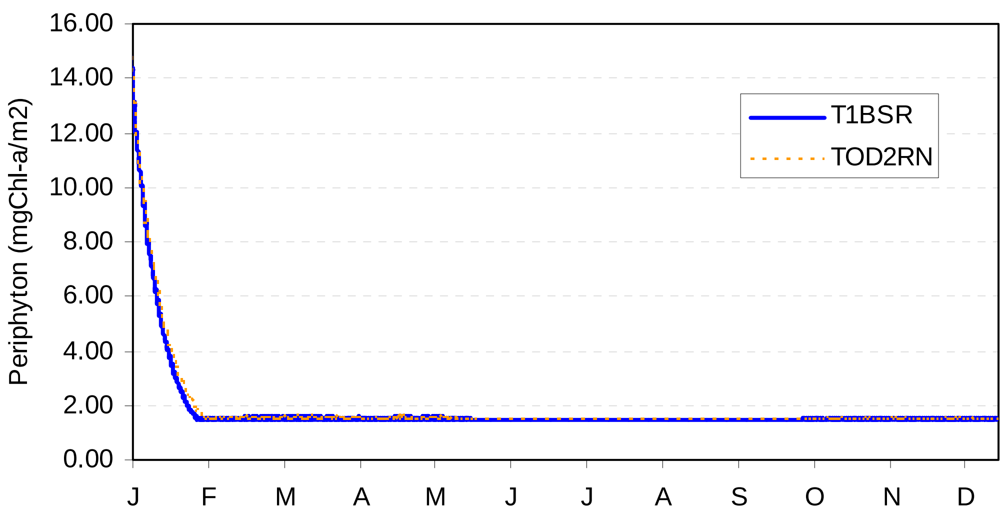
DS KENO USGS



1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
Ammonia as N (mg/L)
T1BSR
TOD2RN
4-day Average Chronic Criteria
J
F
M
A
M
J
J
A
S
O
N
D

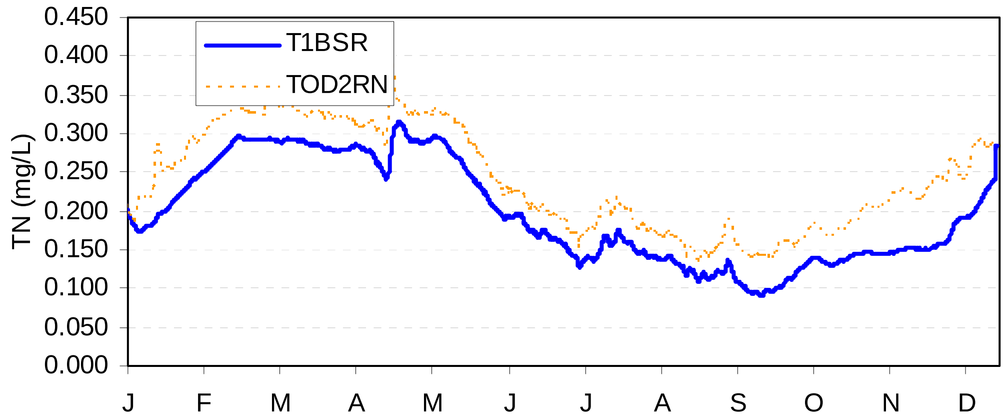


35
30
25
20
15
10
5
0
Chlorophyll-a (ug/L)
T1BSR
TOD2RN
Chl-a Criteria
J
F
M
A
M
J
J
A
S
O
N
D

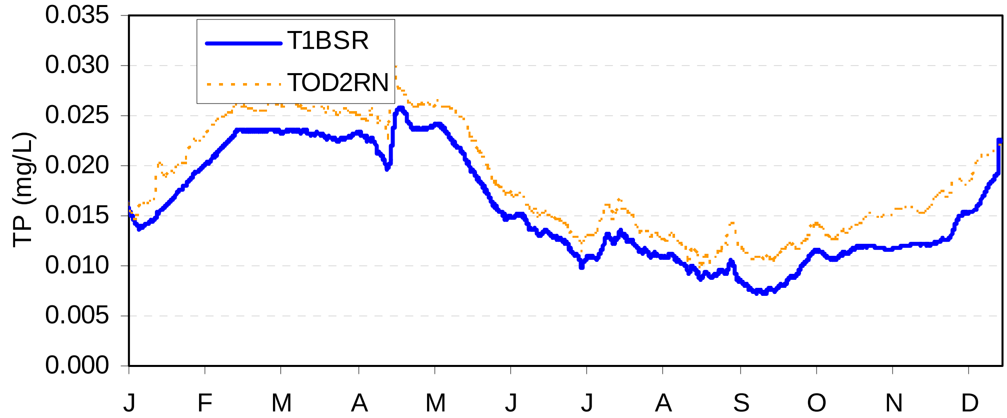


16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
Periphyton (mgChl-a/m2)
T1BSR
TOD2RN
J
F
M
A
M
J
J
A
S
O
N
D

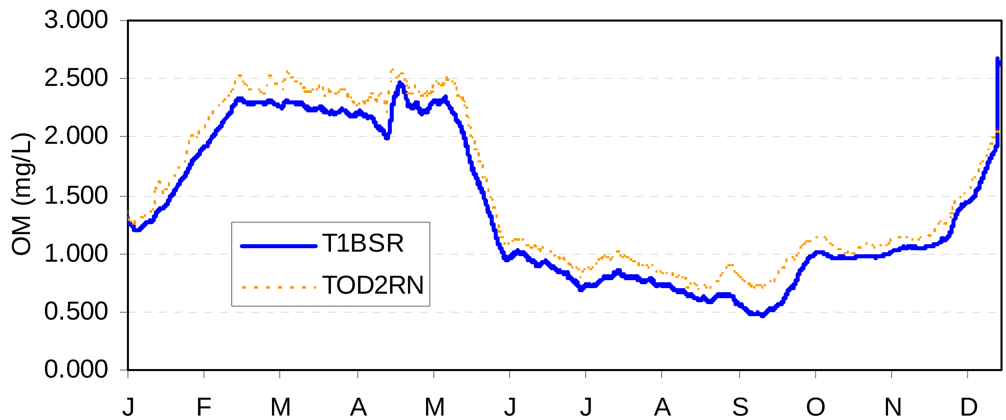
DS KENO USGS



0.450
0.400
0.350
0.300
0.250
0.200
0.150
0.100
0.050
0.000
TN (mg/L)
T1BSR
TOD2RN
J F M A M J J A S O N D

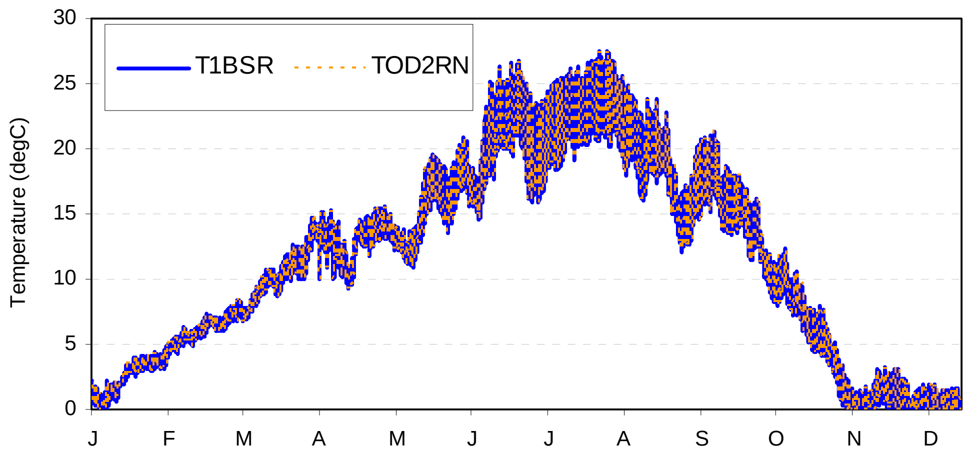


0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
TP (mg/L)
T1BSR
TOD2RN
J F M A M J J A S O N D

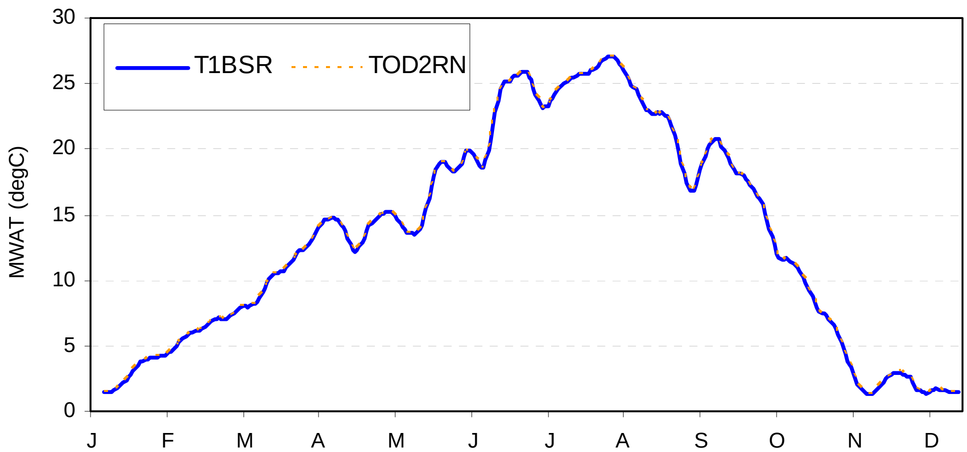


3.000
2.500
2.000
1.500
1.000
0.500
0.000
OM (mg/L)
T1BSR
TOD2RN
J F M A M J J A S O N D

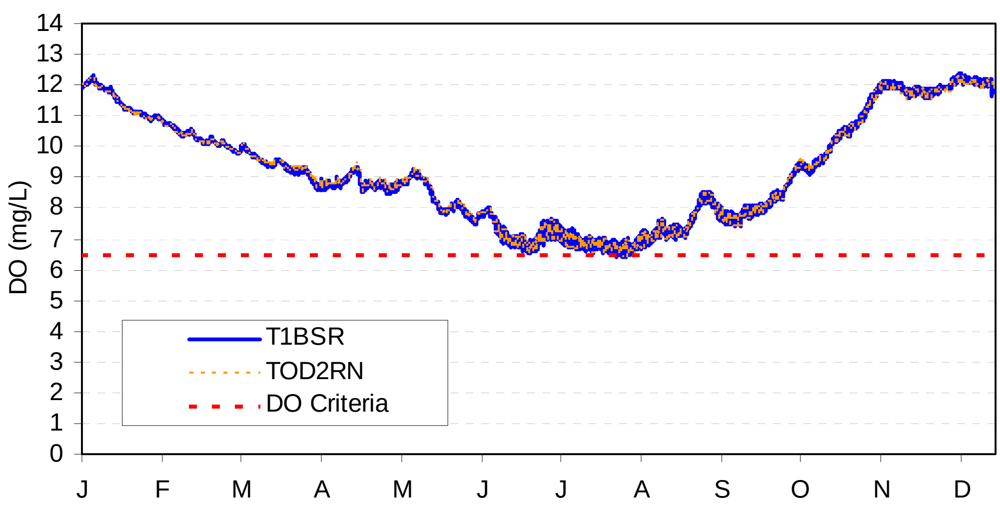
DS JCB DAM



Temperature (degC)
30
25
20
15
10
5
0
T1BSR
TOD2RN
J
F
M
A
M
J
J
A
S
O
N
D

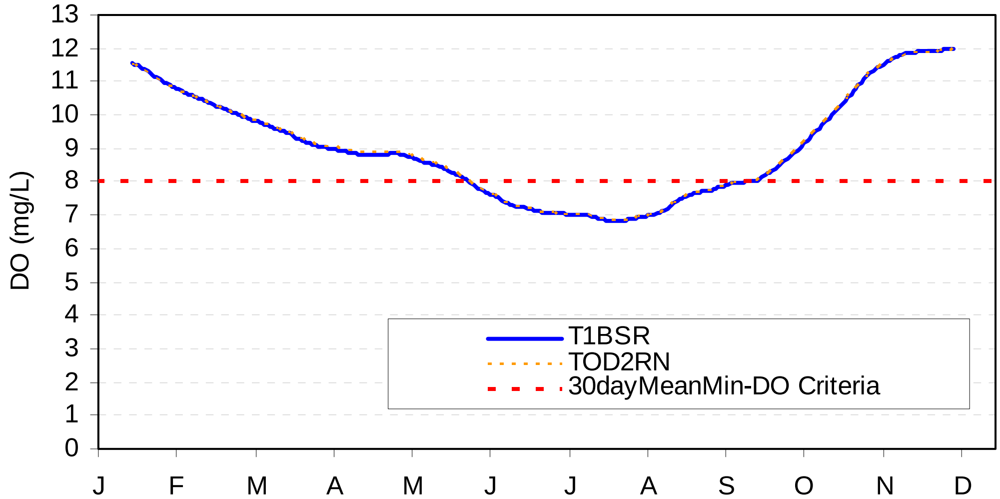


MWAT (degC)
30
25
20
15
10
5
0
T1BSR
TOD2RN
J
F
M
A
M
J
J
A
S
O
N
D

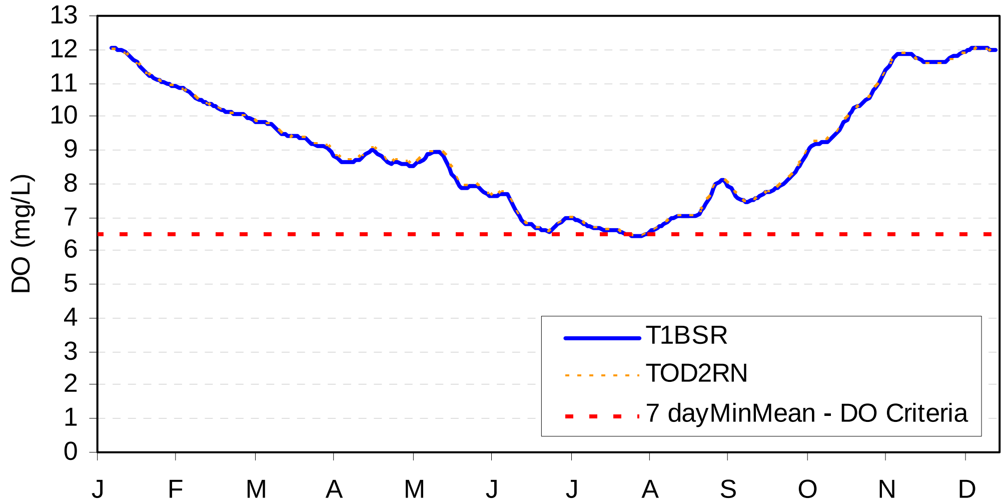


DO (mg/L)
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
T1BSR
TOD2RN
DO Criteria
J
F
M
A
M
J
J
A
S
O
N
D

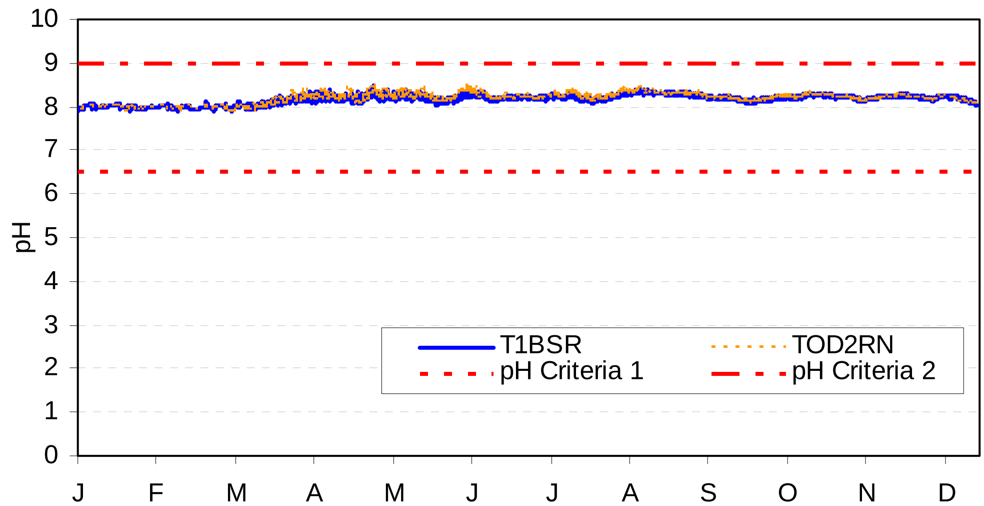
DS JCB DAM



DO (mg/L)
T1BSR
TOD2RN
30dayMeanMin-DO Criteria
J F M A M J J A S O N D

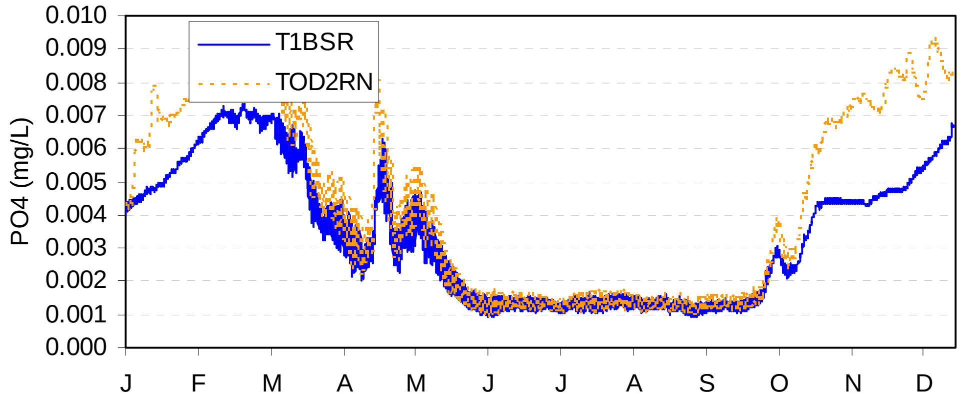


DO (mg/L)
T1BSR
TOD2RN
7 dayMinMean - DO Criteria
J F M A M J J A S O N D

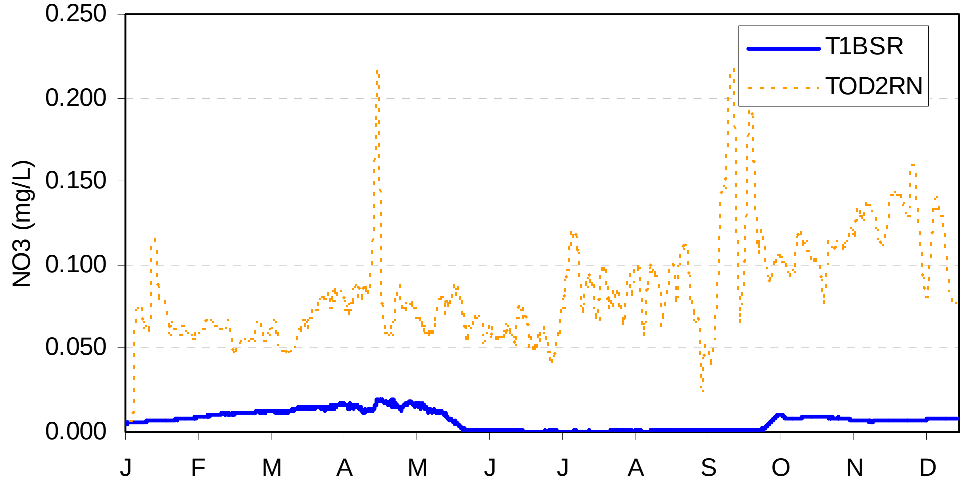


pH
T1BSR
TOD2RN
pH Criteria 1
pH Criteria 2
J F M A M J J A S O N D

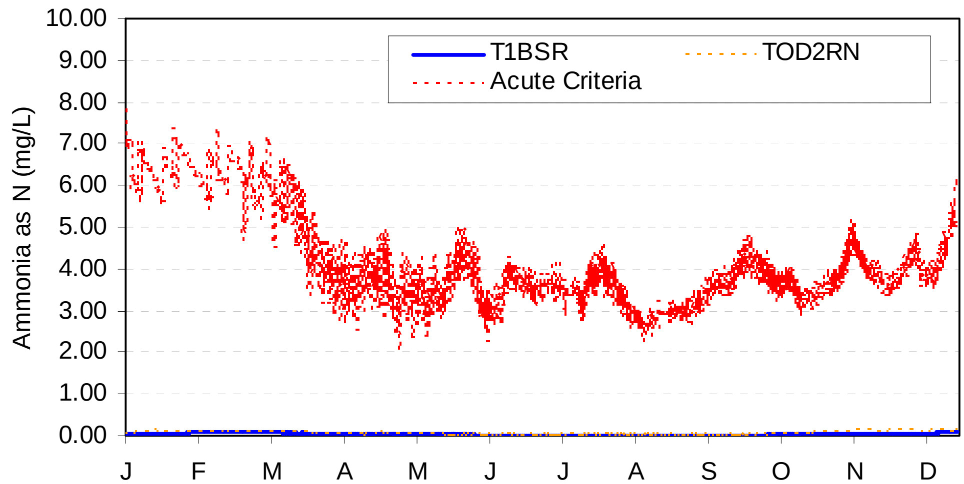
DS JCB DAM



0.010
0.009
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0.000
PO4 (mg/L)
T1BSR
TOD2RN
J F M A M J J A S O N D

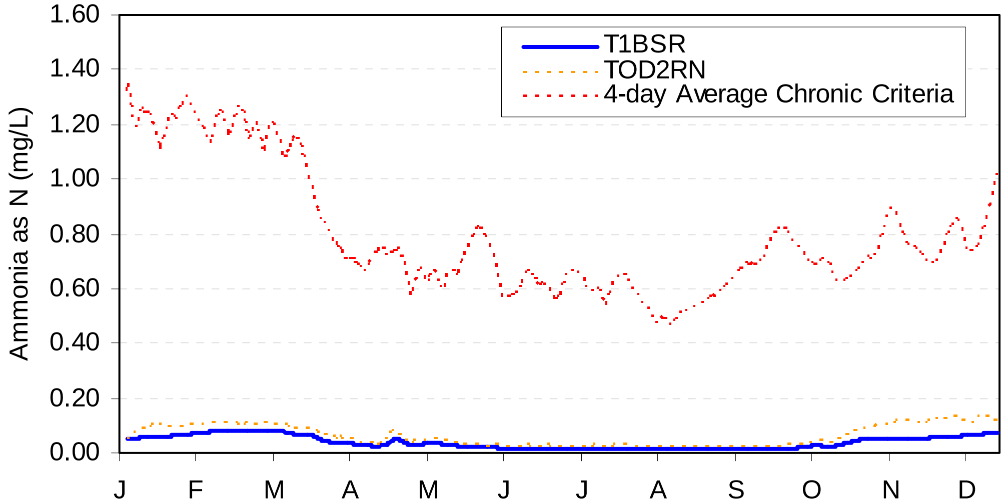


0.250
0.200
0.150
0.100
0.050
0.000
NO3 (mg/L)
T1BSR
TOD2RN
J F M A M J J A S O N D

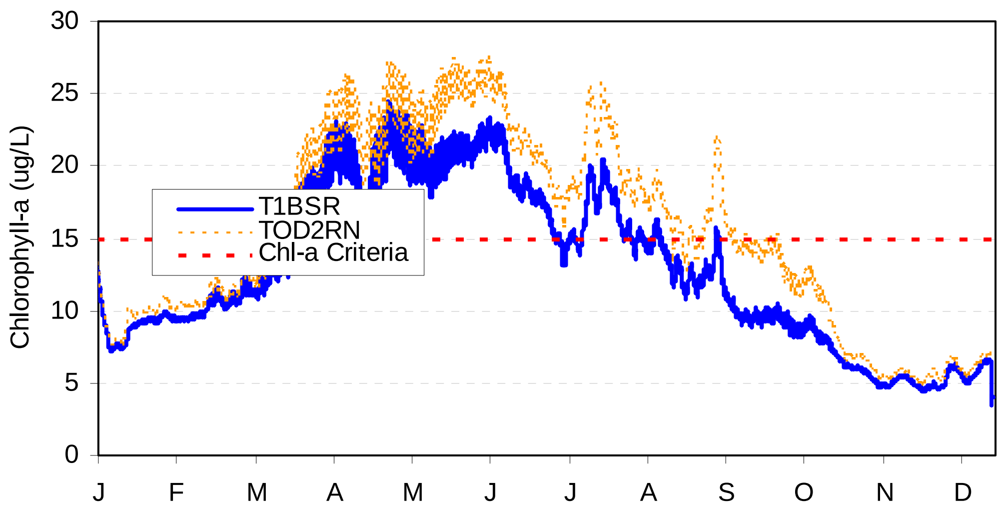


10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Ammonia as N (mg/L)
T1BSR
TOD2RN
Acute Criteria
J F M A M J J A S O N D

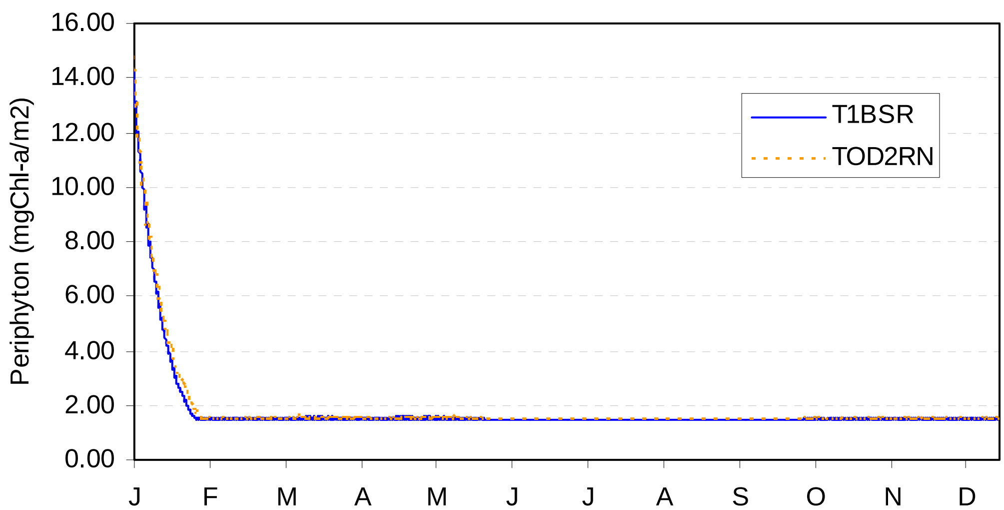
DS JCB DAM



1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
Ammonia as N (mg/L)
T1BSR
TOD2RN
4-day Average Chronic Criteria
J F M A M J J A S O N D

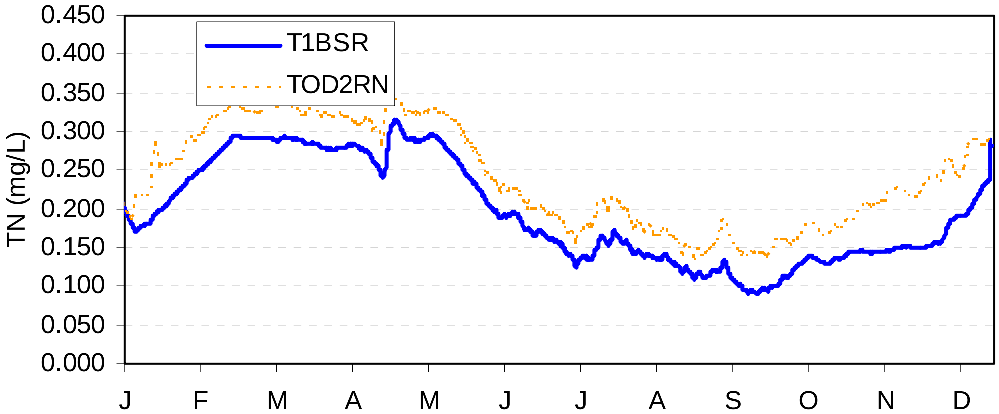


30
25
20
15
10
5
0
Chlorophyll-a (ug/L)
T1BSR
TOD2RN
Chl-a Criteria
J F M A M J J A S O N D

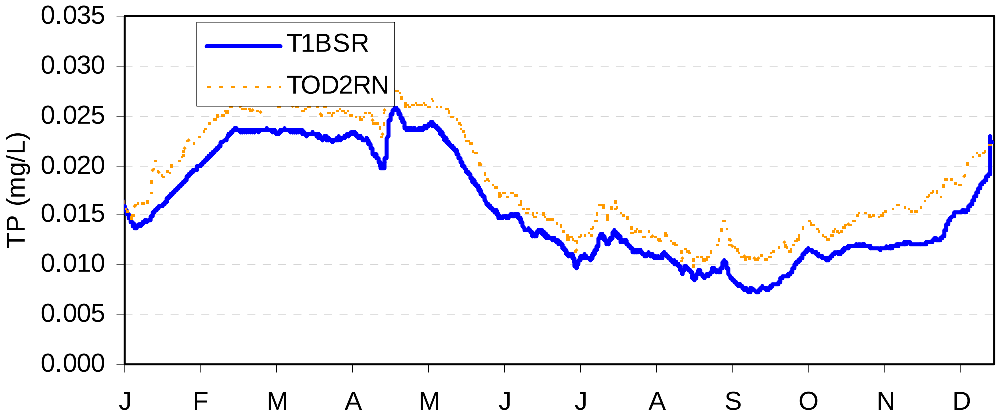


16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
Periphyton (mgChl-a/m2)
T1BSR
TOD2RN
J F M A M J J A S O N D

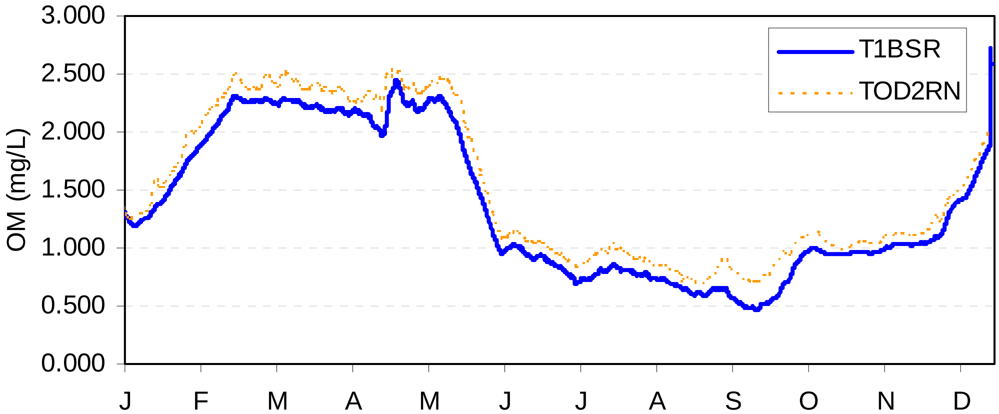
DS JCB DAM



0.450
0.400
0.350
0.300
0.250
0.200
0.150
0.100
0.050
0.000
TN (mg/L)
T1BSR
TOD2RN
J F M A M J J A S O N D

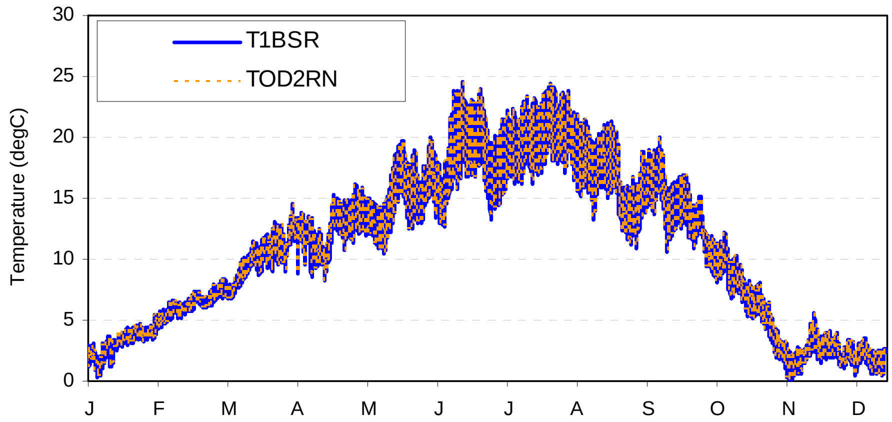


0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
TP (mg/L)
T1BSR
TOD2RN
J F M A M J J A S O N D

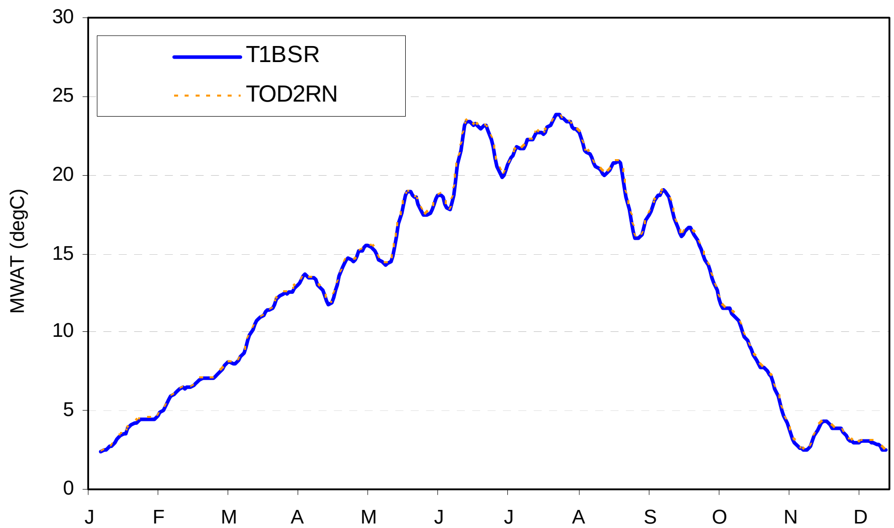


3.000
2.500
2.000
1.500
1.000
0.500
0.000
OM (mg/L)
T1BSR
TOD2RN
J F M A M J J A S O N D

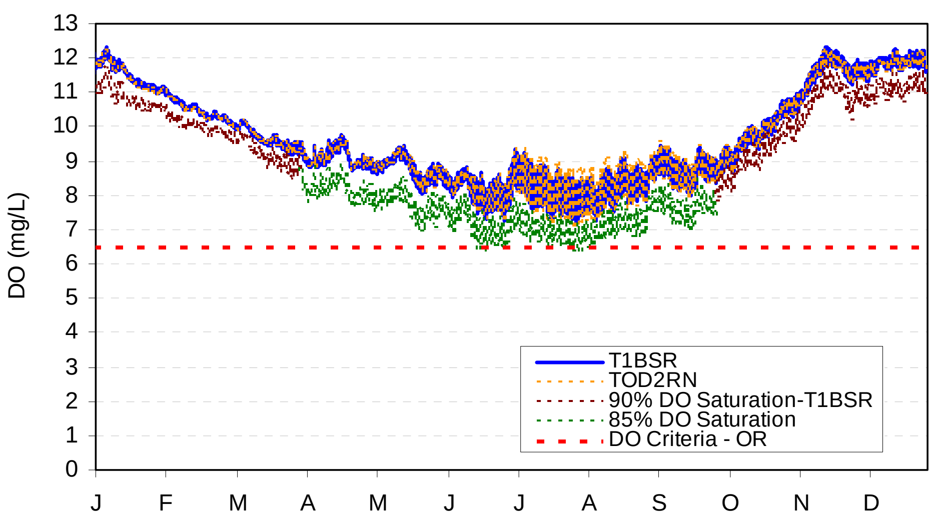
STATELINE



T1BSR
TOD2RN
Temperature (degC)
30
25
20
15
10
5
0
J F M A M J J A S O N D

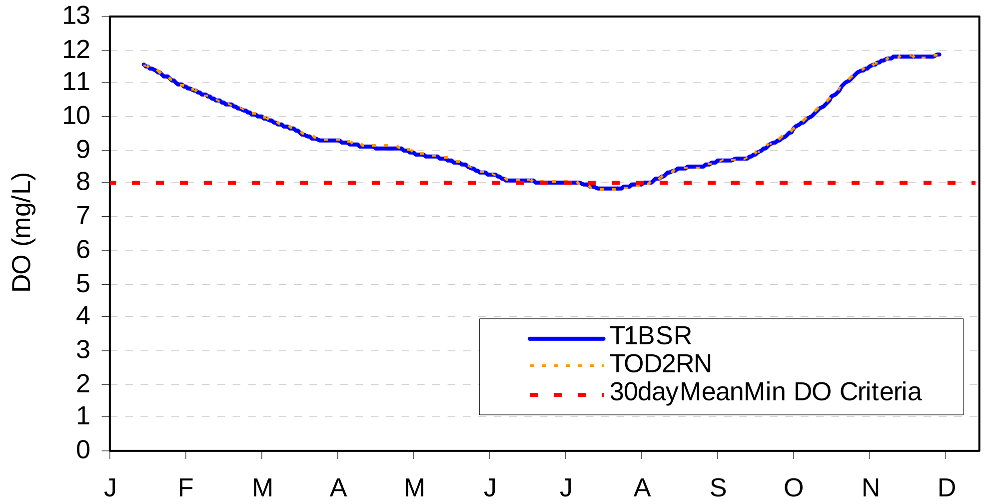


T1BSR
TOD2RN
MWAT (degC)
30
25
20
15
10
5
0
J F M A M J J A S O N D

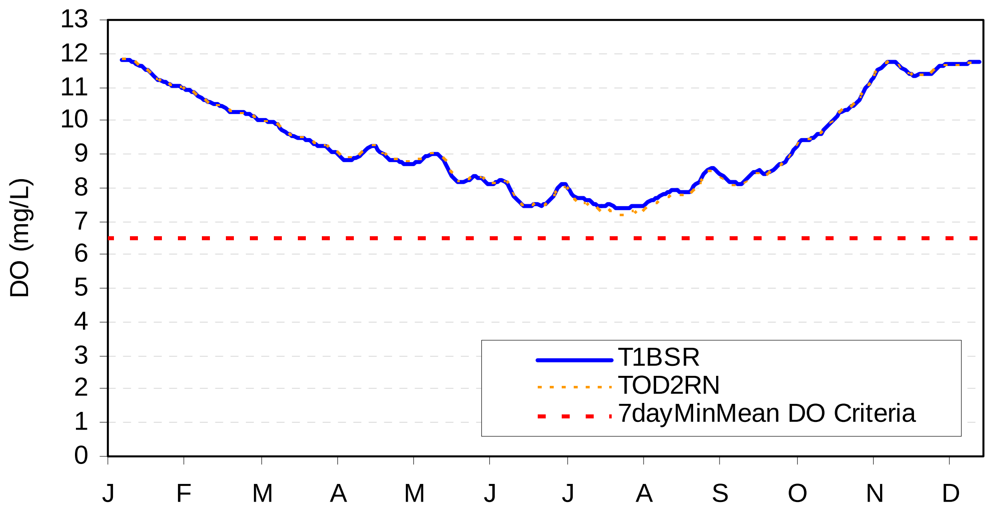


DO (mg/L)
13
12
11
10
9
8
7
6
5
4
3
2
1
0
T1BSR
TOD2RN
90% DO Saturation-T1BSR
85% DO Saturation
DO Criteria - OR
J F M A M J J A S O N D

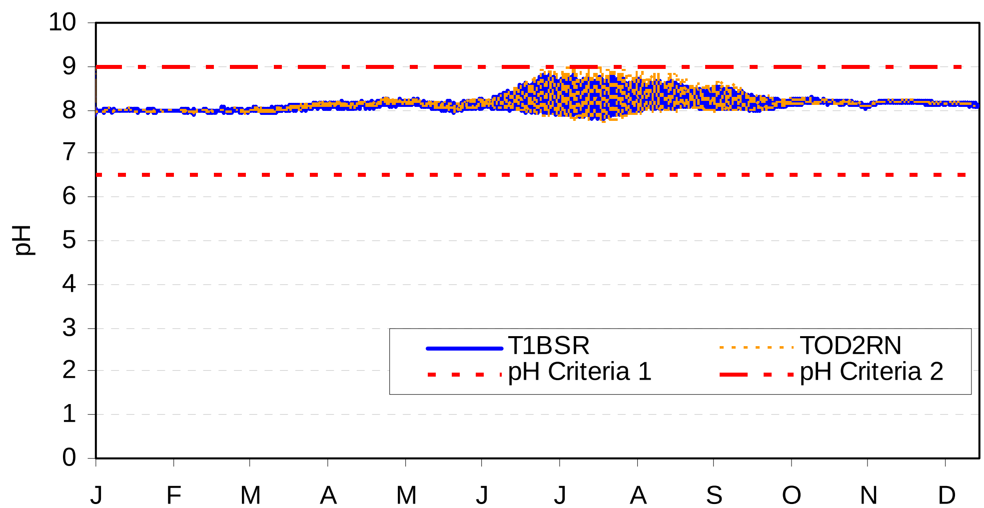
STATELINE



13
12
11
10
9
8
7
6
5
4
3
2
1
0
DO (mg/L)
T1BSR
TOD2RN
30dayMeanMin DO Criteria
J F M A M J J A S O N D

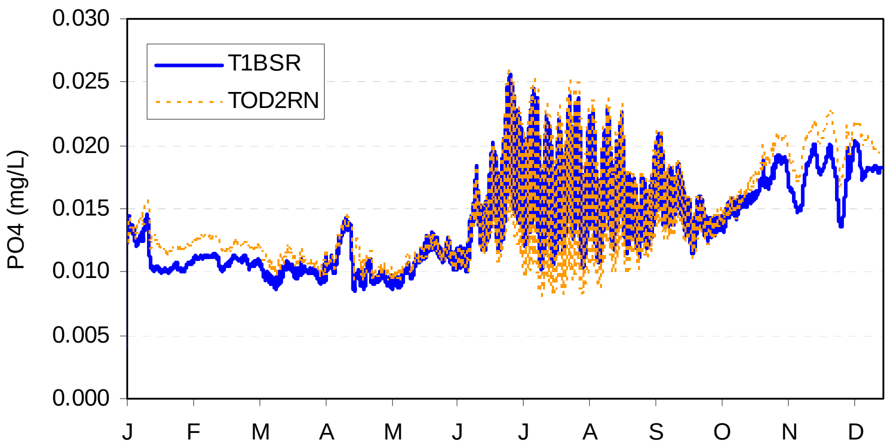


13
12
11
10
9
8
7
6
5
4
3
2
1
0
DO (mg/L)
T1BSR
TOD2RN
7dayMinMean DO Criteria
J F M A M J J A S O N D

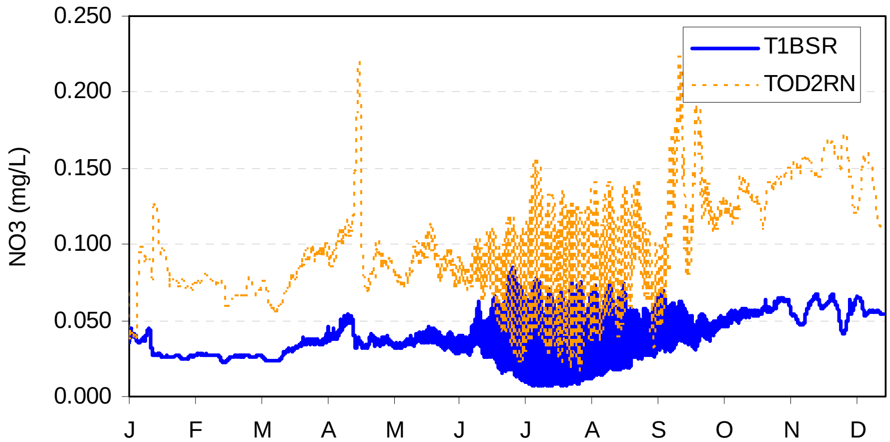


10
9
8
7
6
5
4
3
2
1
0
pH
T1BSR
TOD2RN
pH Criteria 1
pH Criteria 2
J F M A M J J A S O N D

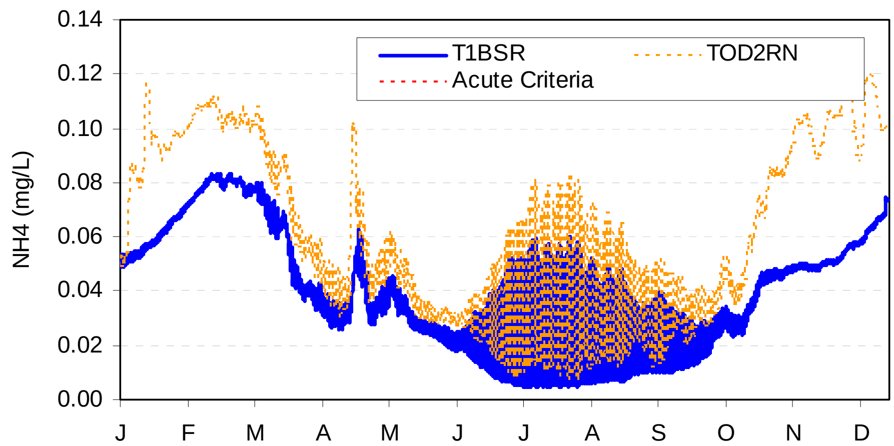
STATELINE



PO4 (mg/L)
0.030
0.025
0.020
0.015
0.010
0.005
0.000
T1BSR
TOD2RN
J
F
M
A
M
J
J
A
S
O
N
D

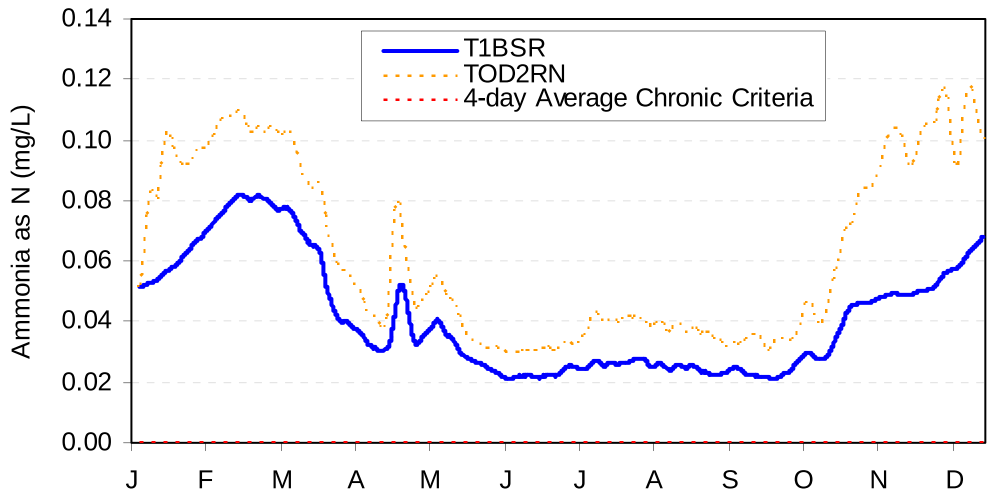


NO3 (mg/L)
0.250
0.200
0.150
0.100
0.050
0.000
T1BSR
TOD2RN
J
F
M
A
M
J
J
A
S
O
N
D

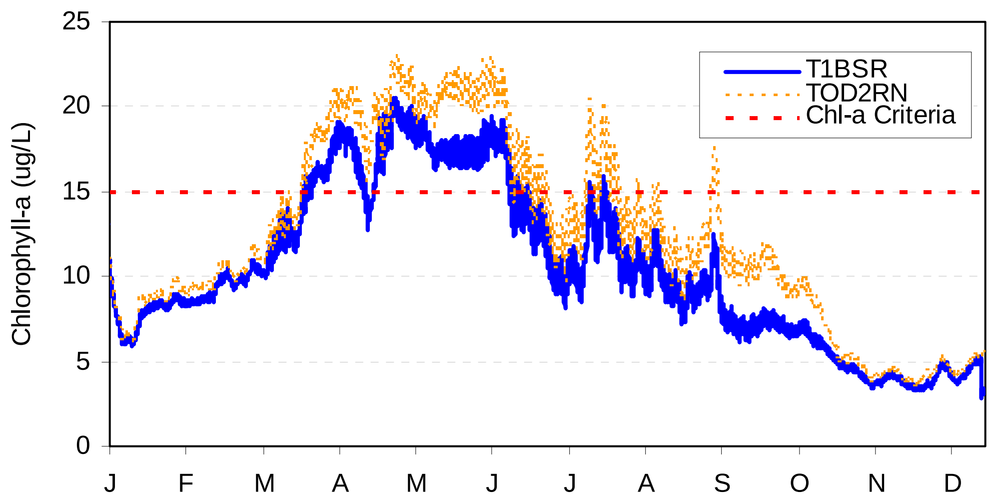


NH4 (mg/L)
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
T1BSR
TOD2RN
Acute Criteria
J
F
M
A
M
J
J
A
S
O
N
D

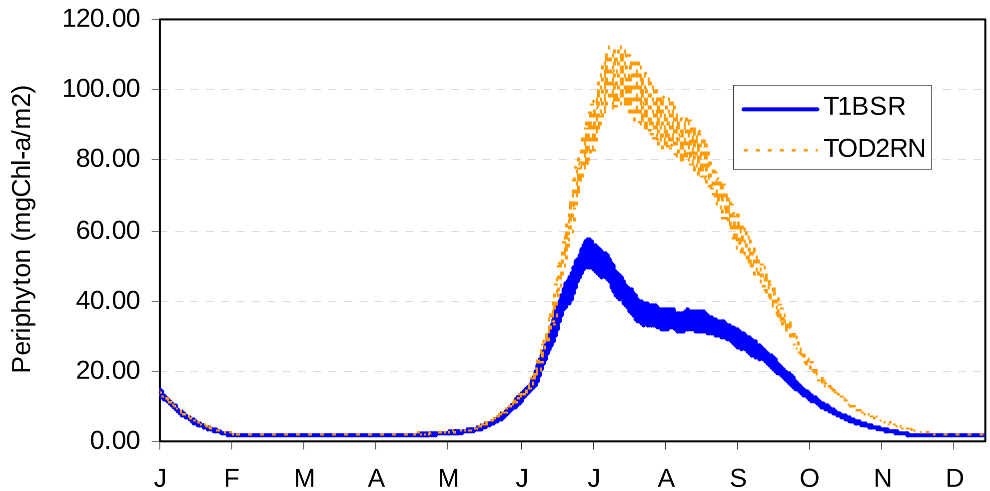
STATELINE



0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
Ammonia as N (mg/L)
T1BSR
TOD2RN
4-day Average Chronic Criteria
J
F
M
A
M
J
J
A
S
O
N
D

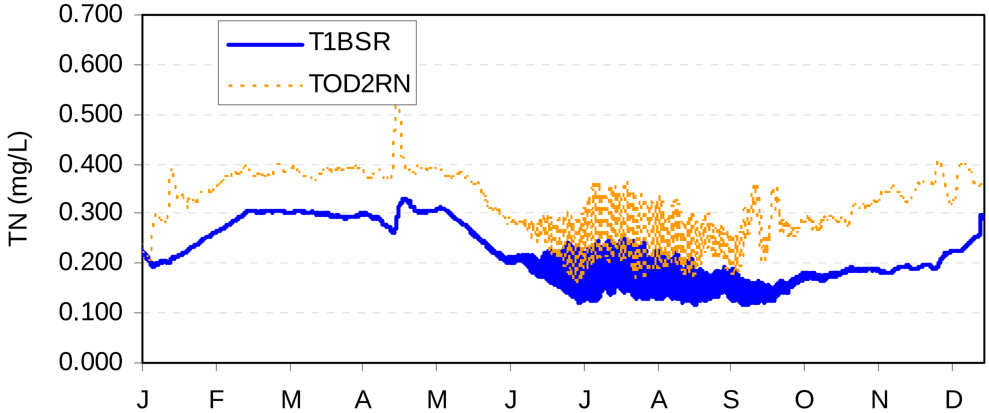


25
20
15
10
5
0
Chlorophyll-a (ug/L)
T1BSR
TOD2RN
Chl-a Criteria
J
F
M
A
M
J
J
A
S
O
N
D

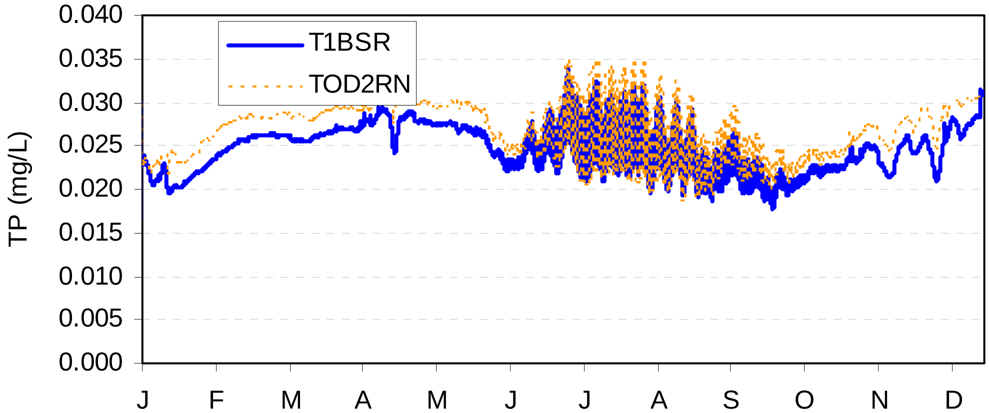


120.00
100.00
80.00
60.00
40.00
20.00
0.00
Periphyton (mgChl-a/m2)
T1BSR
TOD2RN
J
F
M
A
M
J
J
A
S
O
N
D

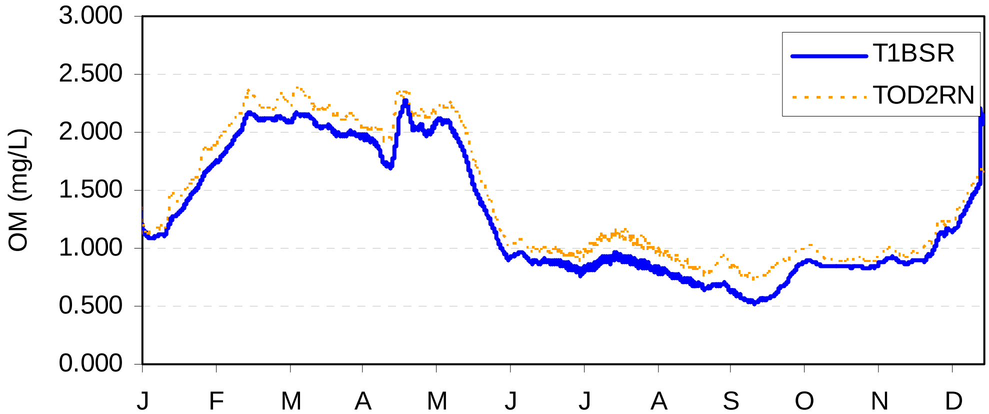
STATELINE



TN (mg/L)
0.700
0.600
0.500
0.400
0.300
0.200
0.100
0.000
T1BSR
TOD2RN
J F M A M J J A S O N D

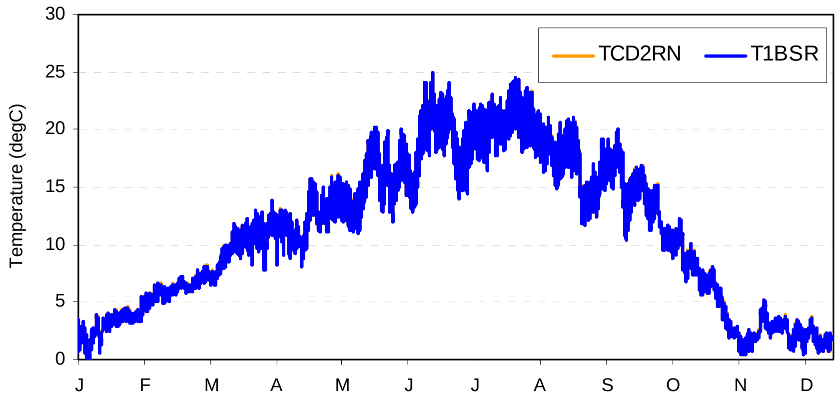


TP (mg/L)
0.040
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
T1BSR
TOD2RN
J F M A M J J A S O N D

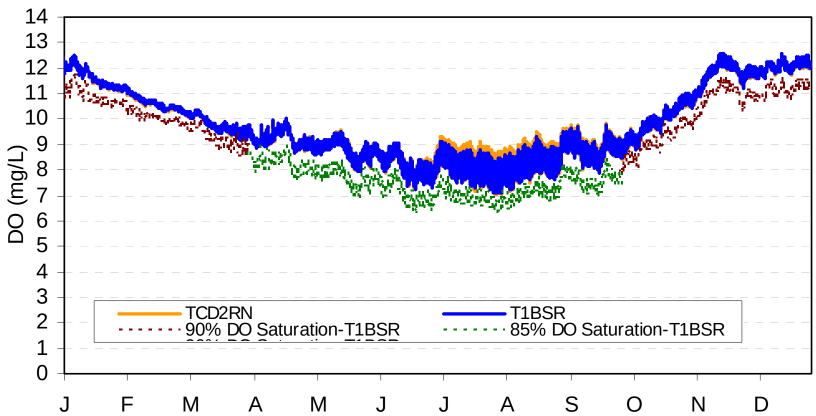


OM (mg/L)
3.000
2.500
2.000
1.500
1.000
0.500
0.000
T1BSR
TOD2RN
J F M A M J J A S O N D

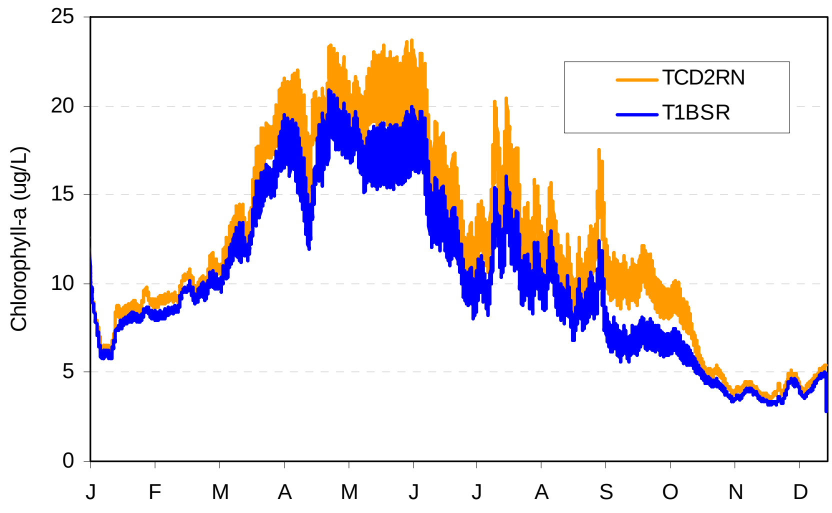
DS_COPCODAM



Temperature (degC)
30
25
20
15
10
5
0
TCD2RN
T1BSR
J
F
M
A
M
J
J
A
S
O
N
D

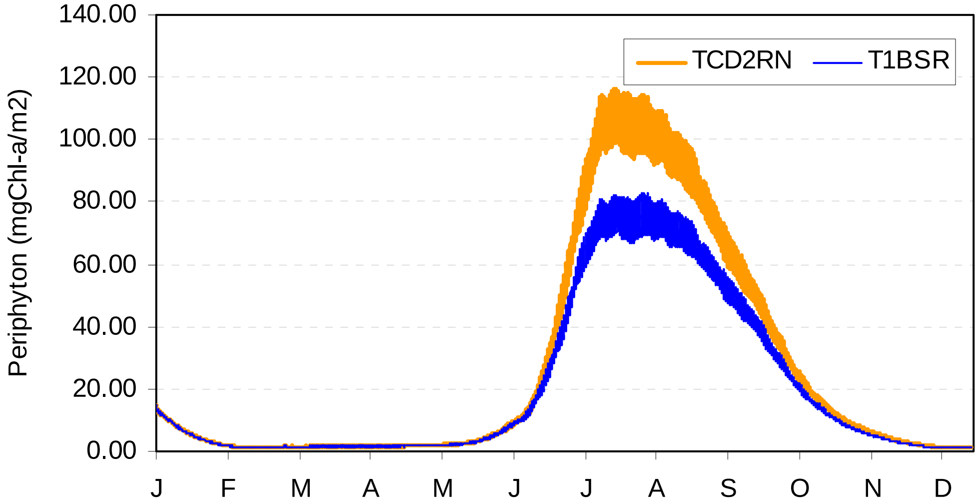


DO (mg/L)
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
TCD2RN
T1BSR
90% DO Saturation-T1BSR
85% DO Saturation-T1BSR
J
F
M
A
M
J
J
A
S
O
N
D

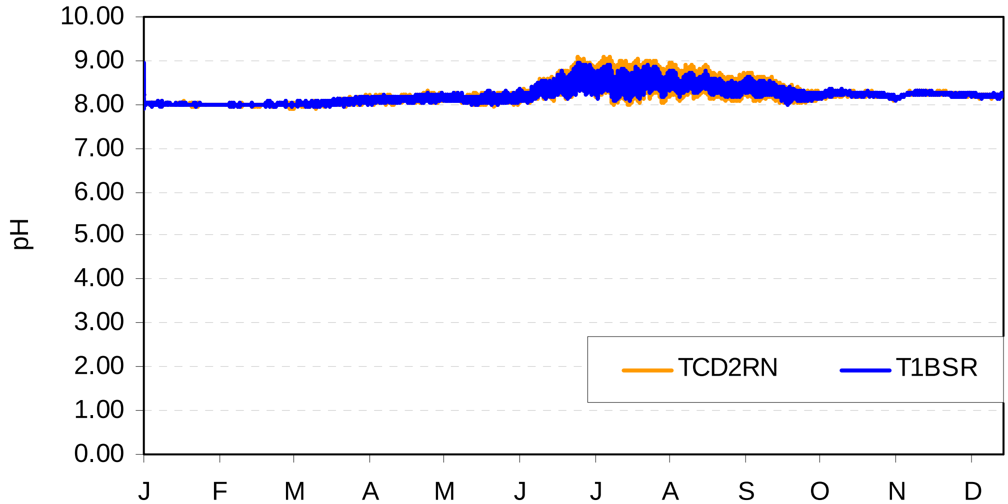


Chlorophyll-a (ug/L)
25
20
15
10
5
0
TCD2RN
T1BSR
J
F
M
A
M
J
J
A
S
O
N
D

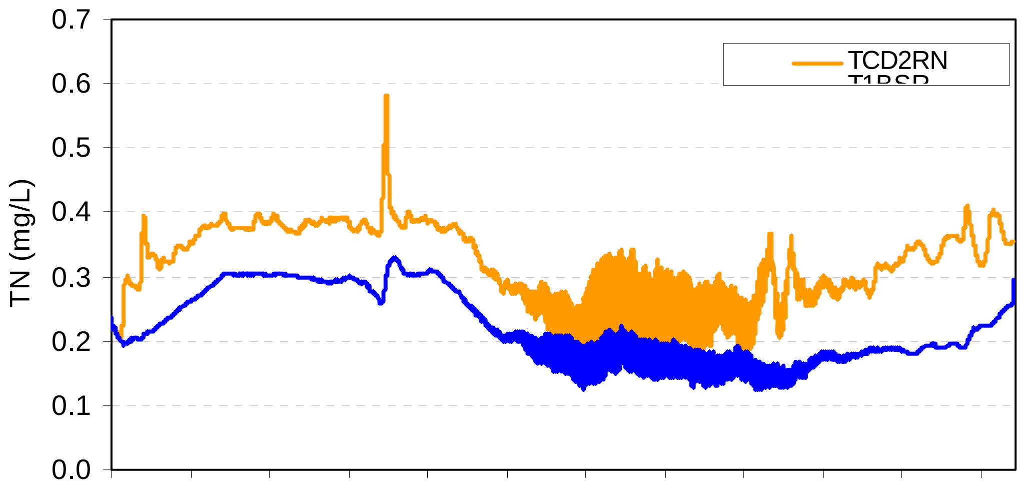
DS_COPCODAM



Periphyton (mgChl-a/m2)
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
TCD2RN
T1BSR
J F M A M J J A S O N D

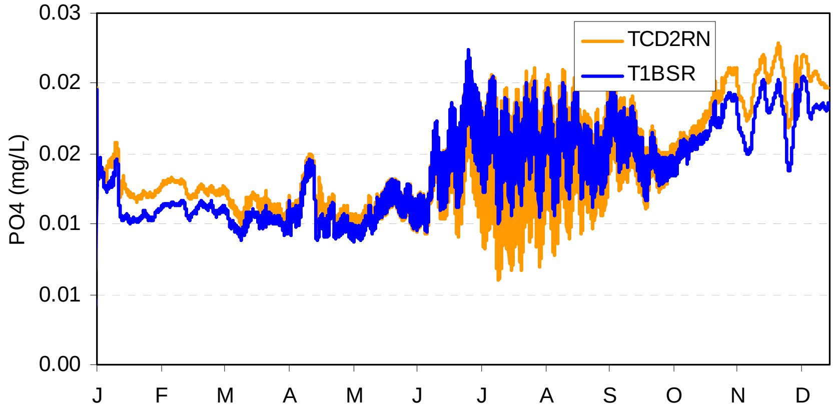


pH
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
TCD2RN
T1BSR
J F M A M J J A S O N D

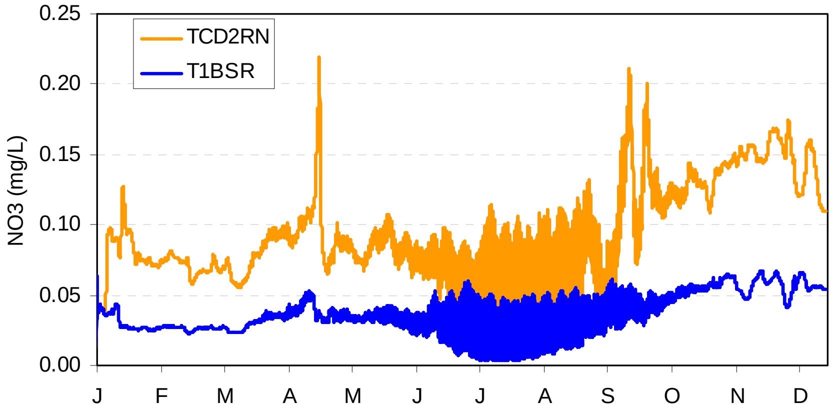


TN (mg/L)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
TCD2RN

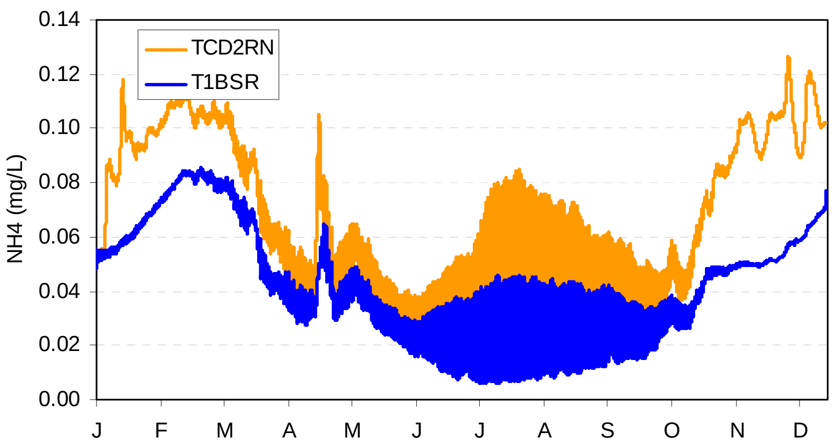
DS_COPCODAM



0.03
0.02
0.02
0.01
0.01
0.00
PO4 (mg/L)
TCD2RN
T1BSR
J
F
M
A
M
J
J
A
S
O
N
D

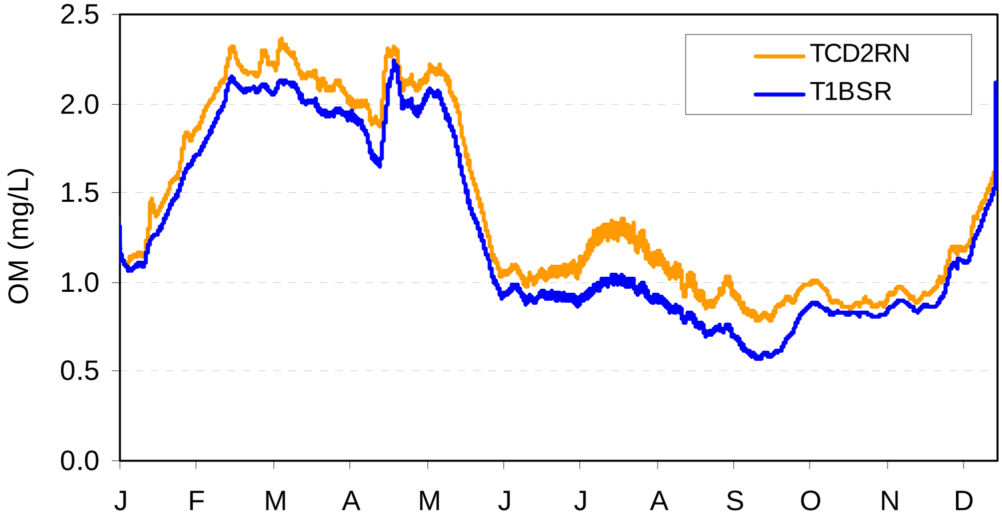


0.25
0.20
0.15
0.10
0.05
0.00
NO3 (mg/L)
TCD2RN
T1BSR
J
F
M
A
M
J
J
A
S
O
N
D

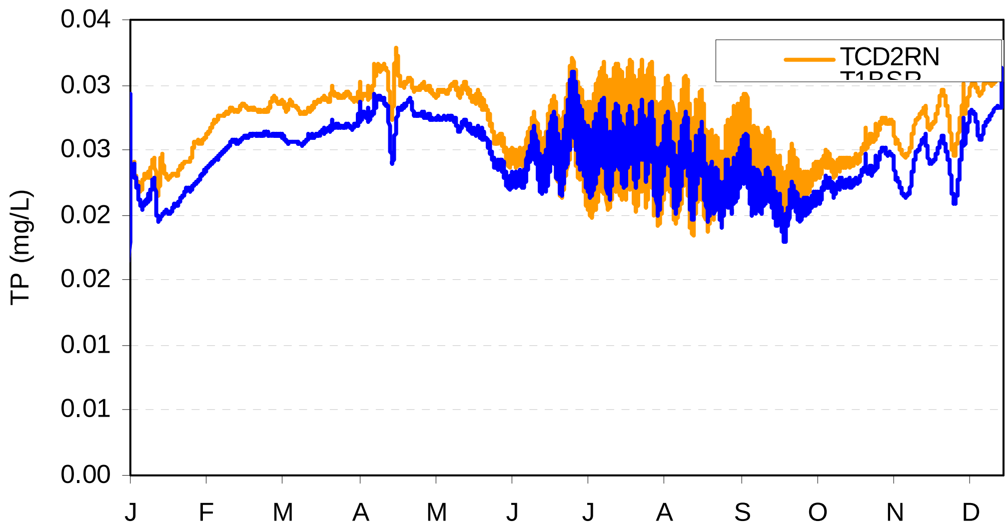


0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
NH4 (mg/L)
TCD2RN
T1BSR
J
F
M
A
M
J
J
A
S
O
N
D

DS_COPCODAM

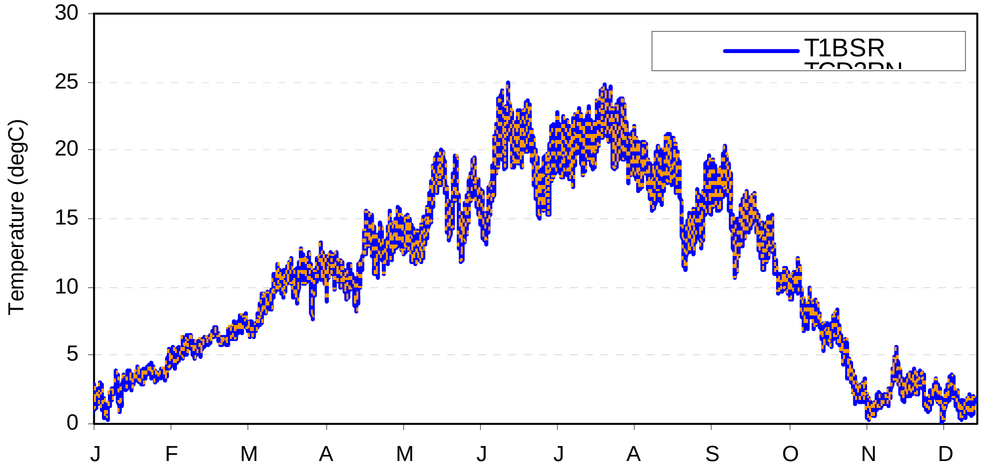


2.5
2.0
1.5
1.0
0.5
0.0
OM (mg/L)
J
F
M
A
M
J
J
A
S
O
N
D
TCD2RN
T1BSR

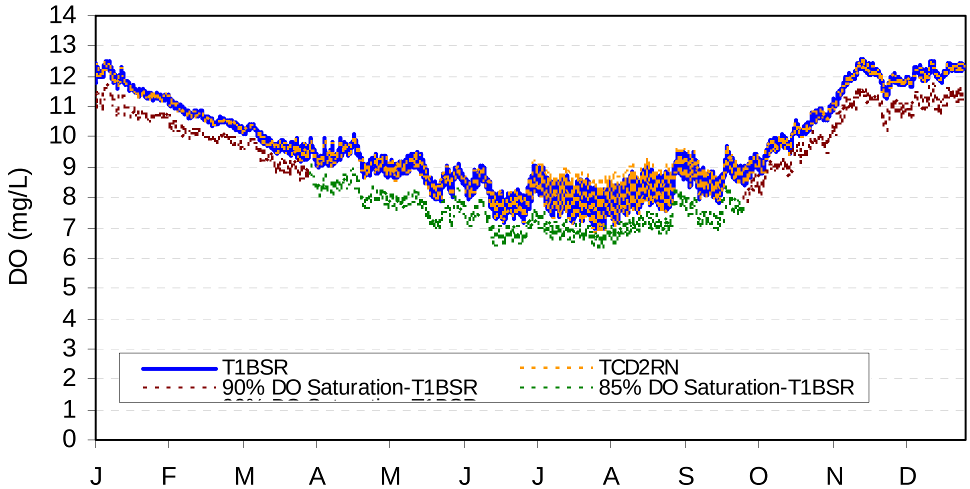


0.04
0.03
0.03
0.02
0.02
0.01
0.01
0.00
TP (mg/L)
J
F
M
A
M
J
J
A
S
O
N
D
TCD2RN

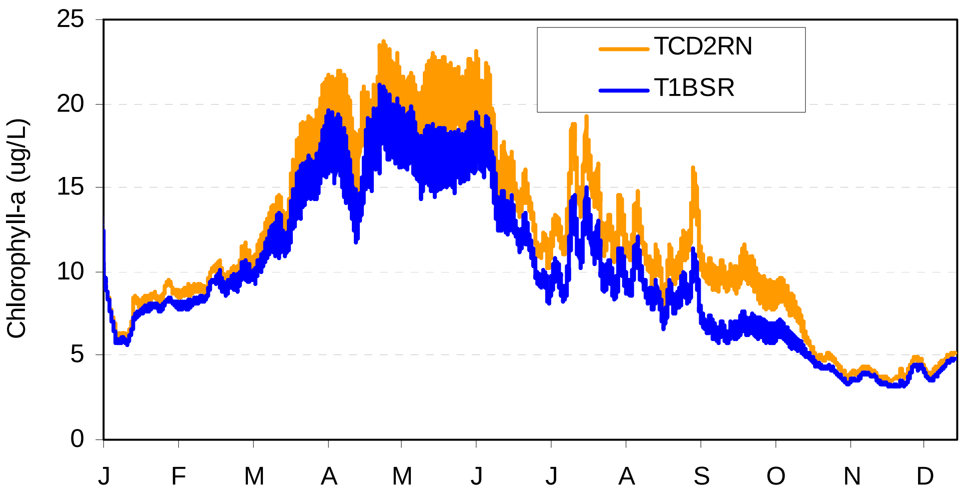
US_IG_DAM



Temperature (degC)
30
25
20
15
10
5
0
T1BSR
J
F
M
A
M
J
J
A
S
O
N
D

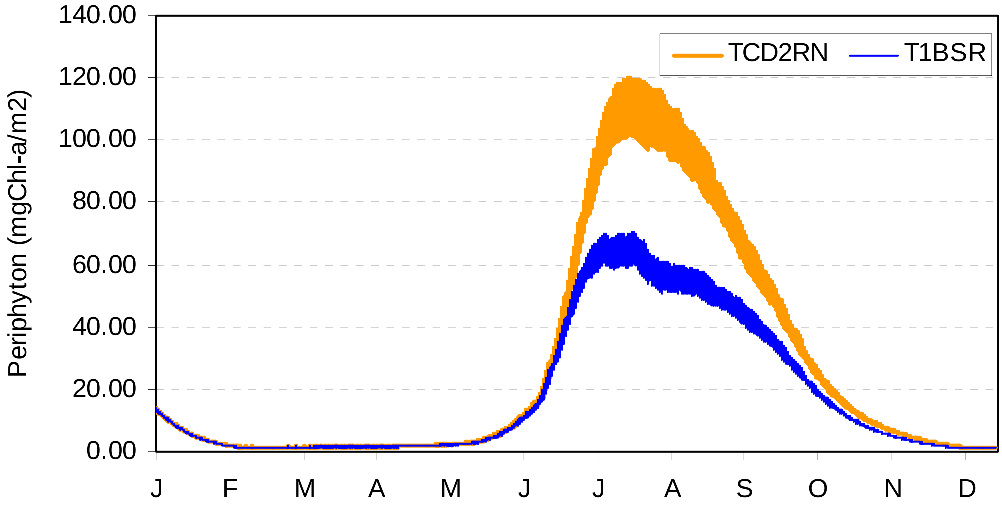


DO (mg/L)
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
T1BSR
TCD2RN
90% DO Saturation-T1BSR
85% DO Saturation-T1BSR
J
F
M
A
M
J
J
A
S
O
N
D

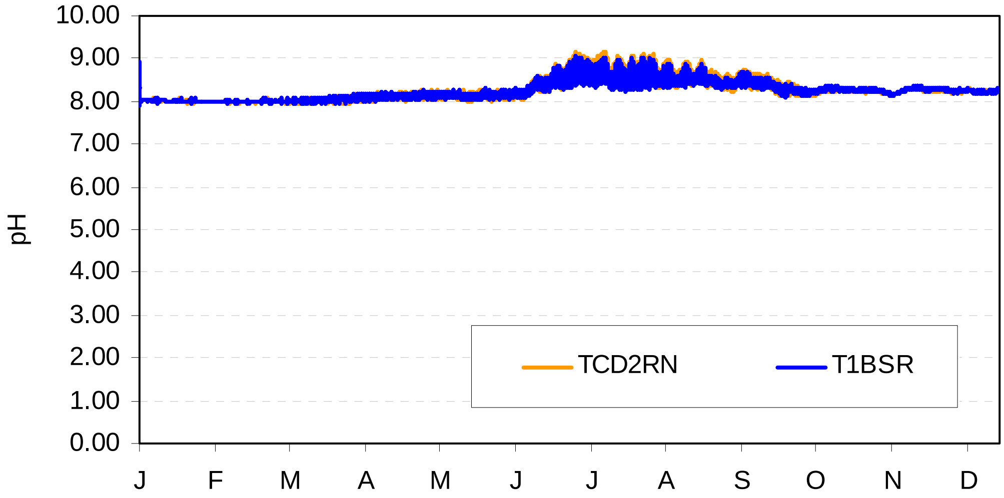


Chlorophyll-a (ug/L)
25
20
15
10
5
0
TCD2RN
T1BSR
J
F
M
A
M
J
J
A
S
O
N
D

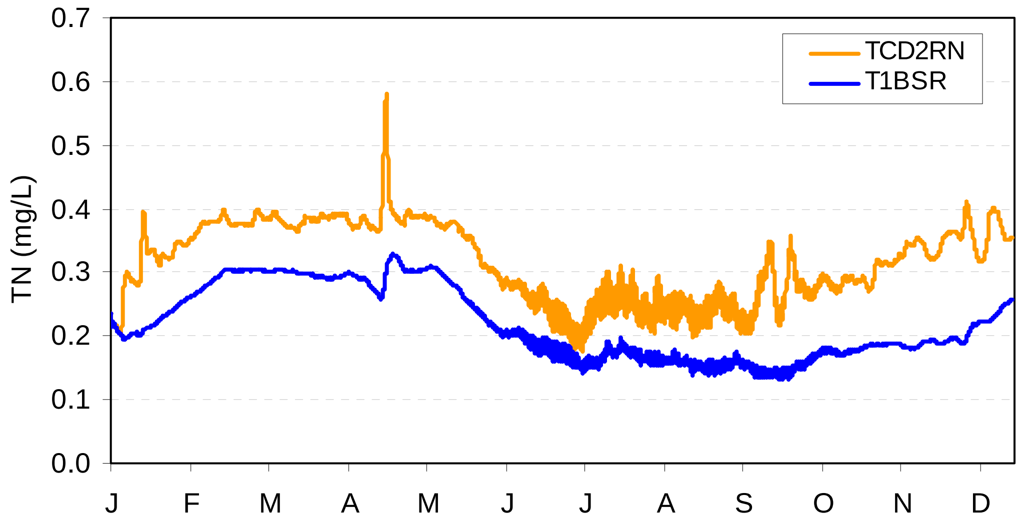
US_IG_DAM



Periphyton (mgChl-a/m2)
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
TCD2RN
T1BSR
J F M A M J J A S O N D

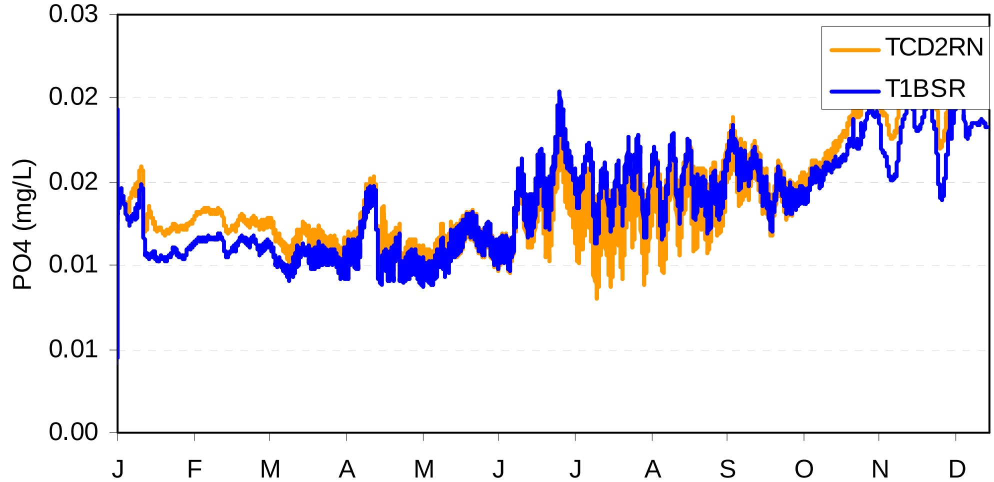


pH
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
TCD2RN
T1BSR
J F M A M J J A S O N D

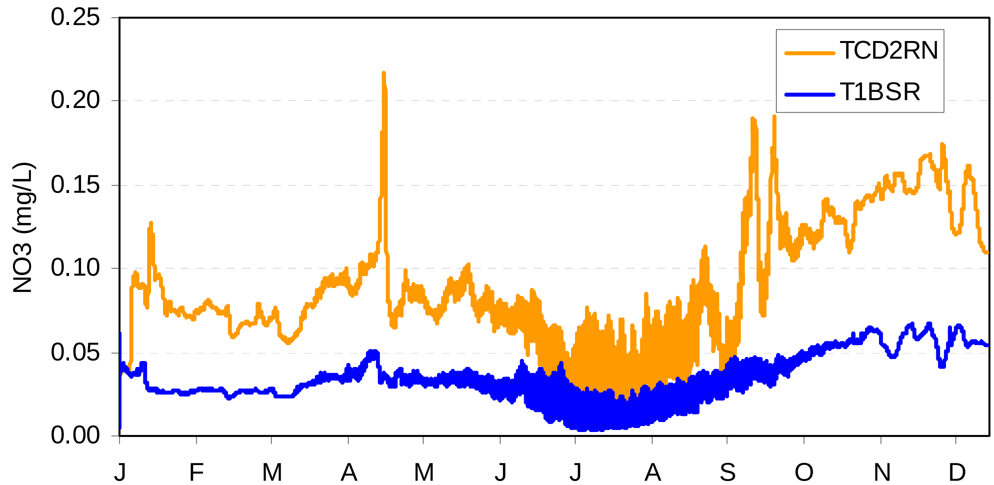


TN (mg/L)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
TCD2RN
T1BSR
J F M A M J J A S O N D

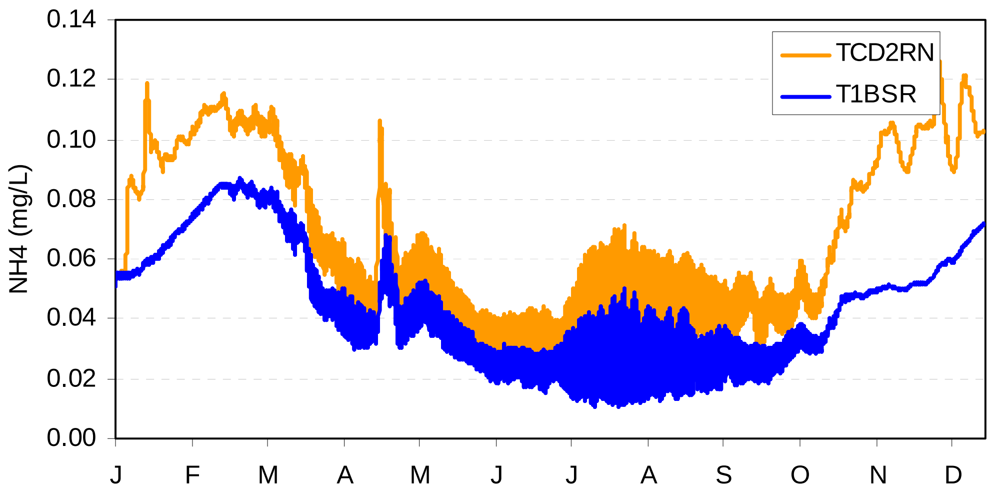
US_IG_DAM



0.03
0.02
0.02
0.01
0.01
0.00
PO4 (mg/L)
J
F
M
A
M
J
J
A
S
O
N
D
TCD2RN
T1BSR

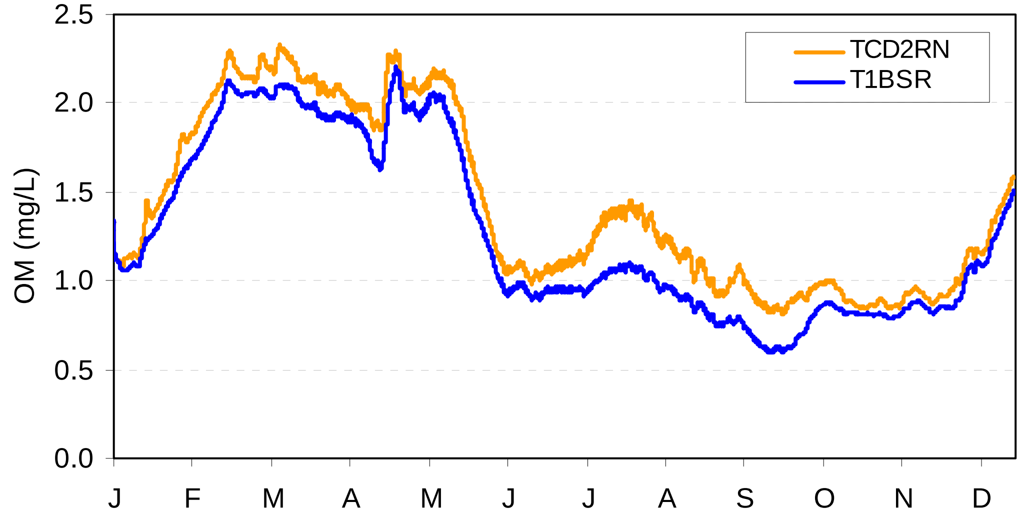


0.25
0.20
0.15
0.10
0.05
0.00
NO3 (mg/L)
J
F
M
A
M
J
J
A
S
O
N
D
TCD2RN
T1BSR

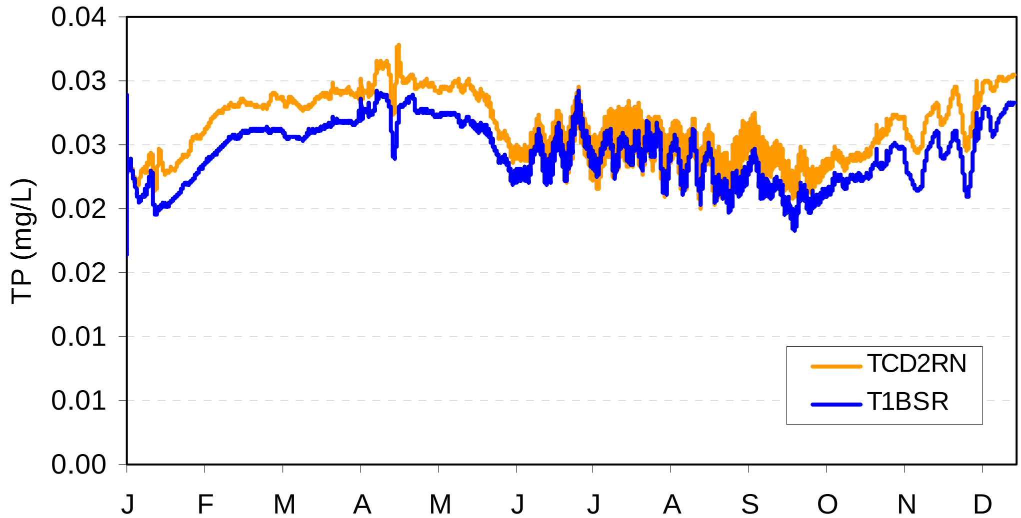


0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
NH4 (mg/L)
J
F
M
A
M
J
J
A
S
O
N
D
TCD2RN
T1BSR

US_IG_DAM

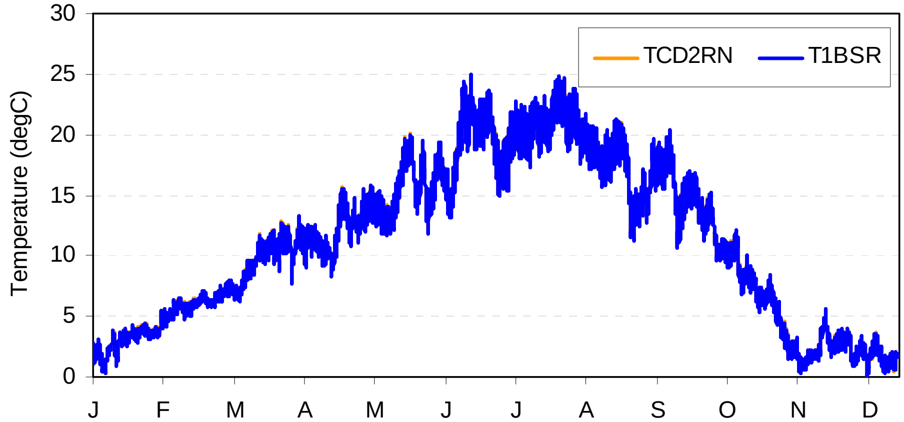


TCD2RN
T1BSR
OM (mg/L)
2.5
2.0
1.5
1.0
0.5
0.0
J F M A M J J A S O N D

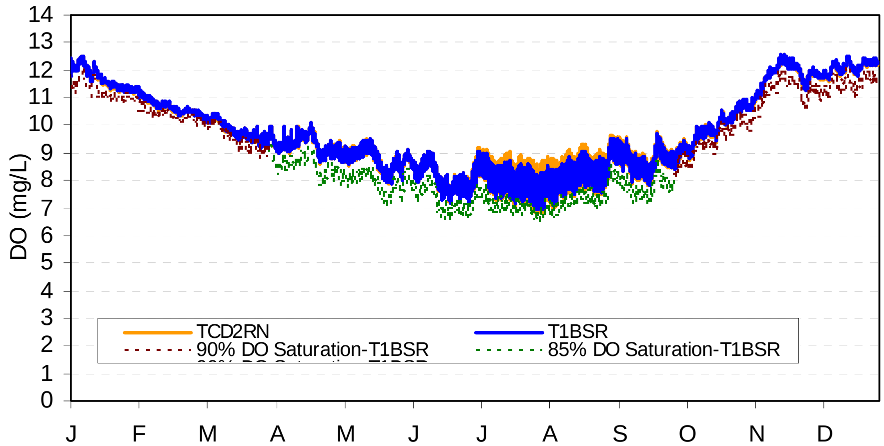


TCD2RN
T1BSR
TP (mg/L)
0.04
0.03
0.03
0.02
0.02
0.01
0.01
0.00
J F M A M J J A S O N D

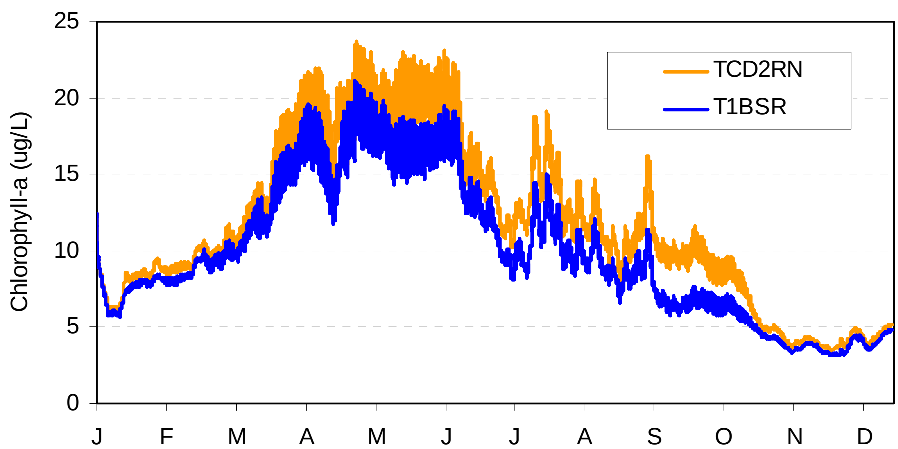
DS_IGDAM



TCD2RN
T1BSR
Temperature (degC)
30
25
20
15
10
5
0
J F M A M J J A S O N D

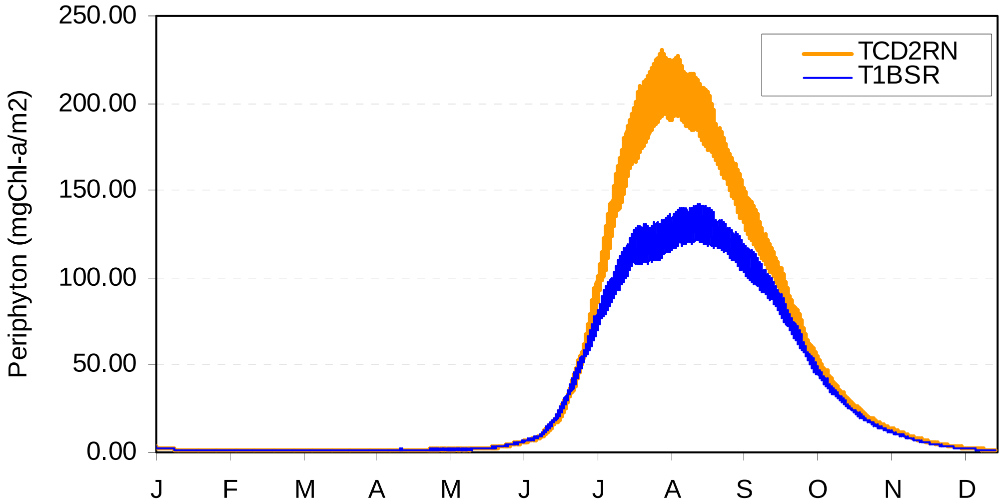


DO (mg/L)
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
TCD2RN
T1BSR
90% DO Saturation-T1BSR
85% DO Saturation-T1BSR
J F M A M J J A S O N D

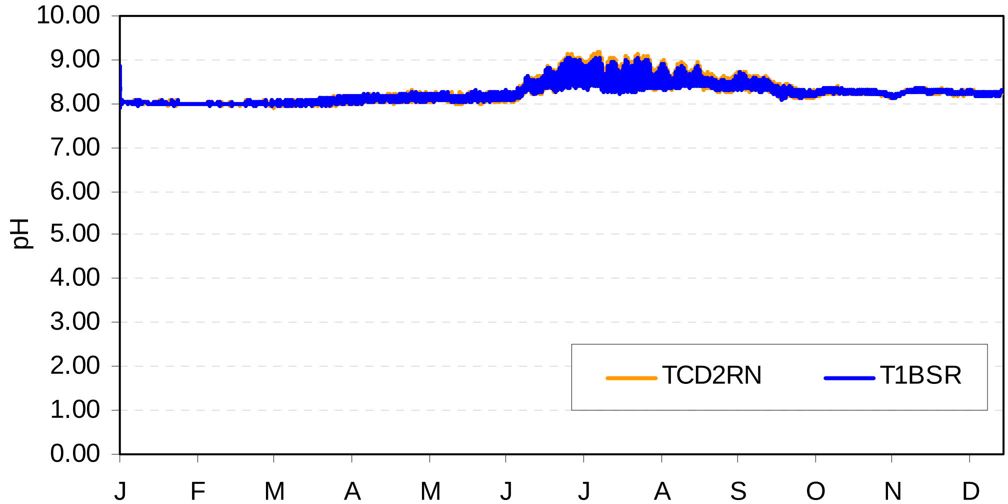


TCD2RN
T1BSR
Chlorophyll-a (ug/L)
25
20
15
10
5
0
J F M A M J J A S O N D

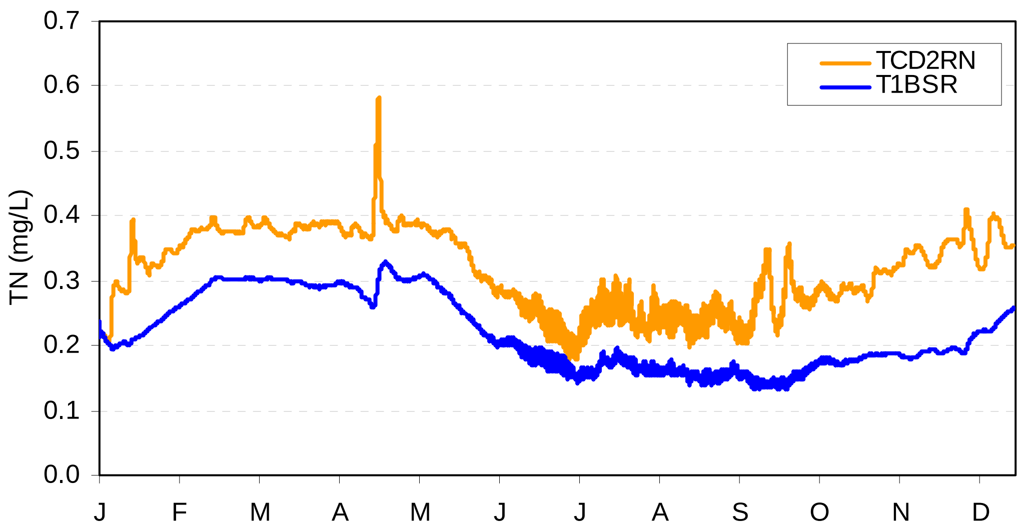
DS_IGDAM



Periphyton (mgChl-a/m2)
250.00
200.00
150.00
100.00
50.00
0.00
TCD2RN
T1BSR
J F M A M J J A S O N D

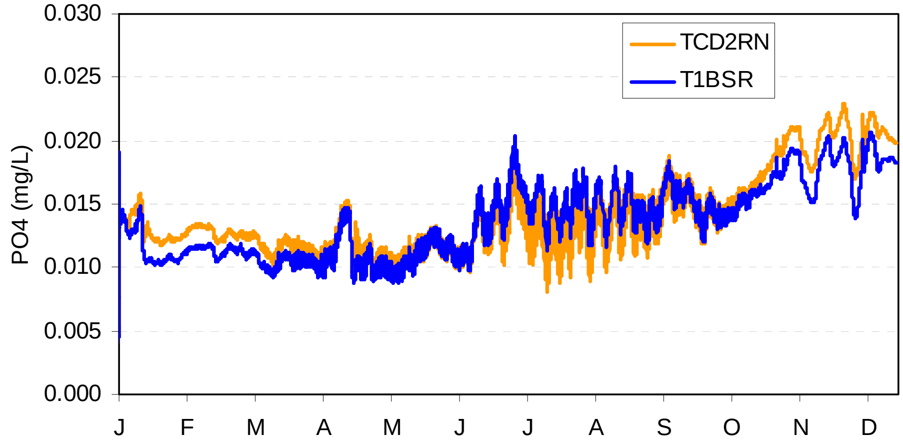


pH
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
TCD2RN
T1BSR
J F M A M J J A S O N D

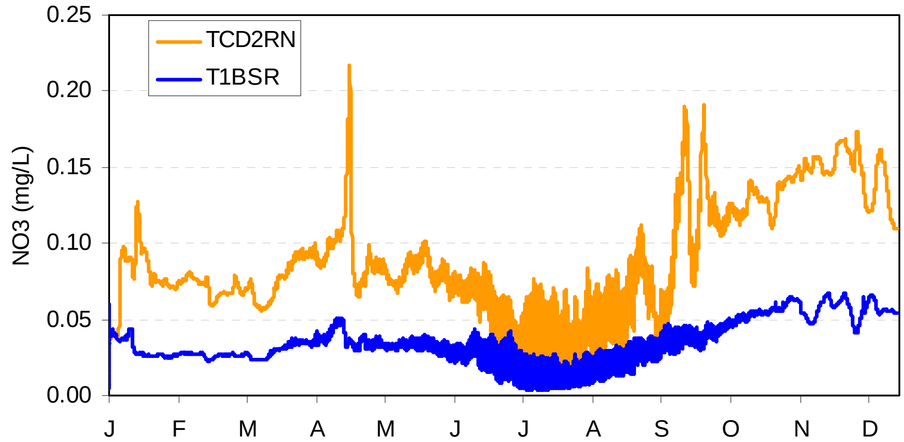


TN (mg/L)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
TCD2RN
T1BSR
J F M A M J J A S O N D

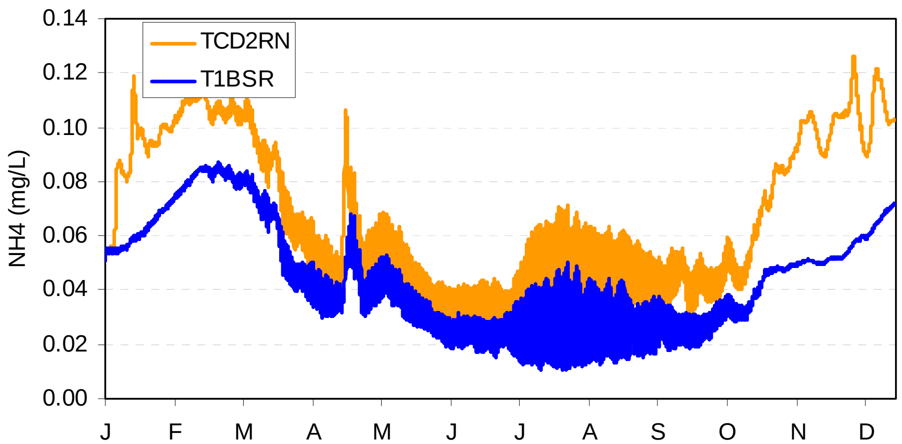
DS_IGDAM



0.030
0.025
0.020
0.015
0.010
0.005
0.000
PO4 (mg/L)
TCD2RN
T1BSR
J F M A M J J A S O N D

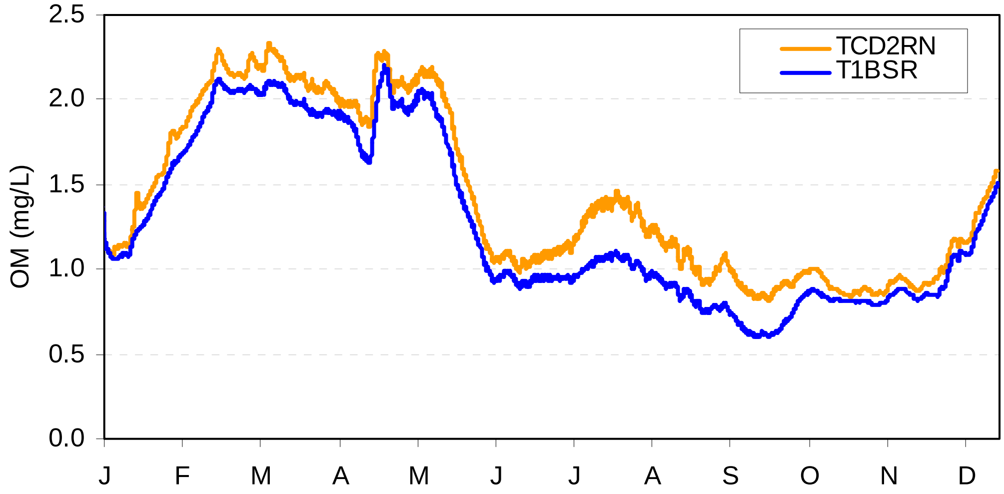


0.25
0.20
0.15
0.10
0.05
0.00
NO3 (mg/L)
TCD2RN
T1BSR
J F M A M J J A S O N D

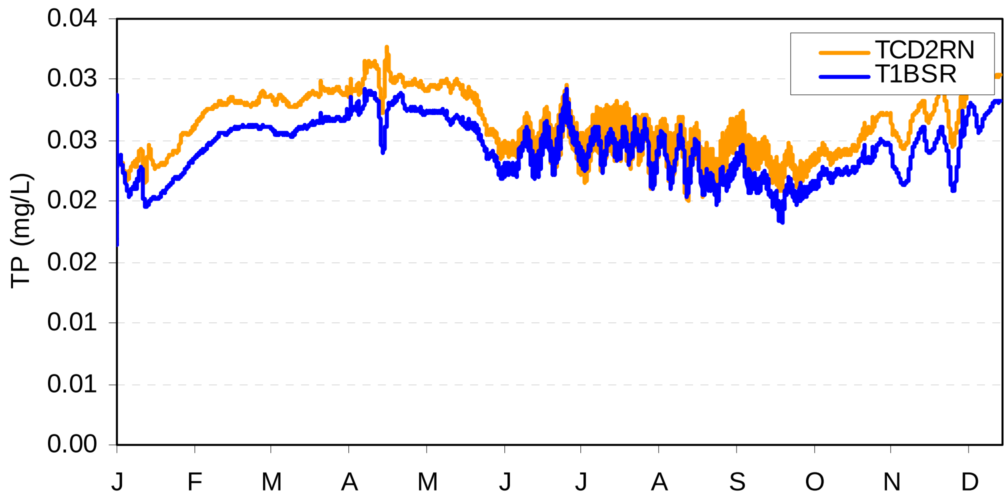


0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
NH4 (mg/L)
TCD2RN
T1BSR
J F M A M J J A S O N D

DS_IGDAM

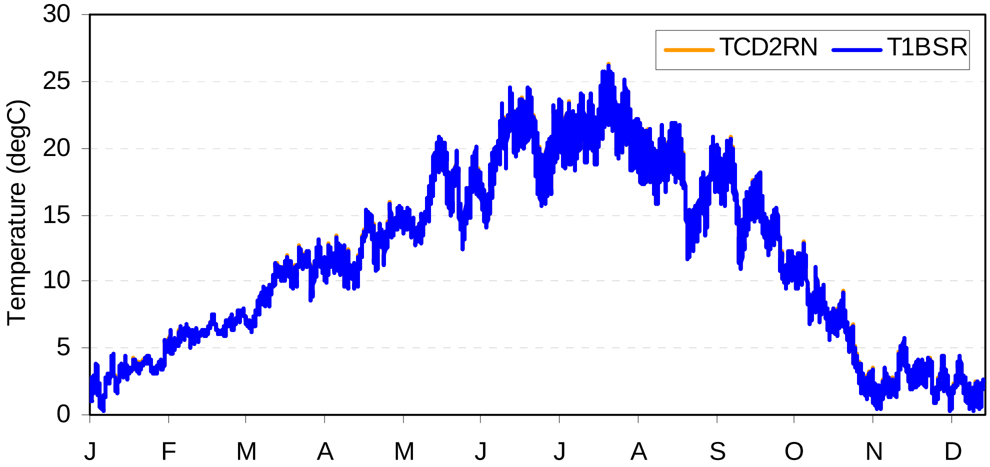


2.5
2.0
1.5
1.0
0.5
0.0
OM (mg/L)
J F M A M J J A S O N D
TCD2RN
T1BSR

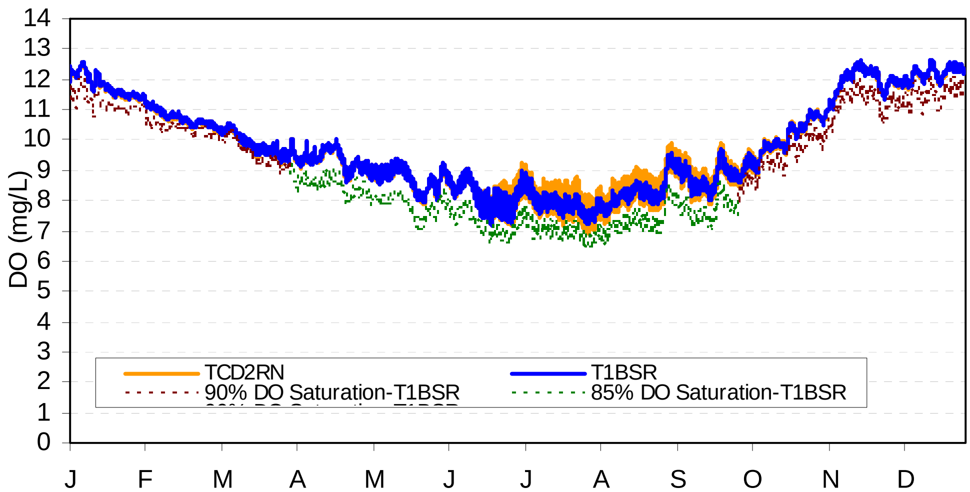


0.04
0.03
0.03
0.02
0.02
0.01
0.01
0.00
TP (mg/L)
J F M A M J J A S O N D
TCD2RN
T1BSR

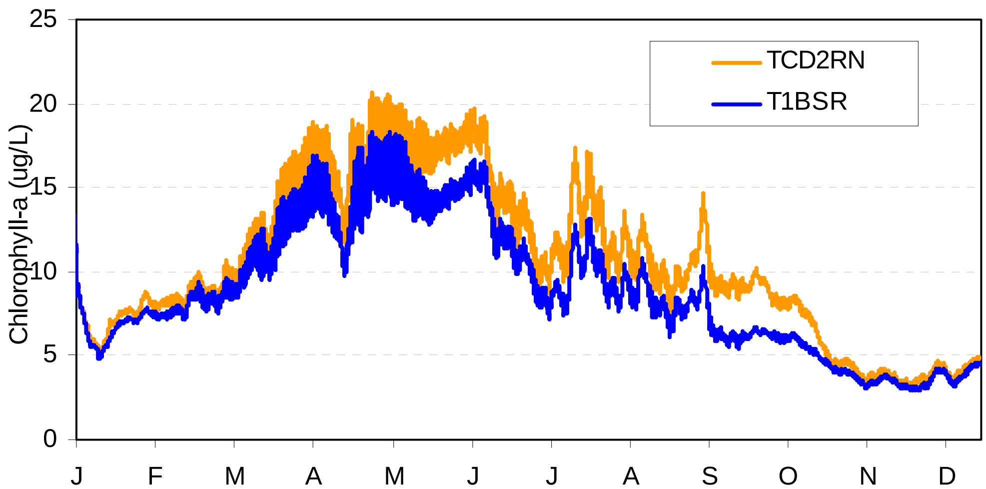
US_SHASTA



Temperature (degC)
30
25
20
15
10
5
0
J
F
M
A
M
J
J
A
S
O
N
D
TCD2RN
T1BSR

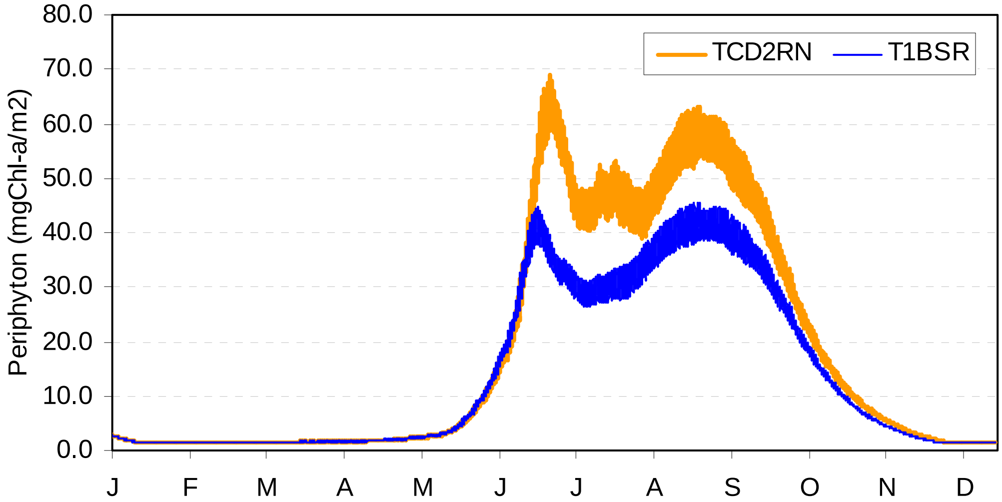


DO (mg/L)
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
J
F
M
A
M
J
J
A
S
O
N
D
TCD2RN
T1BSR
90% DO Saturation-T1BSR
85% DO Saturation-T1BSR

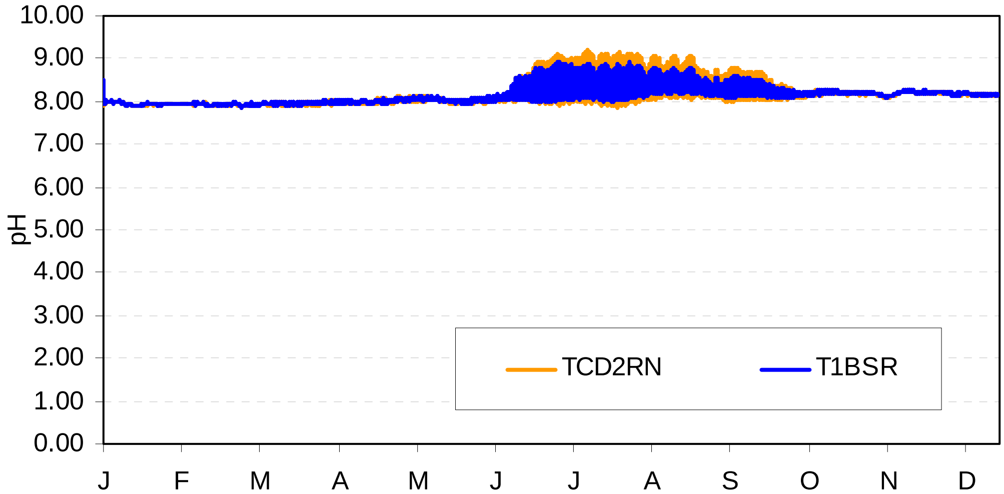


Chlorophyll-a (ug/L)
25
20
15
10
5
0
J
F
M
A
M
J
J
A
S
O
N
D
TCD2RN
T1BSR

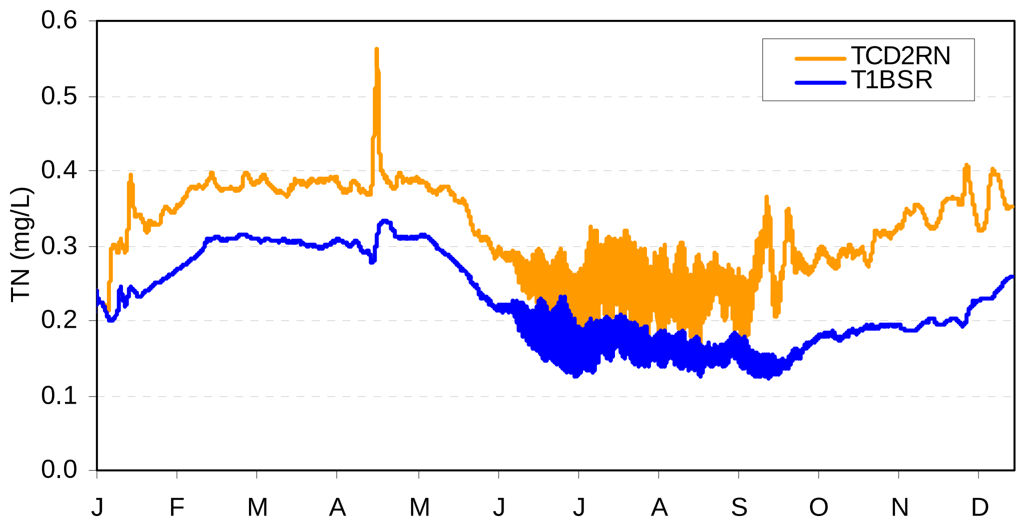
US_SHASTA



TCD2RN
T1BSR
Periphyton (mgChl-a/m2)
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
J
F
M
A
M
J
J
A
S
O
N
D

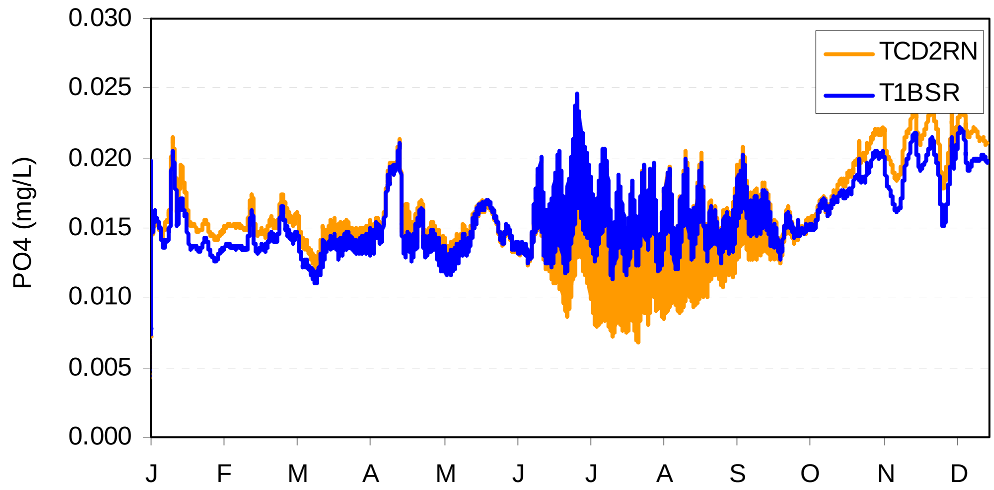


pH
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
TCD2RN
T1BSR
J
F
M
A
M
J
J
A
S
O
N
D

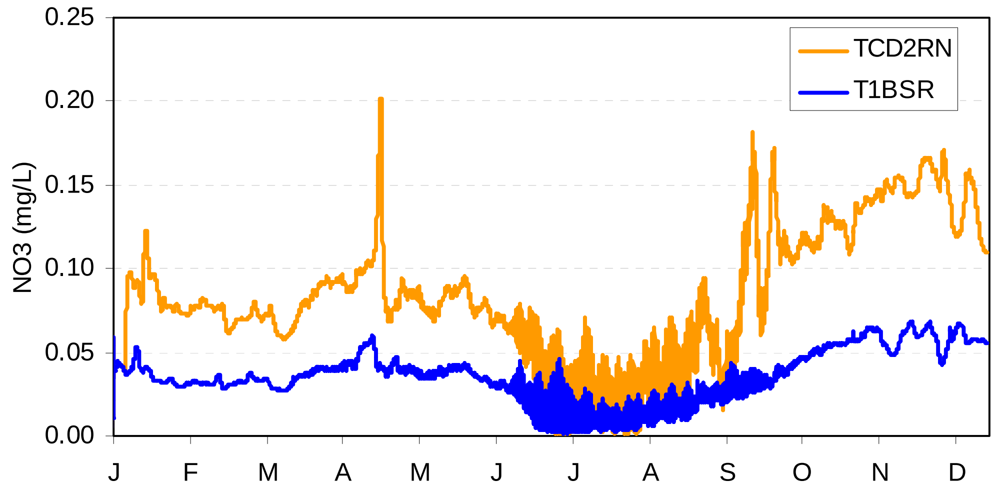


TN (mg/L)
0.6
0.5
0.4
0.3
0.2
0.1
0.0
TCD2RN
T1BSR
J
F
M
A
M
J
J
A
S
O
N
D

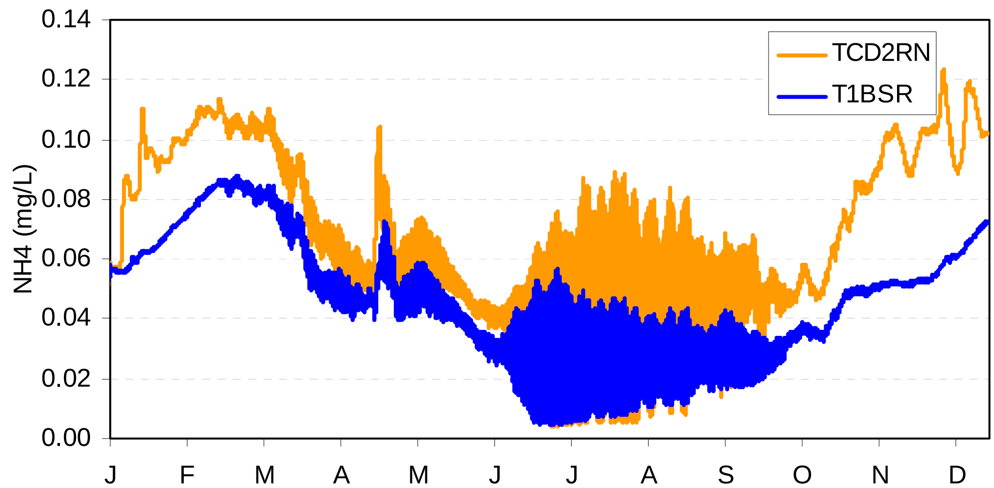
US_SHASTA



0.030
0.025
0.020
0.015
0.010
0.005
0.000
PO4 (mg/L)
TCD2RN
T1BSR
J
F
M
A
M
J
J
A
S
O
N
D

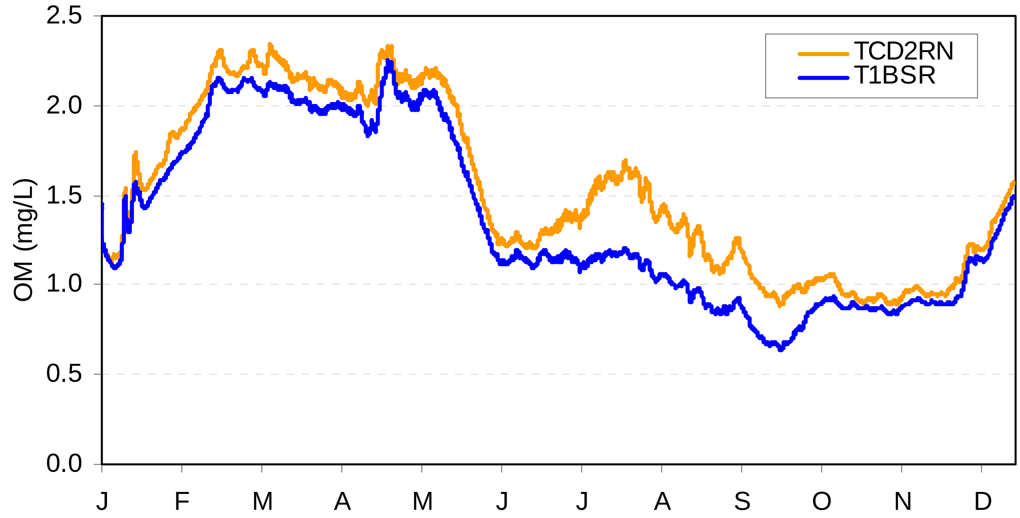


0.25
0.20
0.15
0.10
0.05
0.00
NO3 (mg/L)
TCD2RN
T1BSR
J
F
M
A
M
J
J
A
S
O
N
D

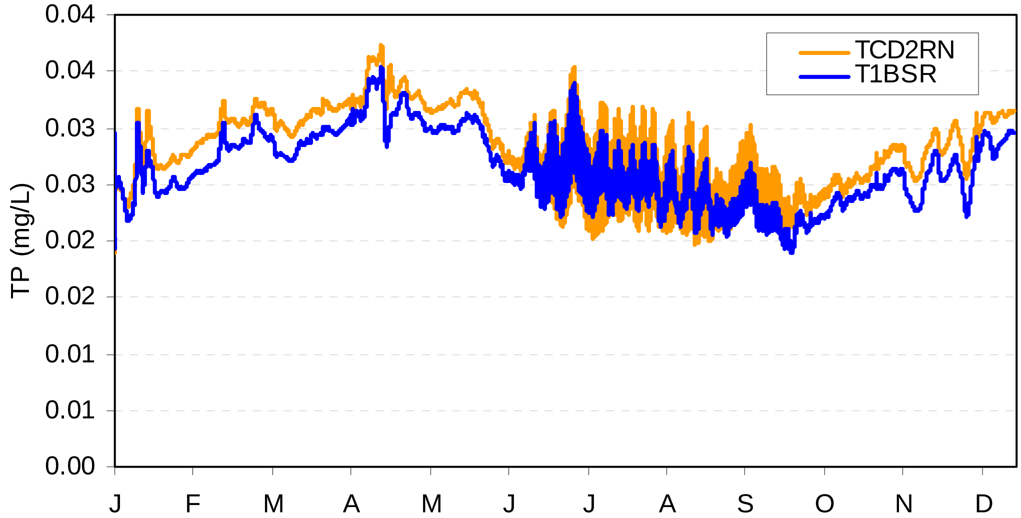


0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
NH4 (mg/L)
TCD2RN
T1BSR
J
F
M
A
M
J
J
A
S
O
N
D

US_SHASTA

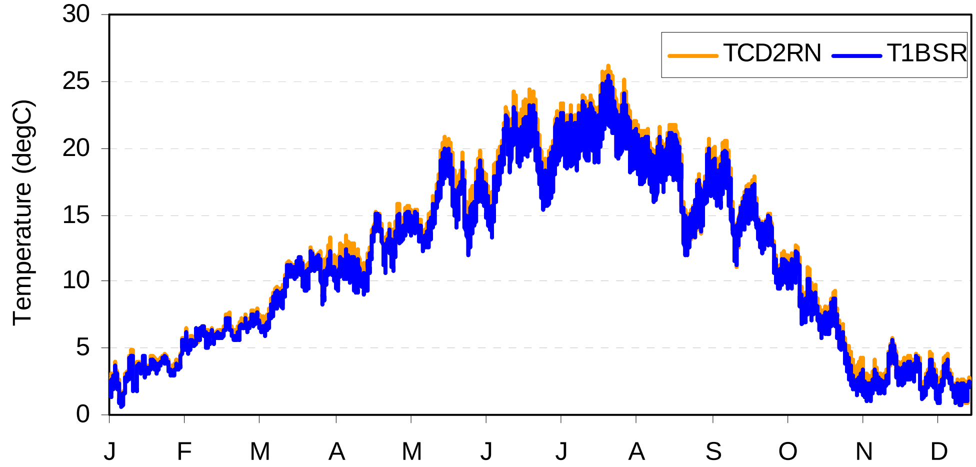


2.5
2.0
1.5
1.0
0.5
0.0
OM (mg/L)
J F M A M J J A S O N D
TCD2RN
T1BSR

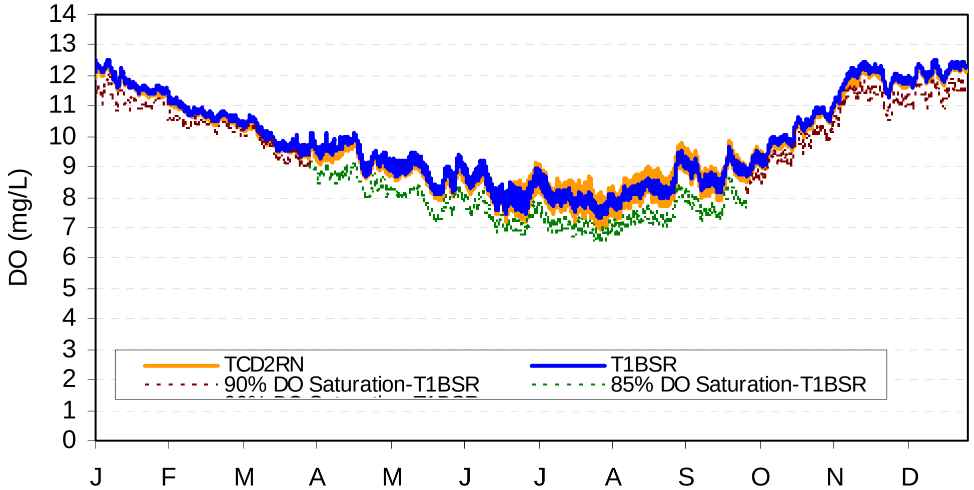


0.04
0.04
0.03
0.03
0.02
0.02
0.01
0.01
0.00
TP (mg/L)
J F M A M J J A S O N D
TCD2RN
T1BSR

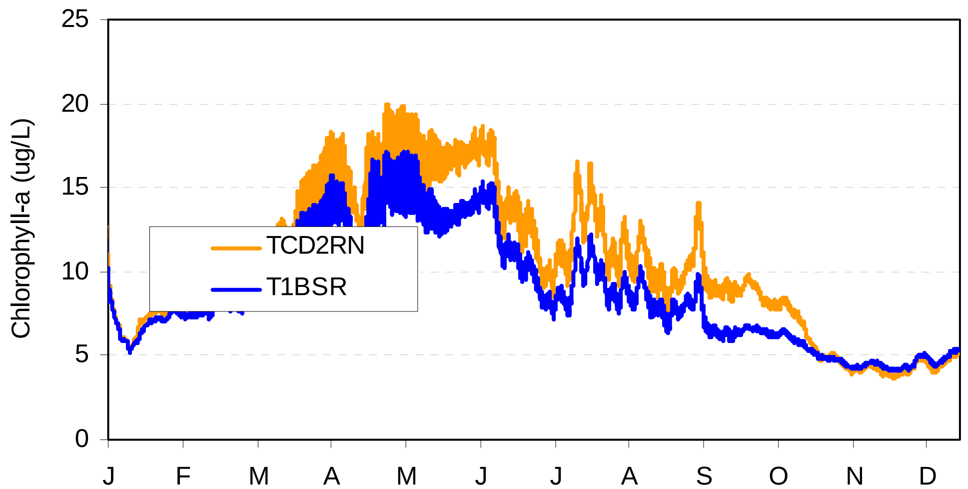
DS_SHASTA



Temperature (degC)
TCD2RN
T1BSR
30
25
20
15
10
5
0
J F M A M J J A S O N D

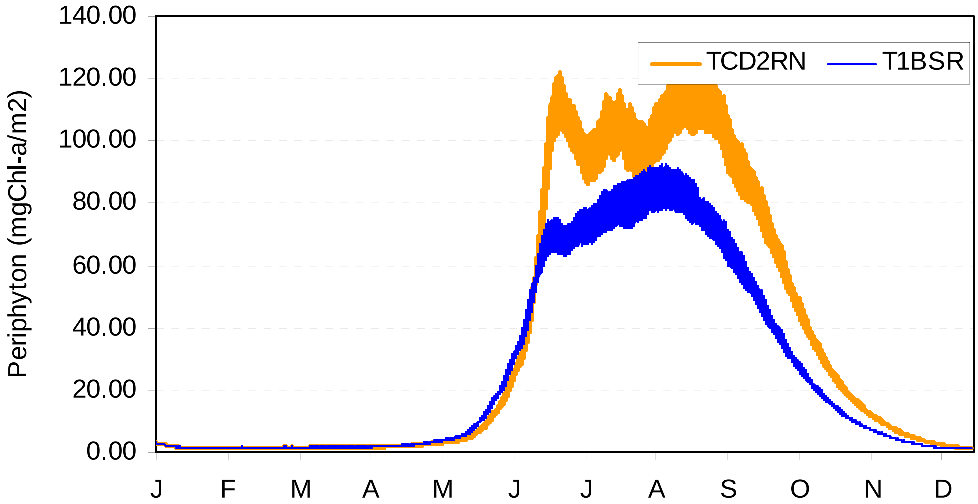


DO (mg/L)
TCD2RN
T1BSR
90% DO Saturation-T1BSR
85% DO Saturation-T1BSR
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
J F M A M J J A S O N D

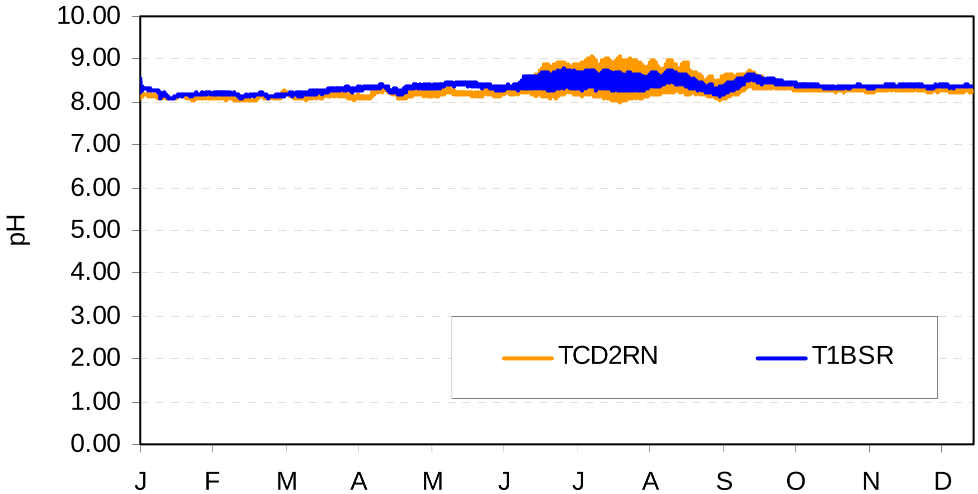


Chlorophyll-a (ug/L)
TCD2RN
T1BSR
25
20
15
10
5
0
J F M A M J J A S O N D

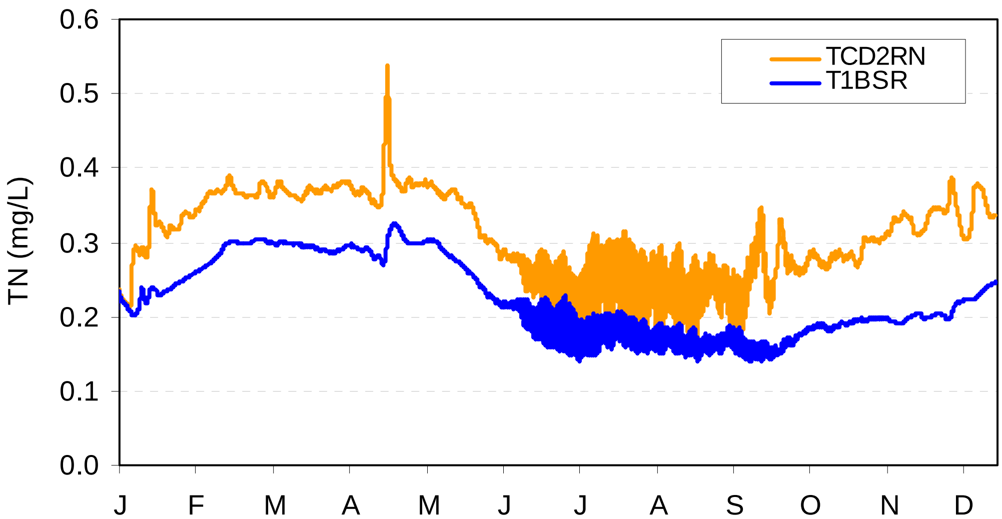
DS_SHASTA



Periphyton (mgChl-a/m2)
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
TCD2RN
T1BSR
J F M A M J J A S O N D

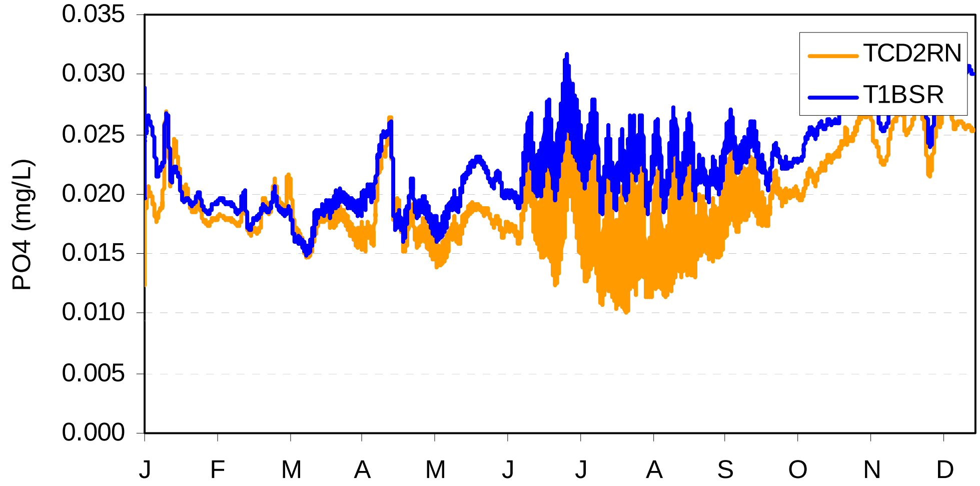


pH
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
TCD2RN
T1BSR
J F M A M J J A S O N D

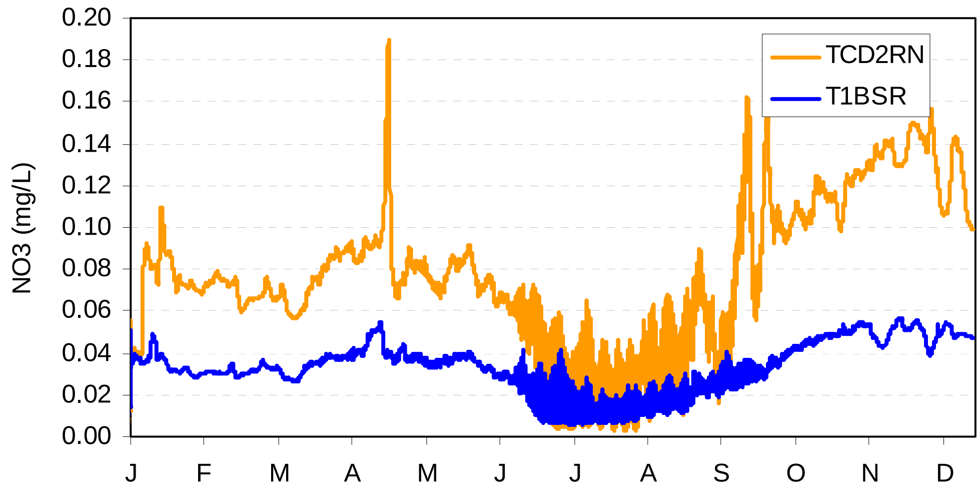


TN (mg/L)
0.6
0.5
0.4
0.3
0.2
0.1
0.0
TCD2RN
T1BSR
J F M A M J J A S O N D

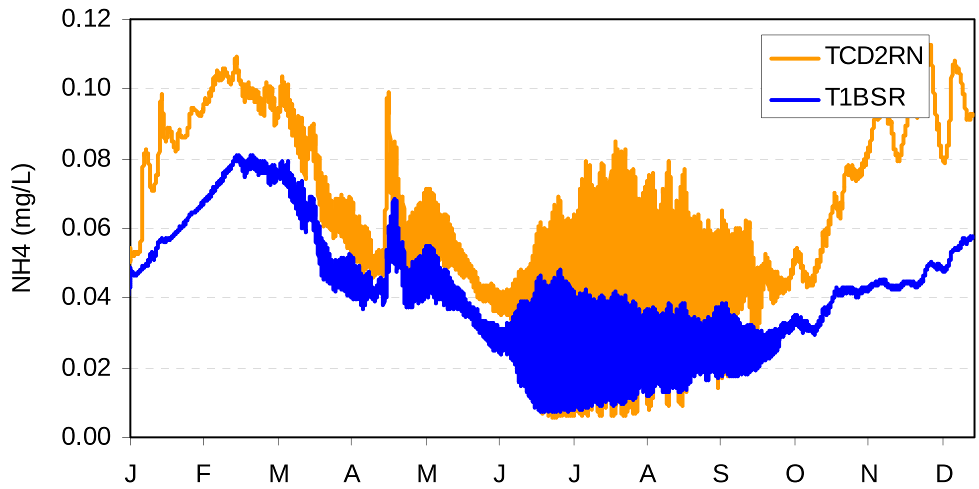
DS_SHASTA



TCD2RN
T1BSR
PO4 (mg/L)
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
J F M A M J J A S O N D

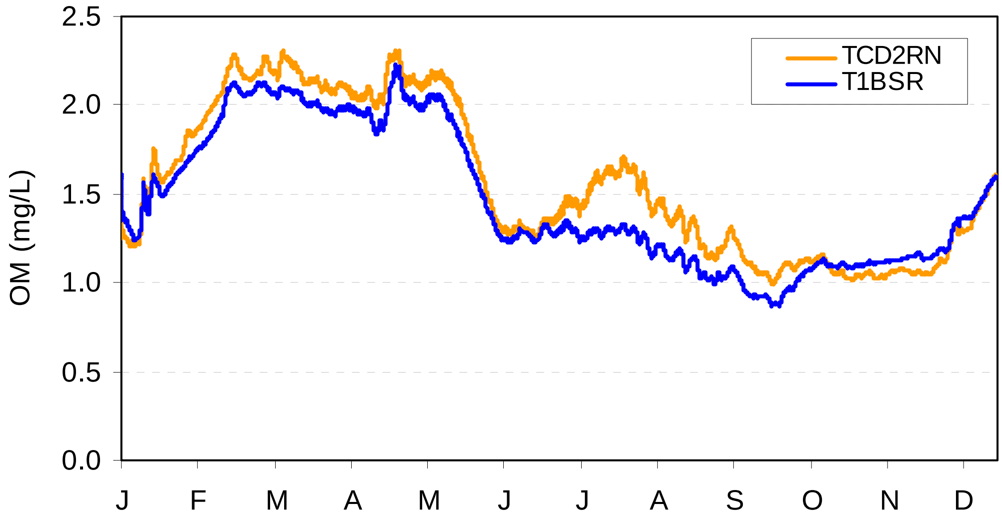


TCD2RN
T1BSR
NO3 (mg/L)
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
J F M A M J J A S O N D

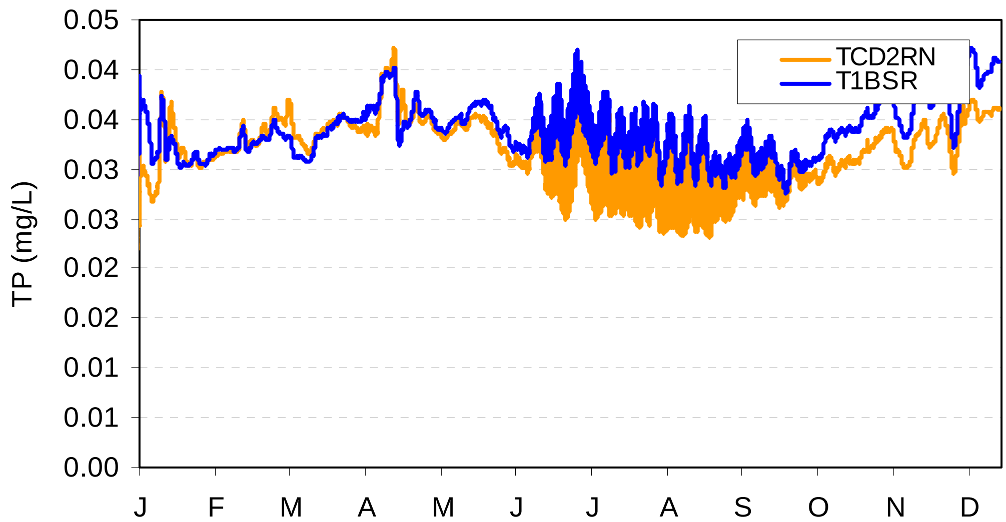


TCD2RN
T1BSR
NH4 (mg/L)
0.12
0.10
0.08
0.06
0.04
0.02
0.00
J F M A M J J A S O N D

DS_SHASTA

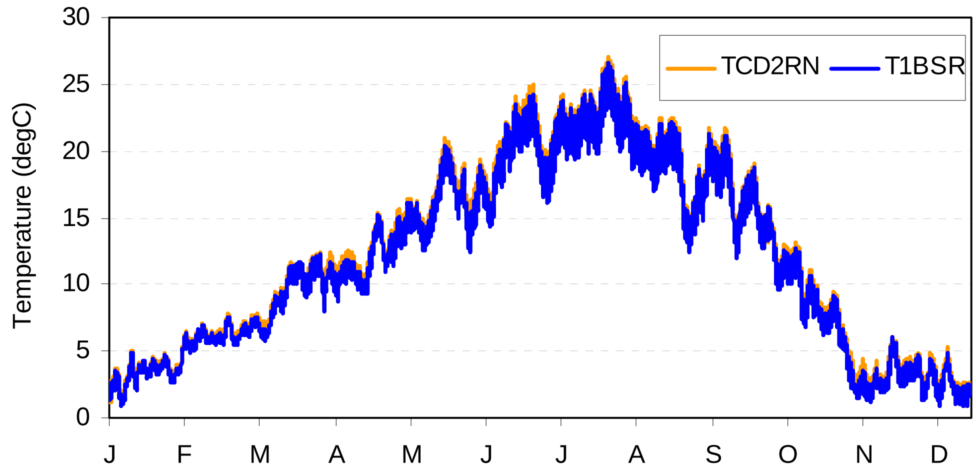


2.5
2.0
1.5
1.0
0.5
0.0
OM (mg/L)
J
F
M
A
M
J
J
A
S
O
N
D
TCD2RN
T1BSR

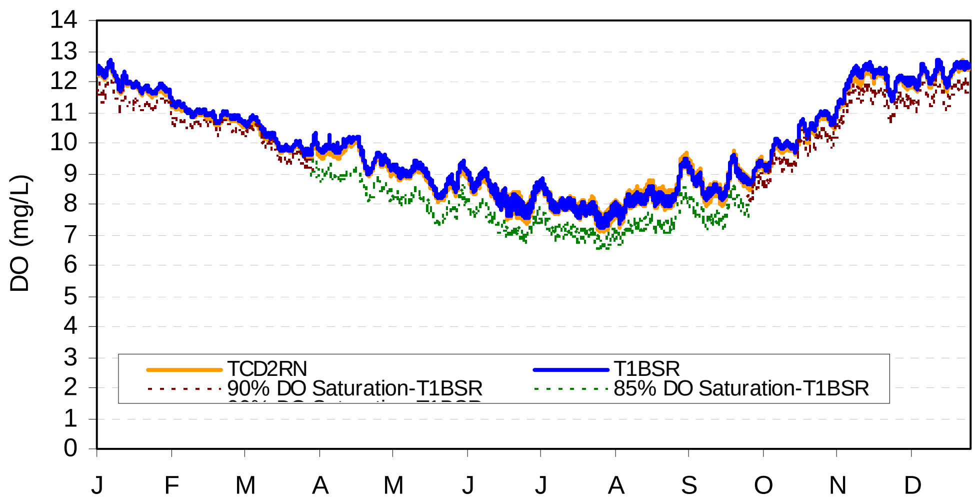


0.05
0.04
0.04
0.03
0.03
0.02
0.02
0.01
0.01
0.00
TP (mg/L)
J
F
M
A
M
J
J
A
S
O
N
D
TCD2RN
T1BSR

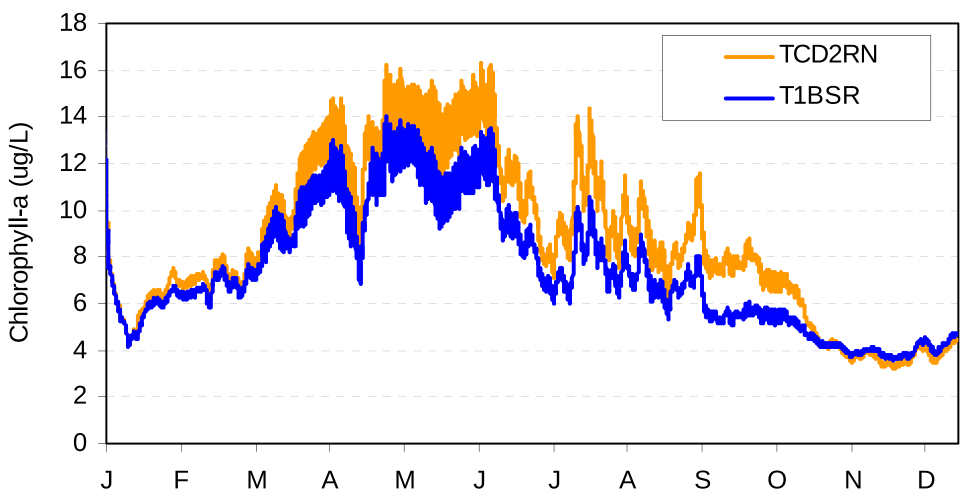
US_SCOTT



Temperature (degC)
30
25
20
15
10
5
0
J F M A M J J A S O N D
TCD2RN
T1BSR

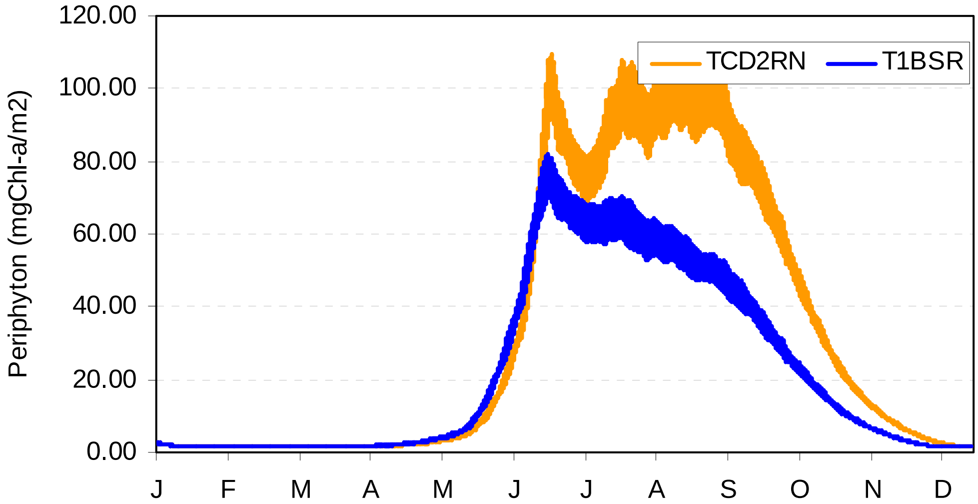


DO (mg/L)
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
J F M A M J J A S O N D
TCD2RN
T1BSR
90% DO Saturation-T1BSR
85% DO Saturation-T1BSR

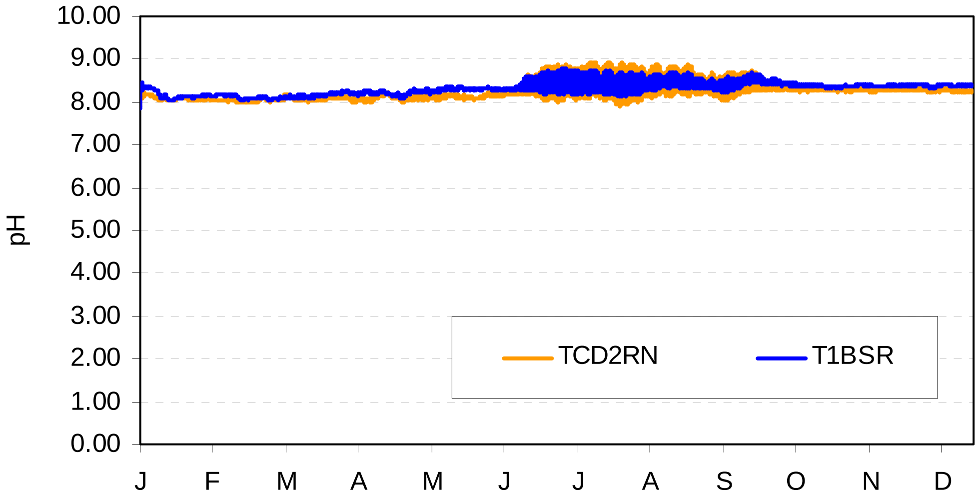


Chlorophyll-a (ug/L)
18
16
14
12
10
8
6
4
2
0
J F M A M J J A S O N D
TCD2RN
T1BSR

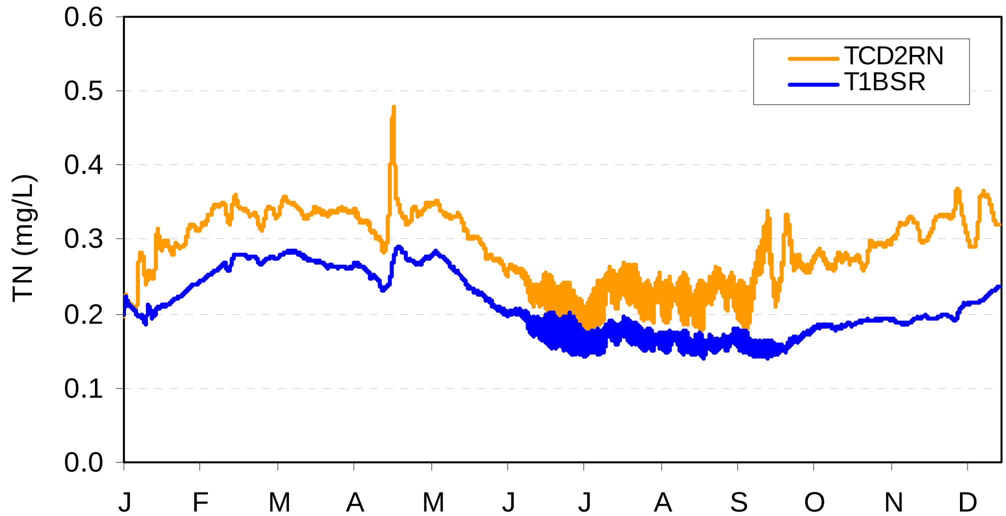
US_SCOTT



Periphyton (mgChl-a/m2)
120.00
100.00
80.00
60.00
40.00
20.00
0.00
TCD2RN
T1BSR
J F M A M J J A S O N D

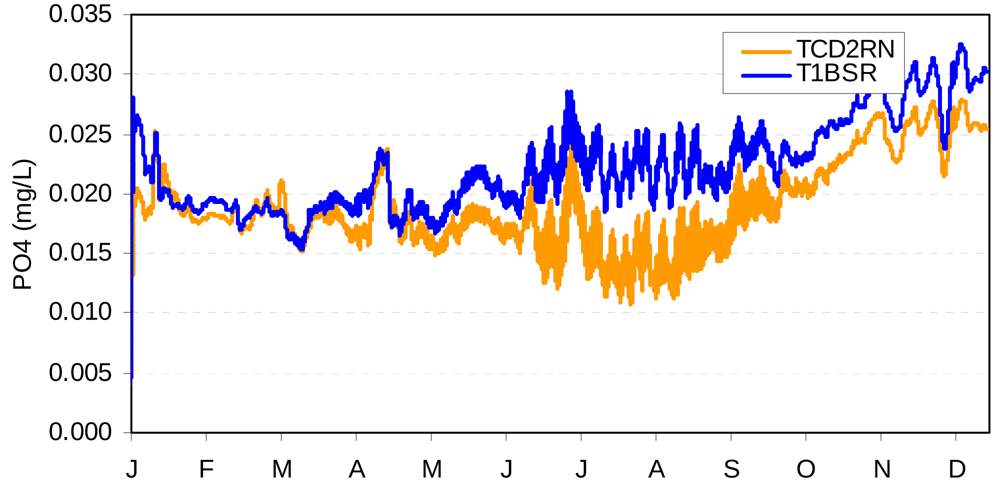


pH
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
TCD2RN
T1BSR
J F M A M J J A S O N D

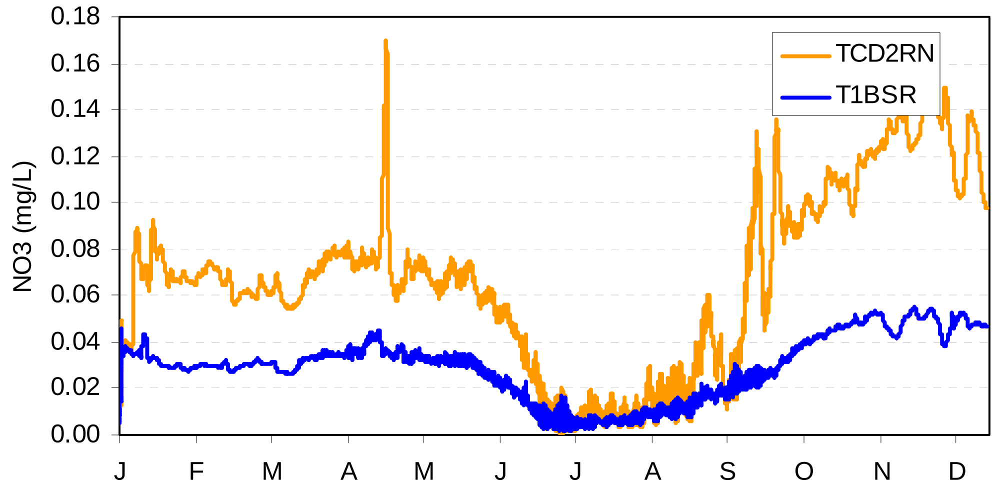


TN (mg/L)
0.6
0.5
0.4
0.3
0.2
0.1
0.0
TCD2RN
T1BSR
J F M A M J J A S O N D

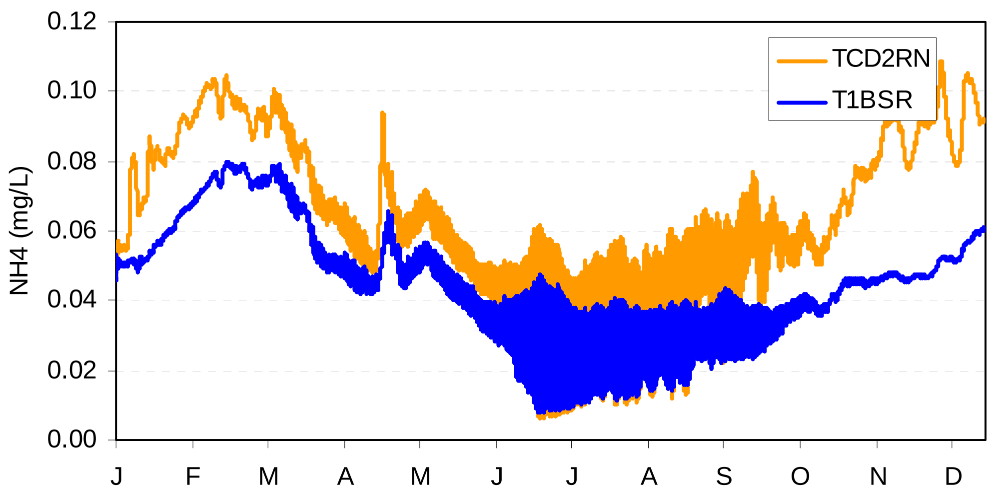
US_SCOTT



0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
PO4 (mg/L)
J F M A M J J A S O N D
TCD2RN
T1BSR

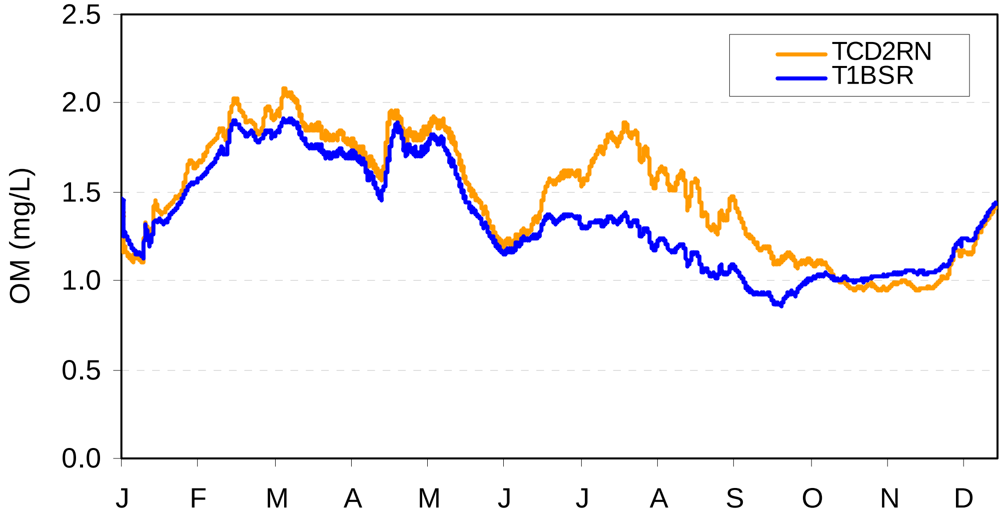


0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
NO3 (mg/L)
J F M A M J J A S O N D
TCD2RN
T1BSR

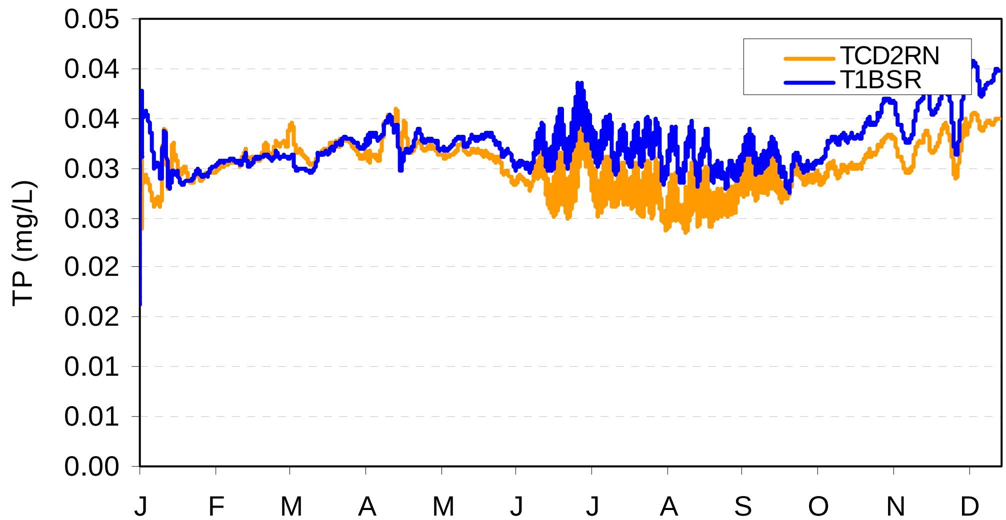


0.12
0.10
0.08
0.06
0.04
0.02
0.00
NH4 (mg/L)
J F M A M J J A S O N D
TCD2RN
T1BSR

US_SCOTT

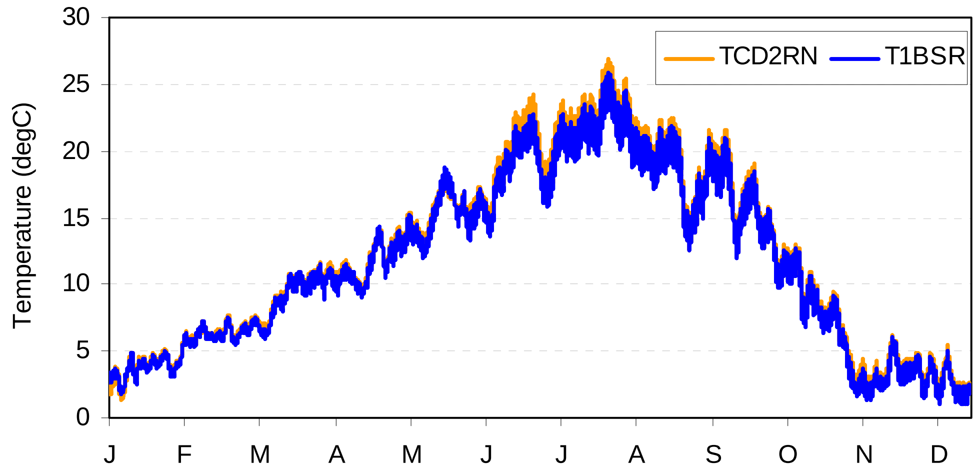


TCD2RN
T1BSR
OM (mg/L)
2.5
2.0
1.5
1.0
0.5
0.0
J F M A M J J A S O N D

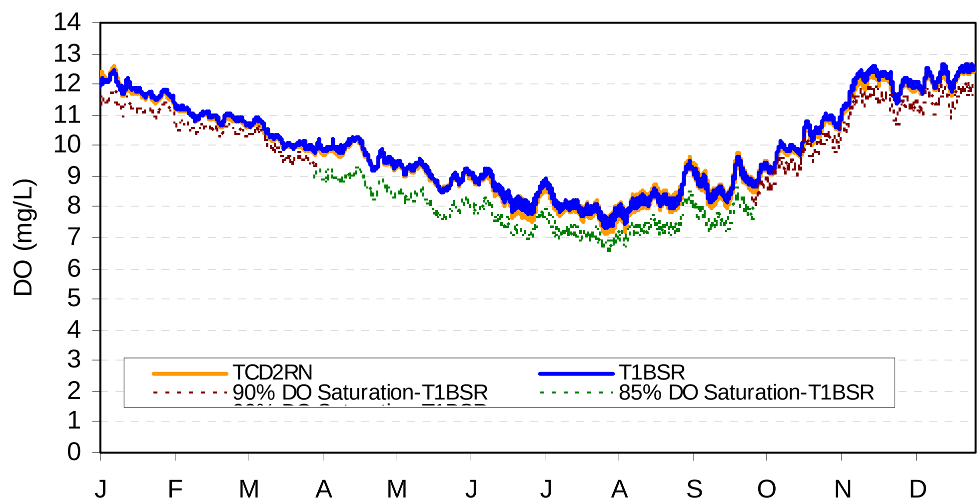


TCD2RN
T1BSR
TP (mg/L)
0.05
0.04
0.04
0.03
0.03
0.02
0.02
0.01
0.01
0.00
J F M A M J J A S O N D

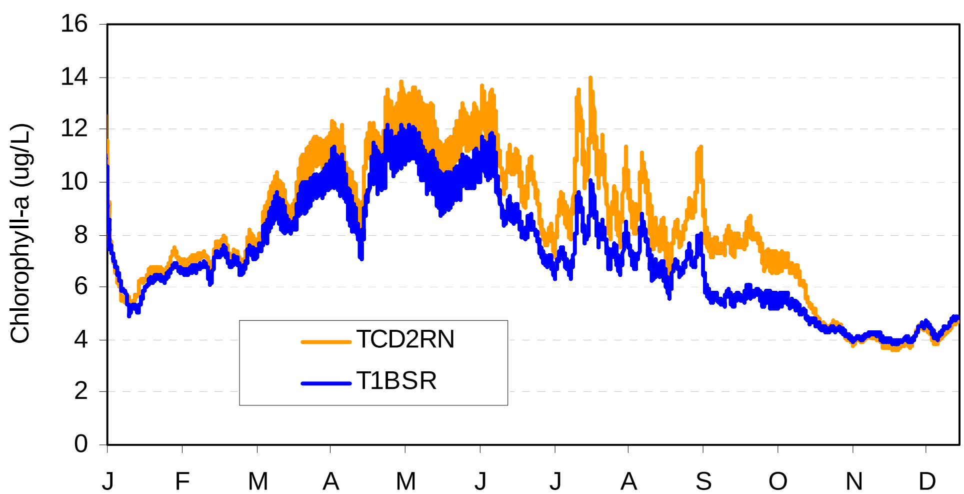
DS_SCOTT



Temperature (degC)
30
25
20
15
10
5
0
J F M A M J J A S O N D
TCD2RN
T1BSR

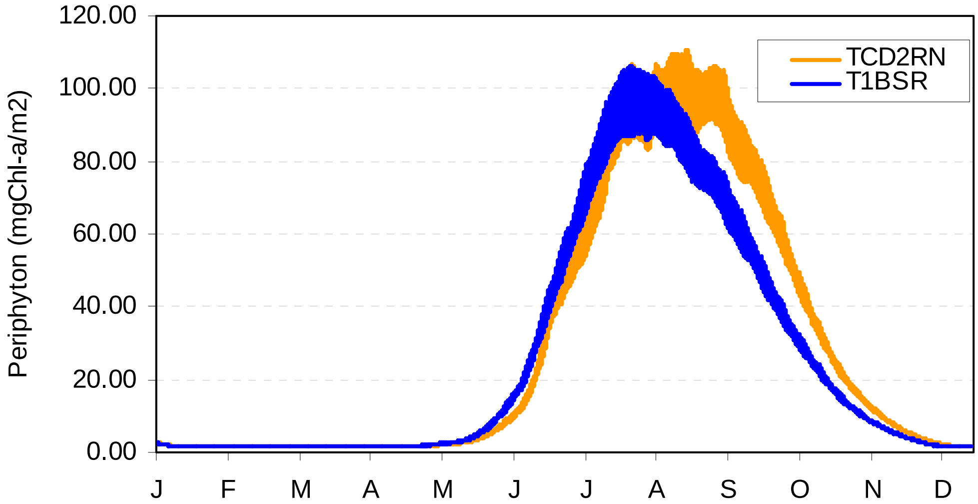


DO (mg/L)
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
J F M A M J J A S O N D
TCD2RN
T1BSR
90% DO Saturation-T1BSR
85% DO Saturation-T1BSR

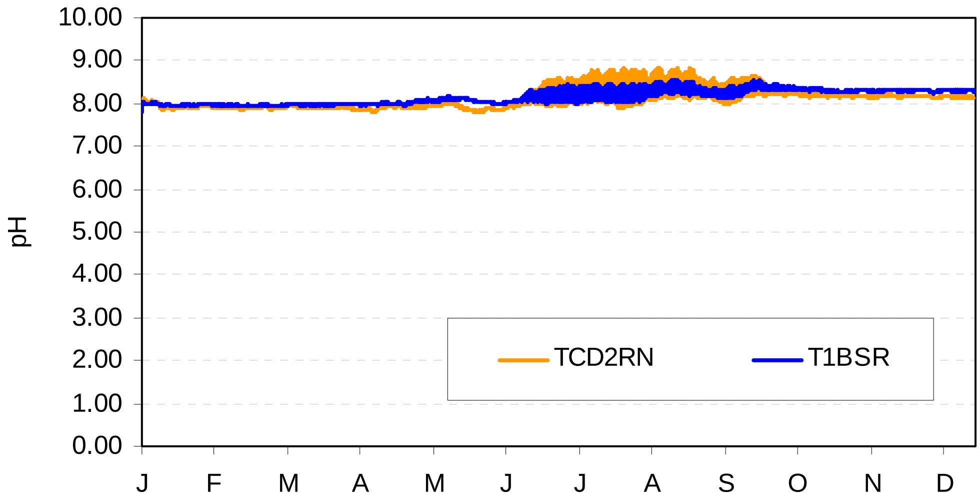


Chlorophyll-a (ug/L)
16
14
12
10
8
6
4
2
0
J F M A M J J A S O N D
TCD2RN
T1BSR

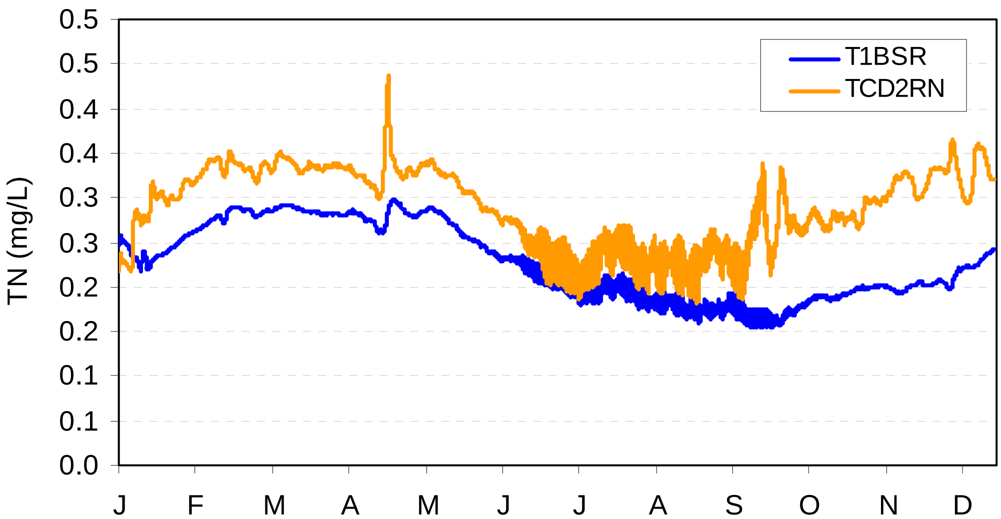
DS_SCOTT



120.00
100.00
80.00
60.00
40.00
20.00
0.00
Periphyton (mgChl-a/m2)
J F M A M J J A S O N D
TCD2RN
T1BSR

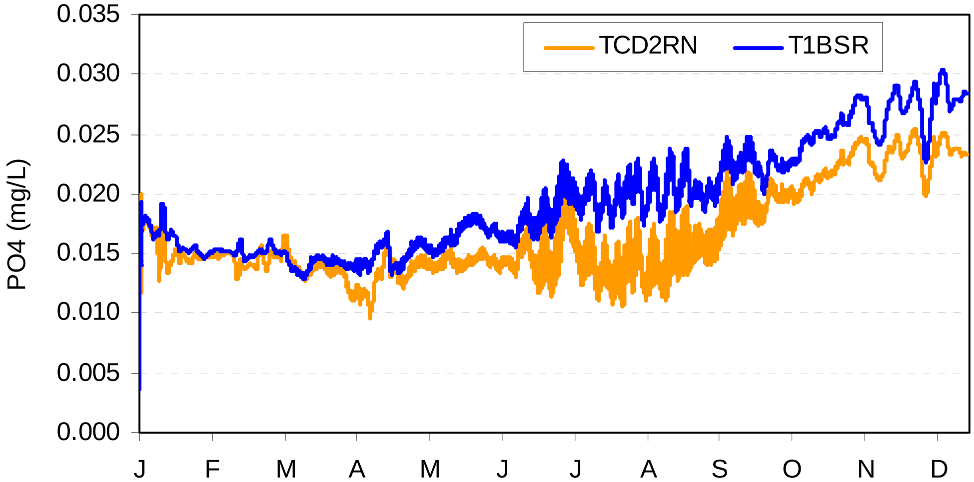


10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
pH
J F M A M J J A S O N D
TCD2RN
T1BSR

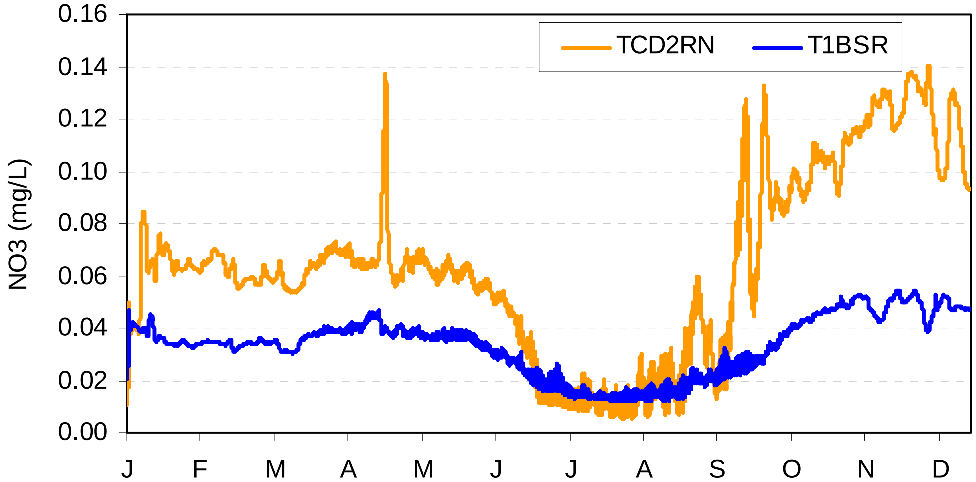


0.5
0.5
0.4
0.4
0.3
0.3
0.2
0.2
0.1
0.1
0.0
TN (mg/L)
J F M A M J J A S O N D
T1BSR
TCD2RN

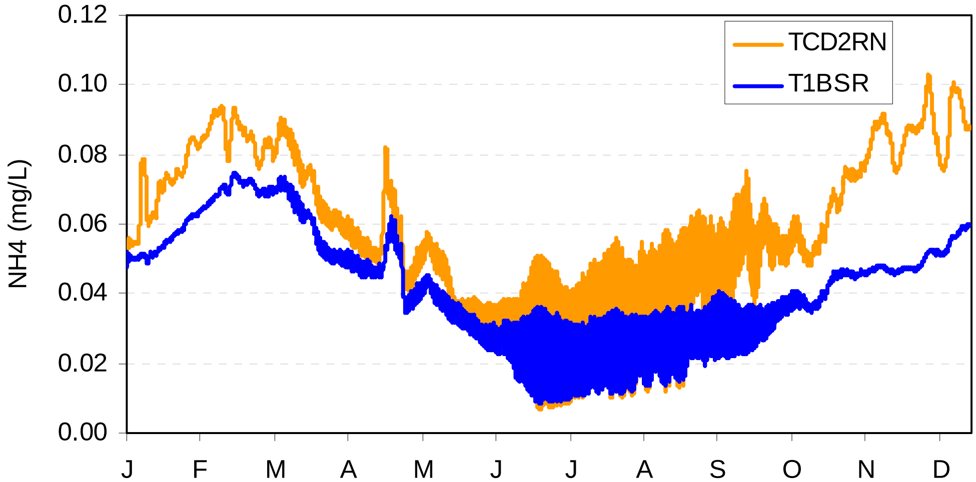
DS_SCOTT



PO4 (mg/L)
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
TCD2RN
T1BSR
J
F
M
A
M
J
J
A
S
O
N
D

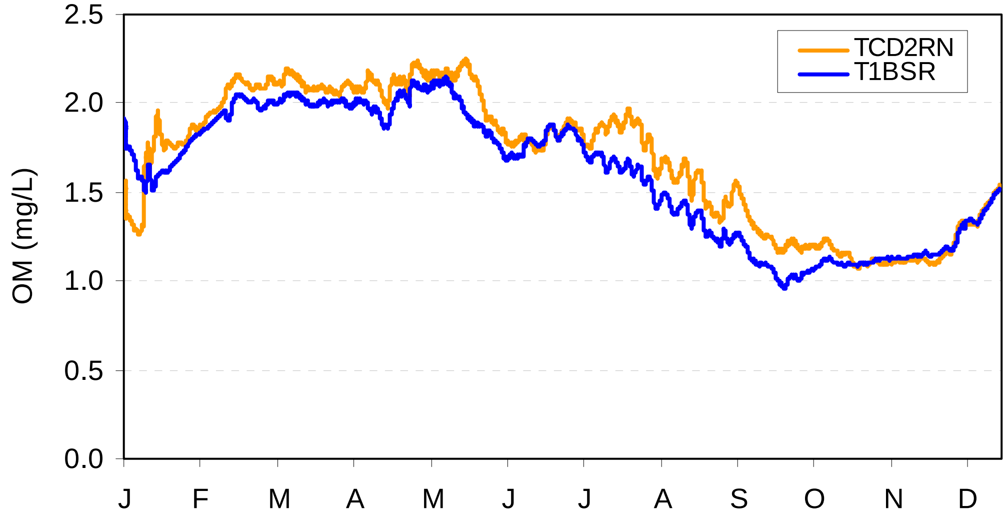


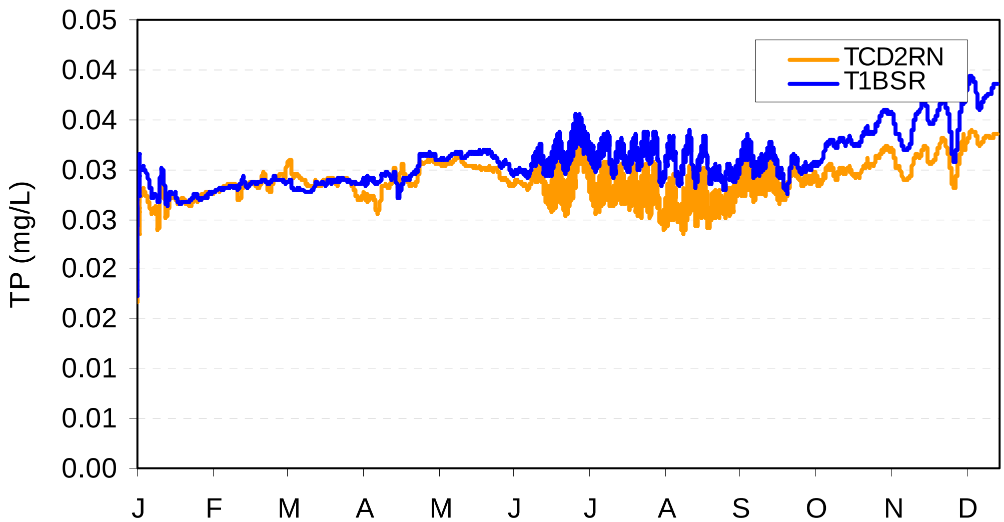
NO3 (mg/L)
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
TCD2RN
T1BSR
J
F
M
A
M
J
J
A
S
O
N
D



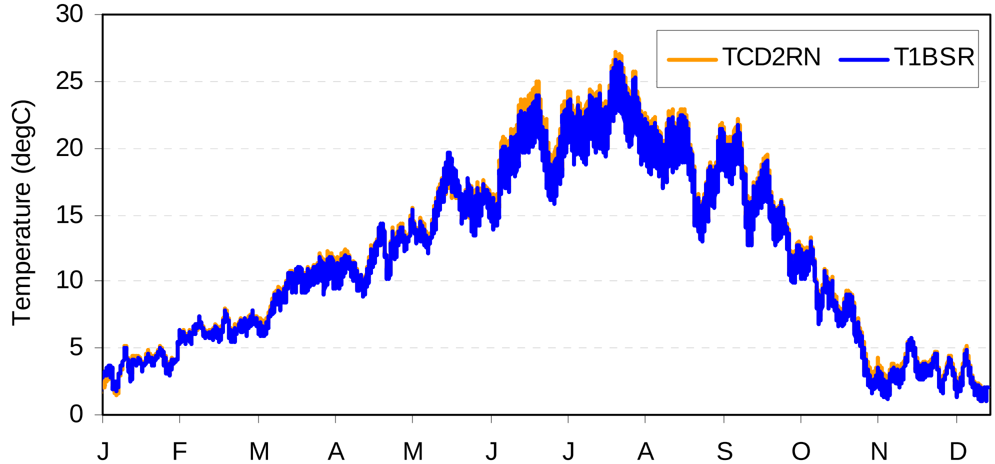
NH4 (mg/L)
0.12
0.10
0.08
0.06
0.04
0.02
0.00
TCD2RN
T1BSR
J
F
M
A
M
J
J
A
S
O
N
D

DS_SCOTT

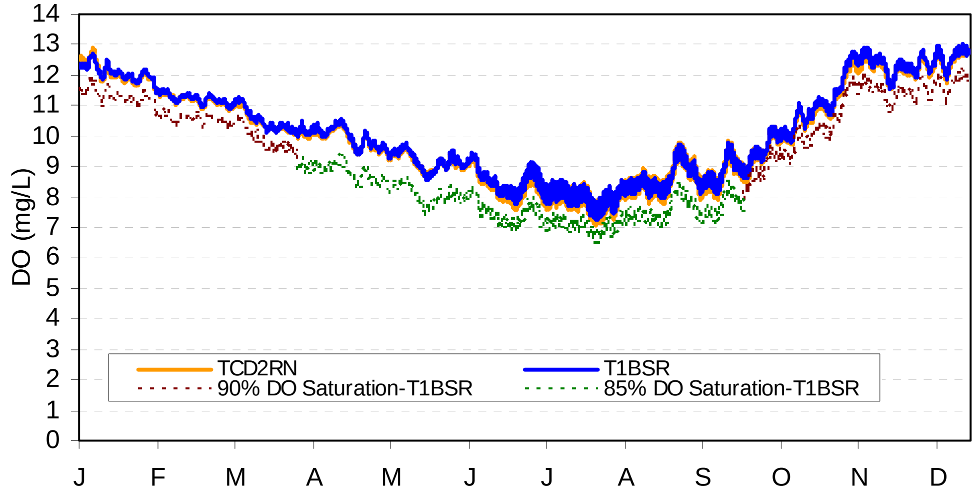

2.5
2.0
1.5
1.0
0.5
0.0
OM (mg/L)
J F M A M J J A S O N D
TCD2RN
T1BSR


0.05
0.04
0.04
0.03
0.03
0.02
0.02
0.01
0.01
0.00
TP (mg/L)
J F M A M J J A S O N D
TCD2RN
T1BSR

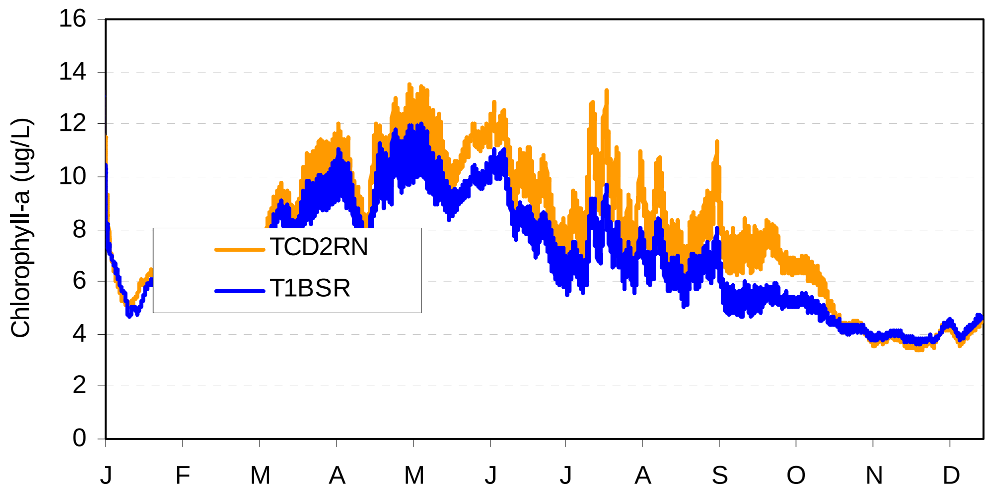
SEIAD



Temperature (degC)
30
25
20
15
10
5
0
TCD2RN
T1BSR
J
F
M
A
M
J
J
A
S
O
N
D

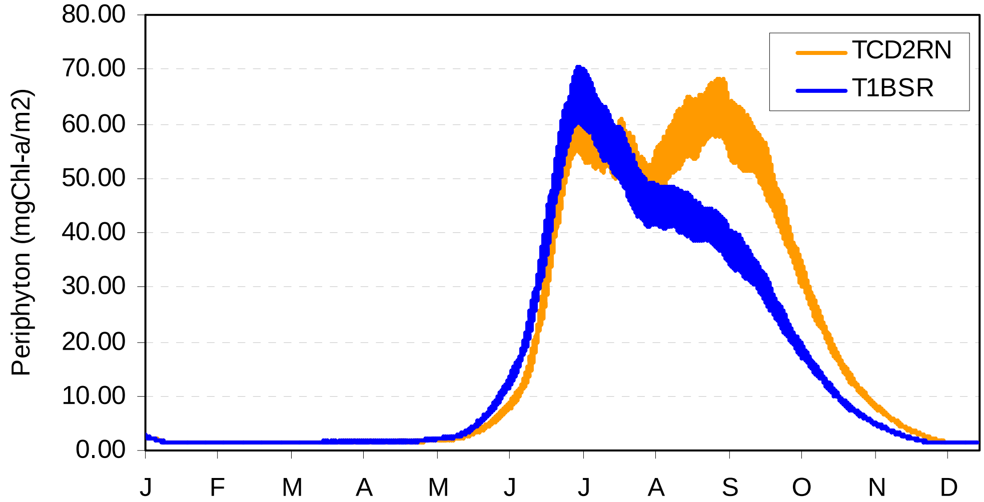


DO (mg/L)
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
TCD2RN
T1BSR
90% DO Saturation-T1BSR
85% DO Saturation-T1BSR
J
F
M
A
M
J
J
A
S
O
N
D

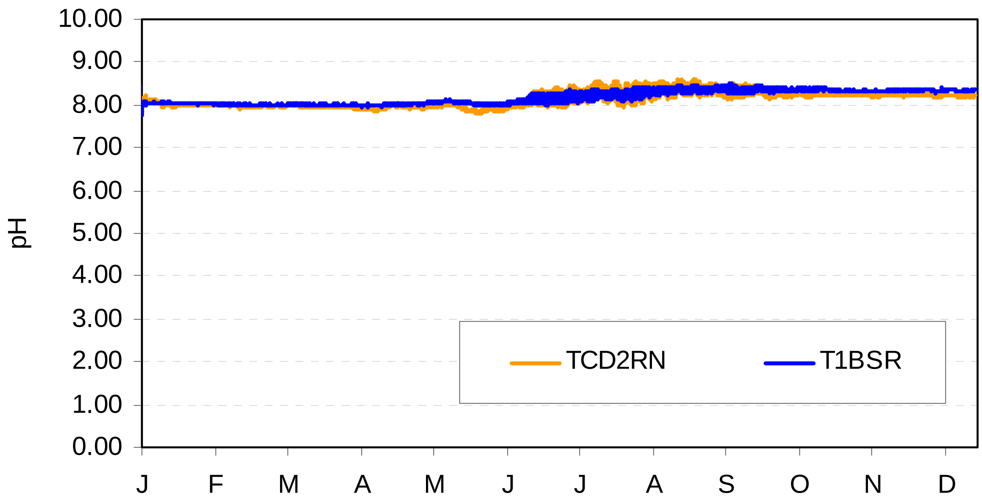


Chlorophyll-a (ug/L)
16
14
12
10
8
6
4
2
0
TCD2RN
T1BSR
J
F
M
A
M
J
J
A
S
O
N
D

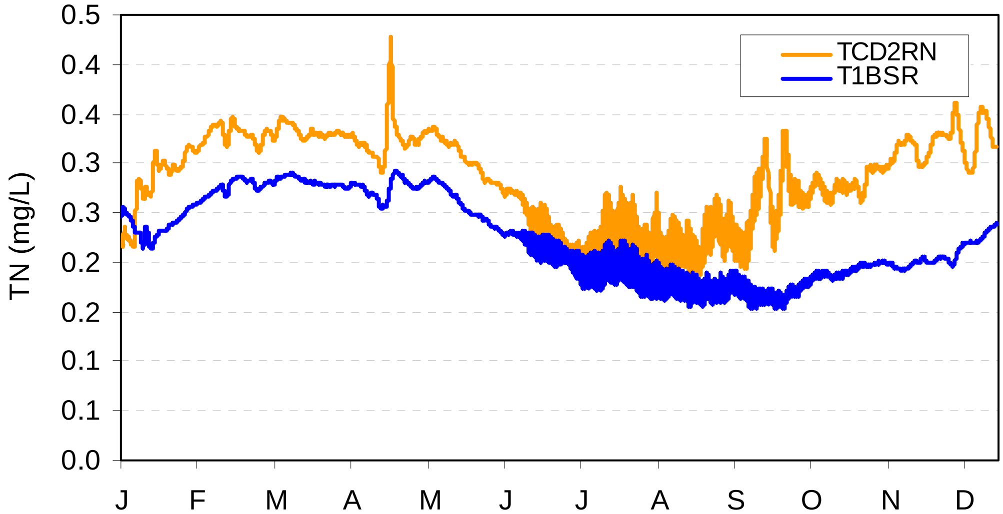
SEIAD



Periphyton (mgChl-a/m2)
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
J F M A M J J A S O N D
TCD2RN
T1BSR

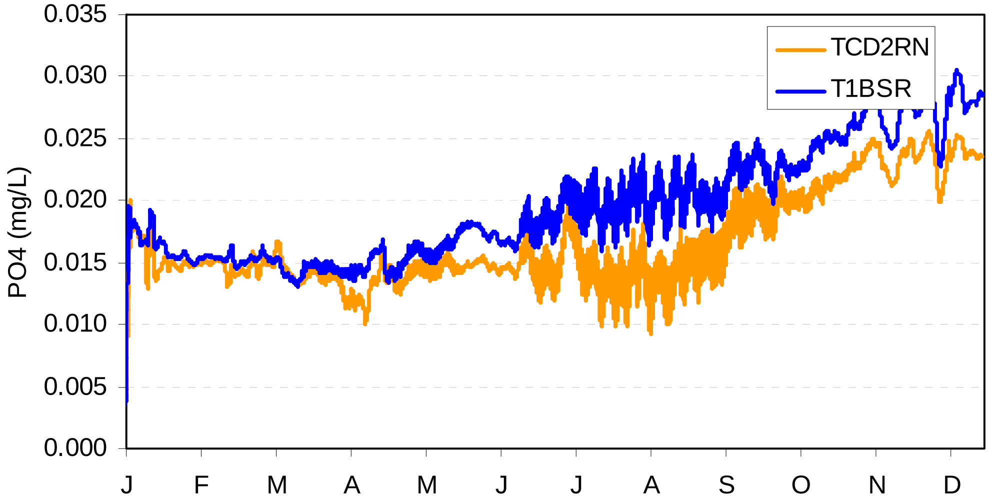


pH
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
J F M A M J J A S O N D
TCD2RN
T1BSR

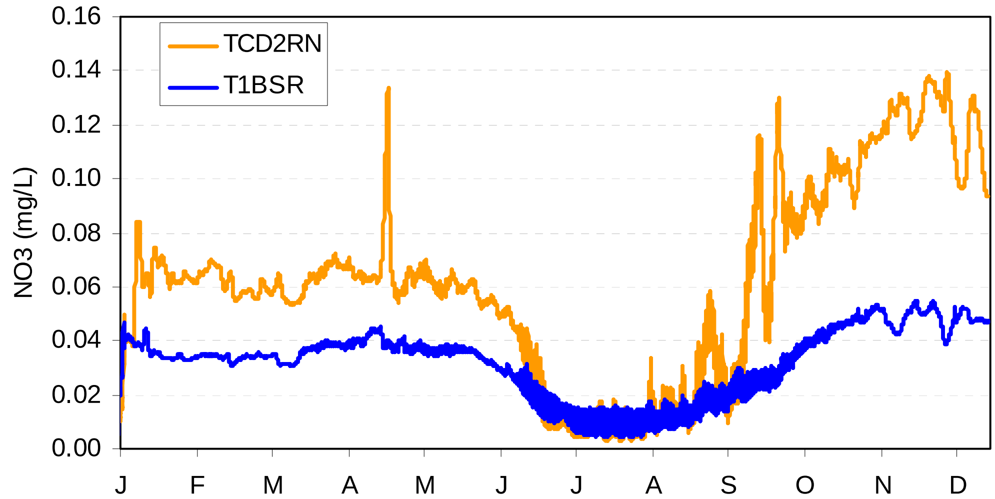


TN (mg/L)
0.5
0.4
0.4
0.3
0.3
0.2
0.2
0.1
0.1
0.0
J F M A M J J A S O N D
TCD2RN
T1BSR

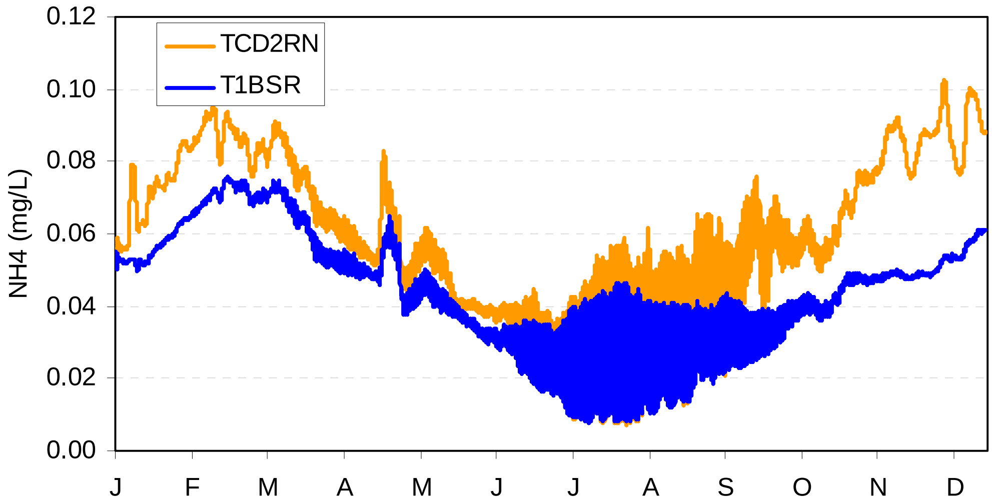
SEIAD



TCD2RN
T1BSR
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
PO4 (mg/L)
J
F
M
A
M
J
J
A
S
O
N
D

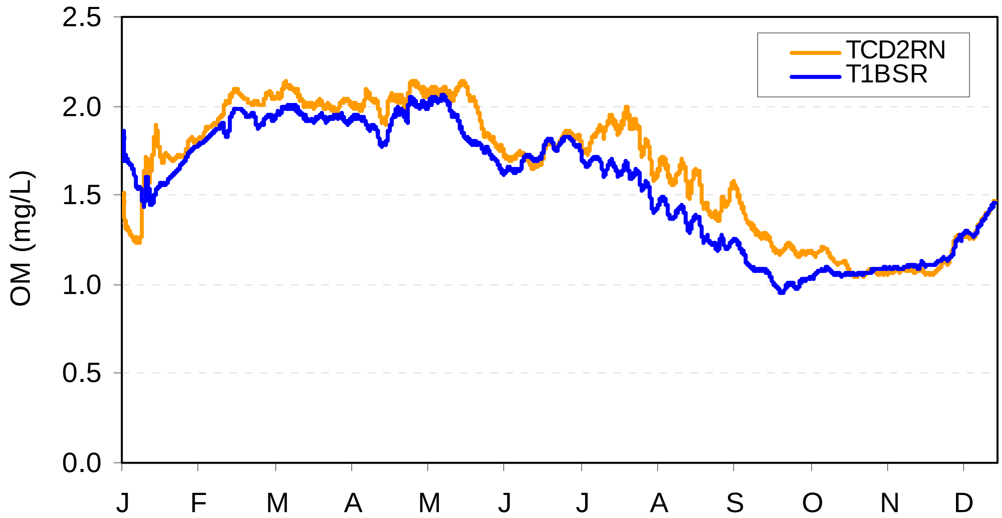


TCD2RN
T1BSR
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
NO3 (mg/L)
J
F
M
A
M
J
J
A
S
O
N
D

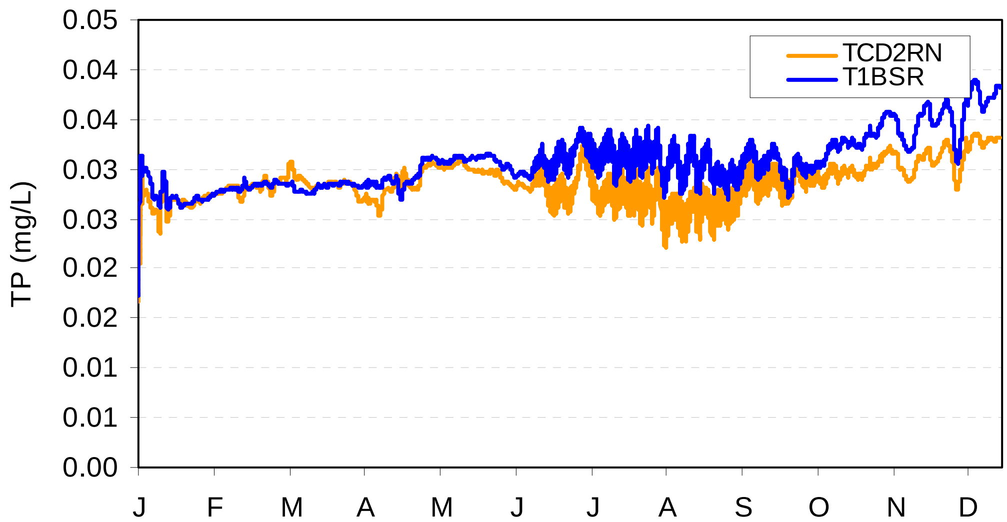


TCD2RN
T1BSR
0.12
0.10
0.08
0.06
0.04
0.02
0.00
NH4 (mg/L)
J
F
M
A
M
J
J
A
S
O
N
D

SEIAD

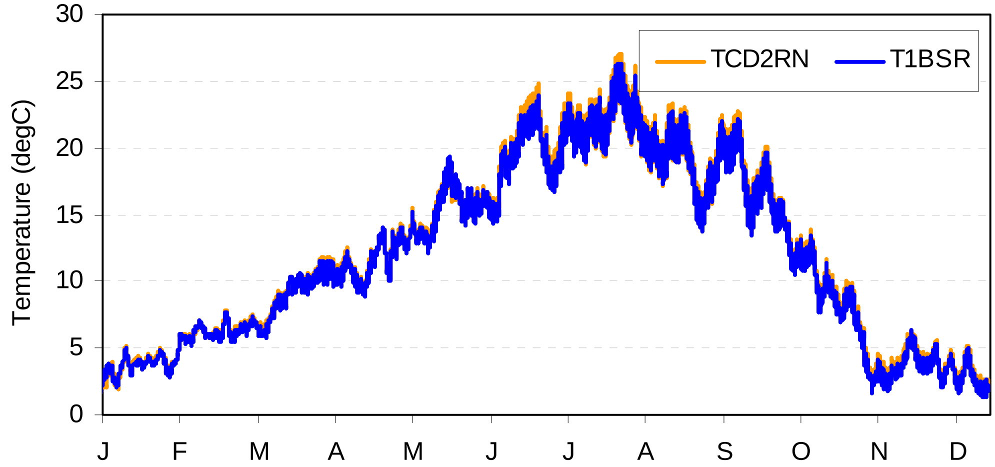


2.5
2.0
1.5
1.0
0.5
0.0
OM (mg/L)
TCD2RN
T1BSR
J
F
M
A
M
J
J
A
S
O
N
D

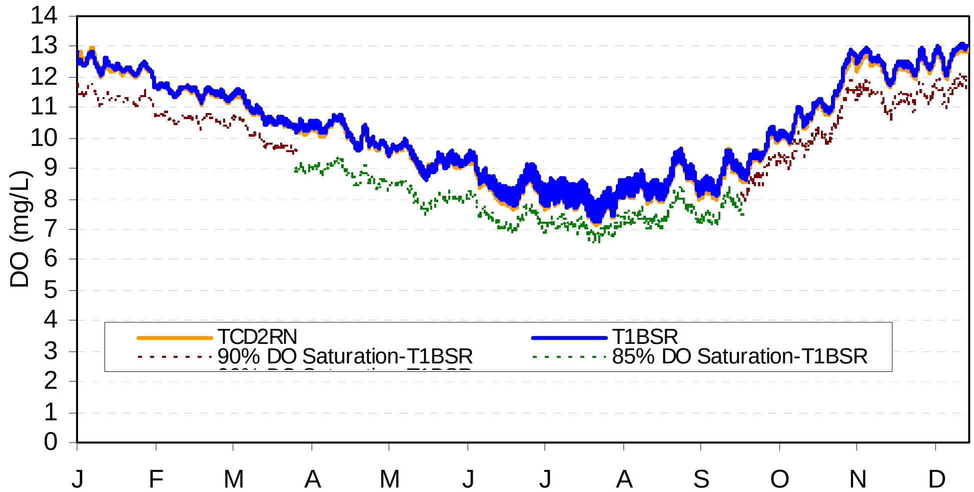


0.05
0.04
0.04
0.03
0.03
0.02
0.02
0.01
0.01
0.00
TP (mg/L)
TCD2RN
T1BSR
J
F
M
A
M
J
J
A
S
O
N
D

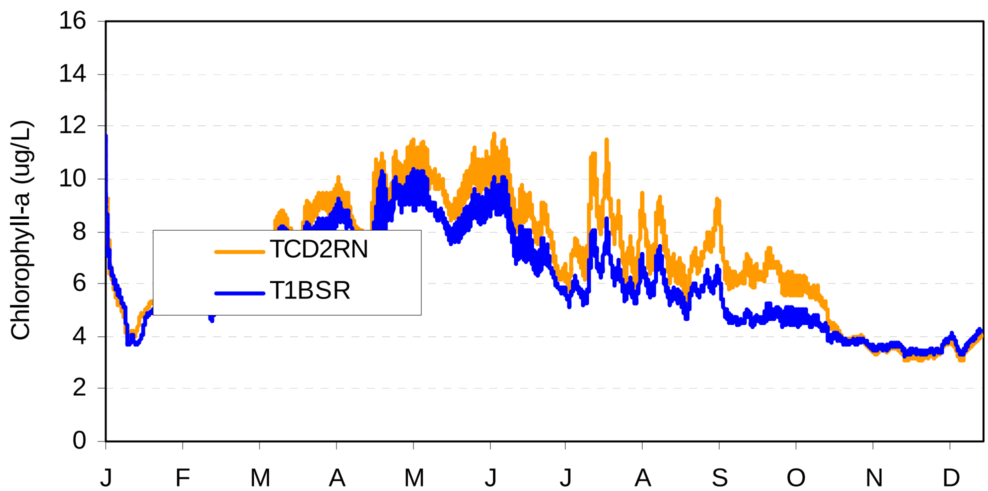
US_INDIAN



Temperature (degC)
30
25
20
15
10
5
0
TCD2RN
T1BSR
J F M A M J J A S O N D

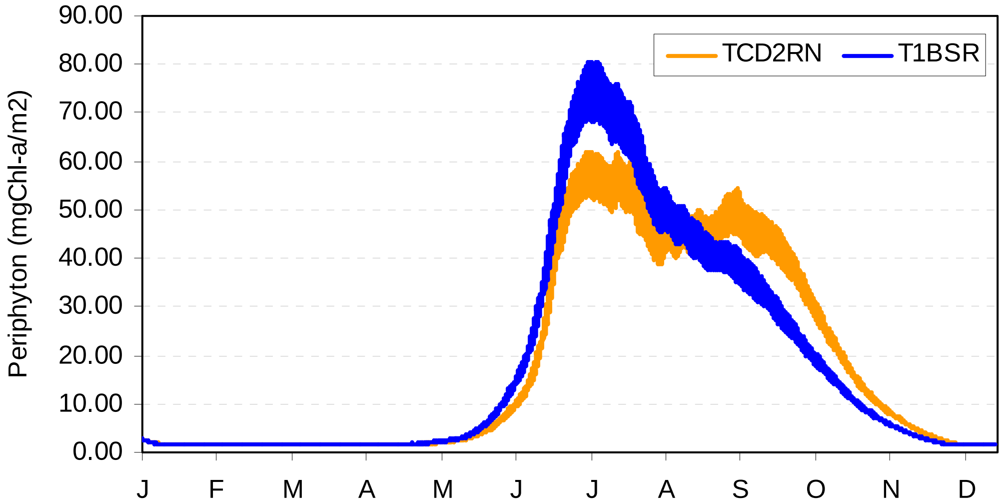


DO (mg/L)
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
TCD2RN
T1BSR
90% DO Saturation-T1BSR
85% DO Saturation-T1BSR
J F M A M J J A S O N D

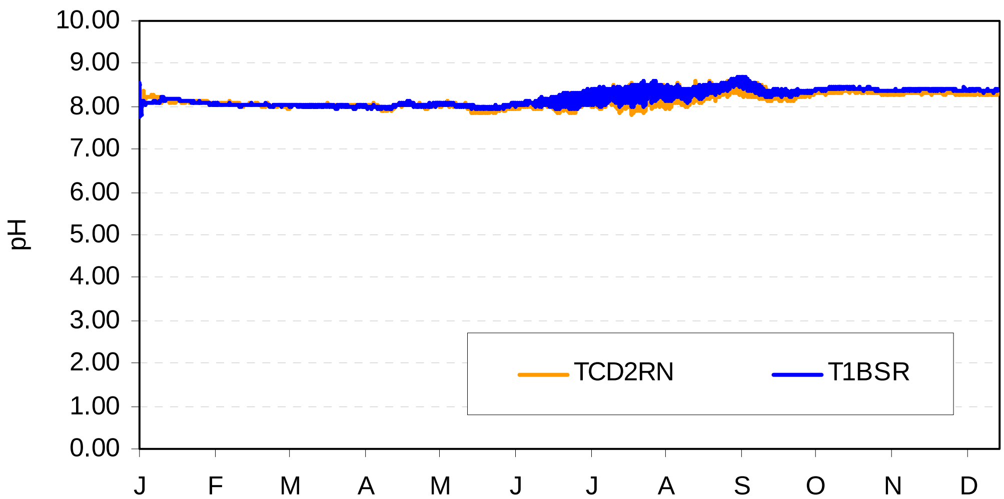


Chlorophyll-a (ug/L)
16
14
12
10
8
6
4
2
0
TCD2RN
T1BSR
J F M A M J J A S O N D

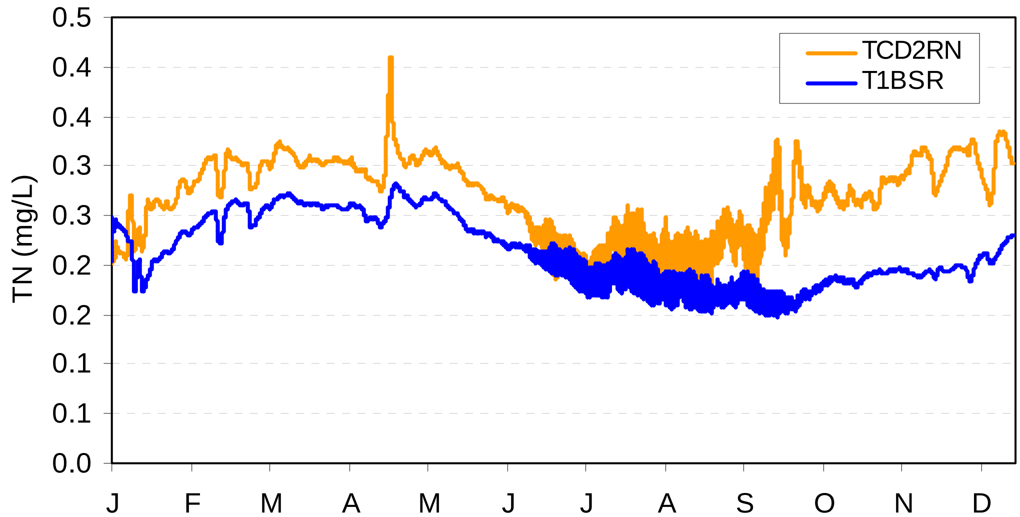
US_INDIAN



TCD2RN
T1BSR
Periphyton (mgChl-a/m2)
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
J F M A M J J A S O N D

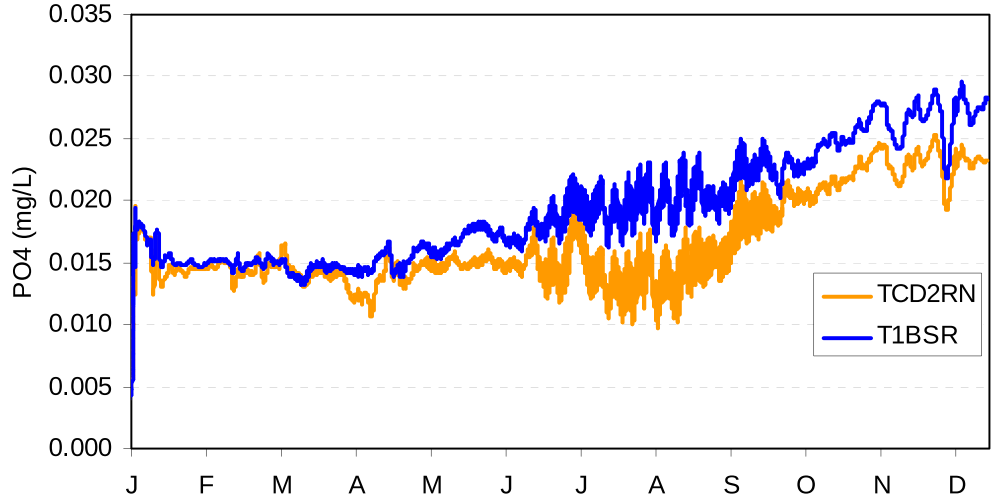


pH
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
TCD2RN
T1BSR
J F M A M J J A S O N D

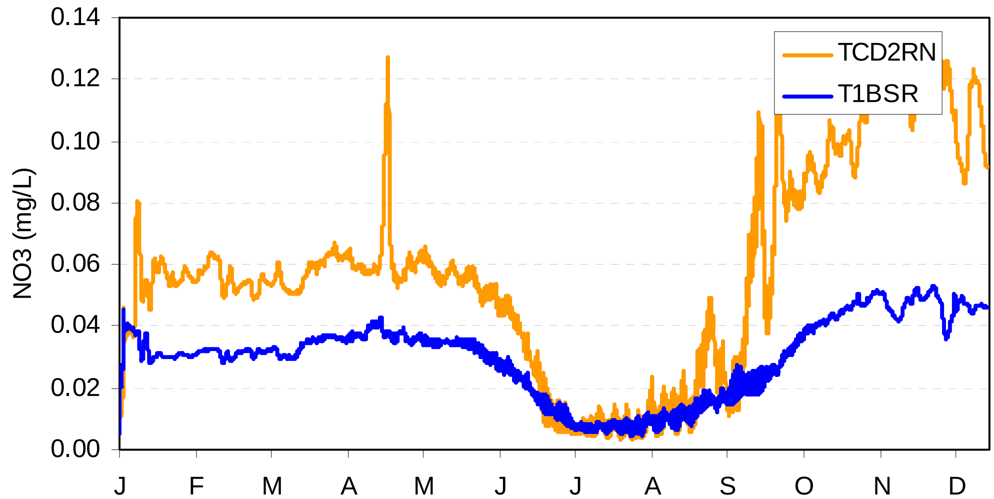


TCD2RN
T1BSR
TN (mg/L)
0.5
0.4
0.4
0.3
0.3
0.2
0.2
0.1
0.1
0.0
J F M A M J J A S O N D

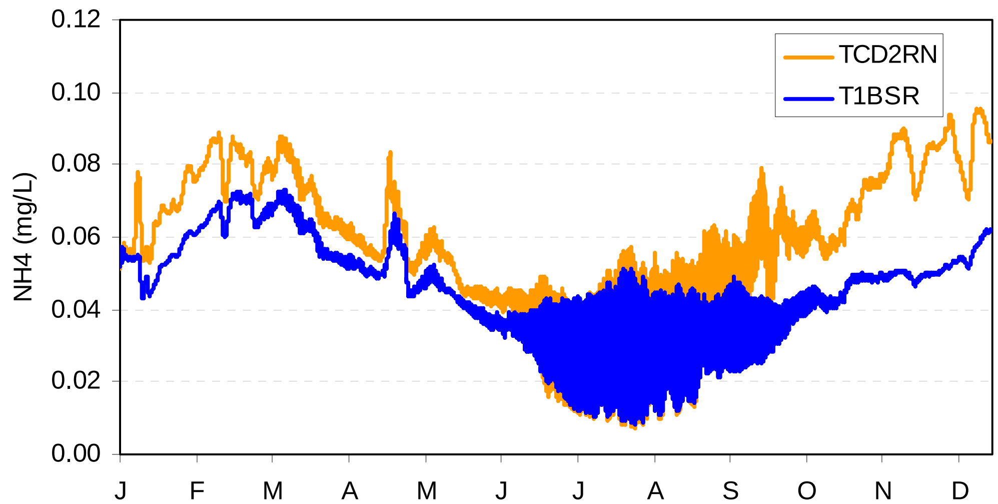
US_INDIAN



0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
PO4 (mg/L)
J F M A M J J A S O N D
TCD2RN
T1BSR

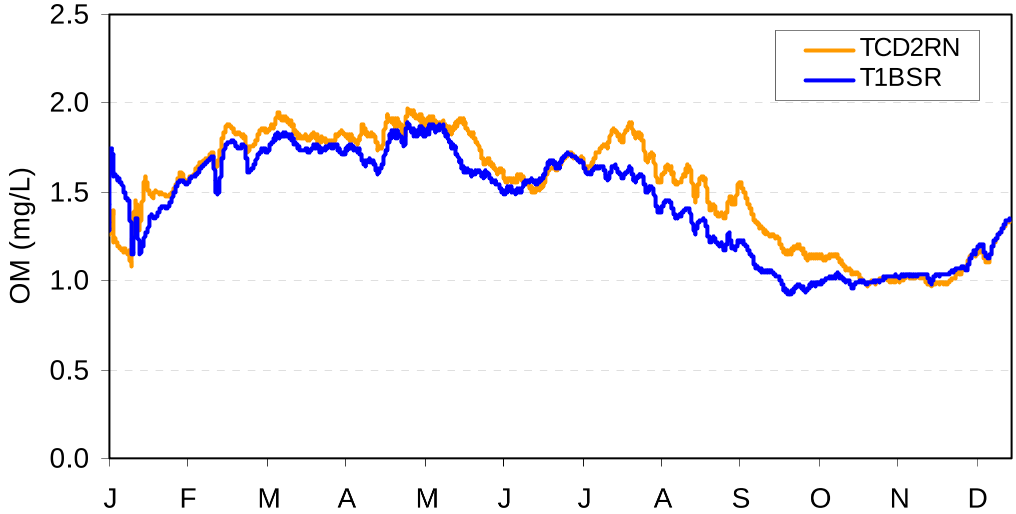


0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
NO3 (mg/L)
J F M A M J J A S O N D
TCD2RN
T1BSR

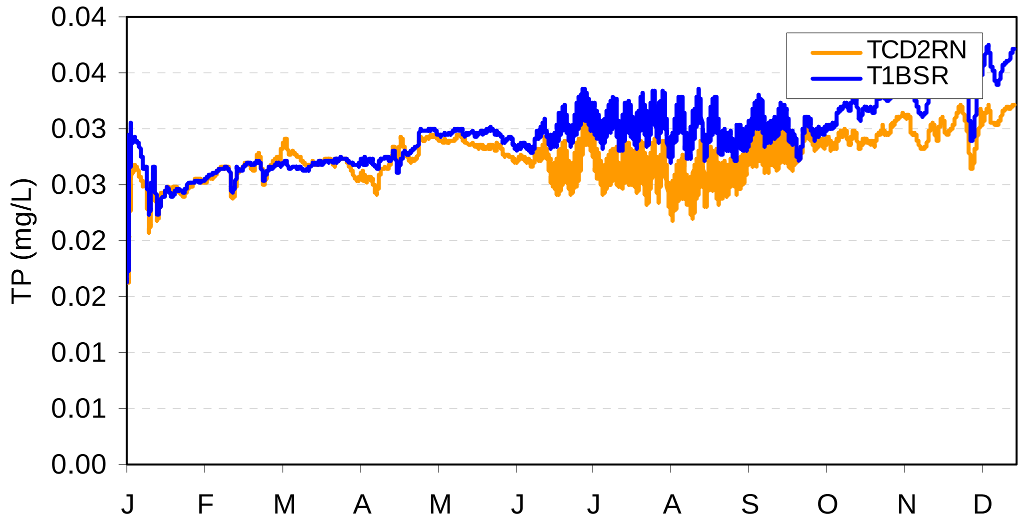


0.12
0.10
0.08
0.06
0.04
0.02
0.00
NH4 (mg/L)
J F M A M J J A S O N D
TCD2RN
T1BSR

US_INDIAN

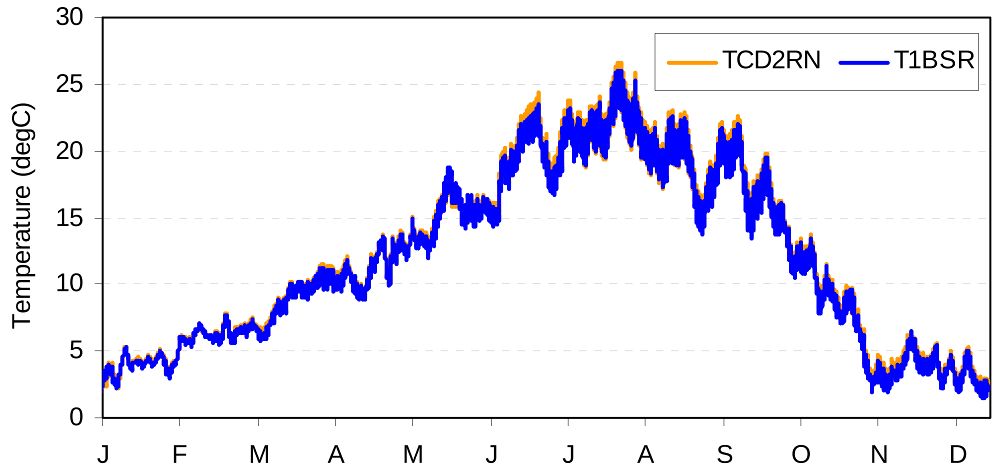


TCD2RN
T1BSR
2.5
2.0
1.5
1.0
0.5
0.0
OM (mg/L)
J
F
M
A
M
J
J
A
S
O
N
D

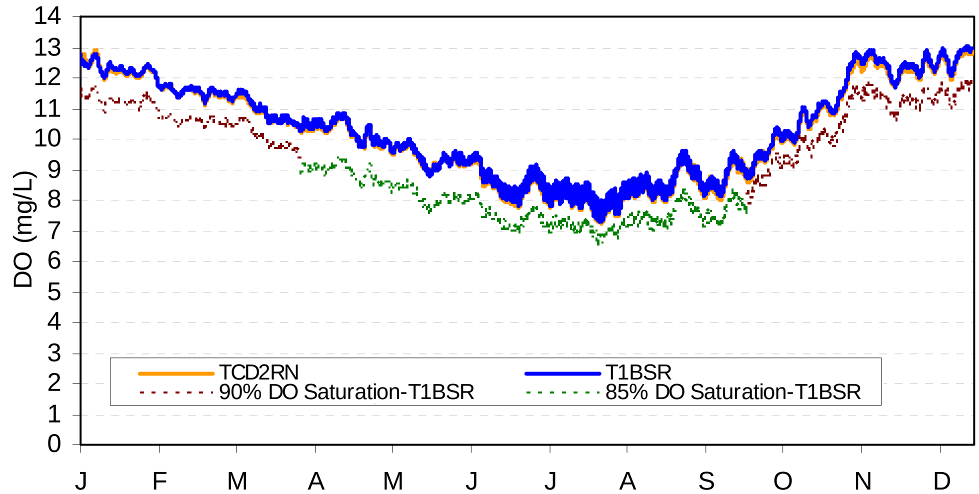


TCD2RN
T1BSR
0.04
0.04
0.03
0.03
0.02
0.02
0.01
0.01
0.00
TP (mg/L)
J
F
M
A
M
J
J
A
S
O
N
D

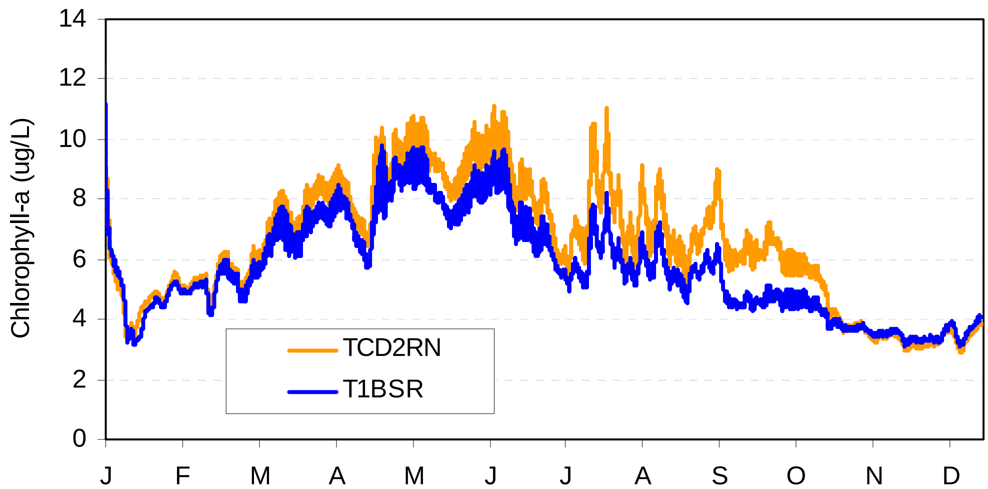
DS_INDIAN



30
25
20
15
10
5
0
Temperature (degC)
J F M A M J J A S O N D
TCD2RN
T1BSR

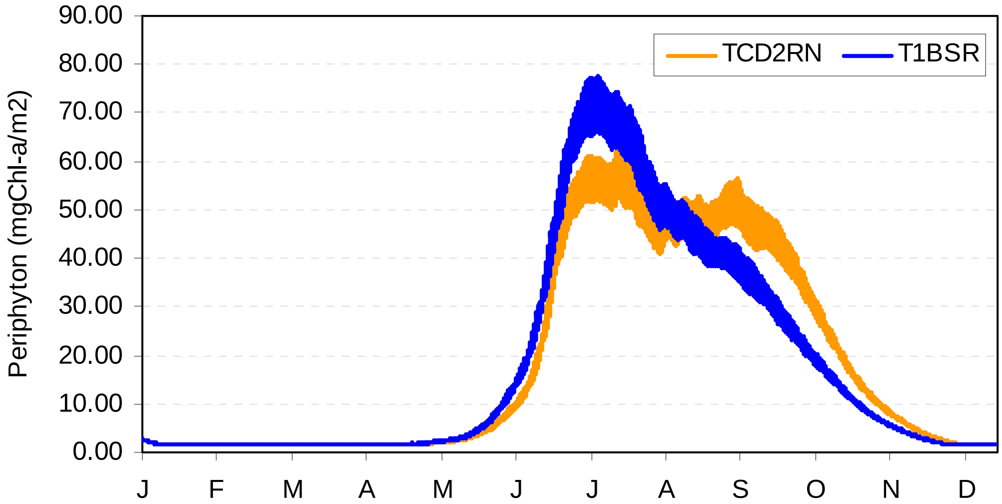


14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
DO (mg/L)
J F M A M J J A S O N D
TCD2RN
T1BSR
90% DO Saturation-T1BSR
85% DO Saturation-T1BSR

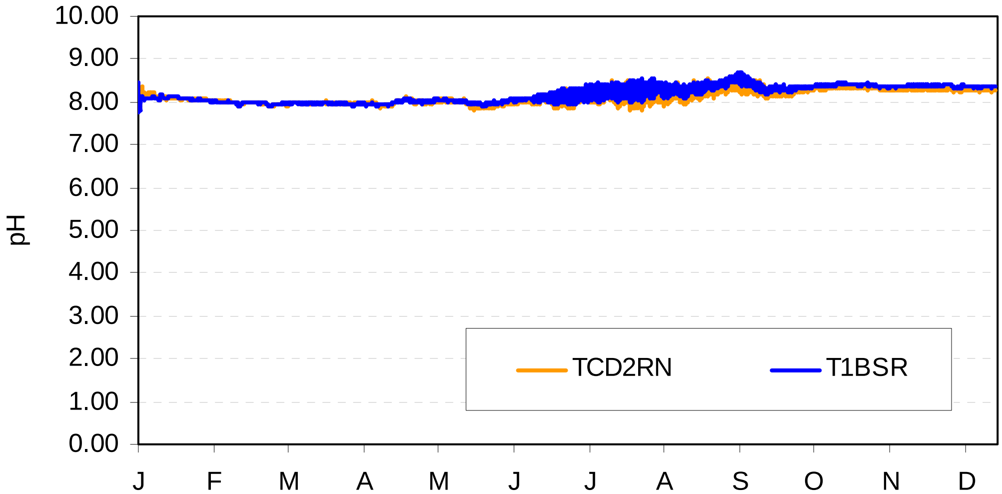


14
12
10
8
6
4
2
0
Chlorophyll-a (ug/L)
J F M A M J J A S O N D
TCD2RN
T1BSR

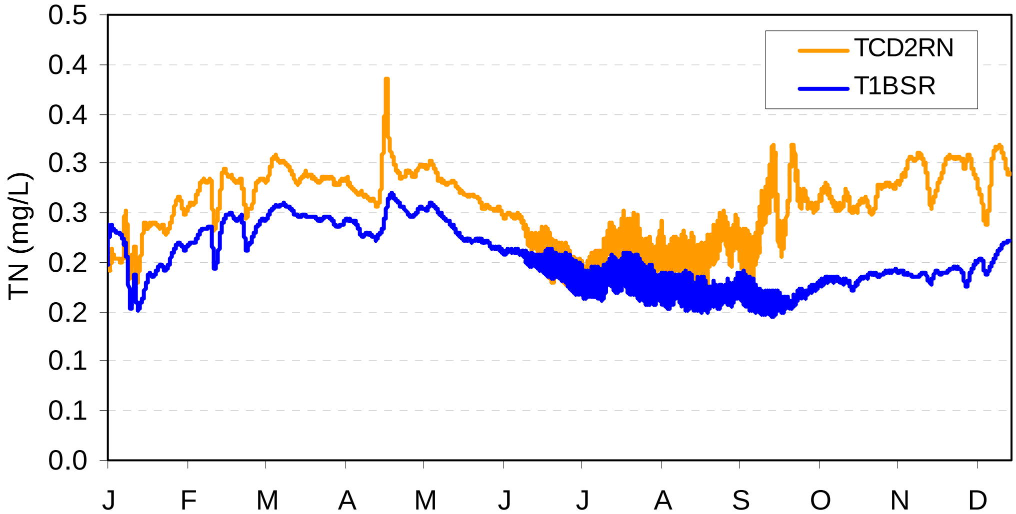
DS_INDIAN



Periphyton (mgChl-a/m2)
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
TCD2RN
T1BSR
J F M A M J J A S O N D

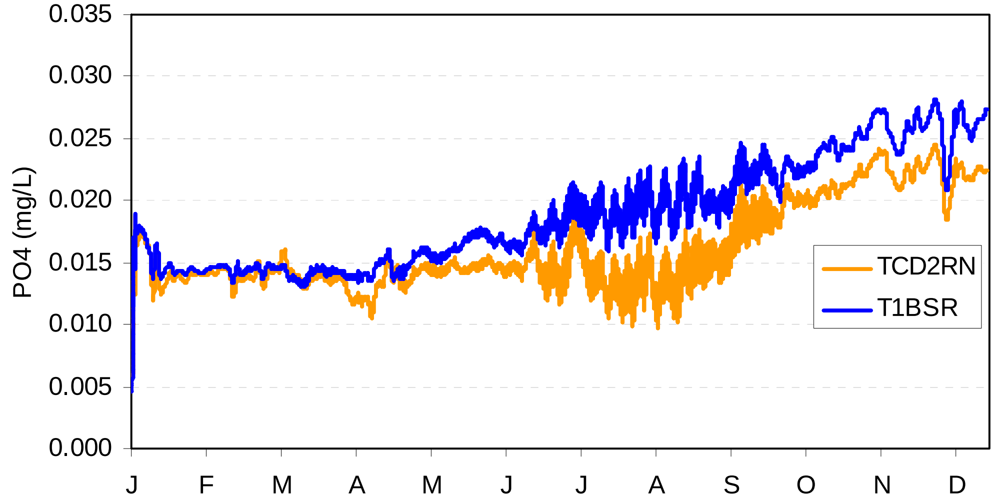


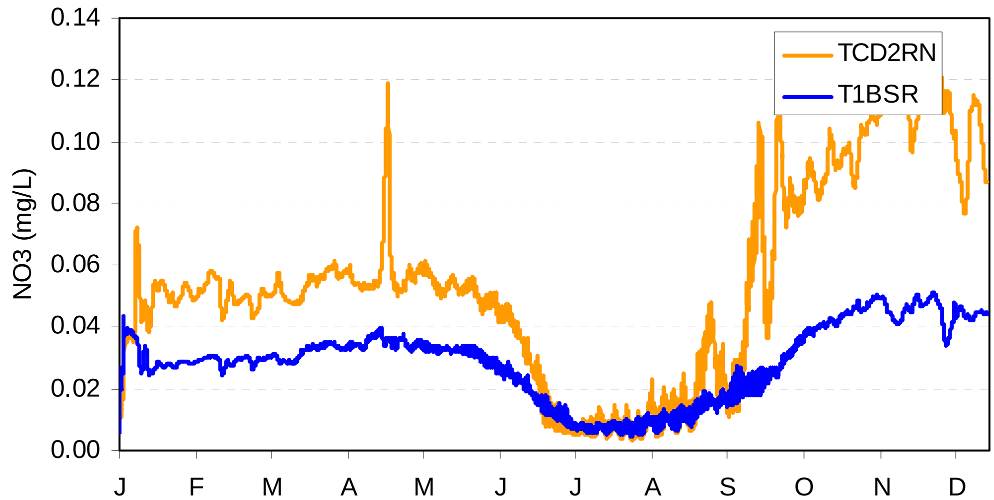
pH
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
TCD2RN
T1BSR
J F M A M J J A S O N D

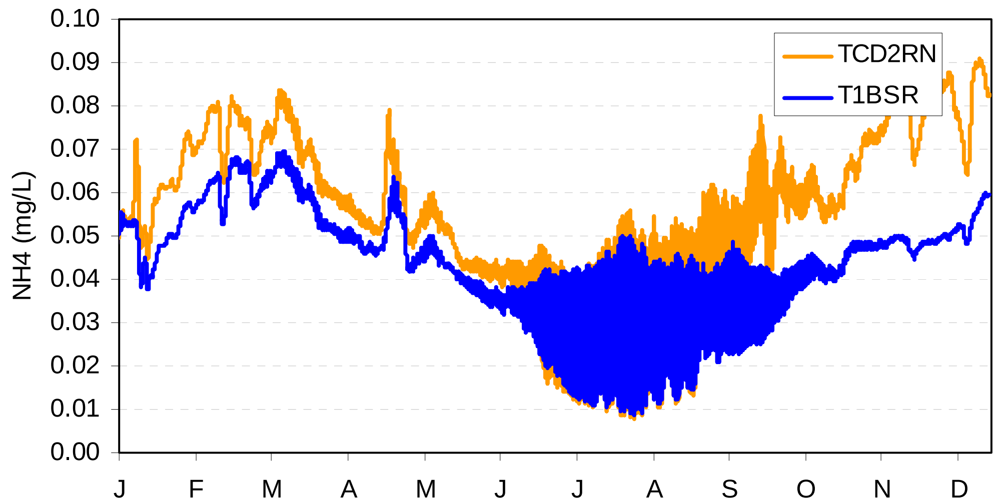


TN (mg/L)
0.5
0.4
0.4
0.3
0.3
0.2
0.2
0.1
0.1
0.0
TCD2RN
T1BSR
J F M A M J J A S O N D

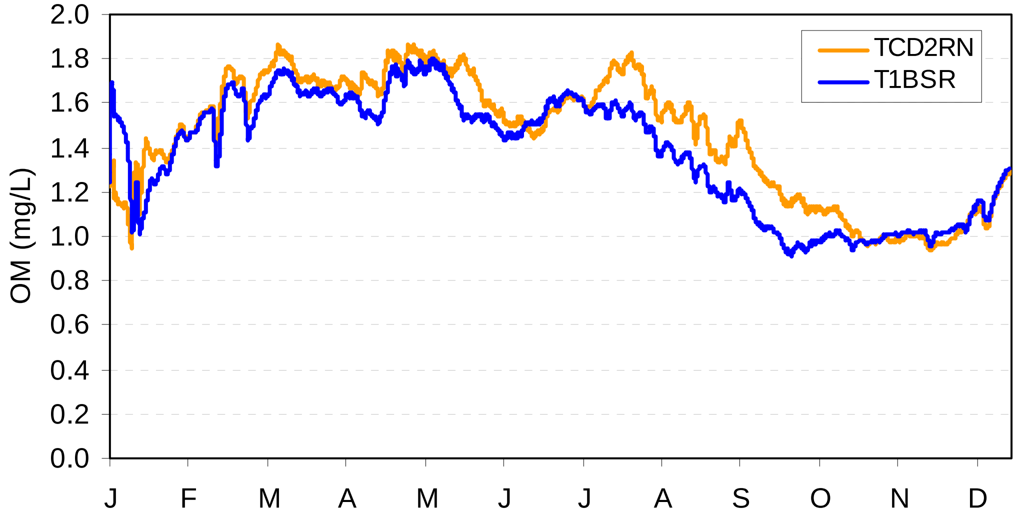
DS_INDIAN


0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
PO4 (mg/L)
J F M A M J J A S O N D
TCD2RN
T1BSR

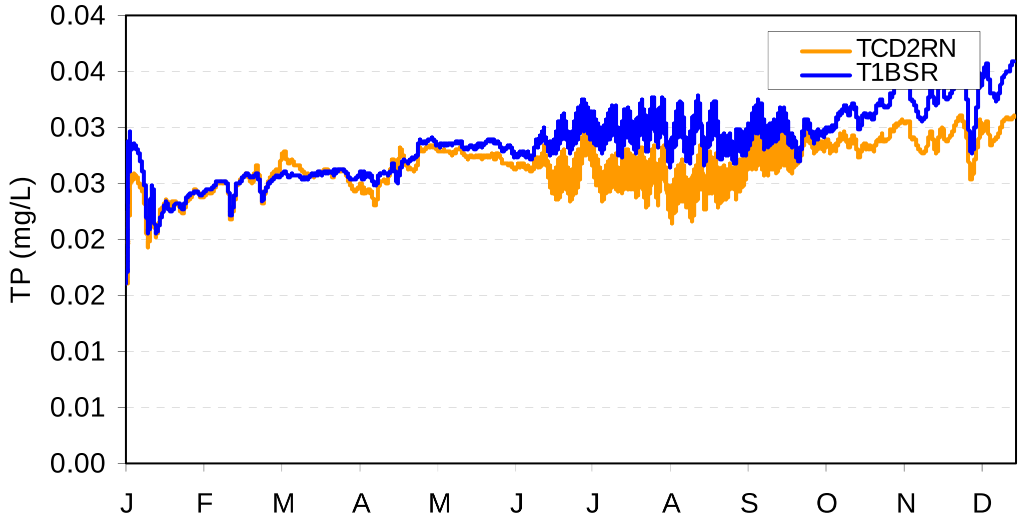

0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
NO3 (mg/L)
J F M A M J J A S O N D
TCD2RN
T1BSR


0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
NH4 (mg/L)
J F M A M J J A S O N D
TCD2RN
T1BSR

DS_INDIAN

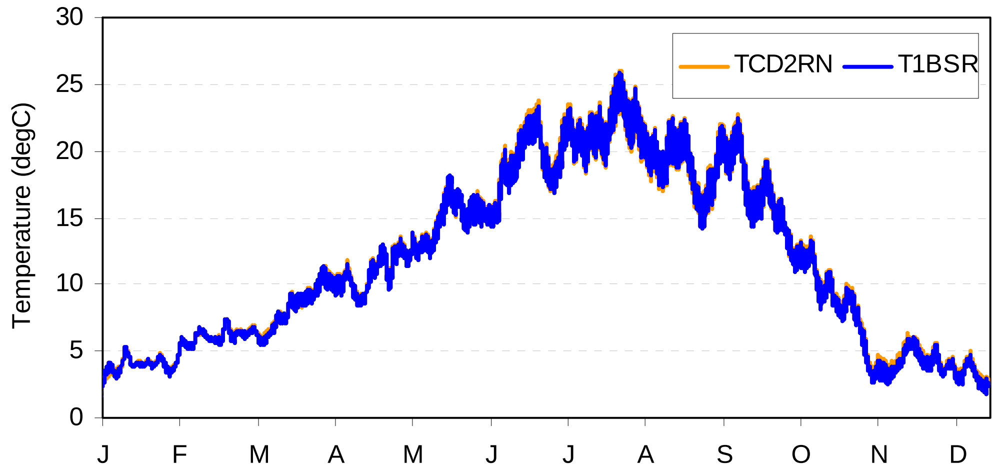


TCD2RN
T1BSR
OM (mg/L)
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
J F M A M J J A S O N D

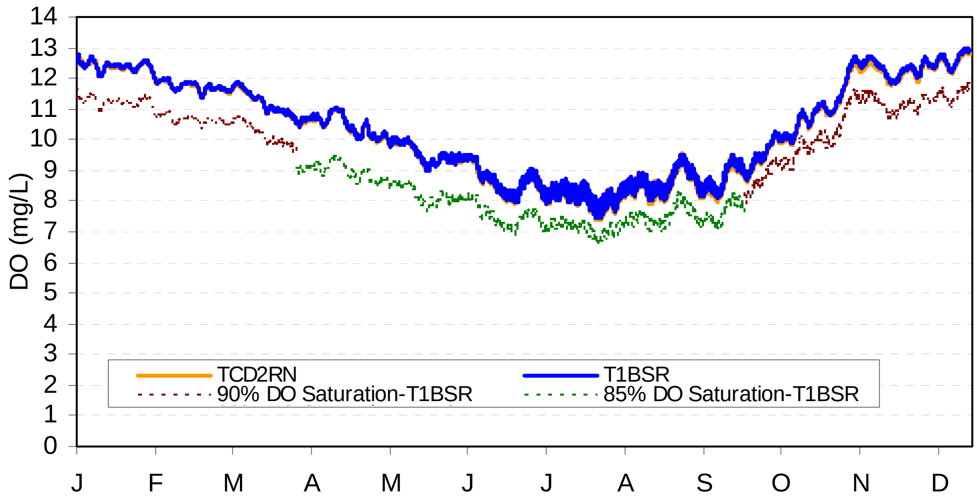


TCD2RN
T1BSR
TP (mg/L)
0.04
0.04
0.03
0.03
0.02
0.02
0.01
0.01
0.00
J F M A M J J A S O N D

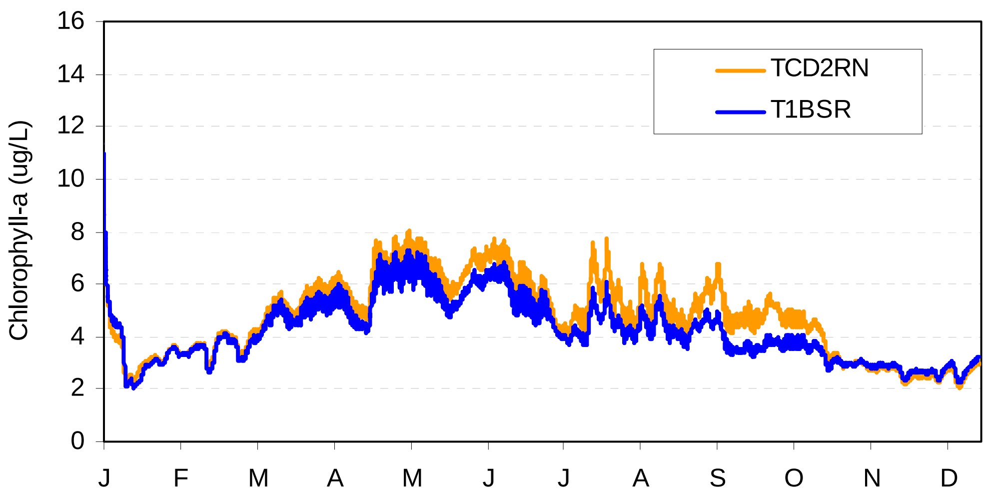
US_SALMON



30
25
20
15
10
5
0
Temperature (degC)
TCD2RN
T1BSR
J F M A M J J A S O N D

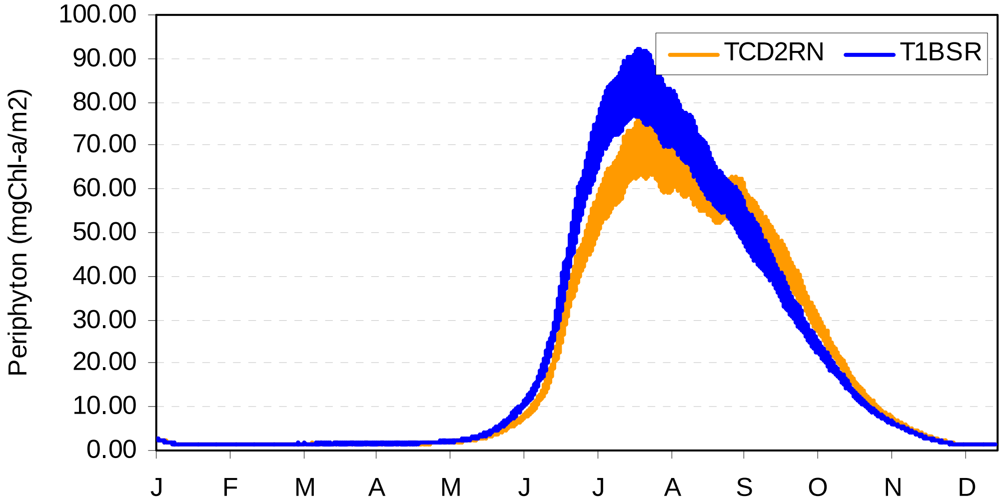


14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
DO (mg/L)
TCD2RN
T1BSR
90% DO Saturation-T1BSR
85% DO Saturation-T1BSR
J F M A M J J A S O N D

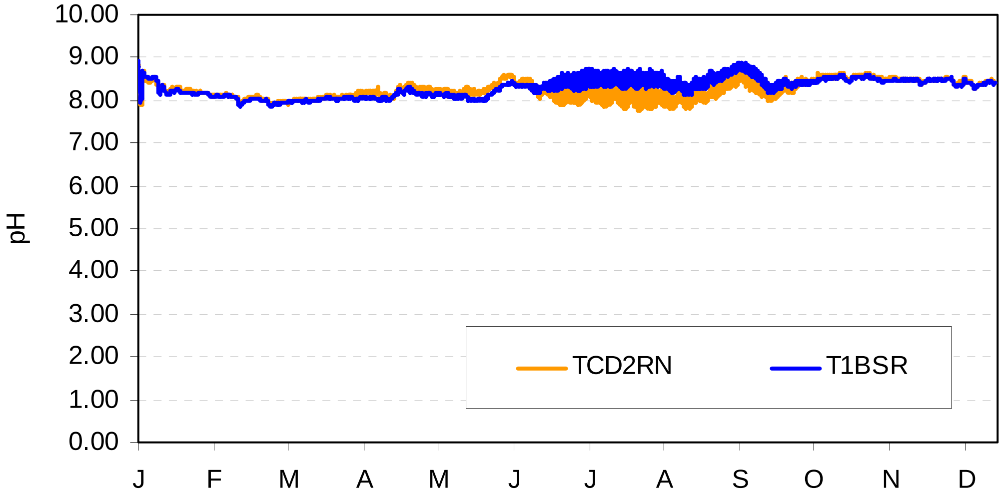


16
14
12
10
8
6
4
2
0
Chlorophyll-a (ug/L)
TCD2RN
T1BSR
J F M A M J J A S O N D

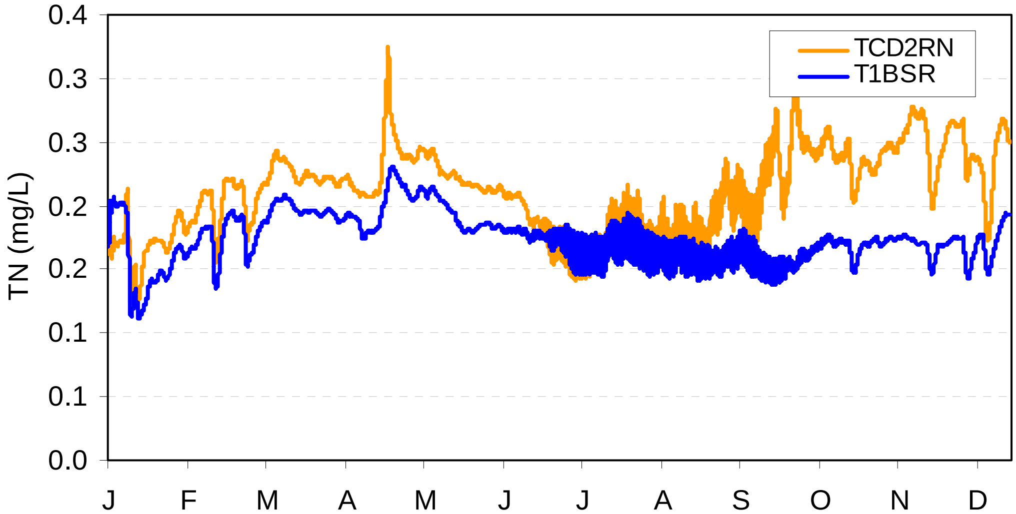
US_SALMON



Periphyton (mgChl-a/m2)
100.00
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
TCD2RN
T1BSR
J F M A M J J A S O N D

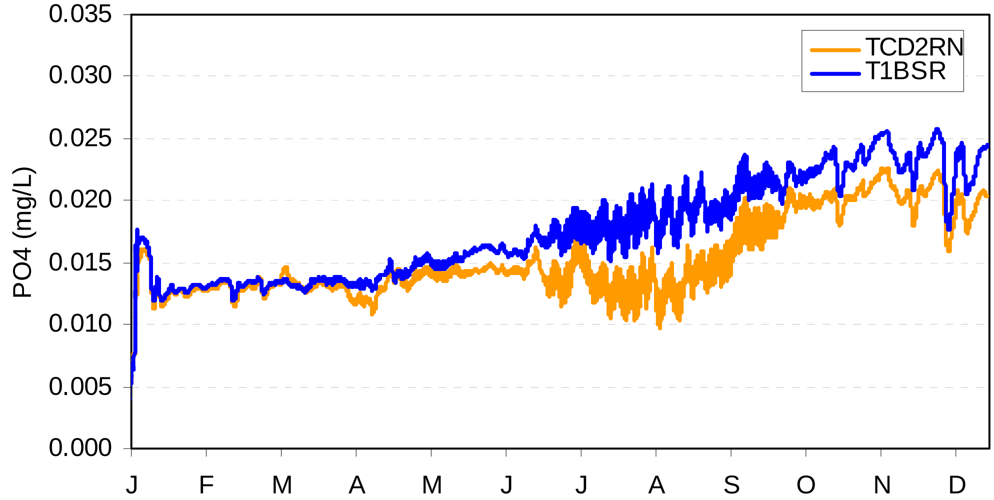


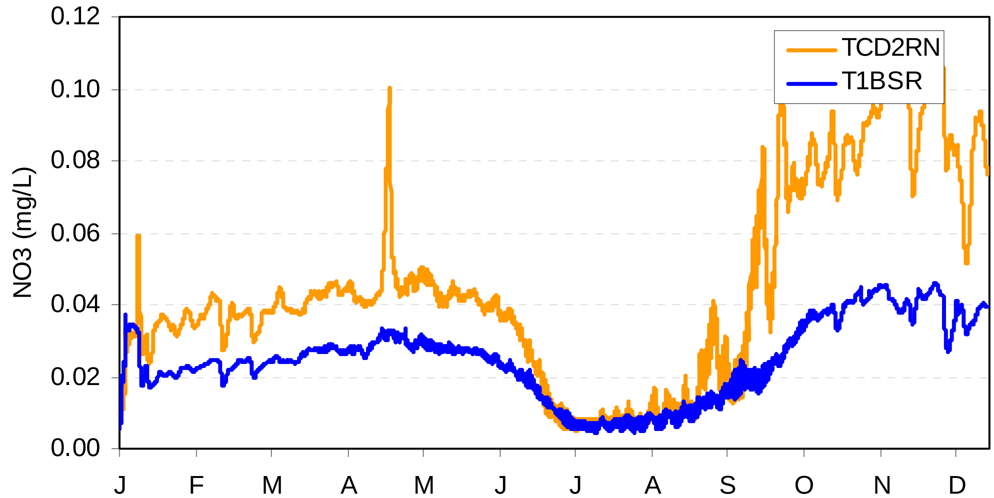
pH
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
TCD2RN
T1BSR
J F M A M J J A S O N D

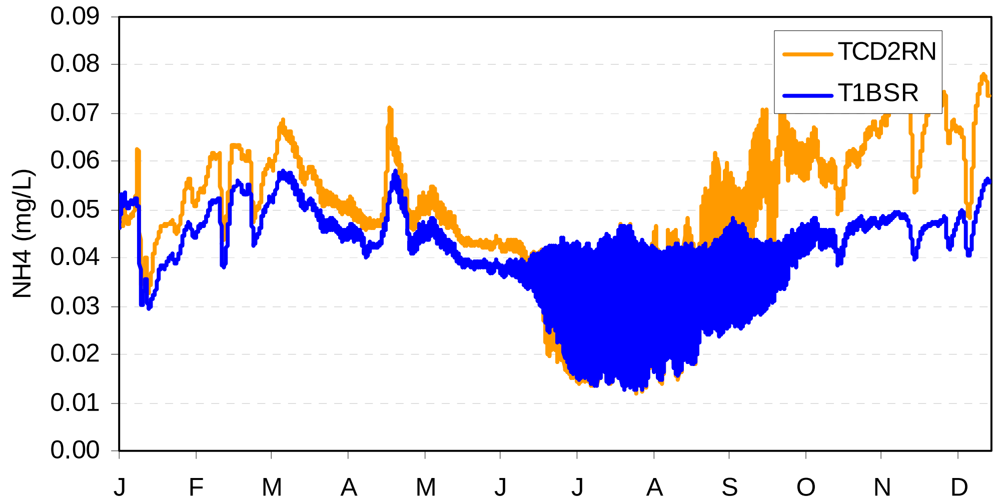


TN (mg/L)
0.4
0.3
0.3
0.2
0.2
0.1
0.1
0.0
TCD2RN
T1BSR
J F M A M J J A S O N D

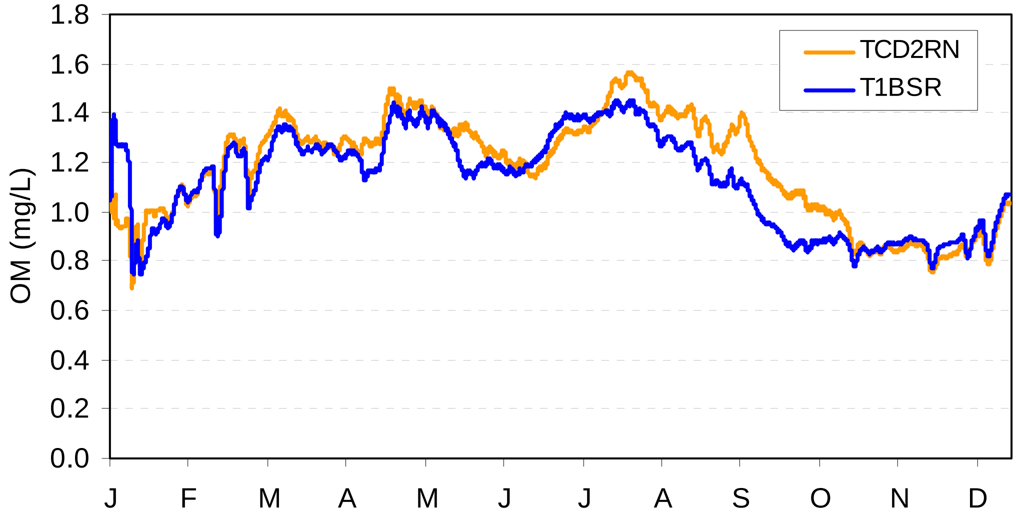
US_SALMON


0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
PO4 (mg/L)
TCD2RN
T1BSR
J
F
M
A
M
J
J
A
S
O
N
D

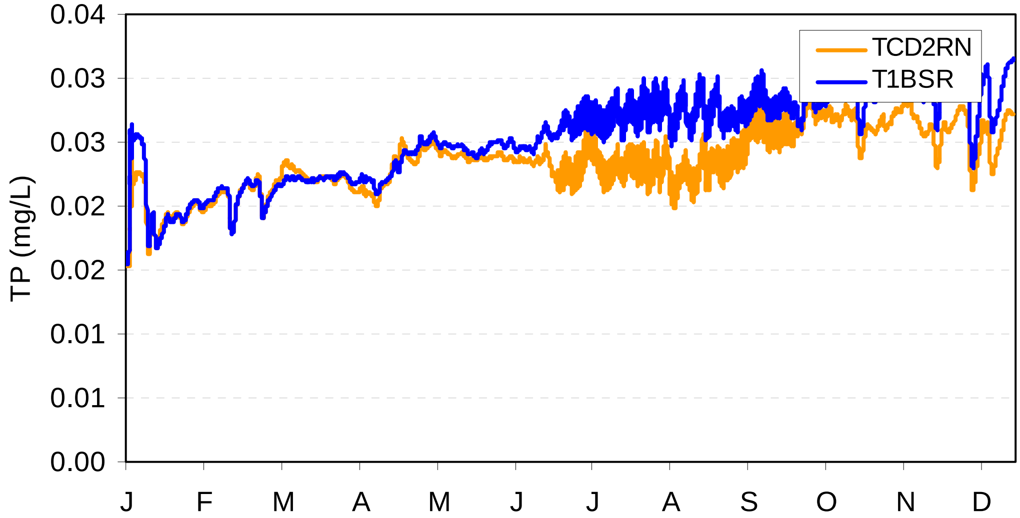

0.12
0.10
0.08
0.06
0.04
0.02
0.00
NO3 (mg/L)
TCD2RN
T1BSR
J
F
M
A
M
J
J
A
S
O
N
D


0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
NH4 (mg/L)
TCD2RN
T1BSR
J
F
M
A
M
J
J
A
S
O
N
D

US_SALMON

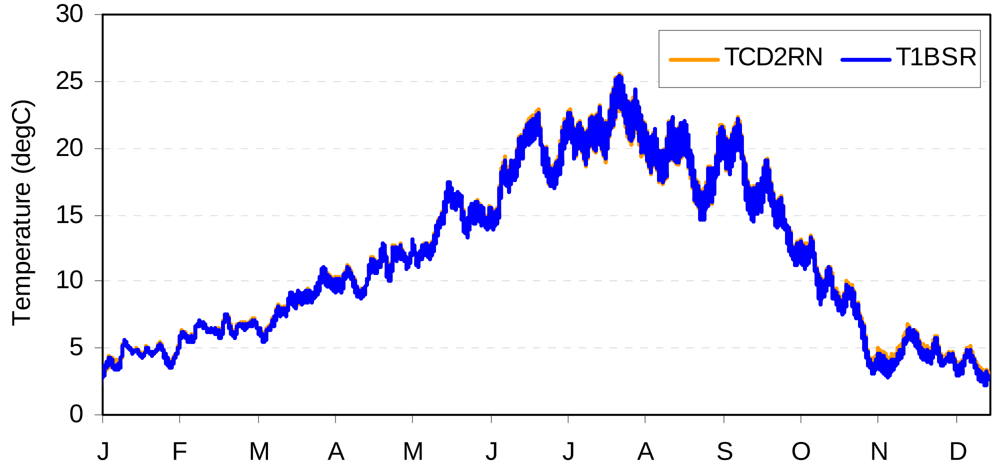


TCD2RN
T1BSR
OM (mg/L)
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
J F M A M J J A S O N D

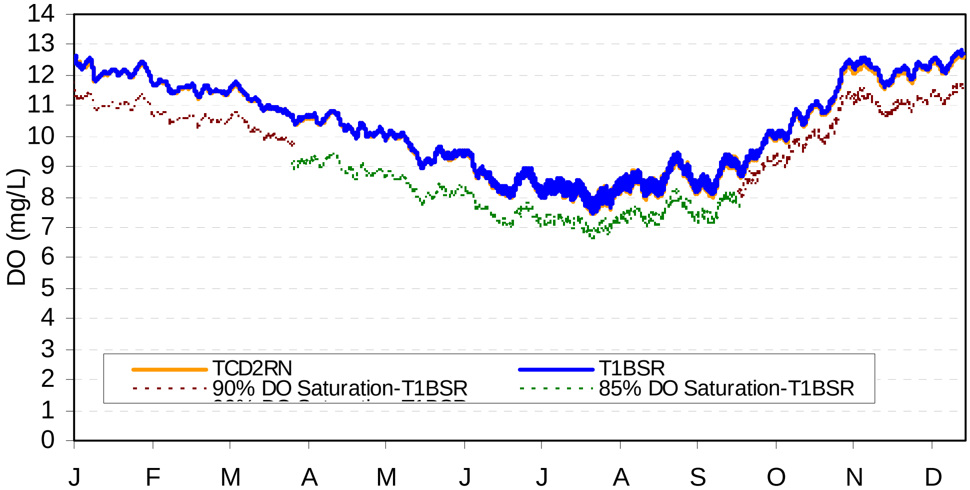


TCD2RN
T1BSR
TP (mg/L)
0.04
0.03
0.03
0.02
0.02
0.01
0.01
0.00
J F M A M J J A S O N D

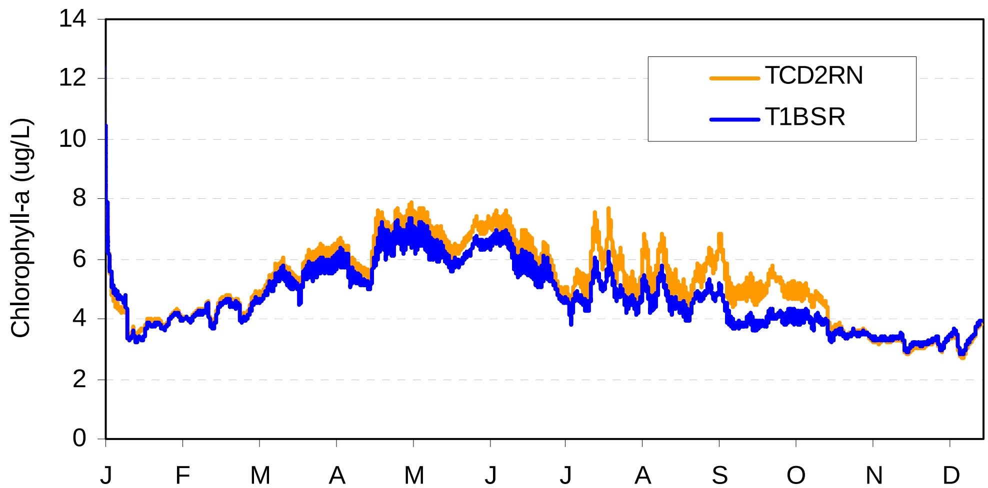
DS_SALMON



TCD2RN
T1BSR
Temperature (degC)
30
25
20
15
10
5
0
J F M A M J J A S O N D

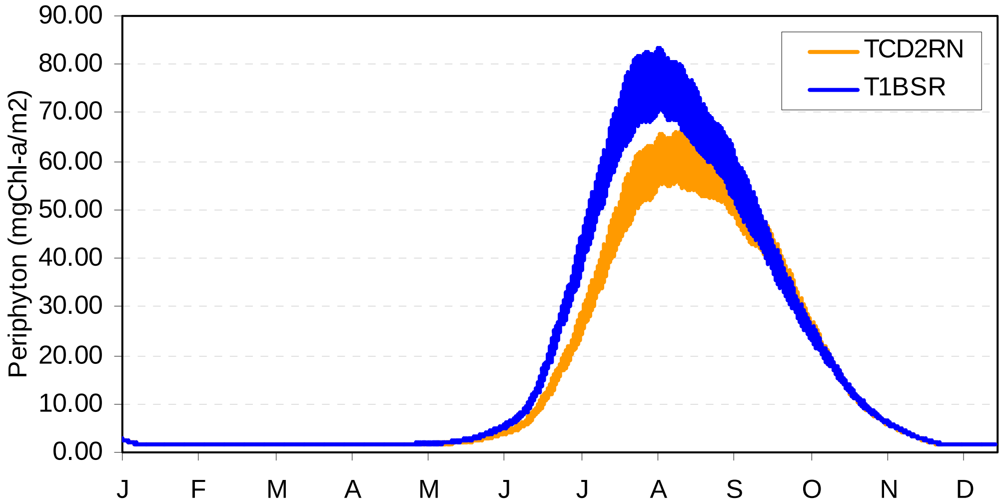


DO (mg/L)
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
TCD2RN
T1BSR
90% DO Saturation-T1BSR
85% DO Saturation-T1BSR
J F M A M J J A S O N D

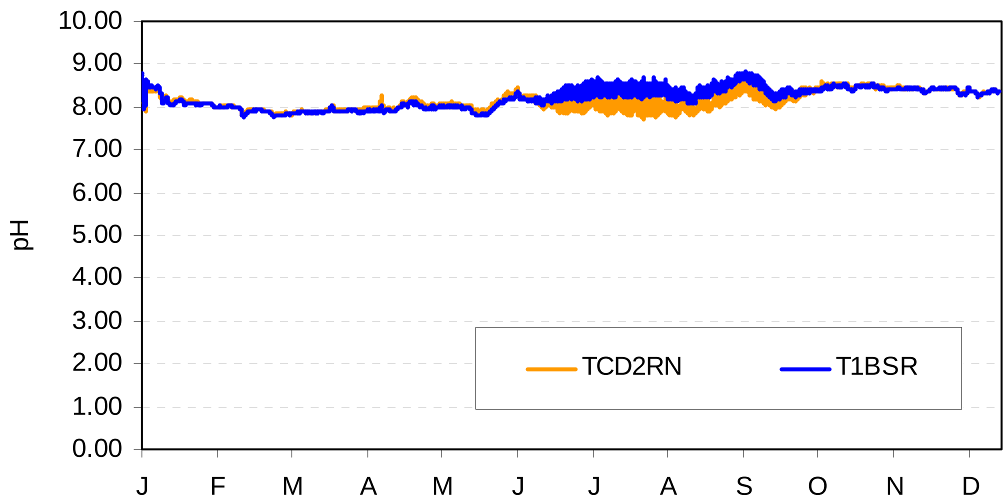


TCD2RN
T1BSR
Chlorophyll-a (ug/L)
14
12
10
8
6
4
2
0
J F M A M J J A S O N D

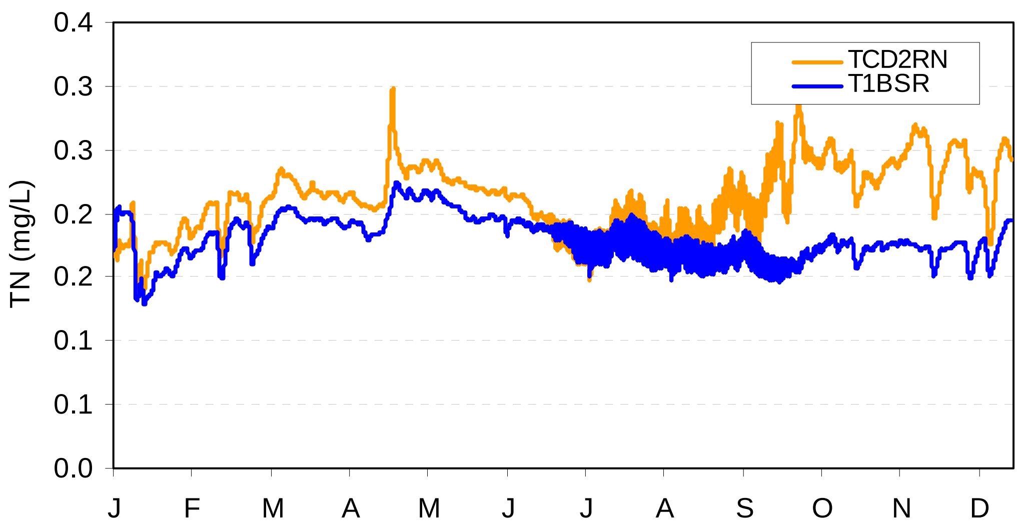
DS_SALMON



Periphyton (mgChl-a/m2)
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
J F M A M J J A S O N D
TCD2RN
T1BSR

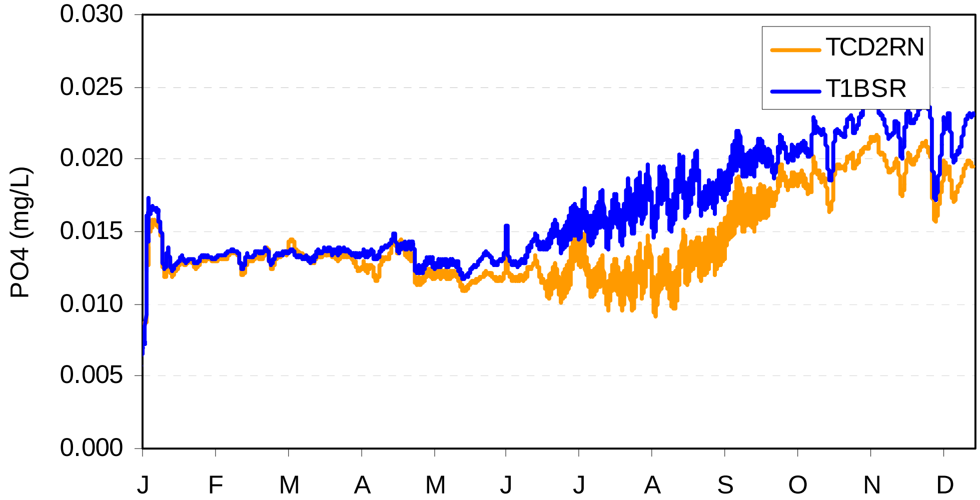


pH
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
J F M A M J J A S O N D
TCD2RN
T1BSR

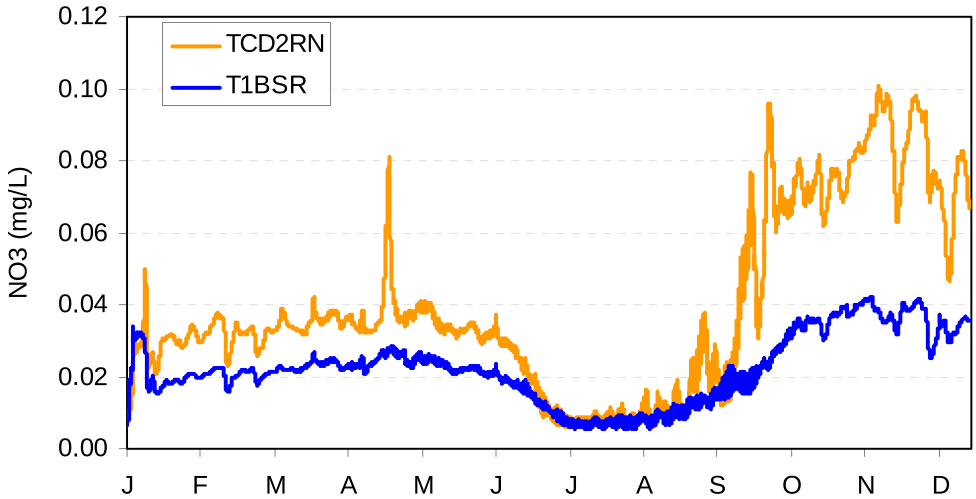


TN (mg/L)
0.4
0.3
0.3
0.2
0.2
0.1
0.1
0.0
J F M A M J J A S O N D
TCD2RN
T1BSR

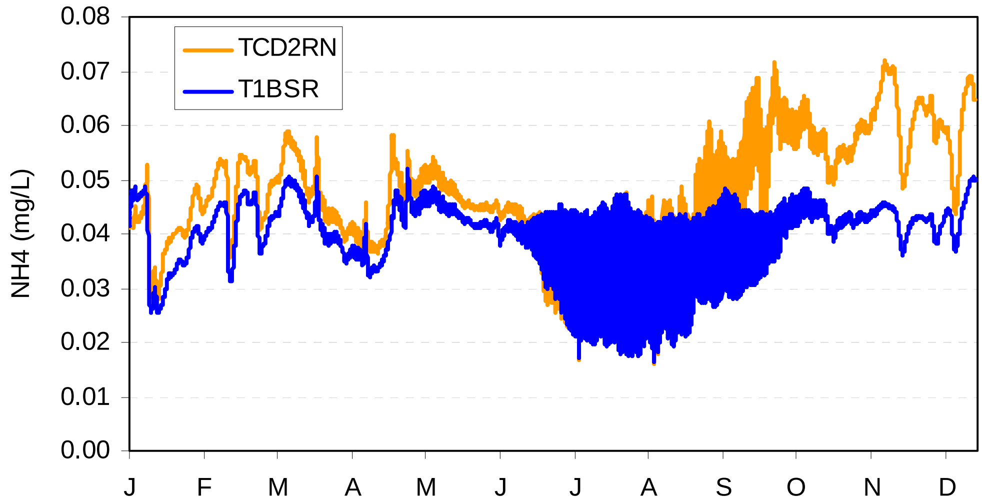
DS_SALMON



0.030
0.025
0.020
0.015
0.010
0.005
0.000
PO4 (mg/L)
TCD2RN
T1BSR
J
F
M
A
M
J
J
A
S
O
N
D

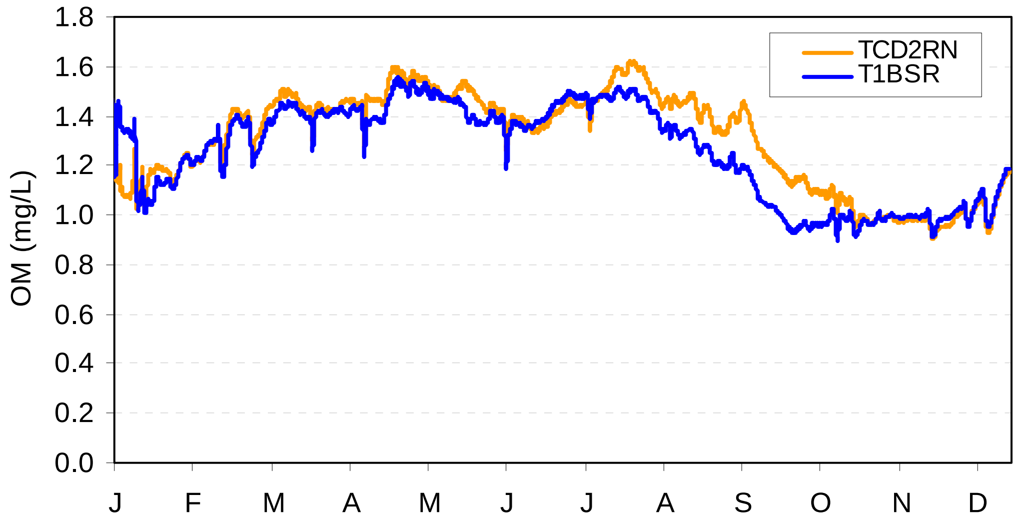


0.12
0.10
0.08
0.06
0.04
0.02
0.00
NO3 (mg/L)
TCD2RN
T1BSR
J
F
M
A
M
J
J
A
S
O
N
D

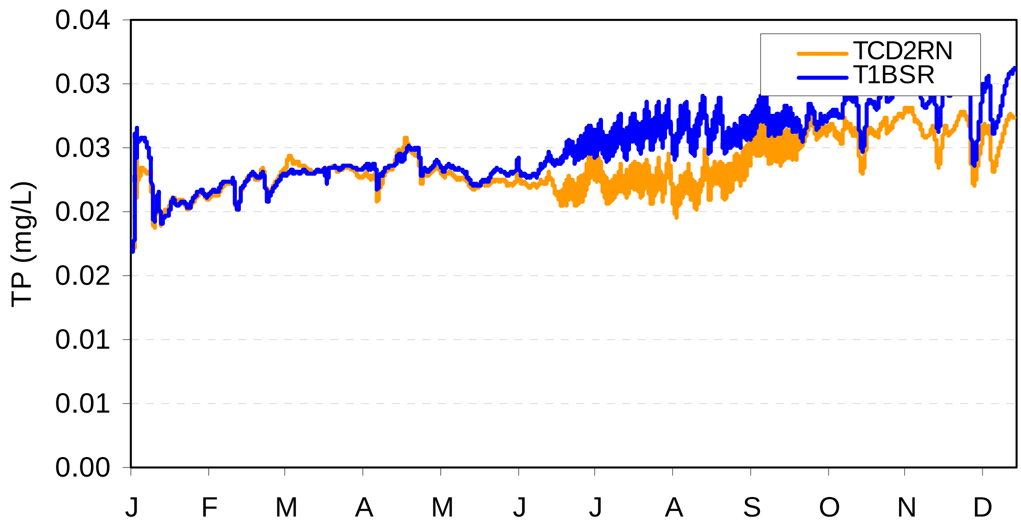


0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
NH4 (mg/L)
TCD2RN
T1BSR
J
F
M
A
M
J
J
A
S
O
N
D

DS_SALMON

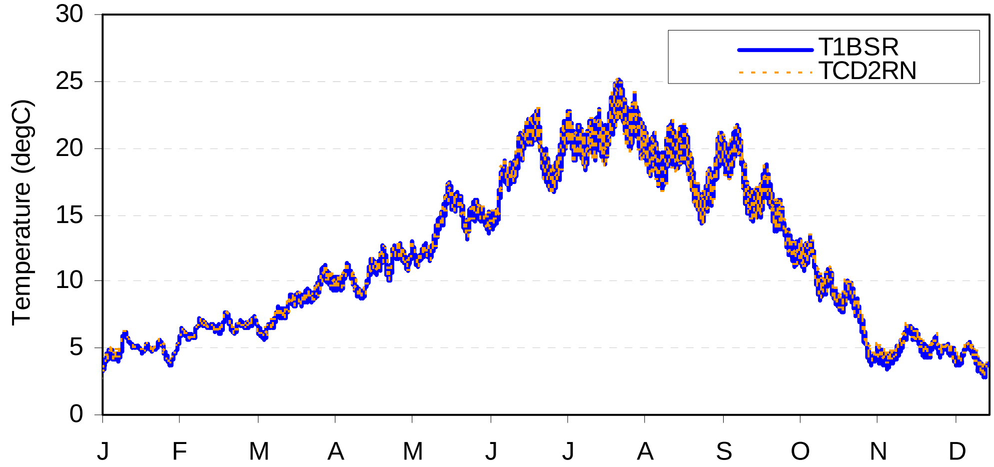


1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
OM (mg/L)
J
F
M
A
M
J
J
A
S
O
N
D
TCD2RN
T1BSR

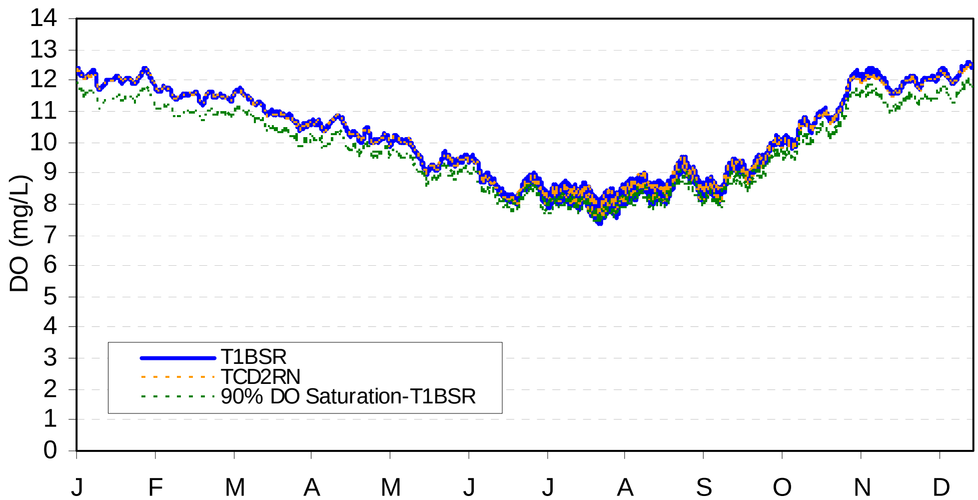


0.04
0.03
0.03
0.02
0.02
0.01
0.01
0.00
TP (mg/L)
J
F
M
A
M
J
J
A
S
O
N
D
TCD2RN
T1BSR

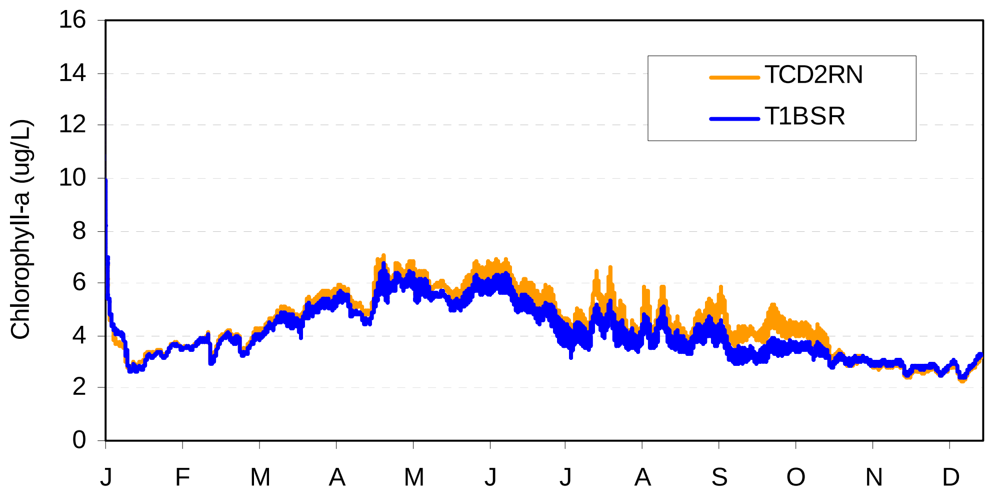
HOOPA



Temperature (degC)
30
25
20
15
10
5
0
J F M A M J J A S O N D
T1BSR
TCD2RN

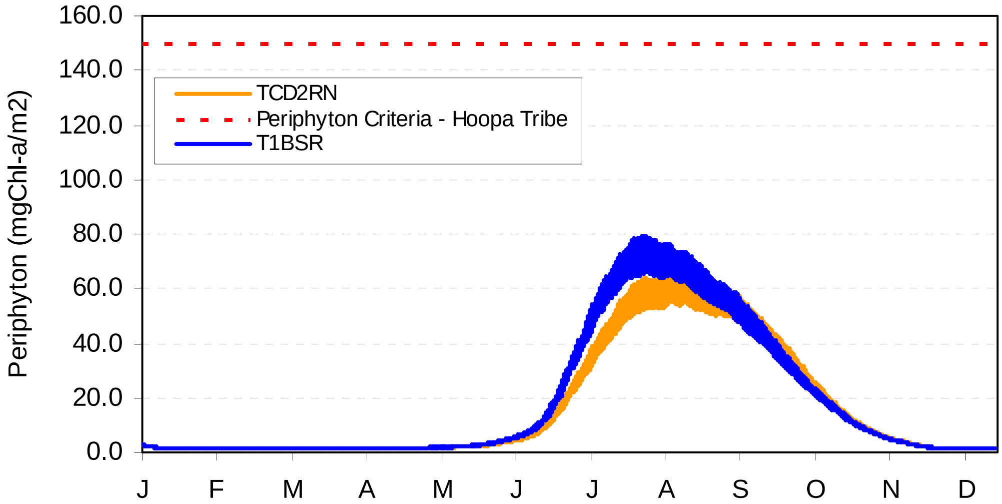


DO (mg/L)
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
J F M A M J J A S O N D
T1BSR
TCD2RN
90% DO Saturation-T1BSR

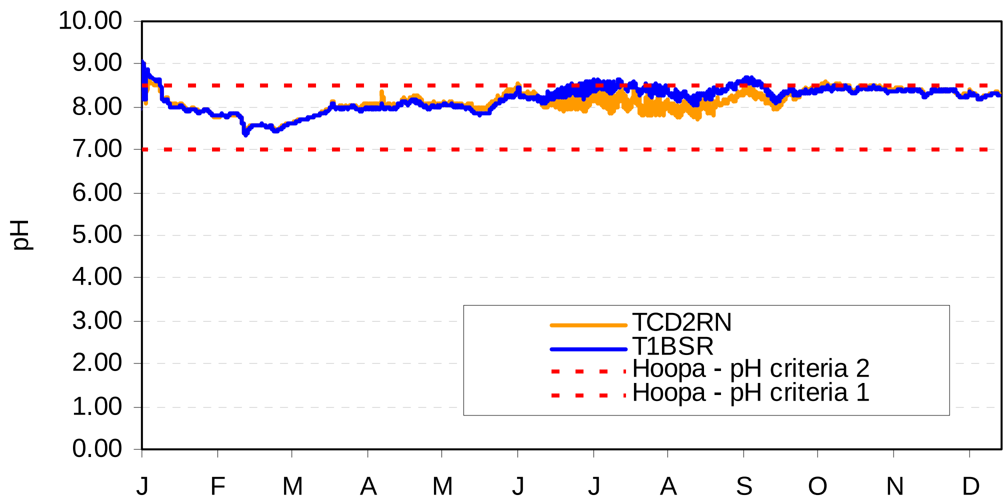


Chlorophyll-a (ug/L)
16
14
12
10
8
6
4
2
0
J F M A M J J A S O N D
TCD2RN
T1BSR

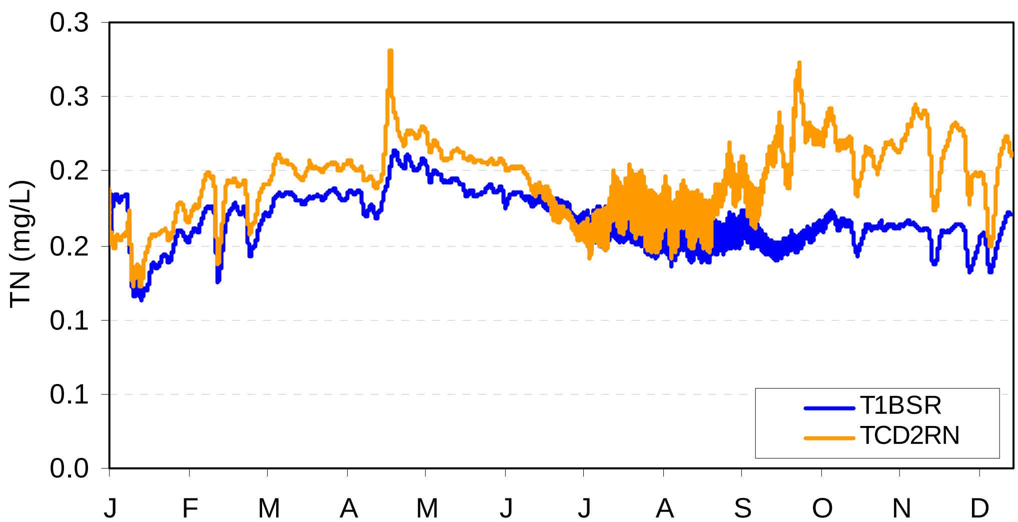
HOOPA



160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
Periphyton (mgChl-a/m2)
TCD2RN
Periphyton Criteria - Hoopa Tribe
T1BSR
J F M A M J J A S O N D

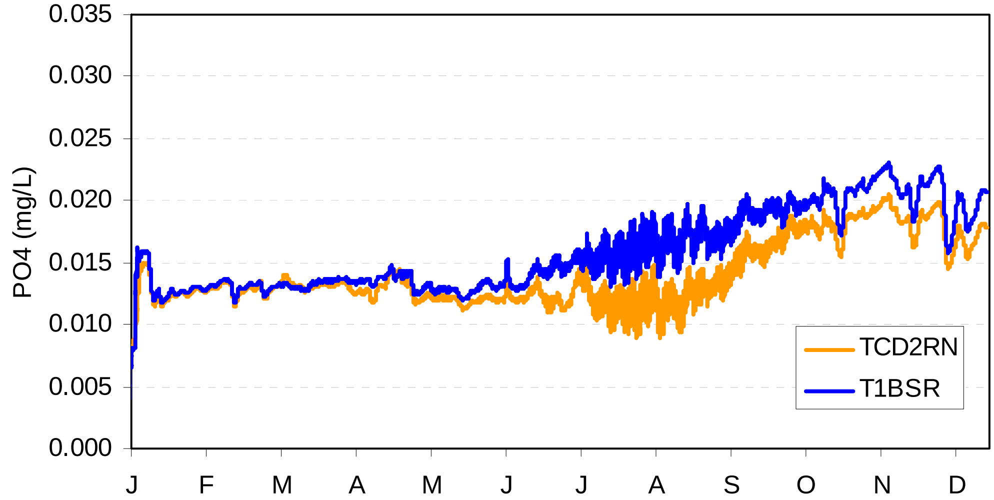


10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
pH
TCD2RN
T1BSR
Hoopa - pH criteria 2
Hoopa - pH criteria 1
J F M A M J J A S O N D

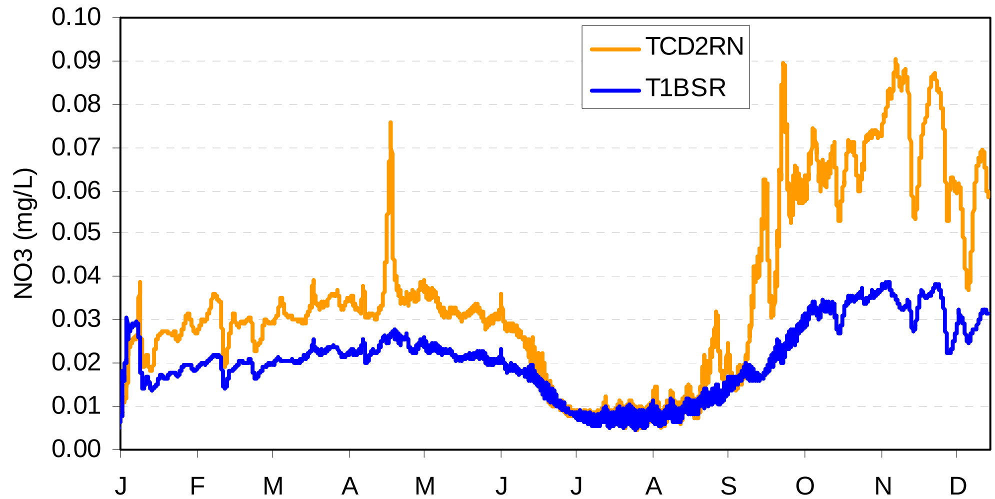


0.3
0.3
0.2
0.2
0.1
0.1
0.0
TN (mg/L)
T1BSR
TCD2RN
J F M A M J J A S O N D

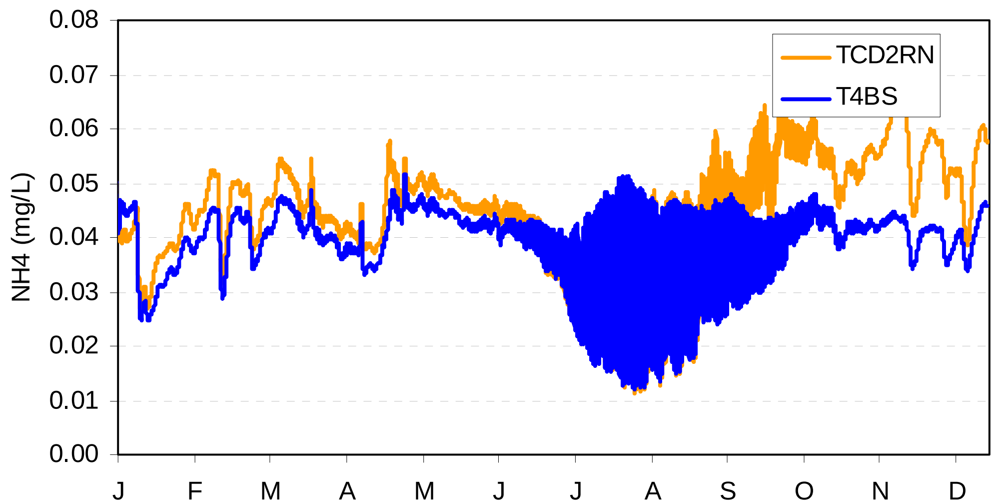
HOOPA



0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
PO4 (mg/L)
J F M A M J J A S O N D
TCD2RN
T1BSR

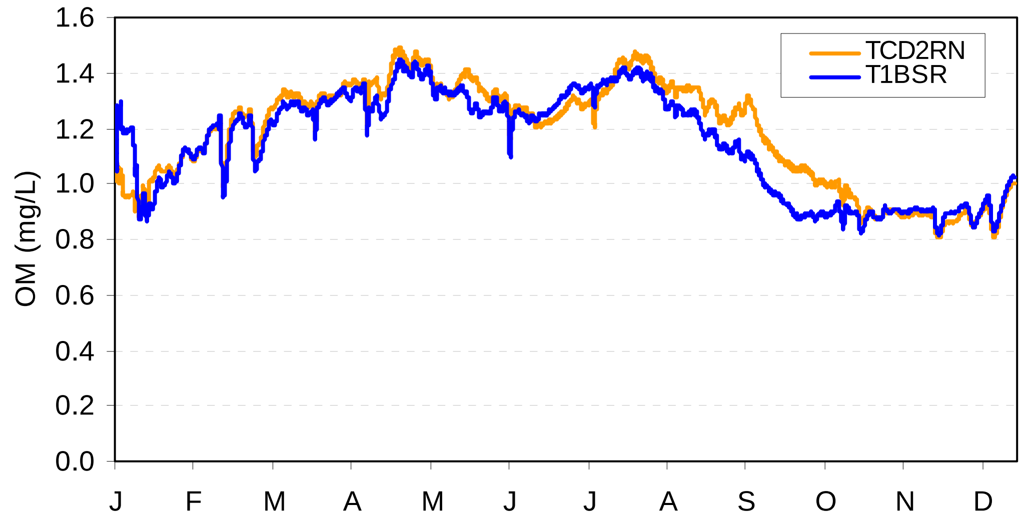


0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
NO3 (mg/L)
J F M A M J J A S O N D
TCD2RN
T1BSR

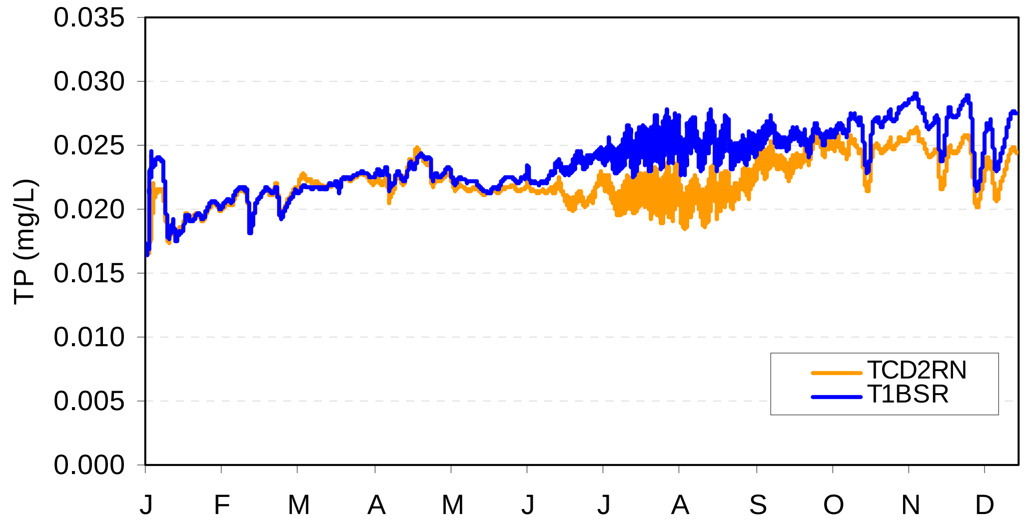


0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
NH4 (mg/L)
J F M A M J J A S O N D
TCD2RN
T4BS

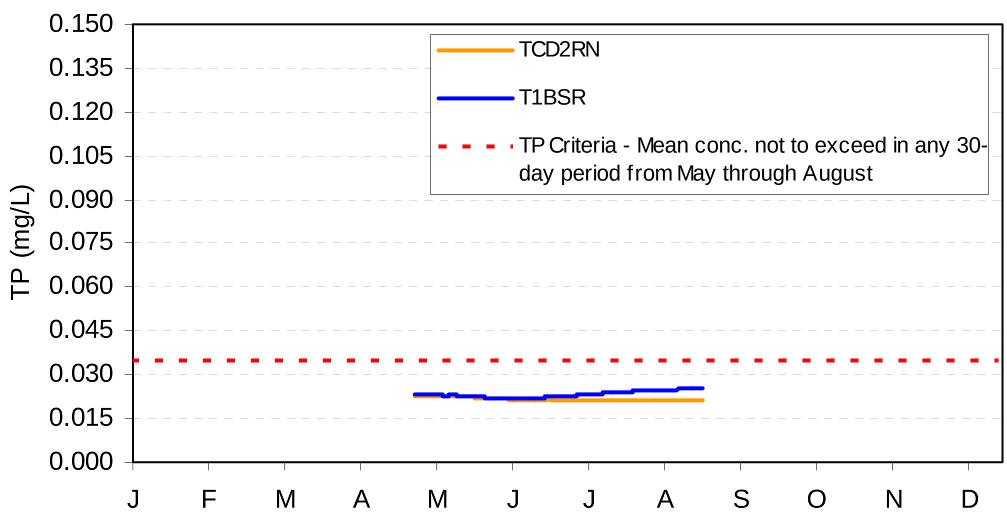
HOOPA



1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
OM (mg/L)
J F M A M J J A S O N D
TCD2RN
T1BSR

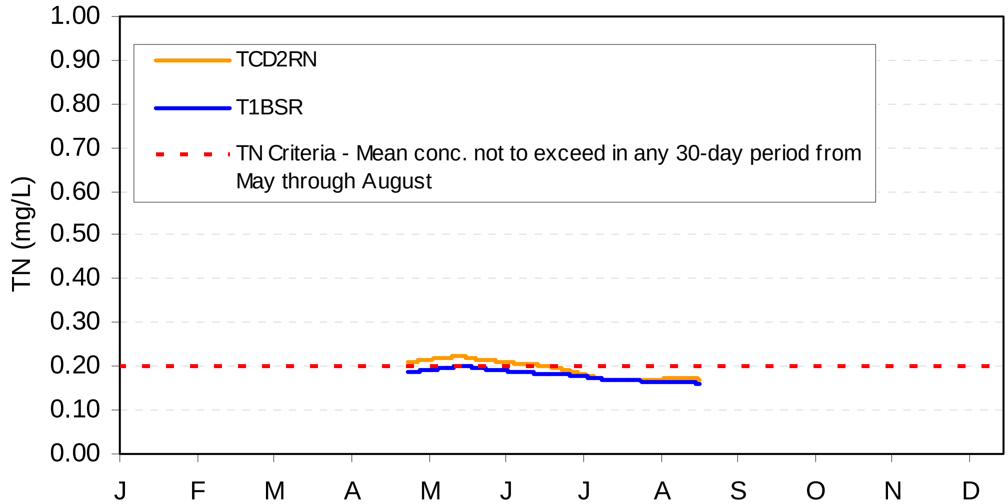


0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
TP (mg/L)
J F M A M J J A S O N D
TCD2RN
T1BSR

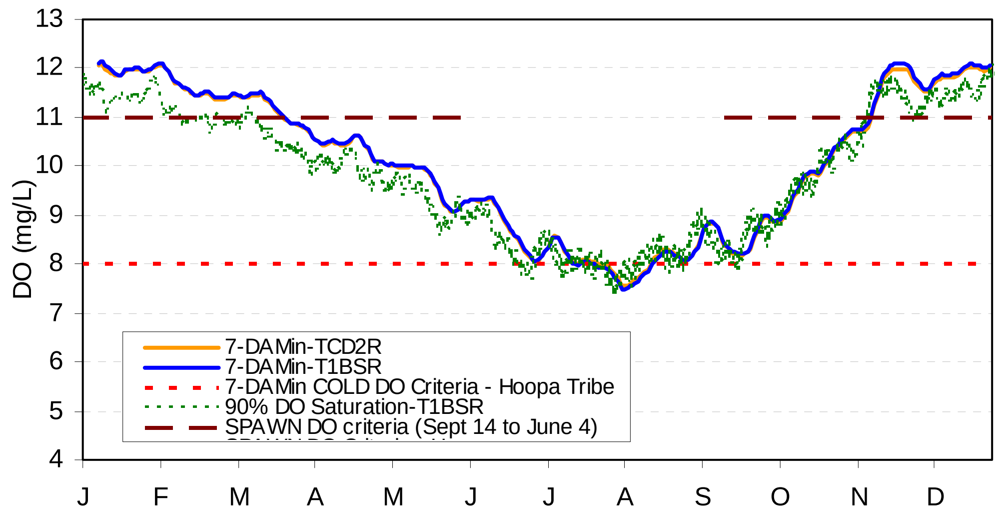


0.150
0.135
0.120
0.105
0.090
0.075
0.060
0.045
0.030
0.015
0.000
TP (mg/L)
J F M A M J J A S O N D
TCD2RN
T1BSR
TP Criteria - Mean conc. not to exceed in any 30-day period from May through August

HOOPA

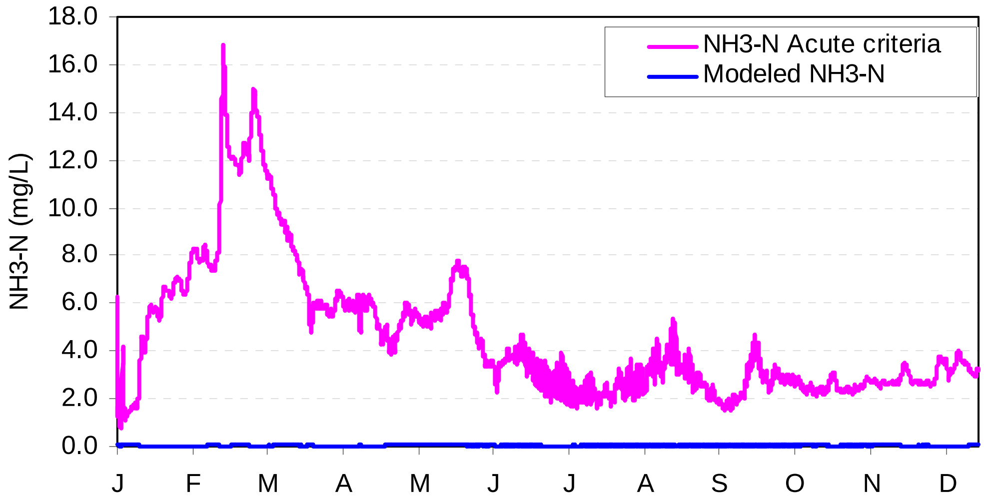


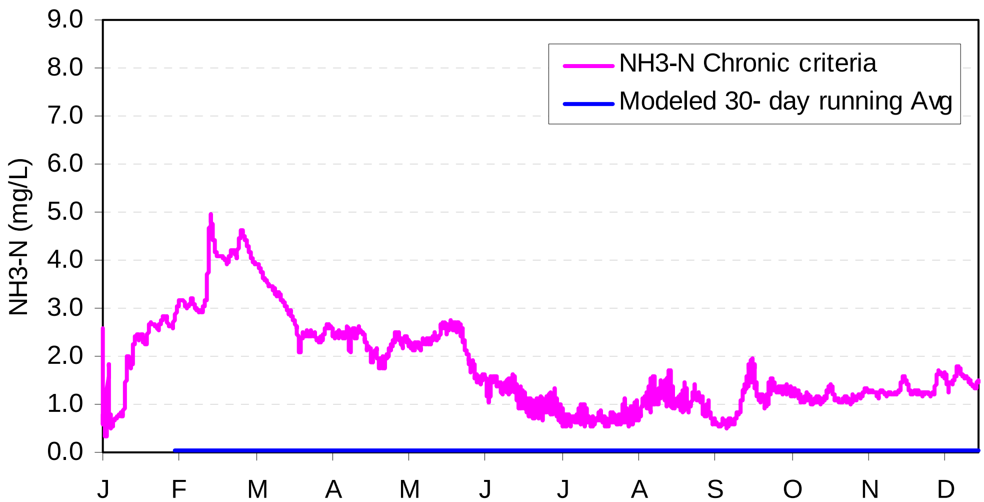
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
TN (mg/L)
TCD2RN
T1BSR
TN Criteria - Mean conc. not to exceed in any 30-day period from May through August
J
F
M
A
M
J
J
A
S
O
N
D

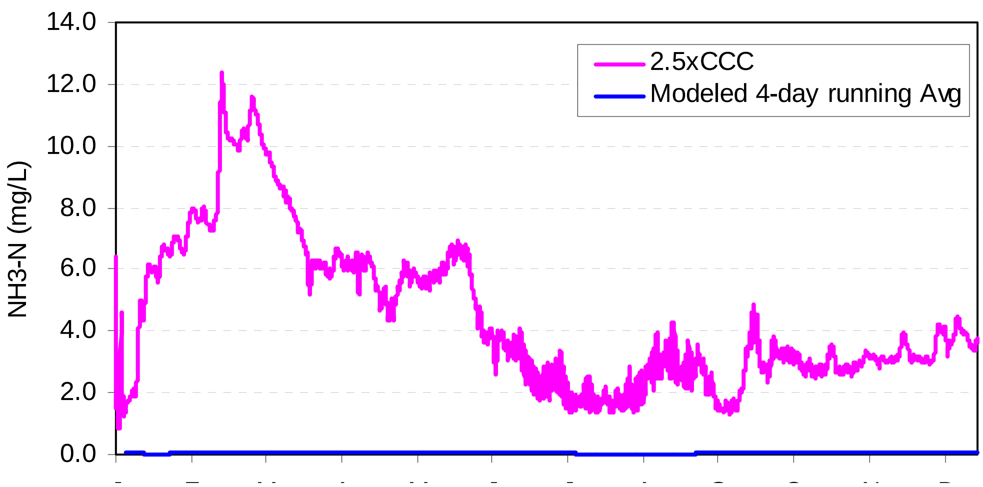


13
12
11
10
9
8
7
6
5
4
DO (mg/L)
7-DAMin-TCD2R
7-DAMin-T1BSR
7-DAMin COLD DO Criteria - Hoopa Tribe
90% DO Saturation-T1BSR
SPAWN DO criteria (Sept 14 to June 4)
J
F
M
A
M
J
J
A
S
O
N
D

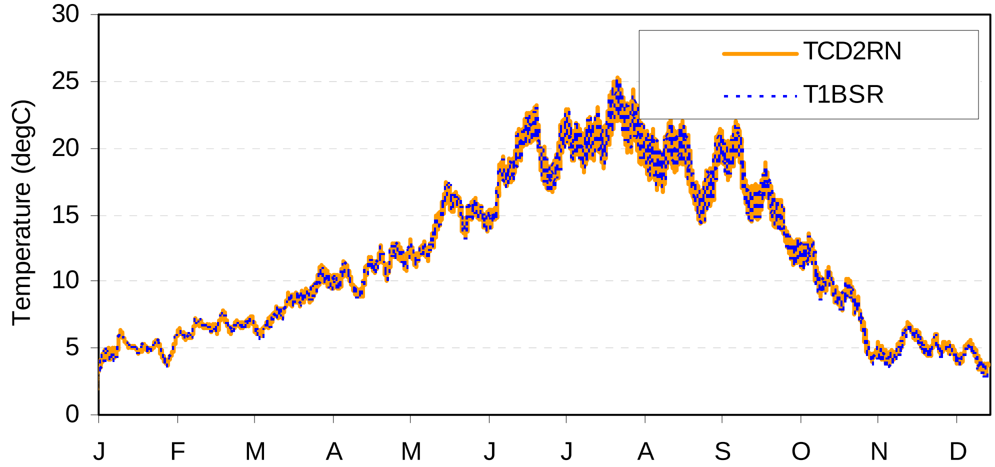
HOOPA

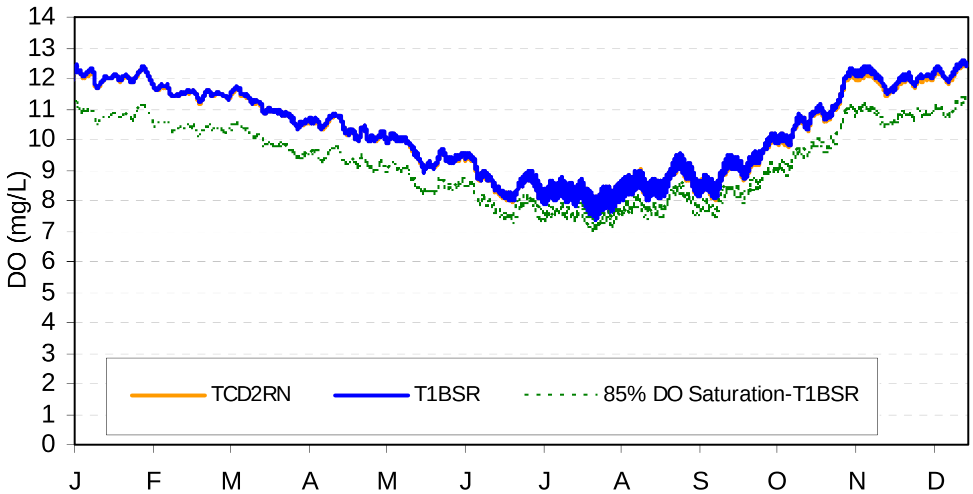

NH3-N Acute criteria
Modeled NH3-N
NH3-N (mg/L)
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
J F M A M J J A S O N D

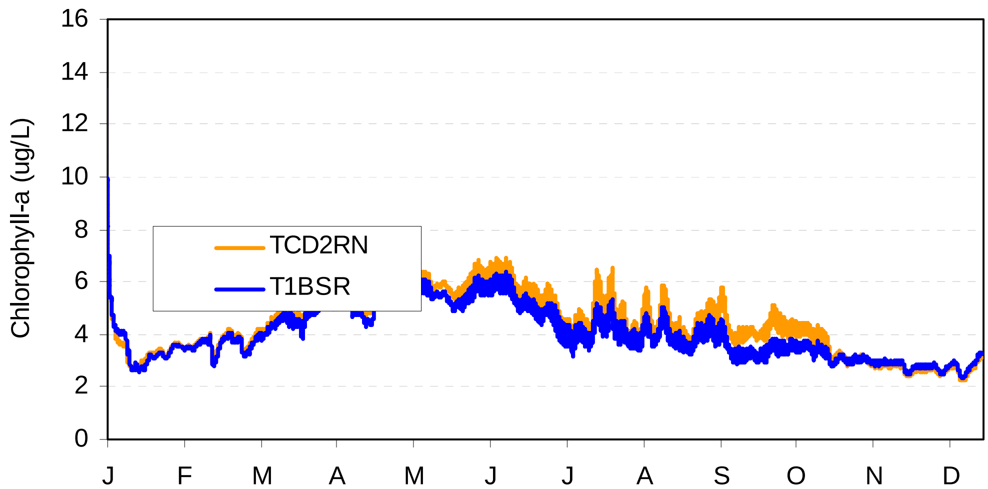

NH3-N Chronic criteria
Modeled 30- day running Avg
NH3-N (mg/L)
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
J F M A M J J A S O N D


2.5xCCC
Modeled 4-day running Avg
NH3-N (mg/L)
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0

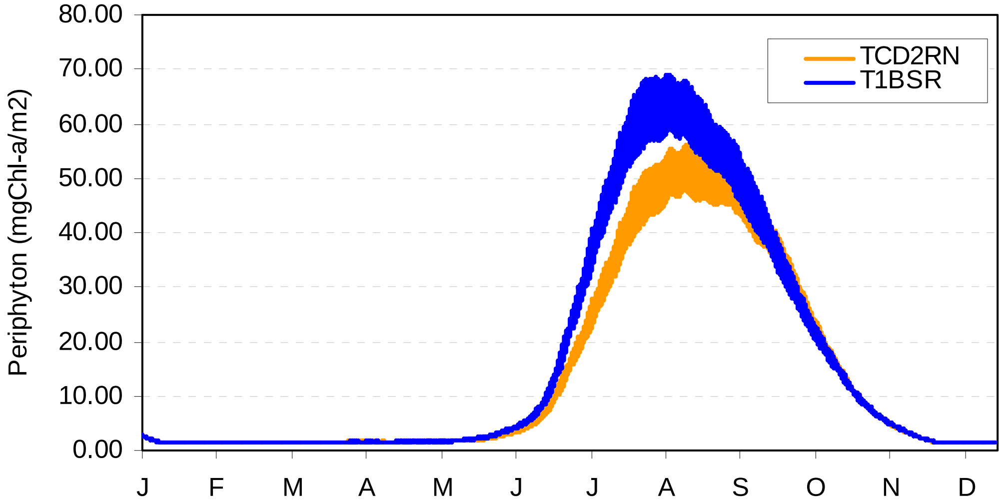
US_TRINITY

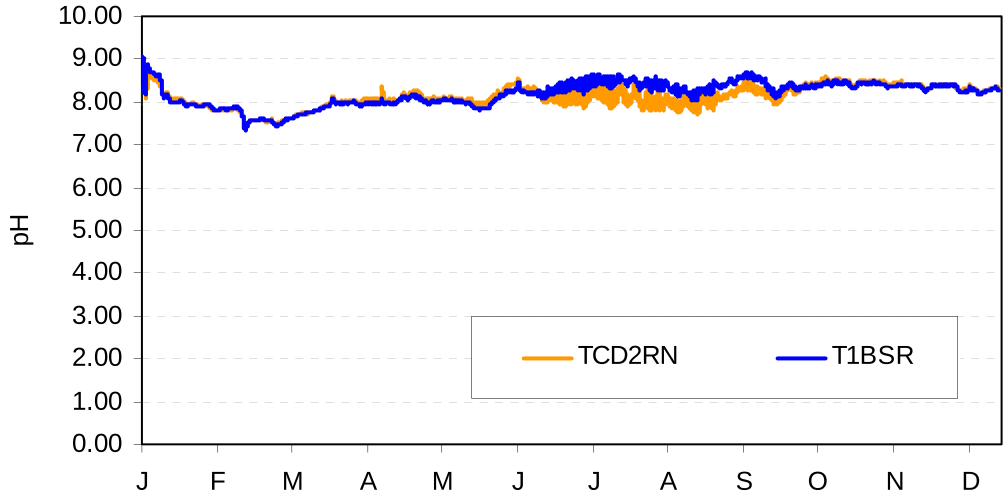

Temperature (degC)
30
25
20
15
10
5
0
TCD2RN
T1BSR
J F M A M J J A S O N D

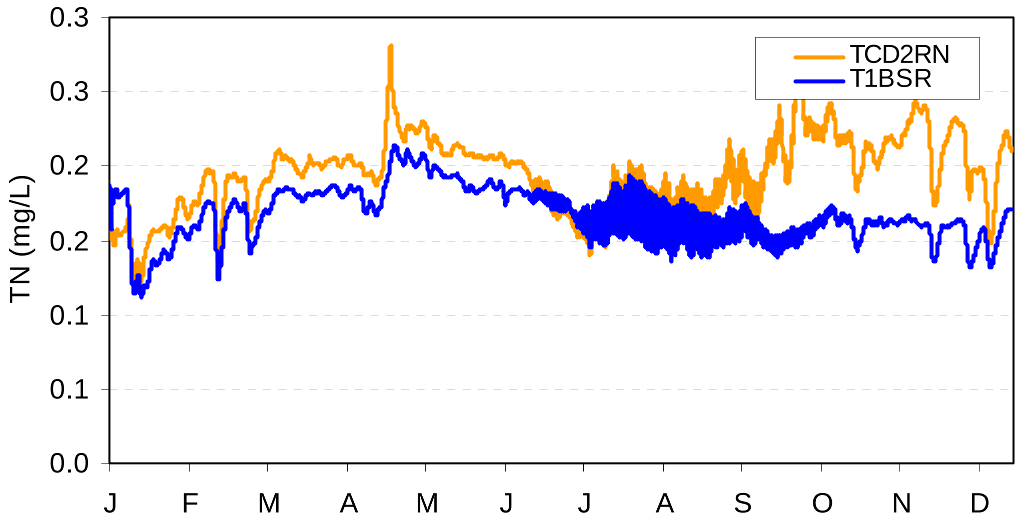

DO (mg/L)
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
TCD2RN
T1BSR
85% DO Saturation-T1BSR
J F M A M J J A S O N D


Chlorophyll-a (ug/L)
16
14
12
10
8
6
4
2
0
TCD2RN
T1BSR
J F M A M J J A S O N D

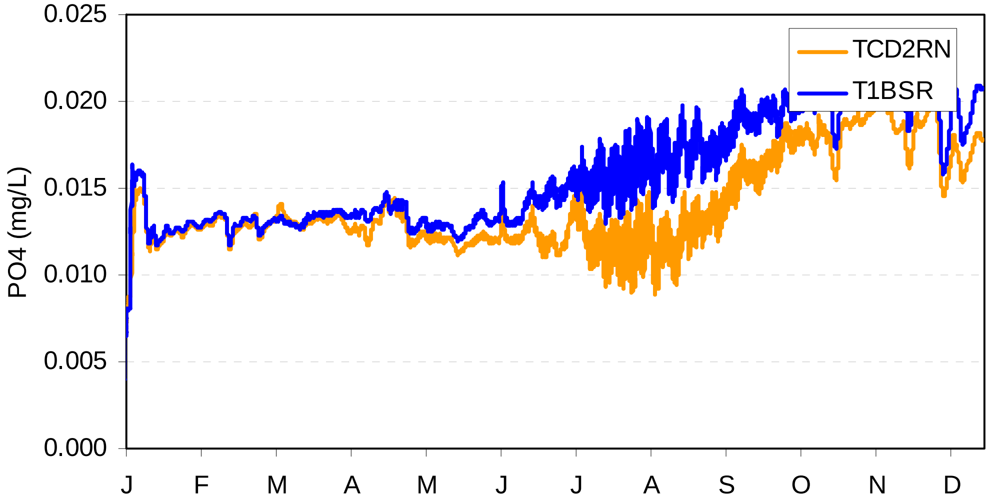
US_TRINITY


80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
Periphyton (mgChl-a/m2)
TCD2RN
T1BSR
J F M A M J J A S O N D

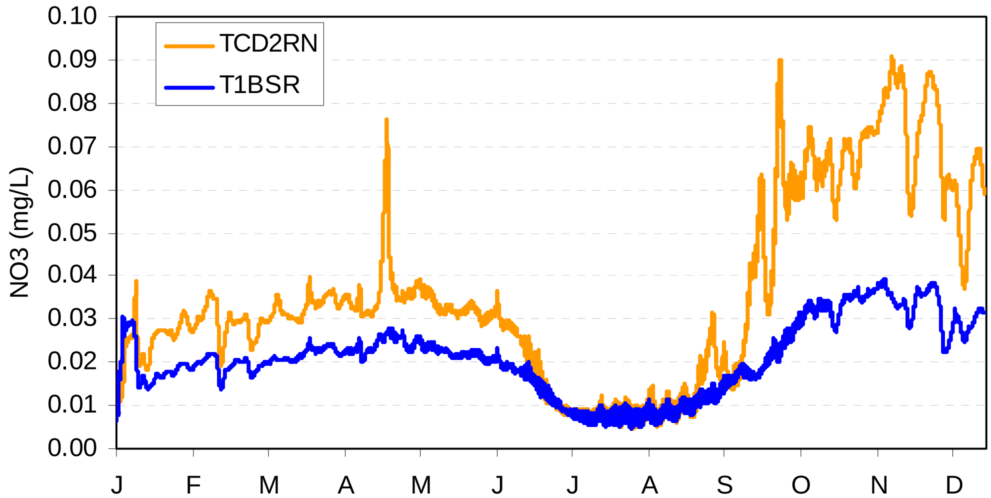

10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
pH
TCD2RN
T1BSR
J F M A M J J A S O N D


0.3
0.3
0.2
0.2
0.1
0.1
0.0
TN (mg/L)
TCD2RN
T1BSR
J F M A M J J A S O N D

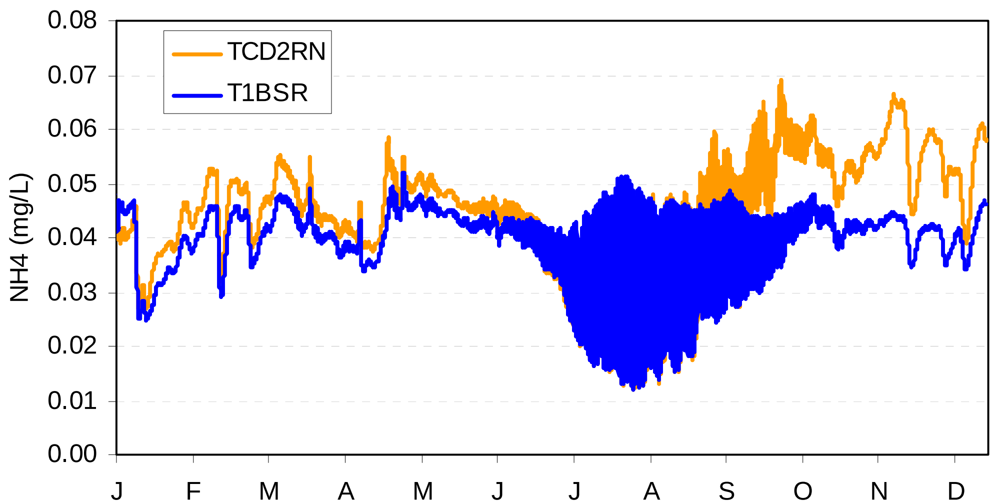
US_TRINITY



0.025
0.020
0.015
0.010
0.005
0.000
PO4 (mg/L)
J F M A M J J A S O N D
TCD2RN
T1BSR

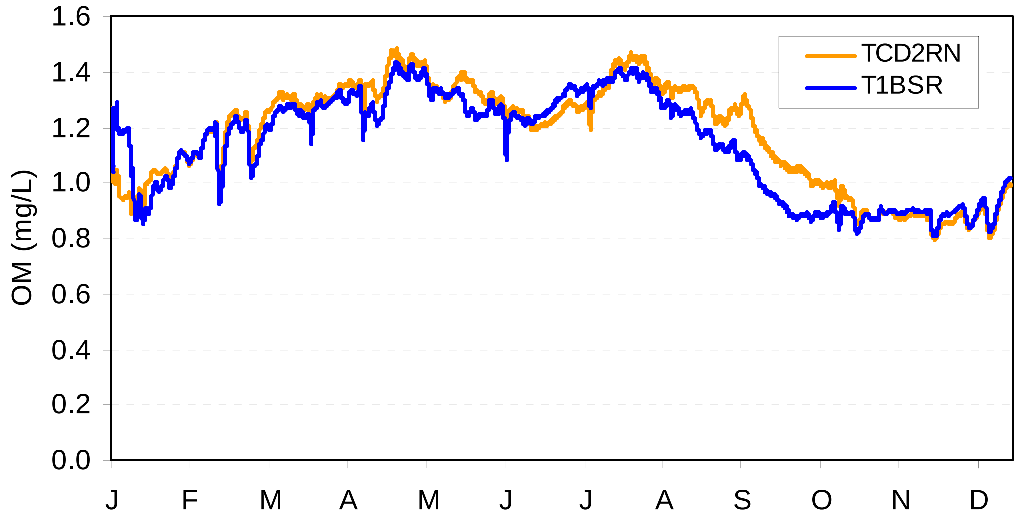


0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
NO3 (mg/L)
J F M A M J J A S O N D
TCD2RN
T1BSR

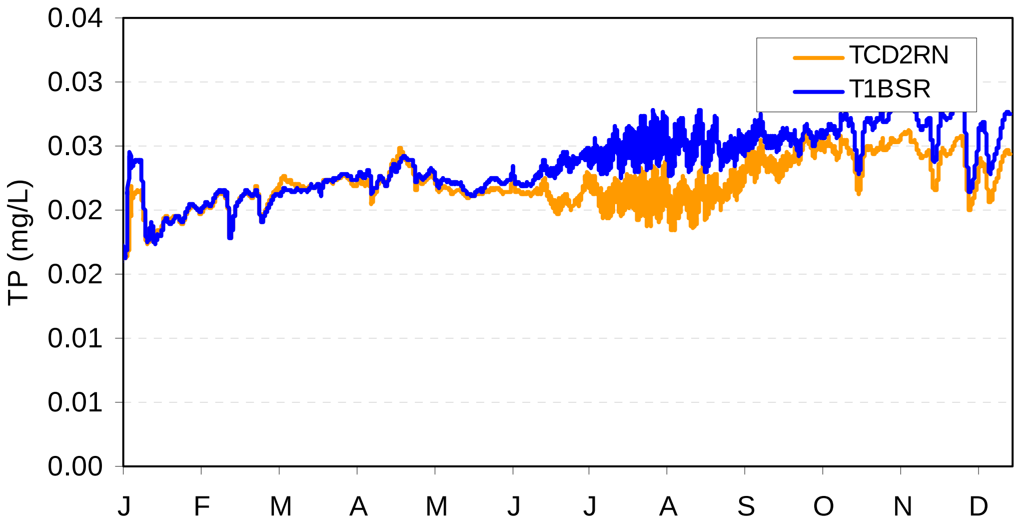


0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
NH4 (mg/L)
J F M A M J J A S O N D
TCD2RN
T1BSR

US_TRINITY

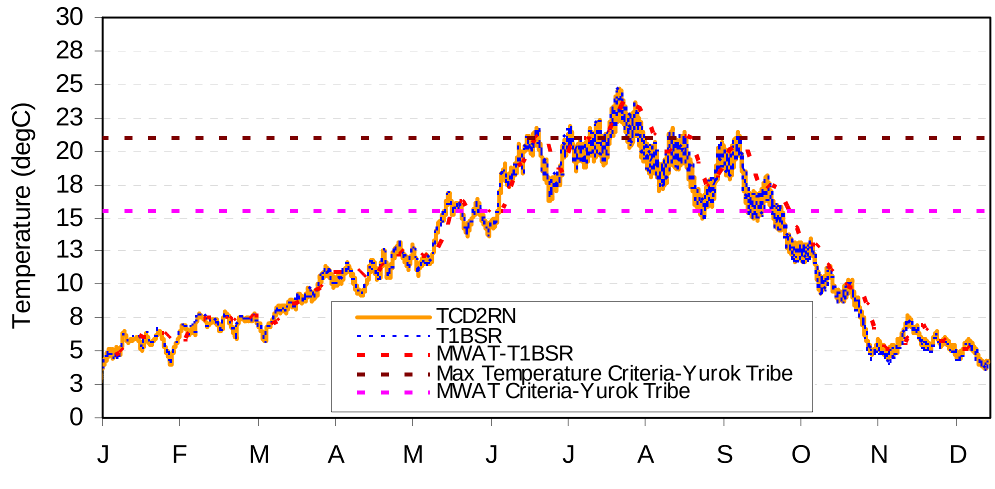


1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
OM (mg/L)
J F M A M J J A S O N D
TCD2RN
T1BSR

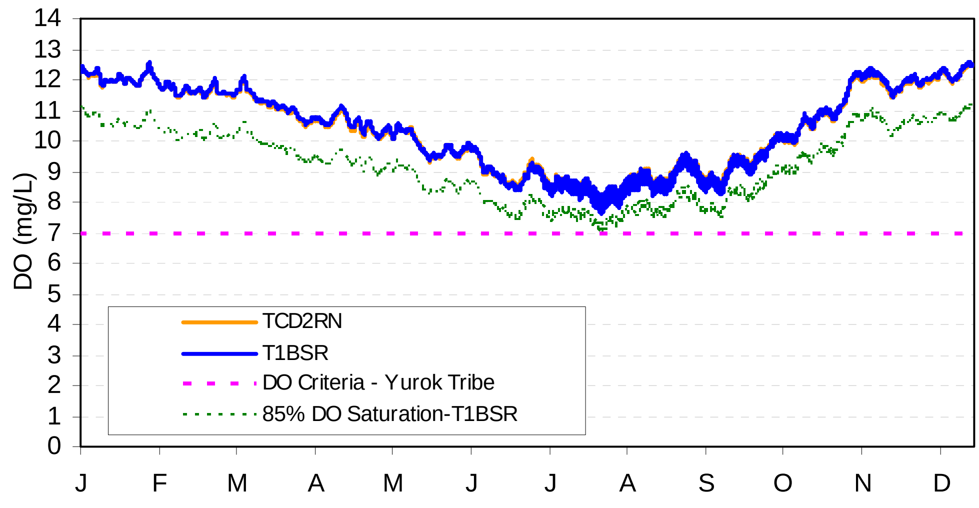


0.04
0.03
0.03
0.02
0.02
0.01
0.01
0.00
TP (mg/L)
J F M A M J J A S O N D
TCD2RN
T1BSR

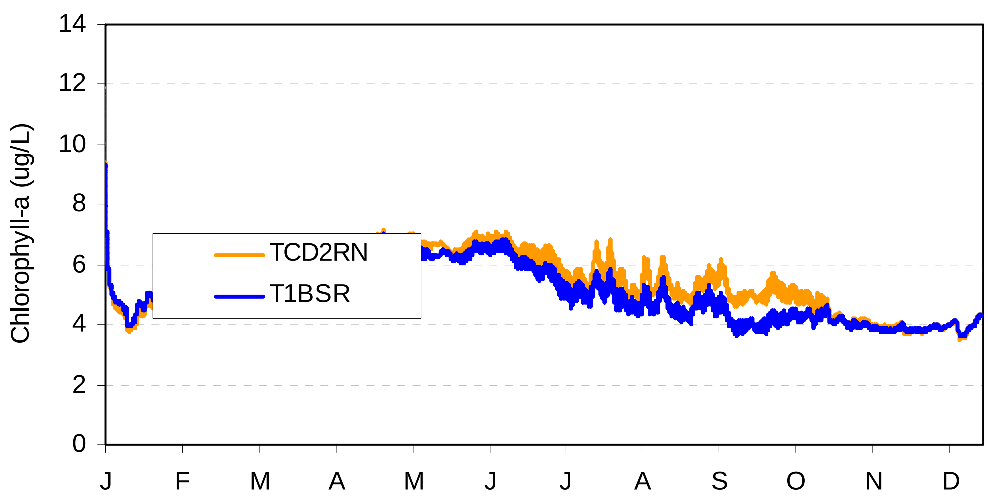
DS_TRINITY



Temperature (degC)
30
28
25
23
20
18
15
13
10
8
5
3
0
J
F
M
A
M
J
J
A
S
O
N
D
TCD2RN
T1BSR
MWAT-T1BSR
Max Temperature Criteria-Yurok Tribe
MWAT Criteria-Yurok Tribe

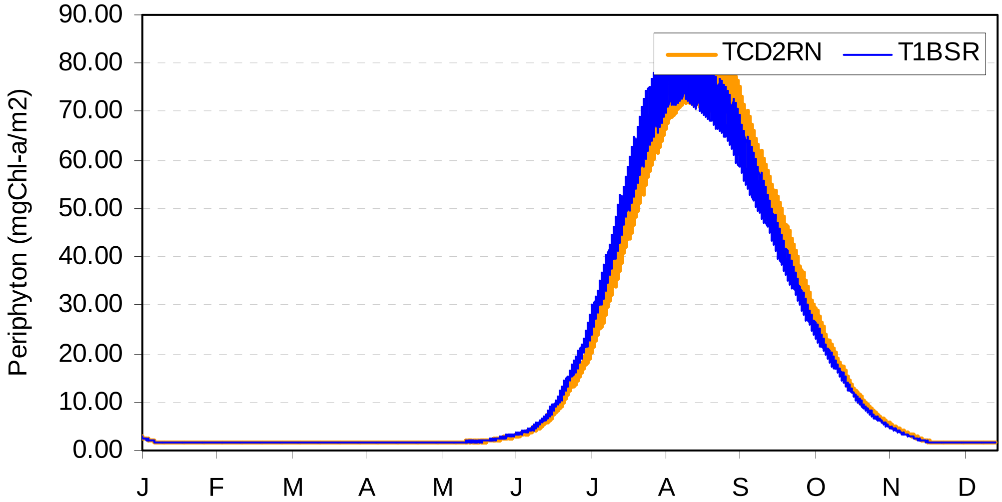


DO (mg/L)
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
J
F
M
A
M
J
J
A
S
O
N
D
TCD2RN
T1BSR
DO Criteria - Yurok Tribe
85% DO Saturation-T1BSR

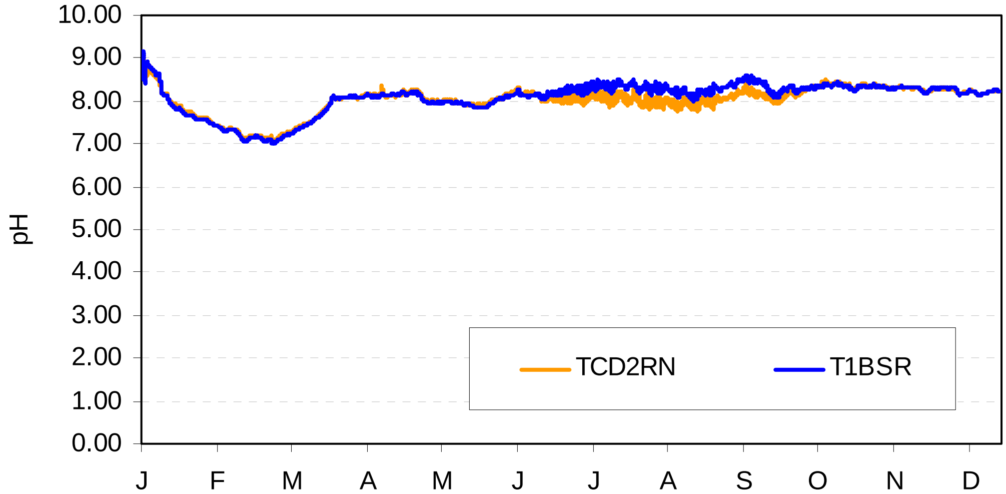


Chlorophyll-a (ug/L)
14
12
10
8
6
4
2
0
J
F
M
A
M
J
J
A
S
O
N
D
TCD2RN
T1BSR

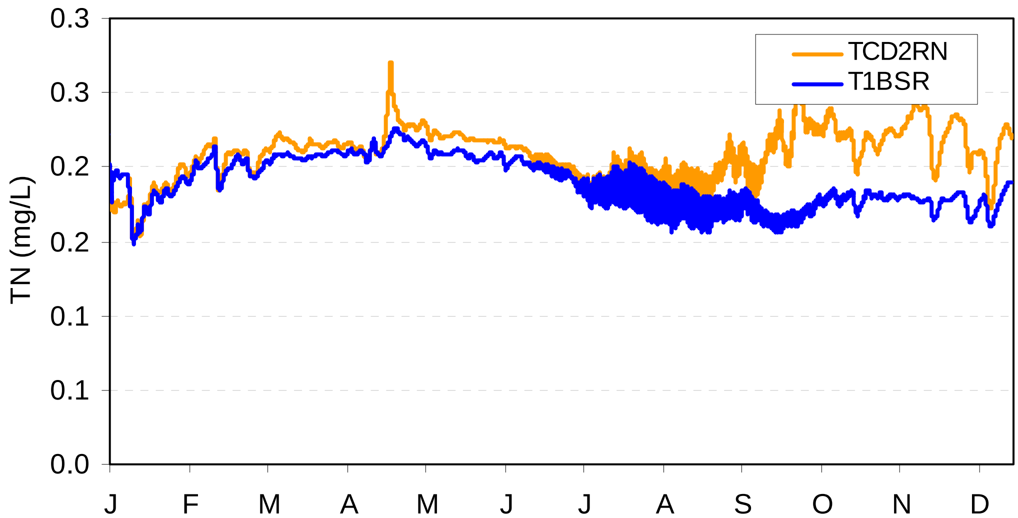
DS_TRINITY



Periphyton (mgChl-a/m2)
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
TCD2RN
T1BSR
J
F
M
A
M
J
J
A
S
O
N
D

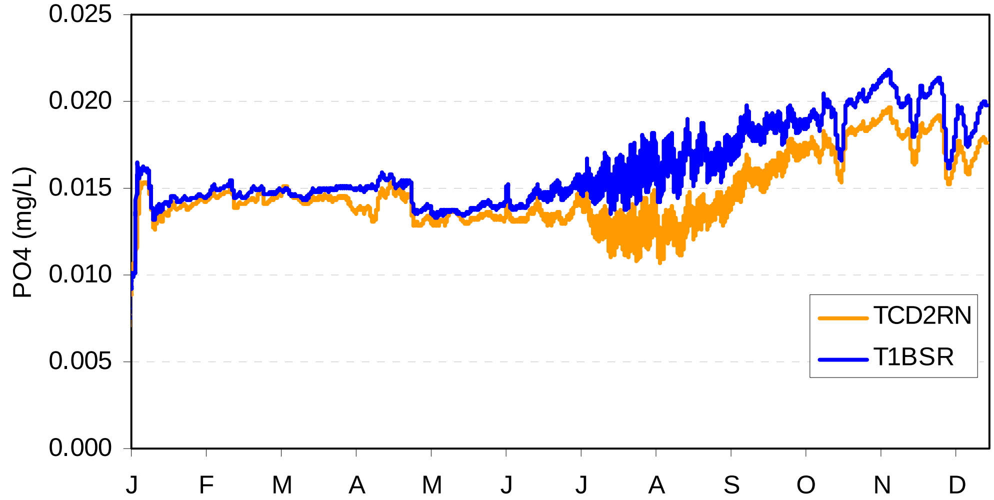


pH
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
TCD2RN
T1BSR
J
F
M
A
M
J
J
A
S
O
N
D

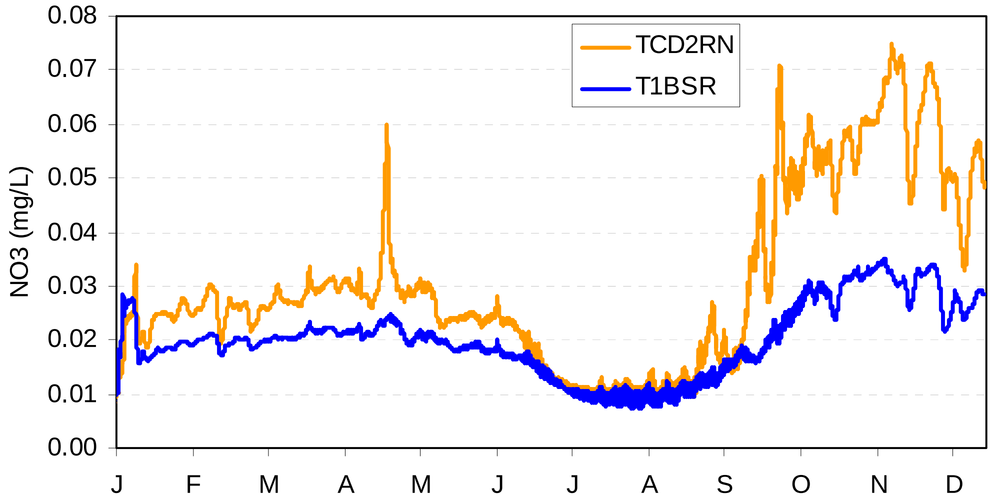


TN (mg/L)
0.3
0.3
0.2
0.2
0.1
0.1
0.0
TCD2RN
T1BSR
J
F
M
A
M
J
J
A
S
O
N
D

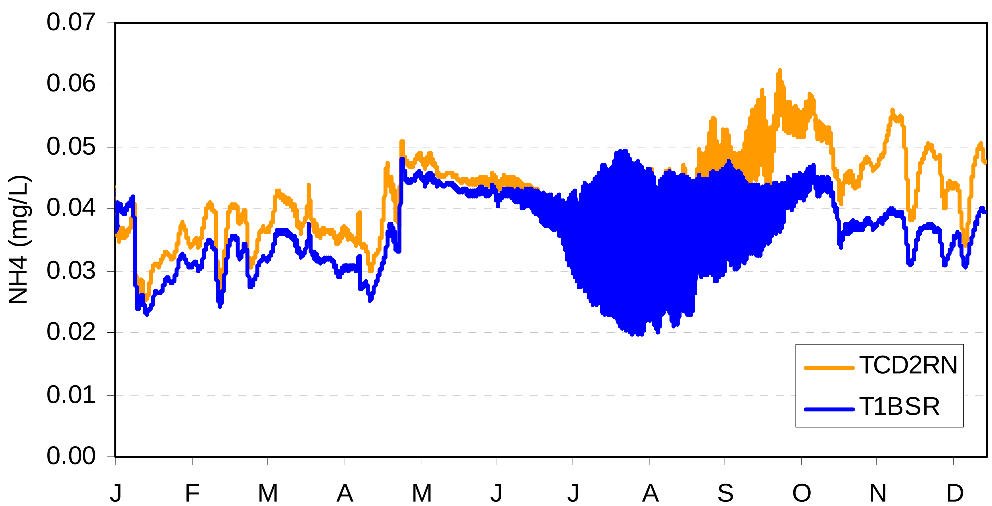
DS_TRINITY



0.025
0.020
0.015
0.010
0.005
0.000
PO4 (mg/L)
J
F
M
A
M
J
J
A
S
O
N
D
TCD2RN
T1BSR

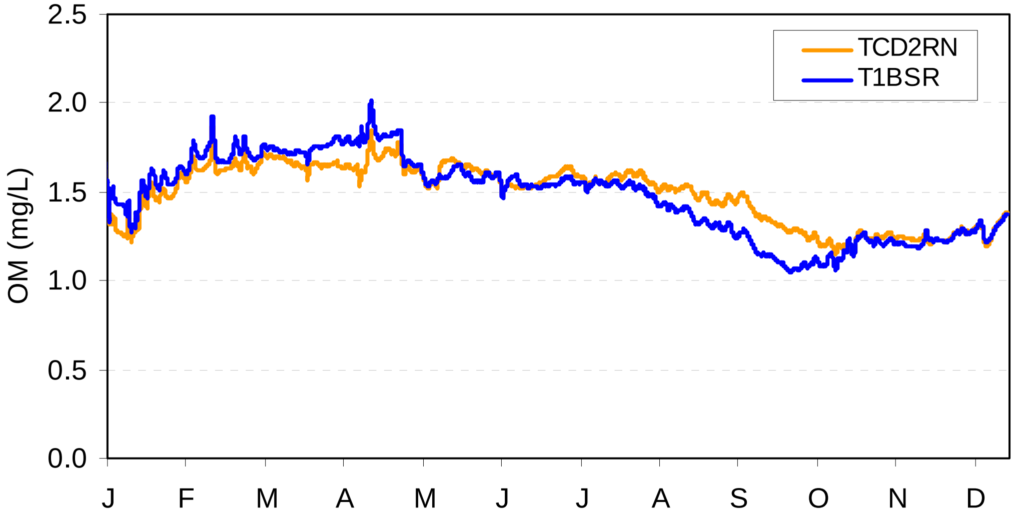


0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
NO3 (mg/L)
J
F
M
A
M
J
J
A
S
O
N
D
TCD2RN
T1BSR

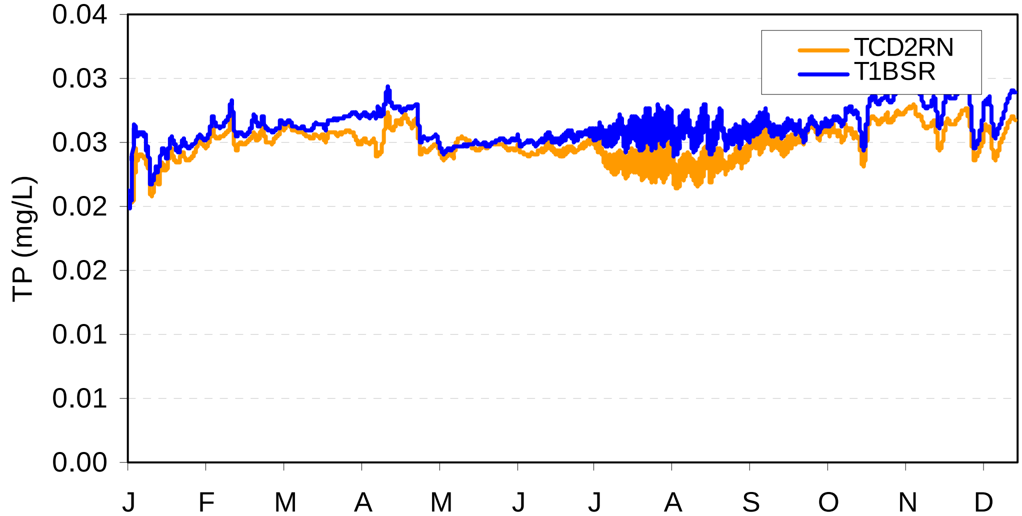


0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
NH4 (mg/L)
J
F
M
A
M
J
J
A
S
O
N
D
TCD2RN
T1BSR

DS_TRINITY

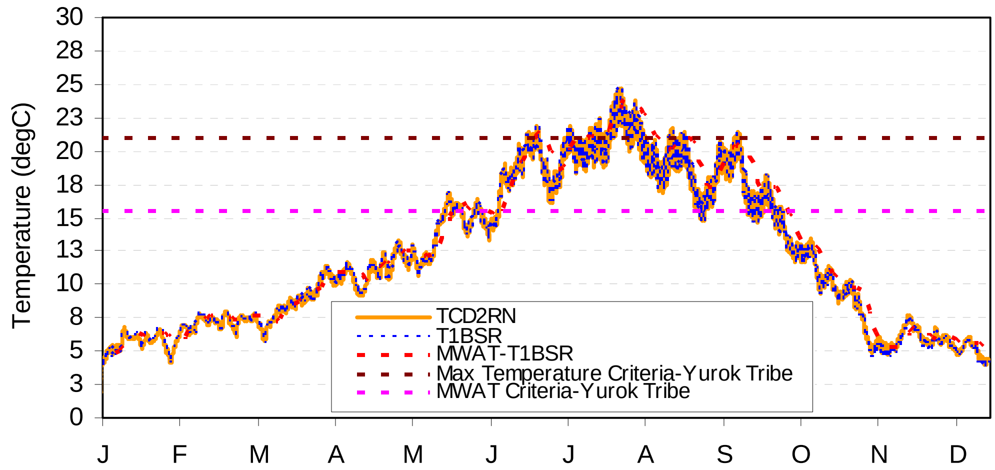


2.5
2.0
1.5
1.0
0.5
0.0
OM (mg/L)
TCD2RN
T1BSR
J
F
M
A
M
J
J
A
S
O
N
D

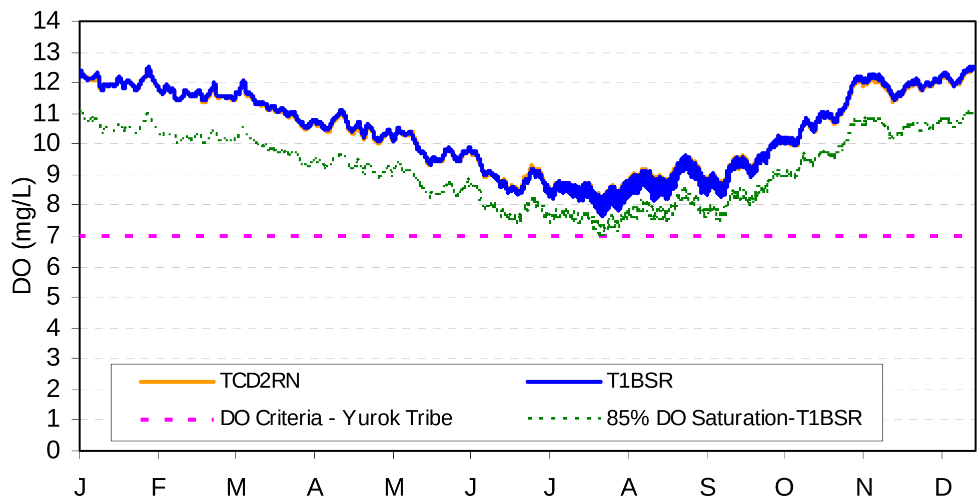


0.04
0.03
0.03
0.02
0.02
0.01
0.01
0.00
TP (mg/L)
TCD2RN
T1BSR
J
F
M
A
M
J
J
A
S
O
N
D

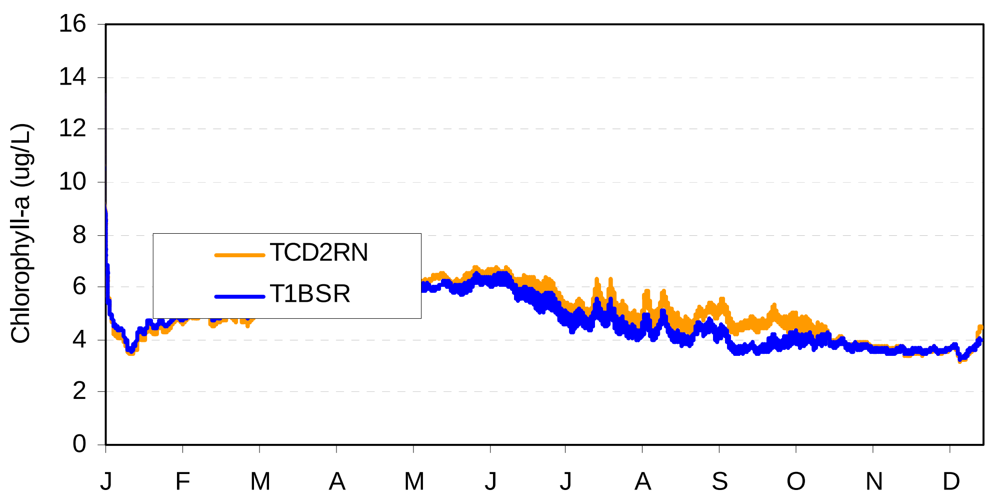
YOUNGSBAR



Temperature (degC)
TCD2RN
T1BSR
MWAT-T1BSR
Max Temperature Criteria-Yurok Tribe
MWAT Criteria-Yurok Tribe
J F M A M J J A S O N D

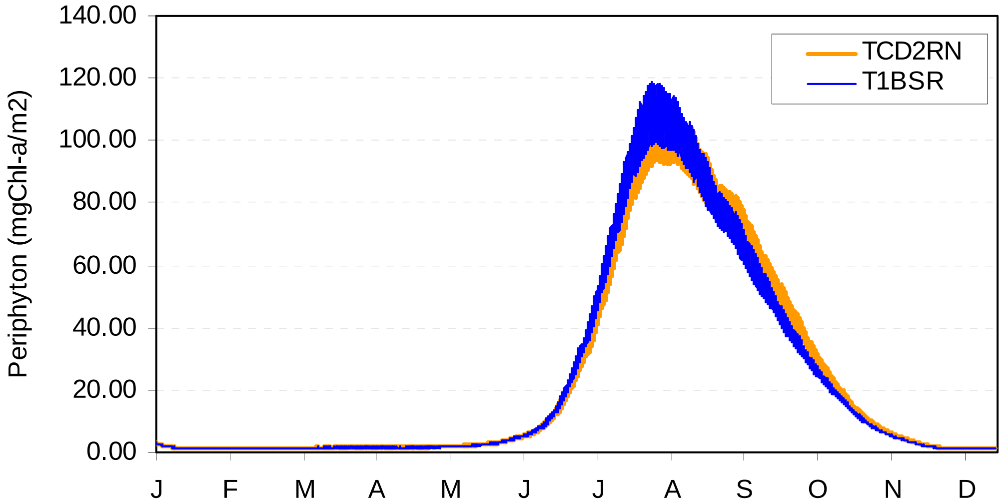


DO (mg/L)
TCD2RN
T1BSR
DO Criteria - Yurok Tribe
85% DO Saturation-T1BSR
J F M A M J J A S O N D

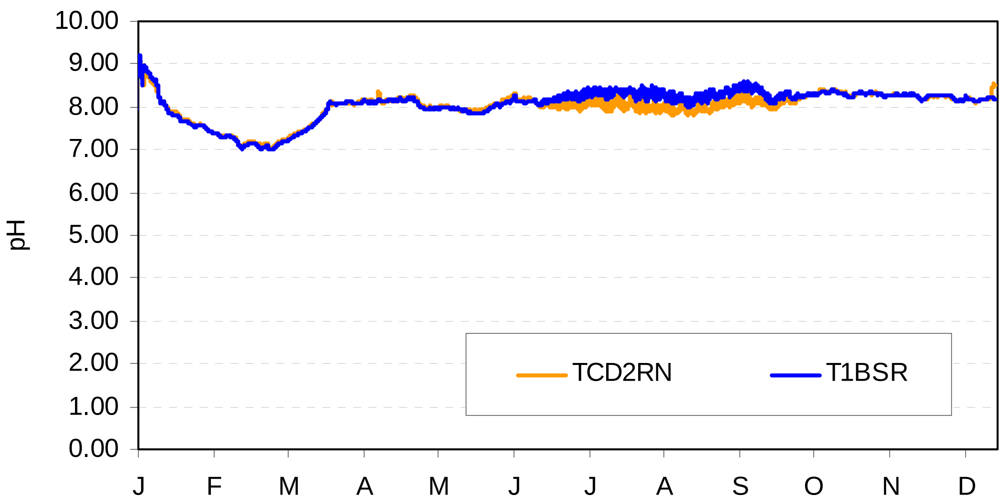


Chlorophyll-a (ug/L)
TCD2RN
T1BSR
J F M A M J J A S O N D

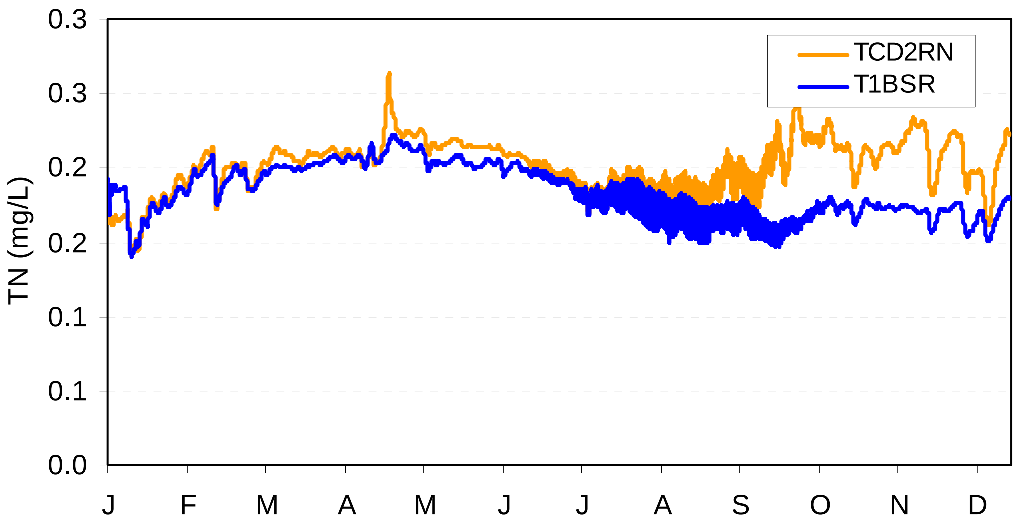
YOUNGSBAR



Periphyton (mgChl-a/m2)
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
J F M A M J J A S O N D
TCD2RN
T1BSR

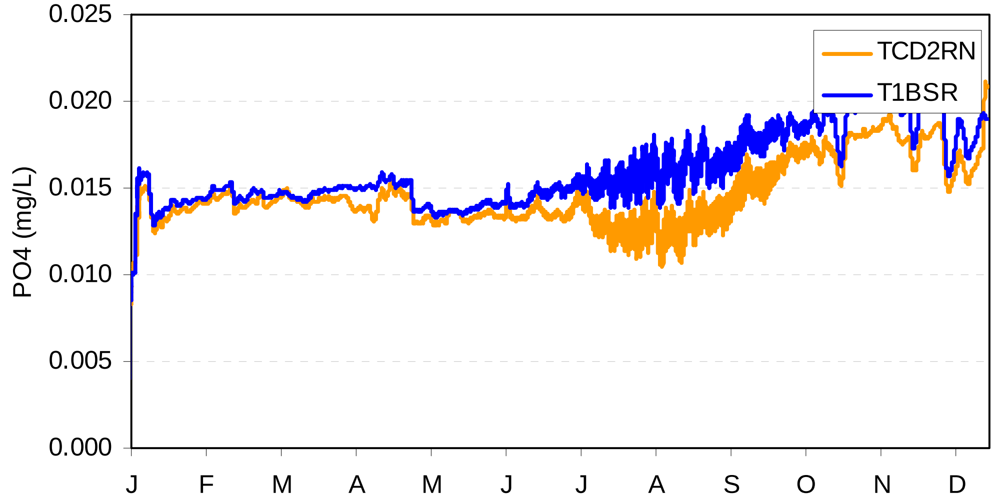


pH
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
J F M A M J J A S O N D
TCD2RN
T1BSR

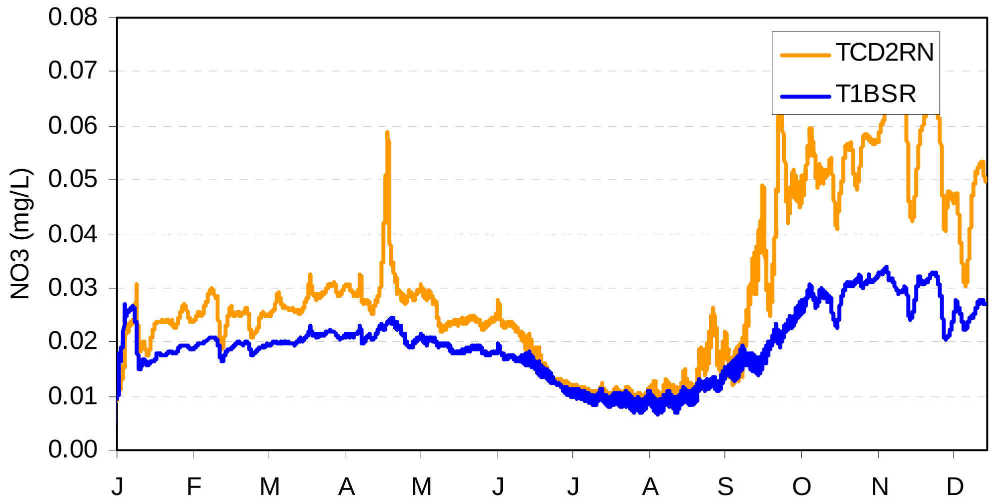


TN (mg/L)
0.3
0.3
0.2
0.2
0.1
0.1
0.0
J F M A M J J A S O N D
TCD2RN
T1BSR

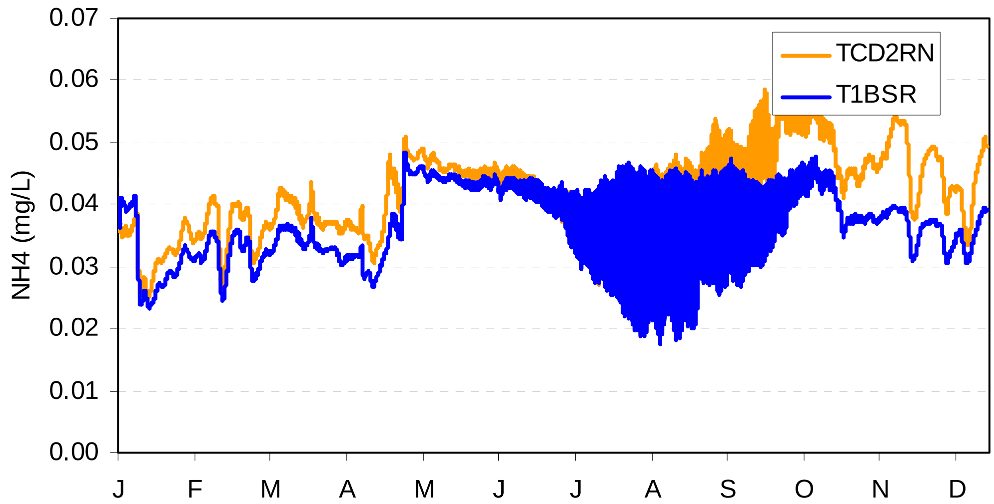
YOUNGSBAR



PO4 (mg/L)
0.025
0.020
0.015
0.010
0.005
0.000
J F M A M J J A S O N D
TCD2RN
T1BSR

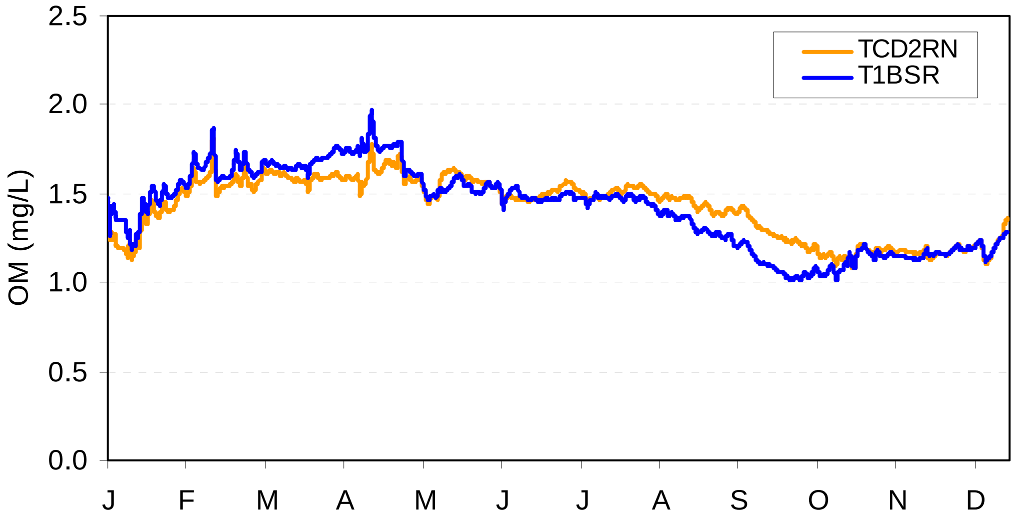


NO3 (mg/L)
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
J F M A M J J A S O N D
TCD2RN
T1BSR

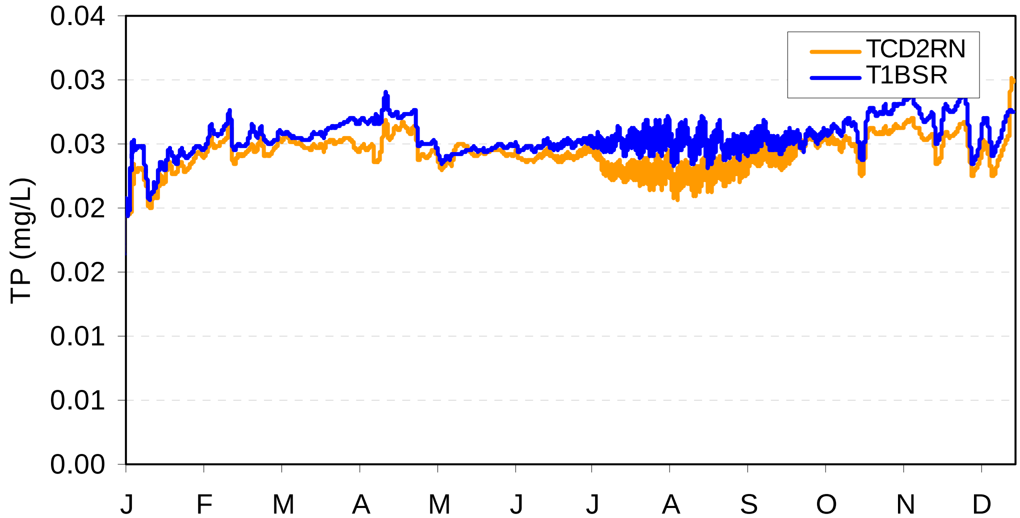


NH4 (mg/L)
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
J F M A M J J A S O N D
TCD2RN
T1BSR

YOUNGSBAR

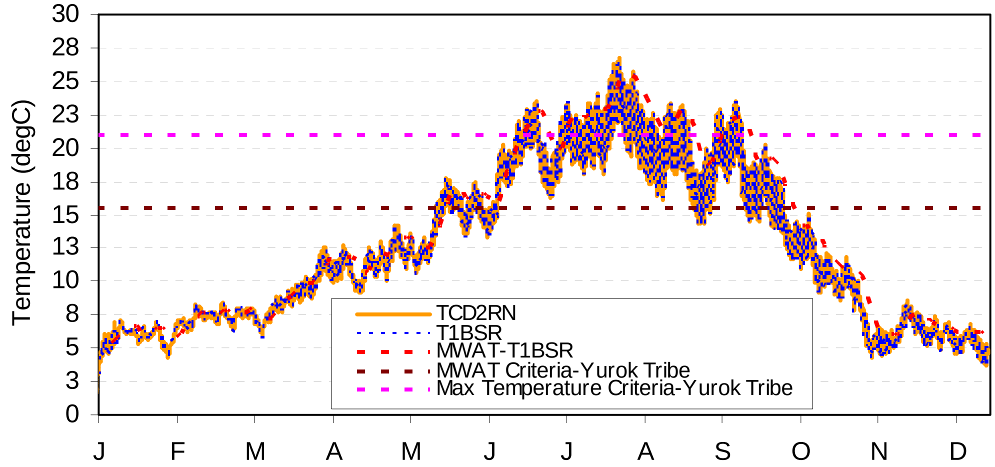


2.5
2.0
1.5
1.0
0.5
0.0
OM (mg/L)
J F M A M J J A S O N D
TCD2RN
T1BSR

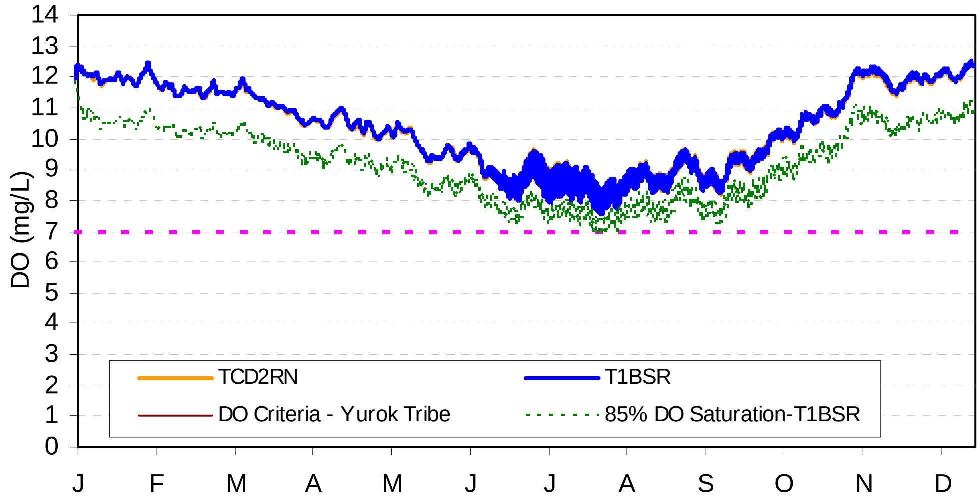


0.04
0.03
0.03
0.02
0.02
0.01
0.01
0.00
TP (mg/L)
J F M A M J J A S O N D
TCD2RN
T1BSR

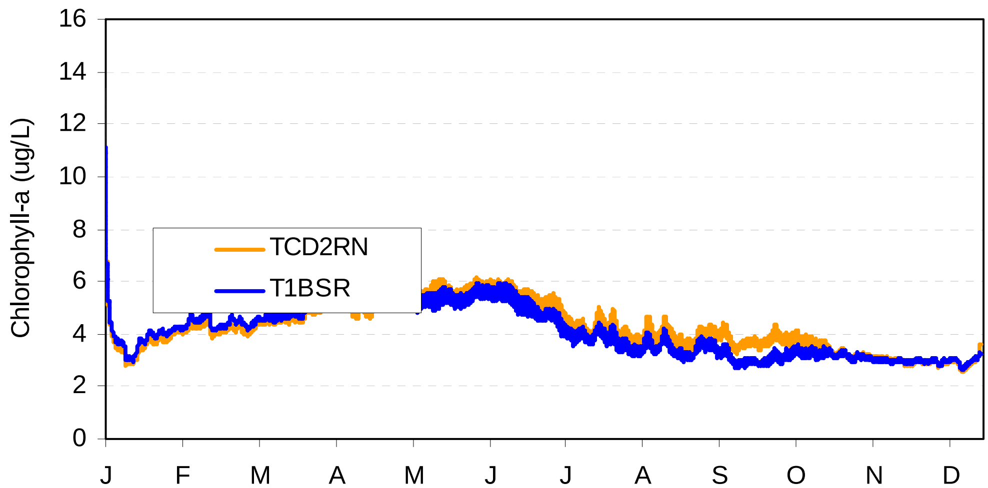
TURWAR



Temperature (degC)
30
28
25
23
20
18
15
13
10
8
5
3
0
J F M A M J J A S O N D
TCD2RN
T1BSR
MWAT-T1BSR
MWAT Criteria-Yurok Tribe
Max Temperature Criteria-Yurok Tribe

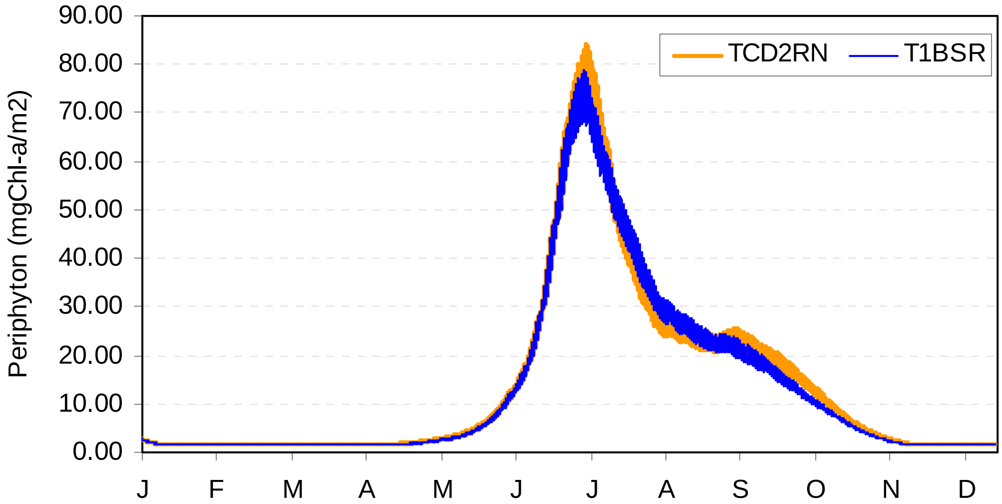


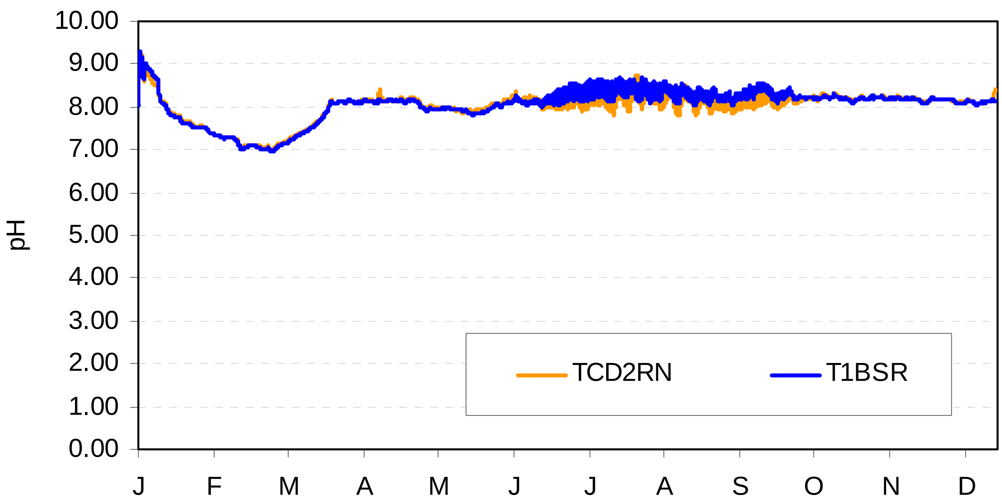
DO (mg/L)
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
J F M A M J J A S O N D
TCD2RN
T1BSR
DO Criteria - Yurok Tribe
85% DO Saturation-T1BSR

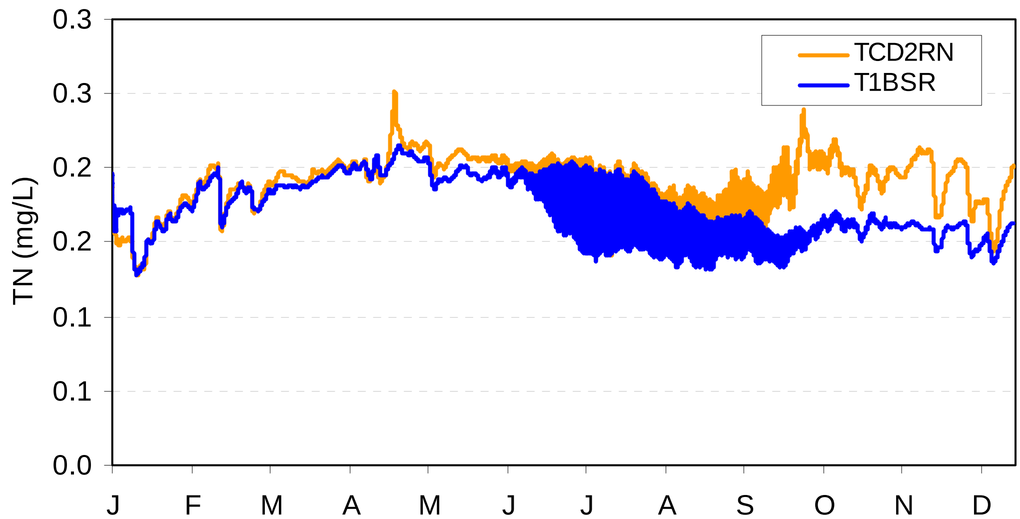


Chlorophyll-a (ug/L)
16
14
12
10
8
6
4
2
0
J F M A M J J A S O N D
TCD2RN
T1BSR

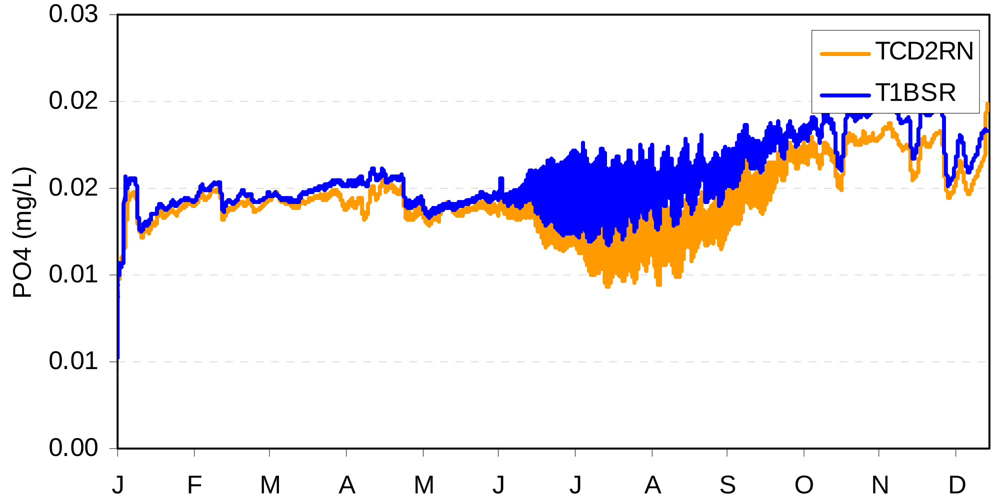
TURWAR


Periphyton (mgChl-a/m2)
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
J F M A M J J A S O N D
TCD2RN
T1BSR

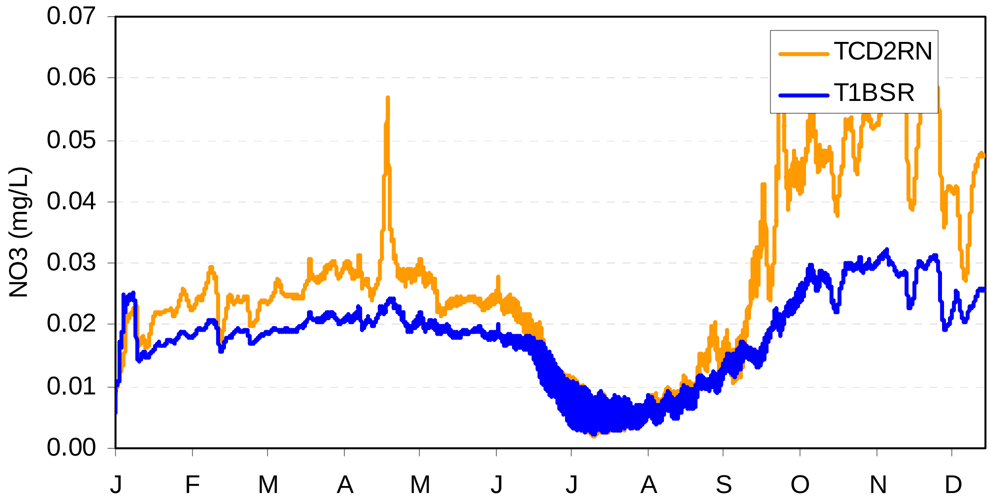

pH
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
J F M A M J J A S O N D
TCD2RN
T1BSR


TN (mg/L)
0.3
0.3
0.2
0.2
0.1
0.1
0.0
J F M A M J J A S O N D
TCD2RN
T1BSR

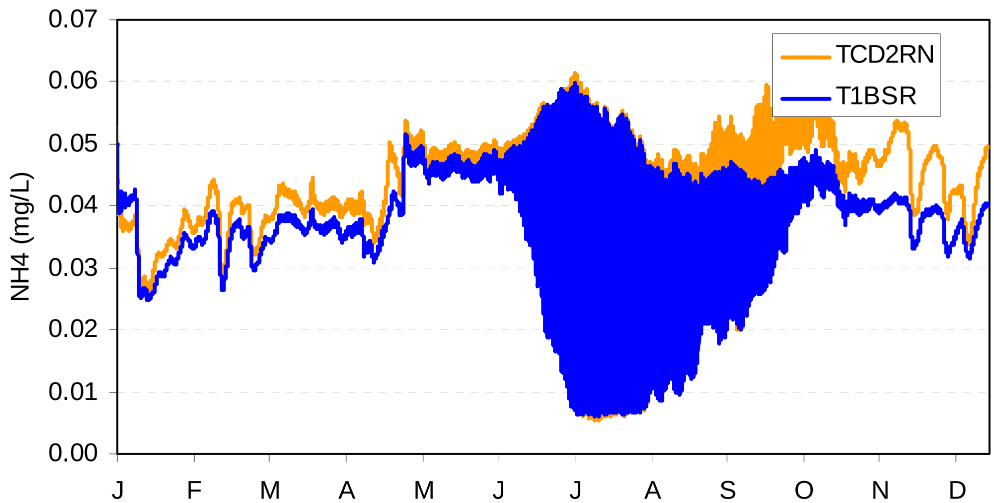
TURWAR



PO4 (mg/L)
0.03
0.02
0.02
0.01
0.01
0.00
J
F
M
A
M
J
J
A
S
O
N
D
TCD2RN
T1BSR

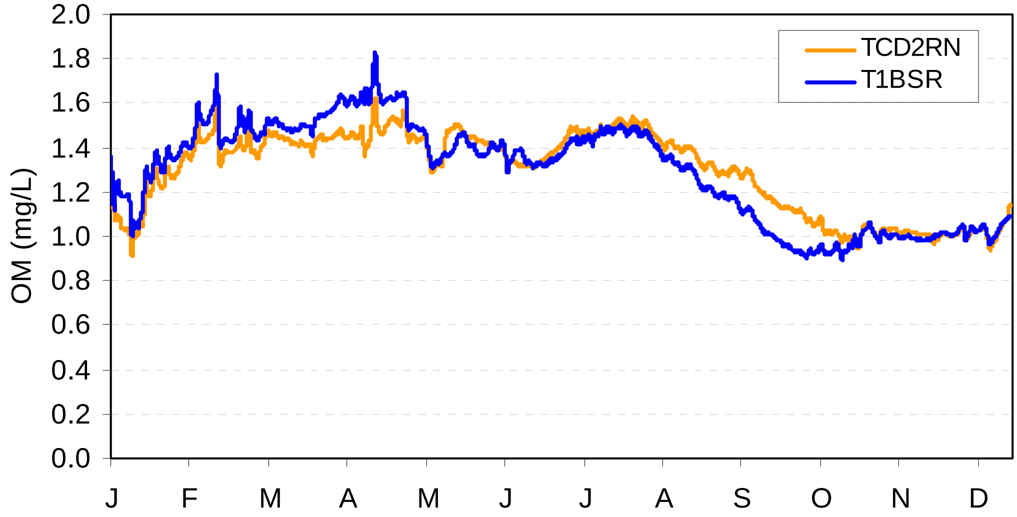


NO3 (mg/L)
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
J
F
M
A
M
J
J
A
S
O
N
D
TCD2RN
T1BSR

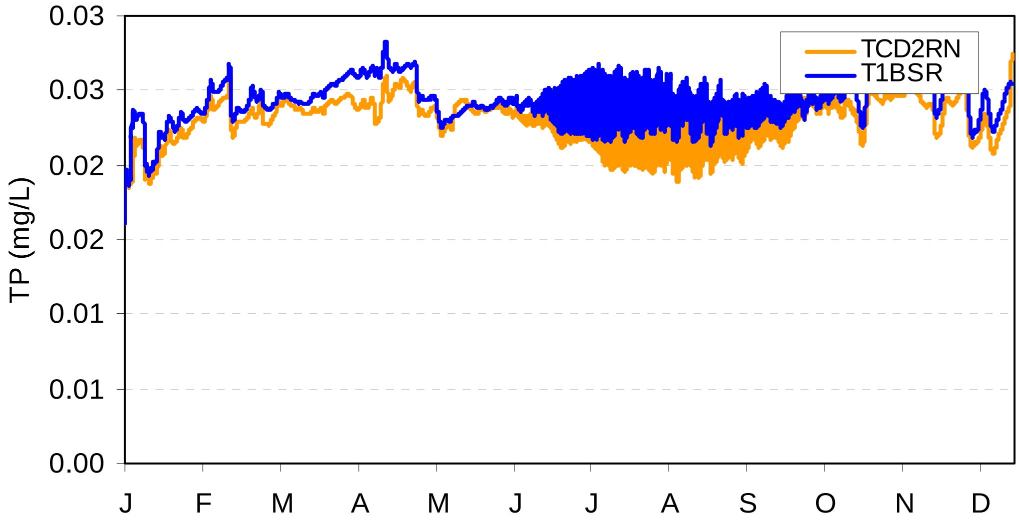


NH4 (mg/L)
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
J
F
M
A
M
J
J
A
S
O
N
D
TCD2RN
T1BSR

TURWAR

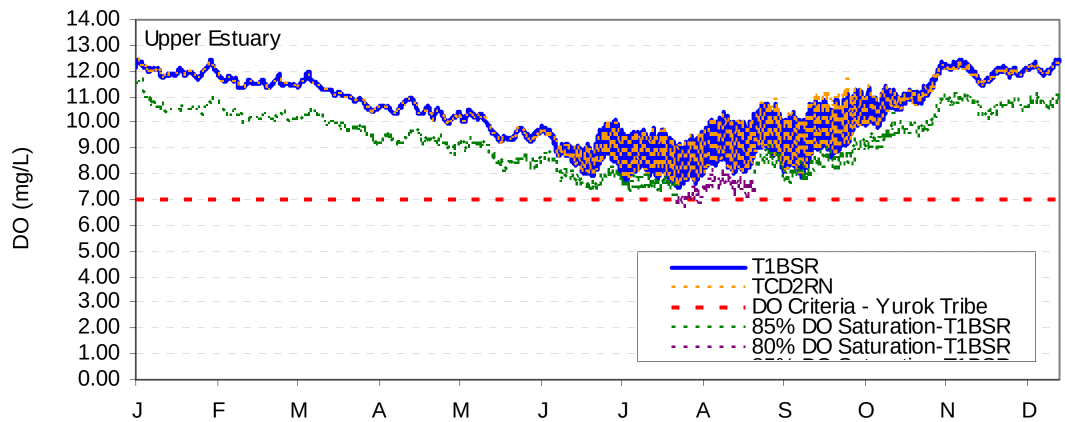


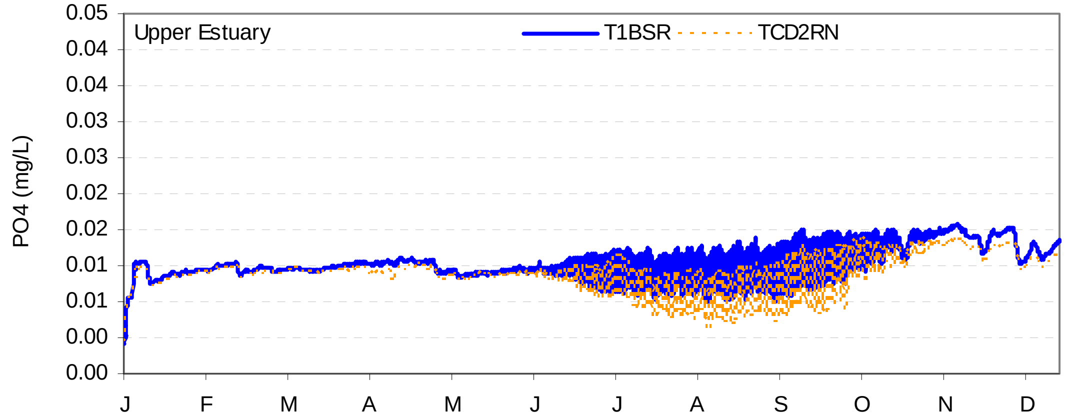
TCD2RN
T1BSR
OM (mg/L)
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
J F M A M J J A S O N D

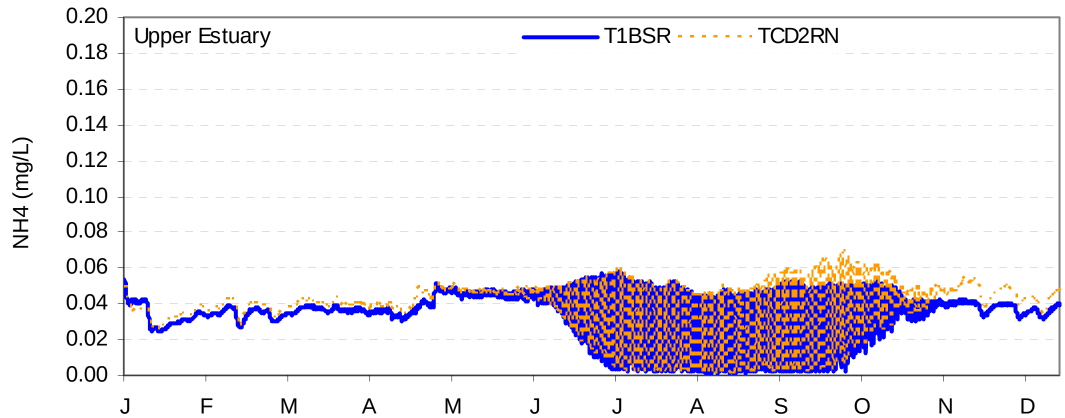


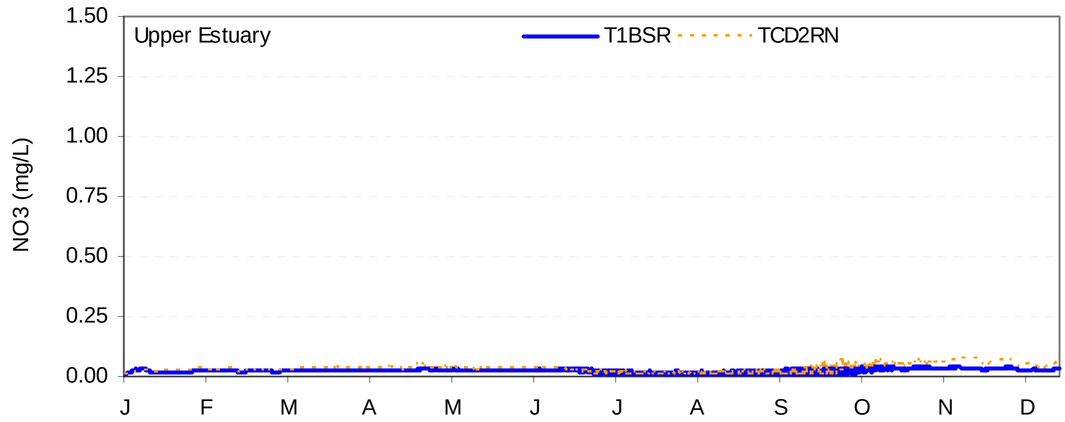
TCD2RN
T1BSR
TP (mg/L)
0.03
0.03
0.02
0.02
0.01
0.01
0.00
J F M A M J J A S O N D

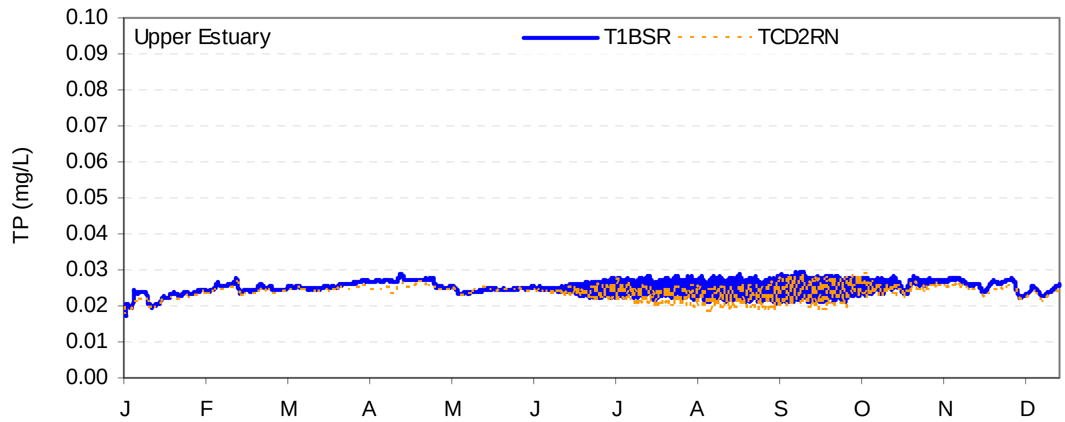
Upper Estuary

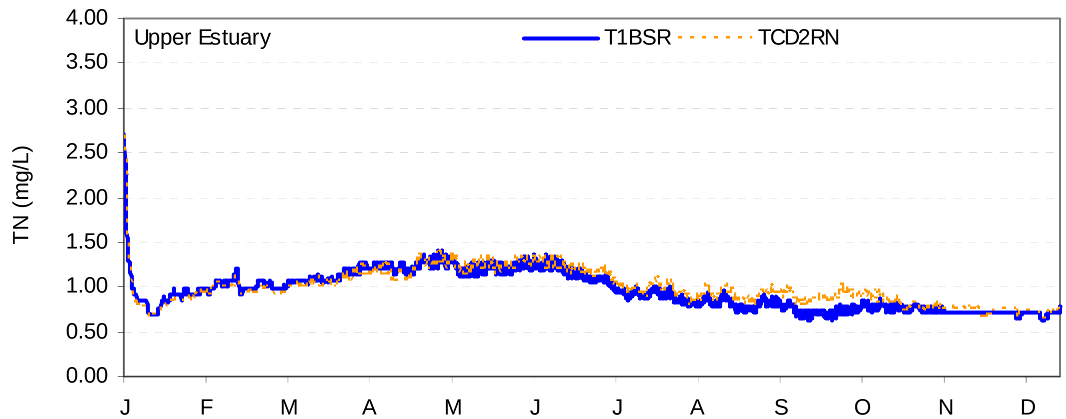


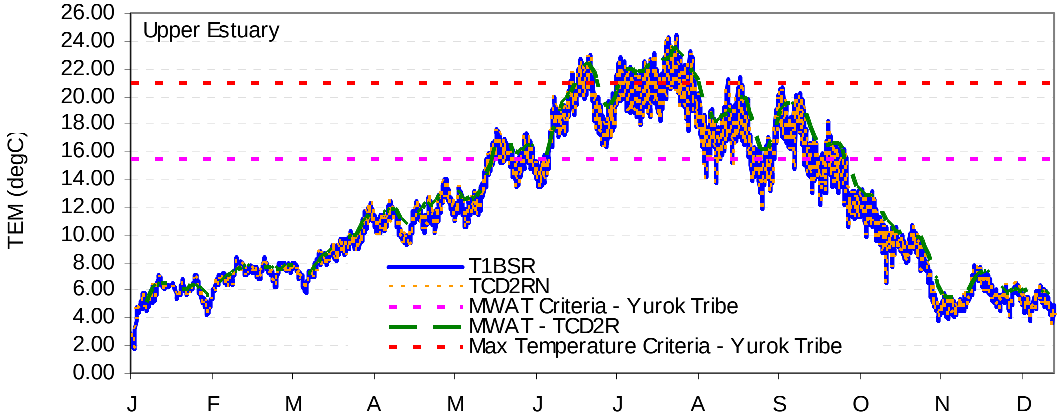


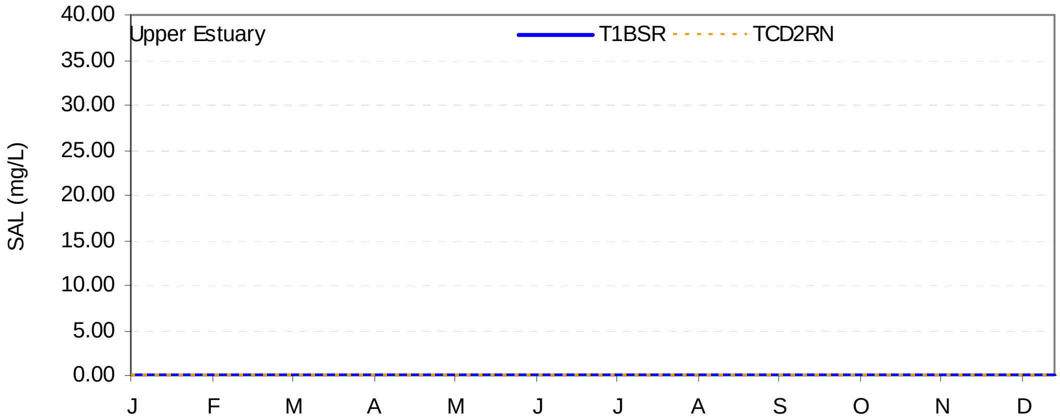


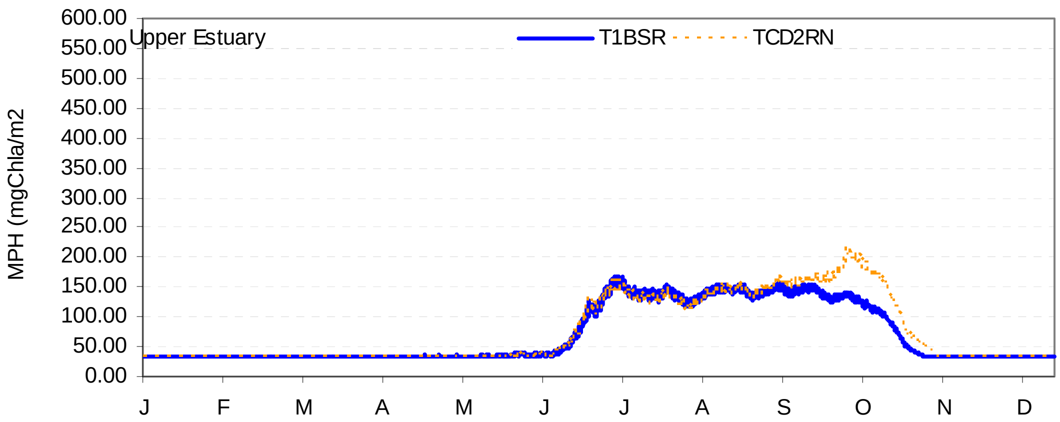

Upper Estuary
T1BSR
TCD2RN
NO3 (mg/L)
1.50
1.25
1.00
0.75
0.50
0.25
0.00
J F M A M J J A S O N D


Upper Estuary
T1BSR
TCD2RN
TP (mg/L)
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
J F M A M J J A S O N D

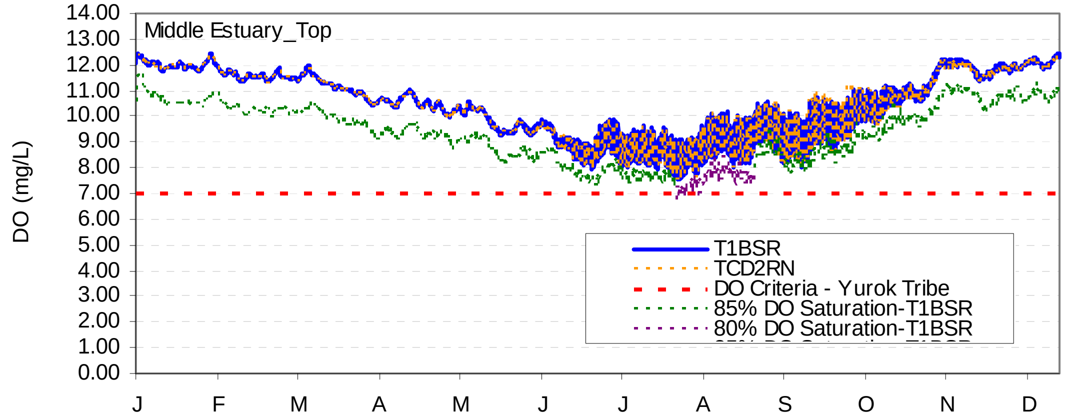

Upper Estuary
T1BSR
TCD2RN
TN (mg/L)
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
J F M A M J J A S O N D

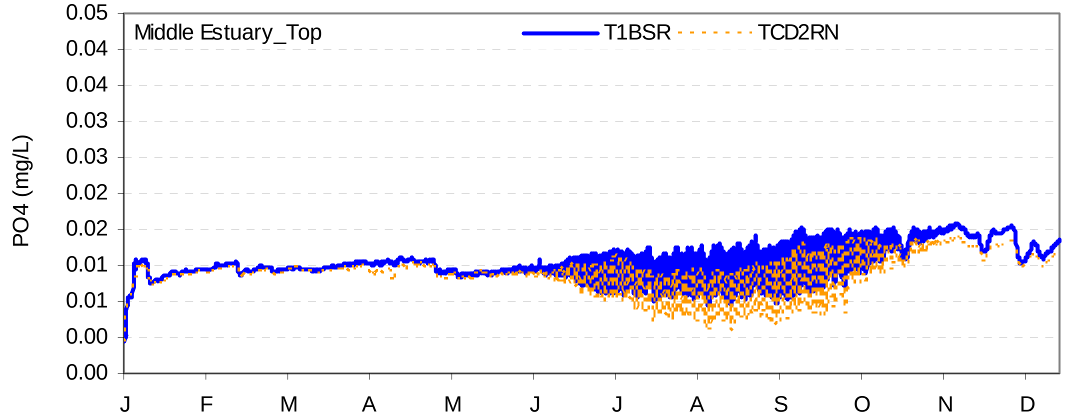

Upper Estuary
TEM (degC)
26.00
24.00
22.00
20.00
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
T1BSR
TCD2RN
MWAT Criteria - Yurok Tribe
MWAT - TCD2R
Max Temperature Criteria - Yurok Tribe
J F M A M J J A S O N D

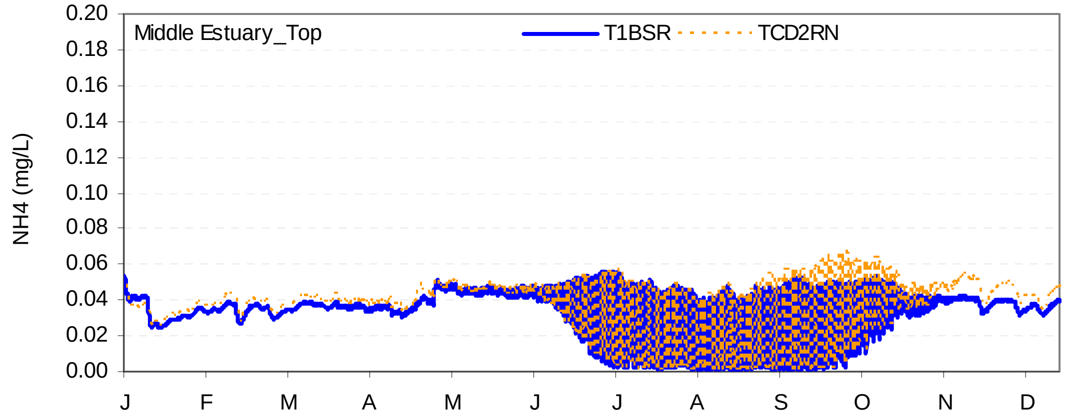

Upper Estuary
T1BSR
TCD2RN
SAL (mg/L)
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
J F M A M J J A S O N D

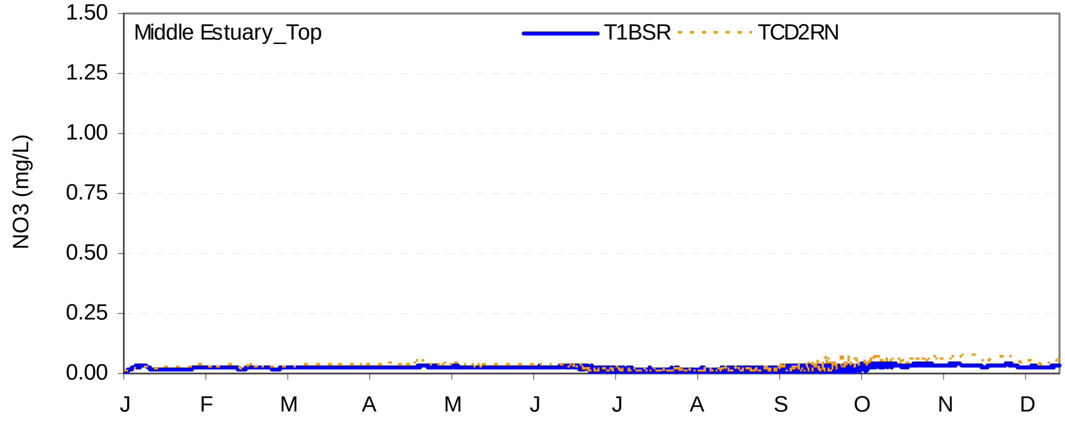

Upper Estuary
T1BSR
TCD2RN
MPH (mgChla/m2
600.00
550.00
500.00
450.00
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
J F M A M J J A S O N D

Middle Estuary - Top

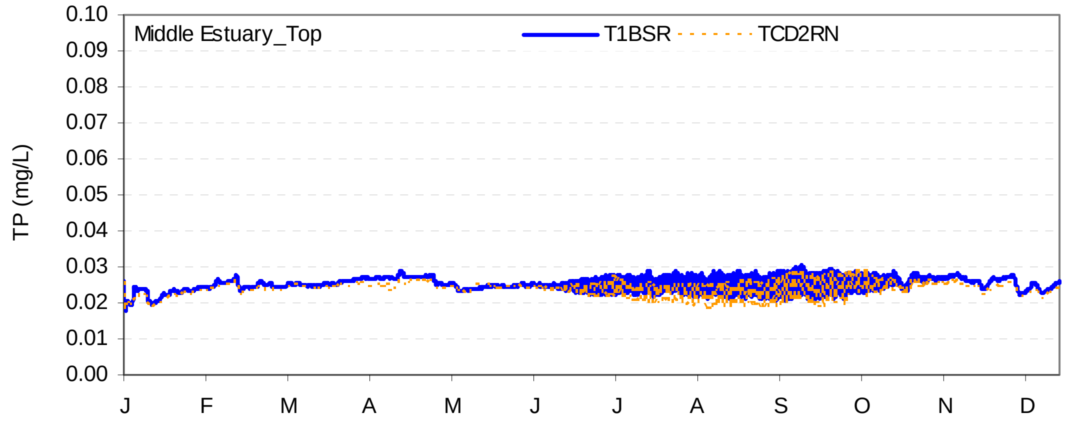




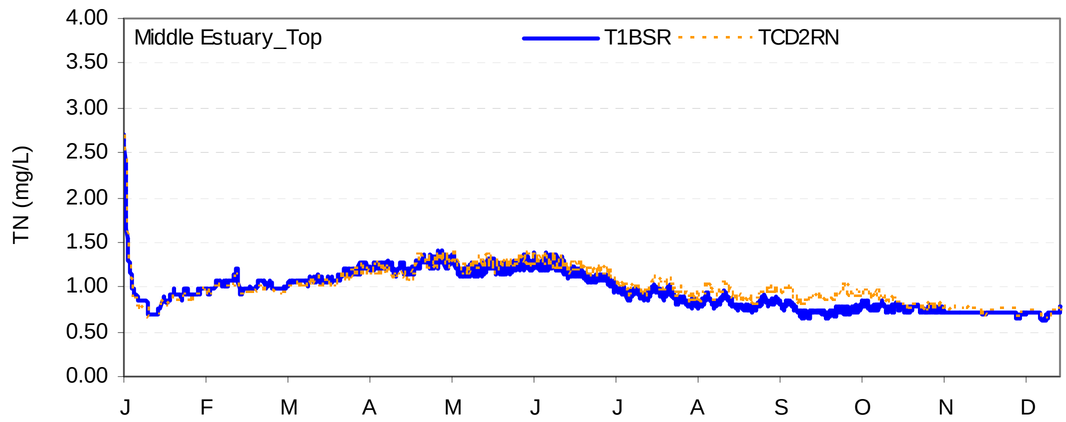




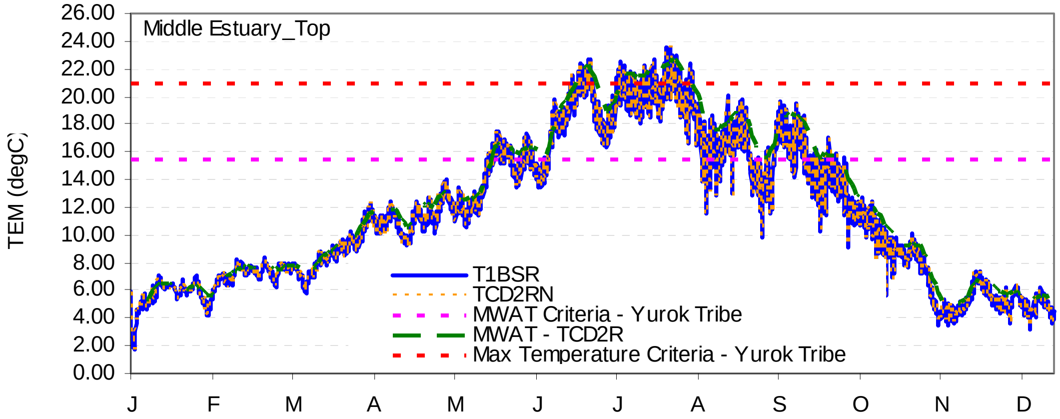
Middle Estuary_Top
T1BSR
TCD2RN
NO3 (mg/L)
1.50
1.25
1.00
0.75
0.50
0.25
0.00
J F M A M J J A S O N D

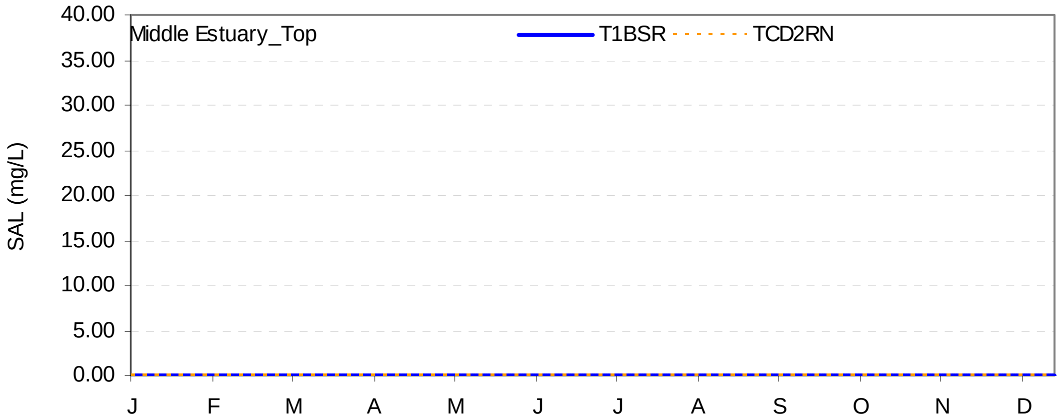


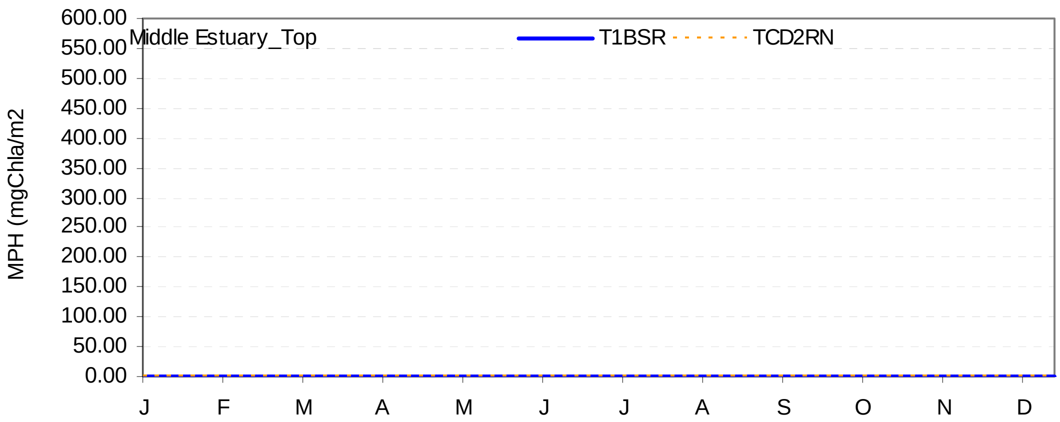
Middle Estuary_Top
T1BSR
TCD2RN
TP (mg/L)
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
J F M A M J J A S O N D



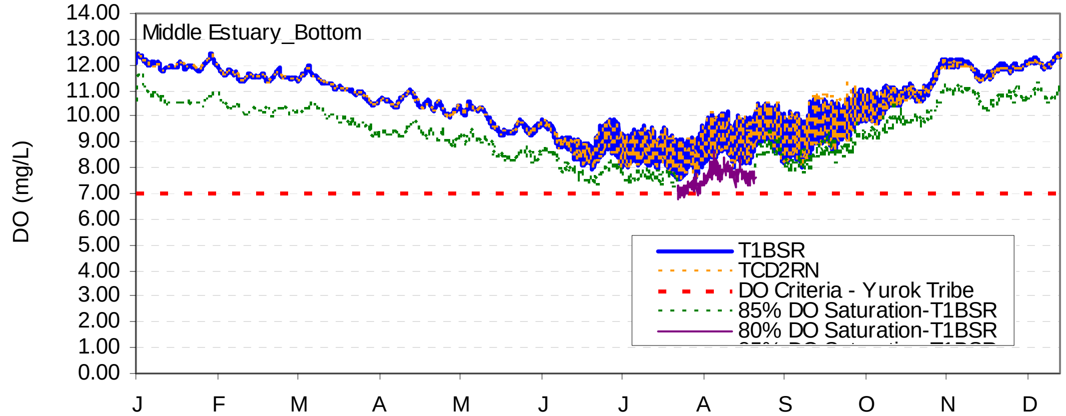
Middle Estuary_Top
T1BSR
TCD2RN
TN (mg/L)
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
J F M A M J J A S O N D

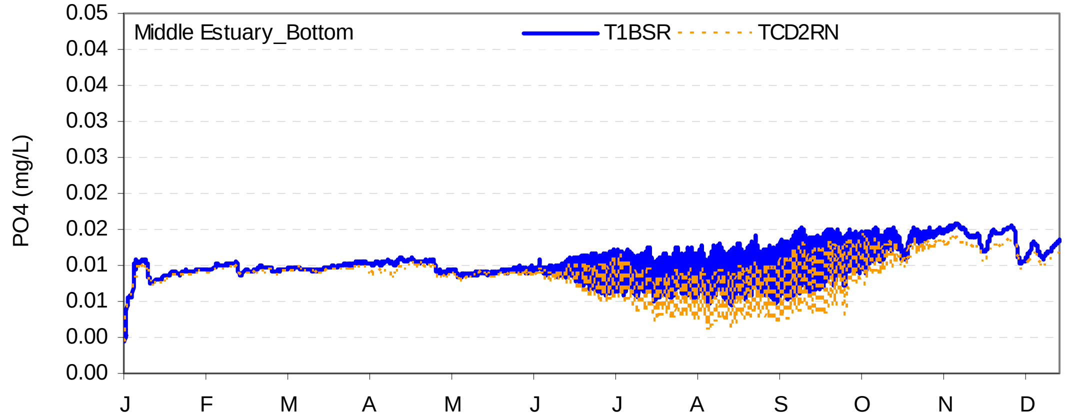

Middle Estuary_Top
TEM (degC)
26.00
24.00
22.00
20.00
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
T1BSR
TCD2RN
MWAT Criteria - Yurok Tribe
MWAT - TCD2R
Max Temperature Criteria - Yurok Tribe
J F M A M J J A S O N D

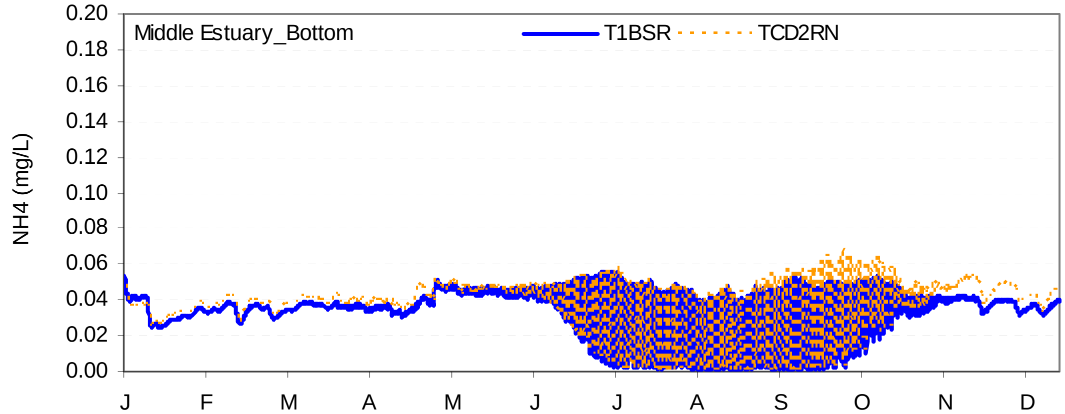

Middle Estuary_Top
T1BSR
TCD2RN
SAL (mg/L)
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
J F M A M J J A S O N D

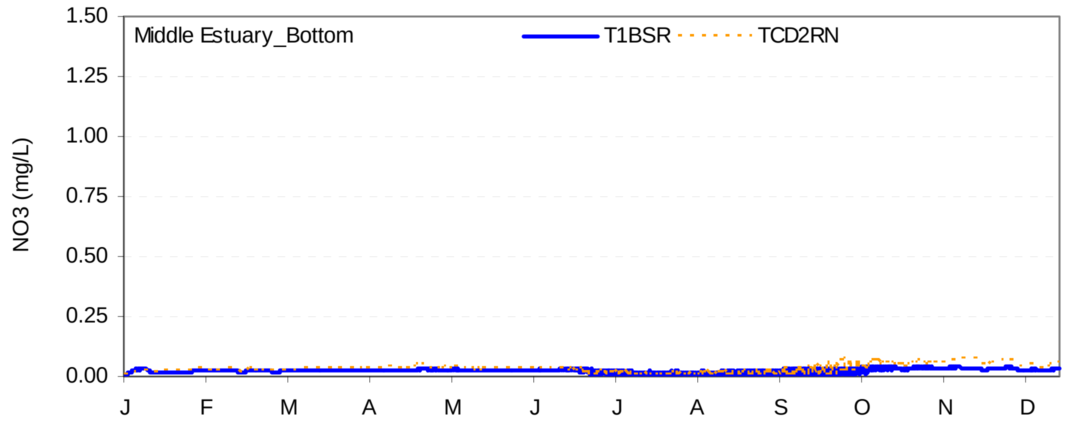

Middle Estuary_Top
T1BSR
TCD2RN
MPH (mgChla/m2
600.00
550.00
500.00
450.00
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
J F M A M J J A S O N D

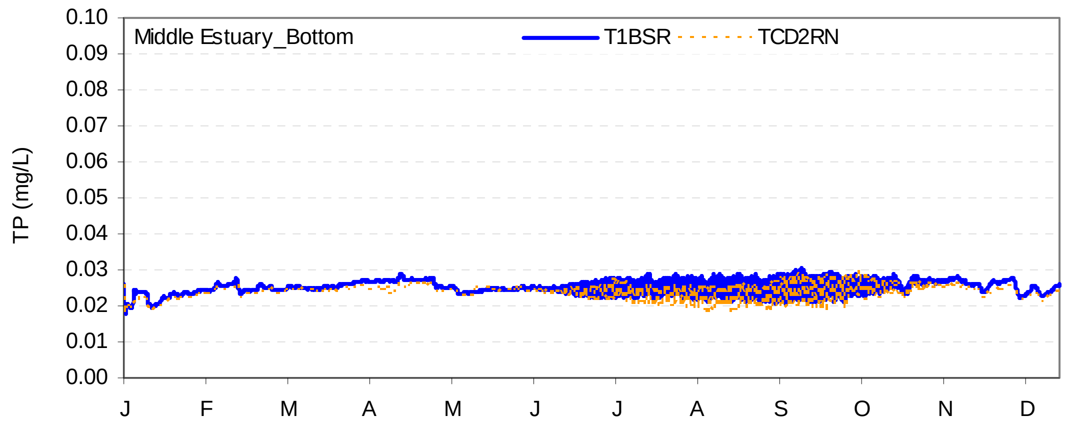
Middle Estuary - Bottom

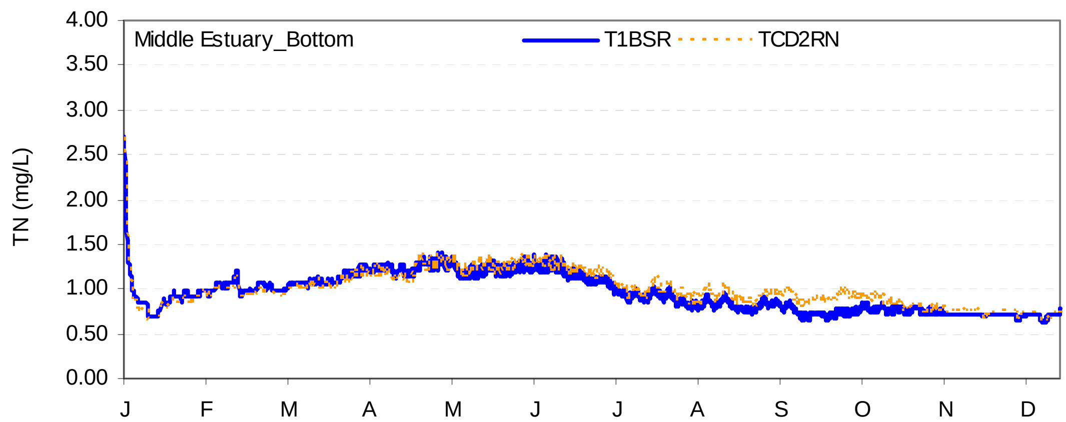


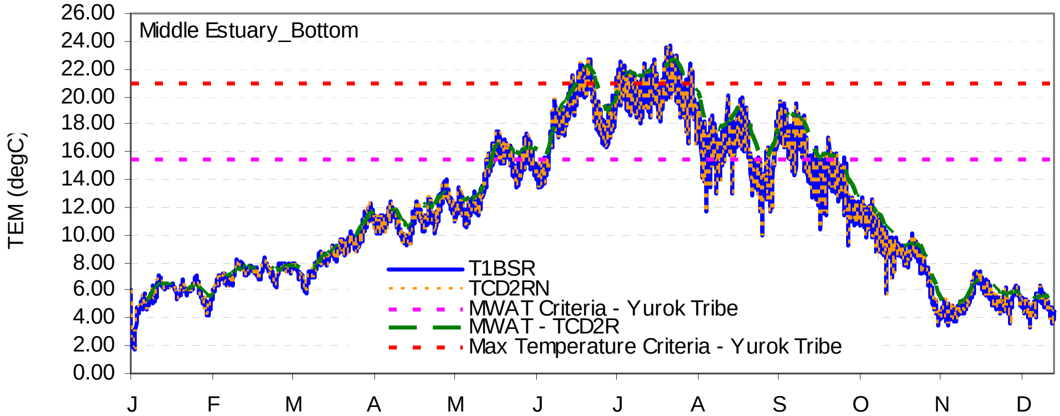


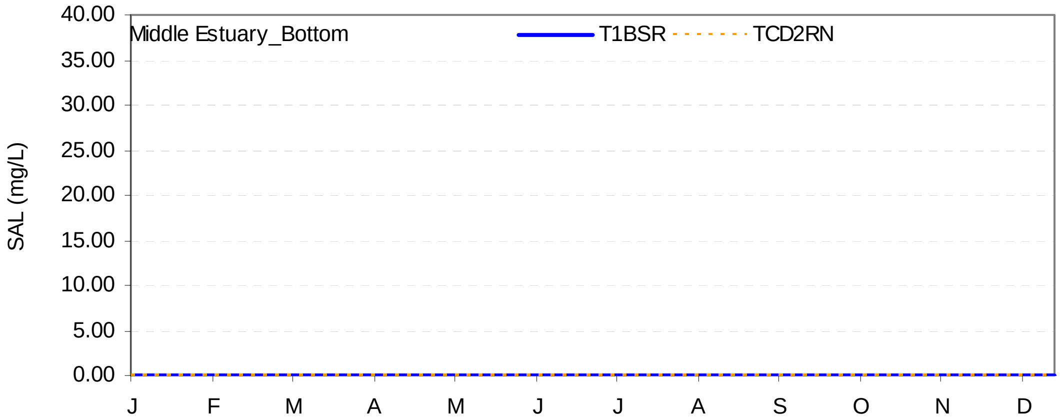


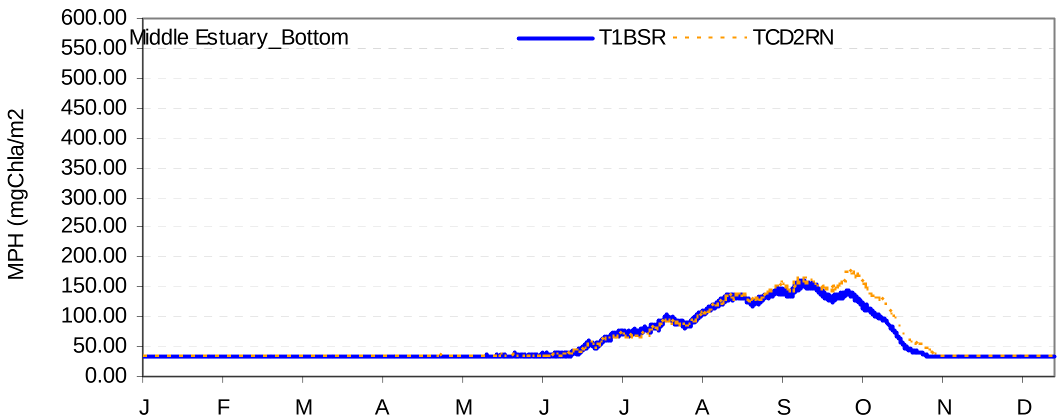

Middle Estuary_Bottom
T1BSR
TCD2RN
NO3 (mg/L)
1.50
1.25
1.00
0.75
0.50
0.25
0.00
J F M A M J J A S O N D


Middle Estuary_Bottom
T1BSR
TCD2RN
TP (mg/L)
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
J F M A M J J A S O N D

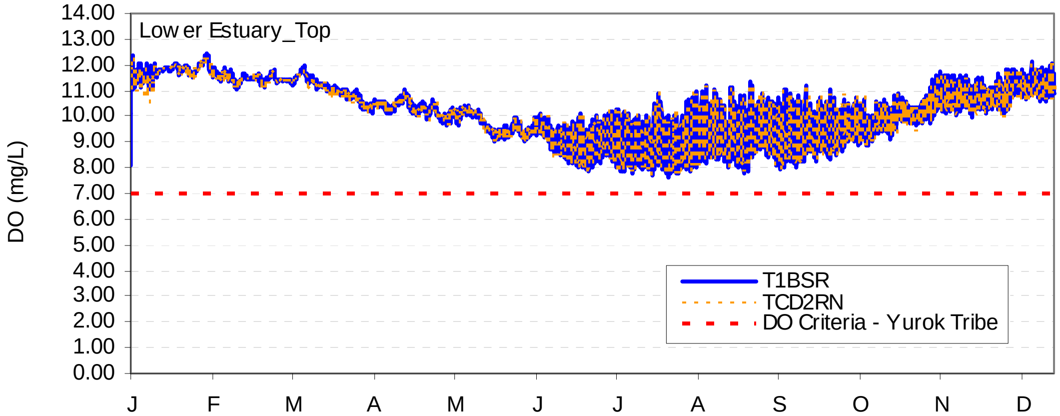

Middle Estuary_Bottom
T1BSR
TCD2RN
TN (mg/L)
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
J F M A M J J A S O N D

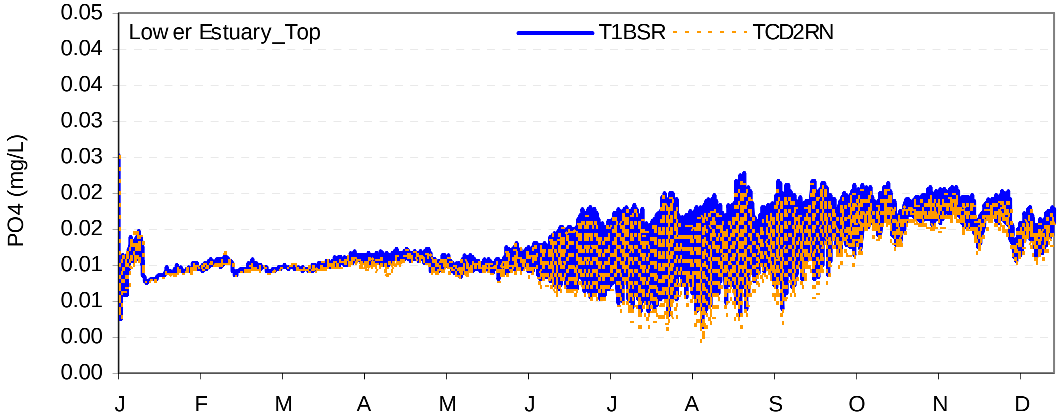

Middle Estuary_Bottom
TEM (degC)
26.00
24.00
22.00
20.00
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
J F M A M J J A S O N D
T1BSR
TCD2RN
MWAT Criteria - Yurok Tribe
MWAT - TCD2R
Max Temperature Criteria - Yurok Tribe

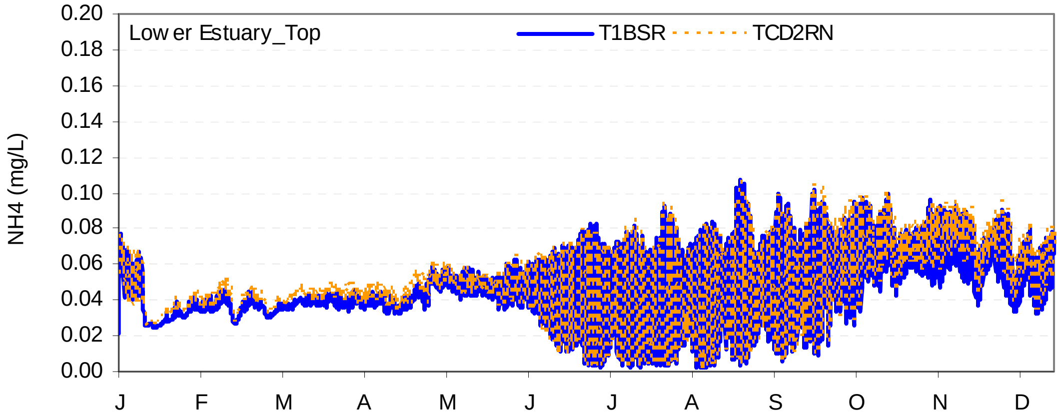

Middle Estuary_Bottom
T1BSR
TCD2RN
SAL (mg/L)
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
J F M A M J J A S O N D

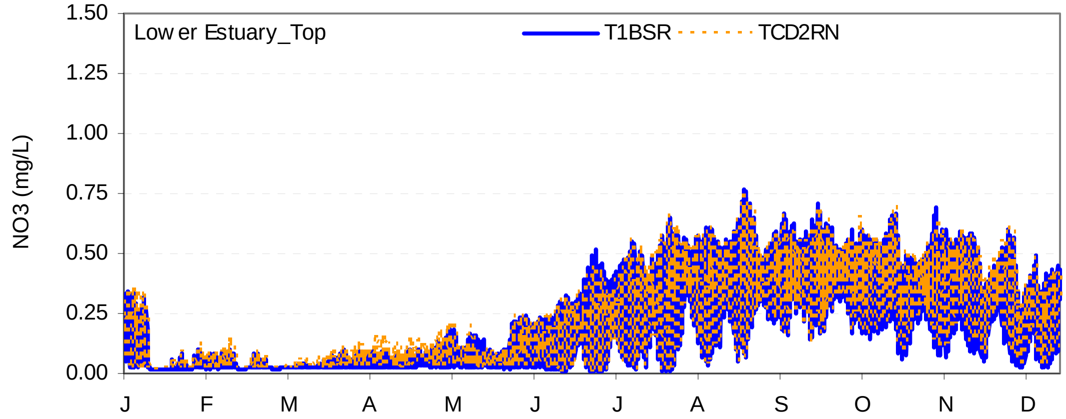

Middle Estuary_Bottom
T1BSR
TCD2RN
MPH (mgChla/m2
600.00
550.00
500.00
450.00
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
J F M A M J J A S O N D

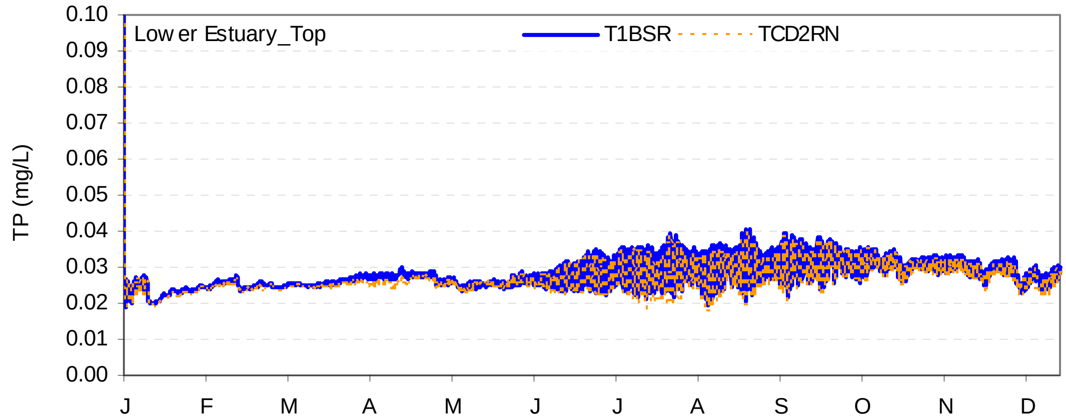
Lower Estuary - Top

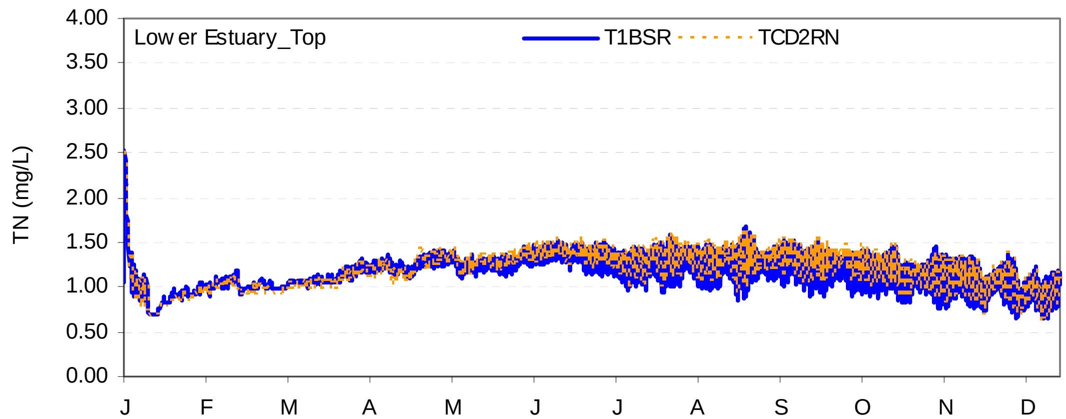


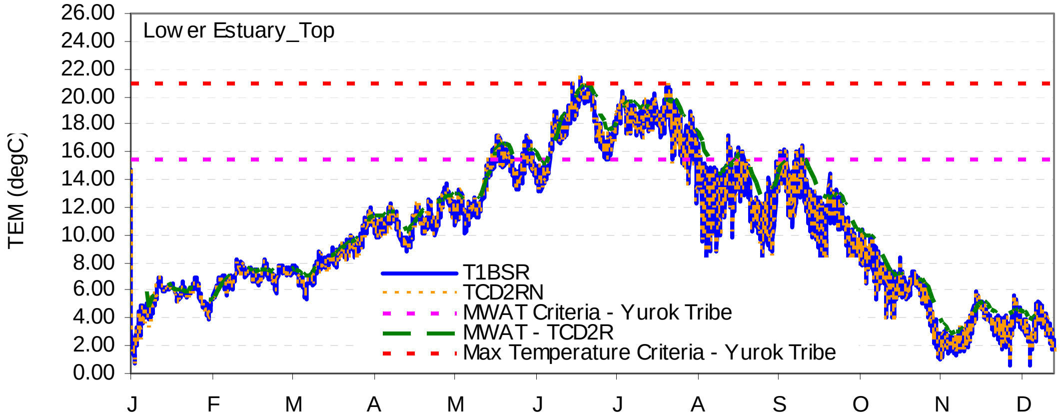


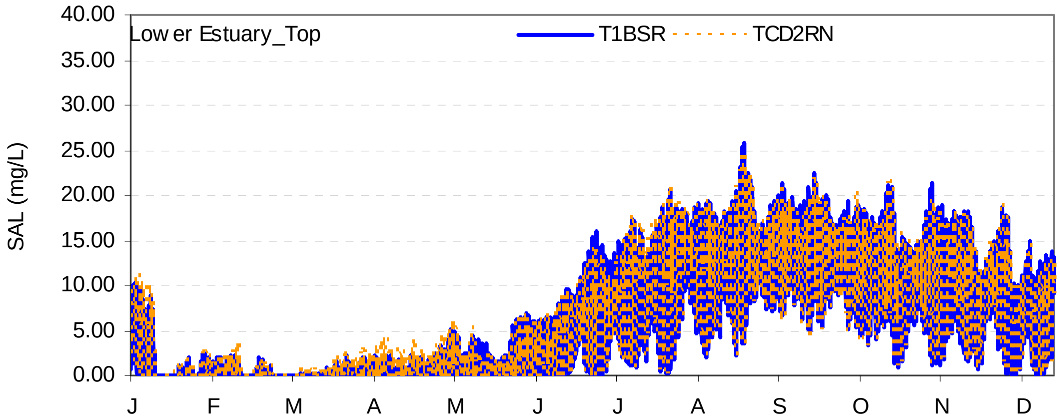


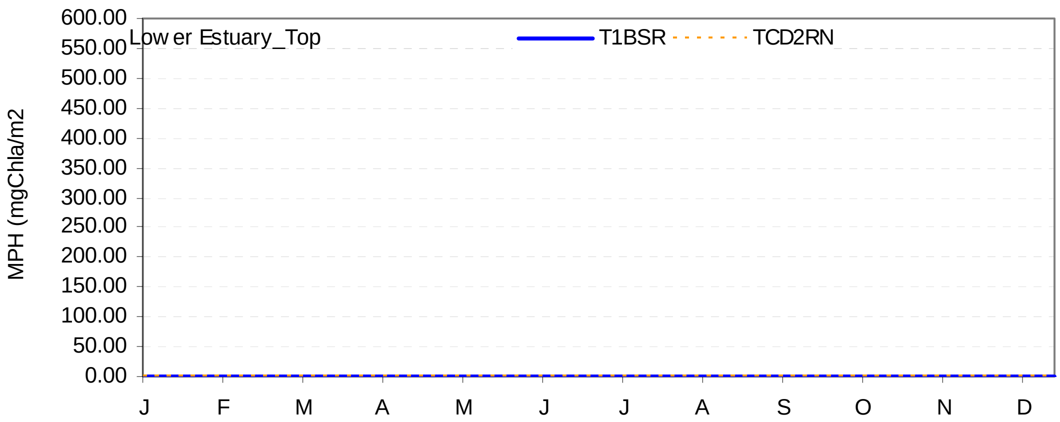

Low er Estuary_Top
T1BSR
TCD2RN
NO3 (mg/L)
1.50
1.25
1.00
0.75
0.50
0.25
0.00
J F M A M J J A S O N D


Low er Estuary_Top
T1BSR
TCD2RN
TP (mg/L)
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
J F M A M J J A S O N D

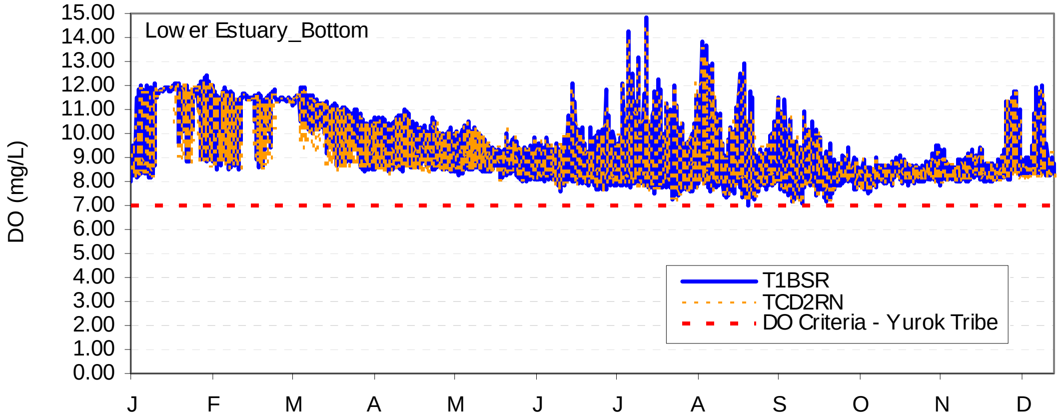

Low er Estuary_Top
T1BSR
TCD2RN
TN (mg/L)
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
J F M A M J J A S O N D

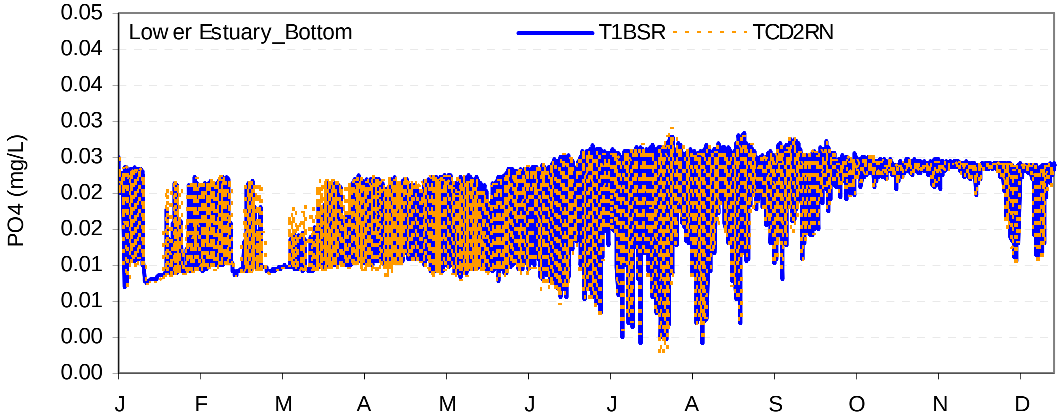

Low er Estuary_Top
TEM (degC)
T1BSR
TCD2RN
MWAT Criteria - Yurok Tribe
MWAT - TCD2R
Max Temperature Criteria - Yurok Tribe
J F M A M J J A S O N D

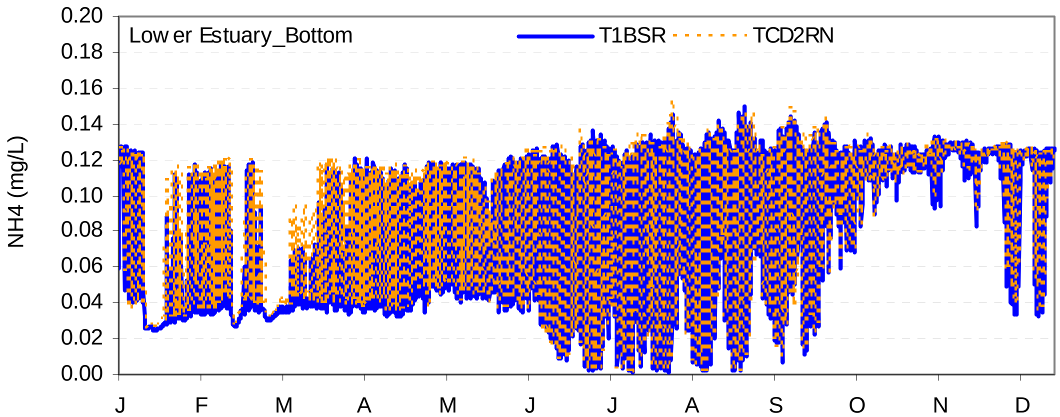

Low er Estuary_Top
SAL (mg/L)
T1BSR
TCD2RN
J F M A M J J A S O N D

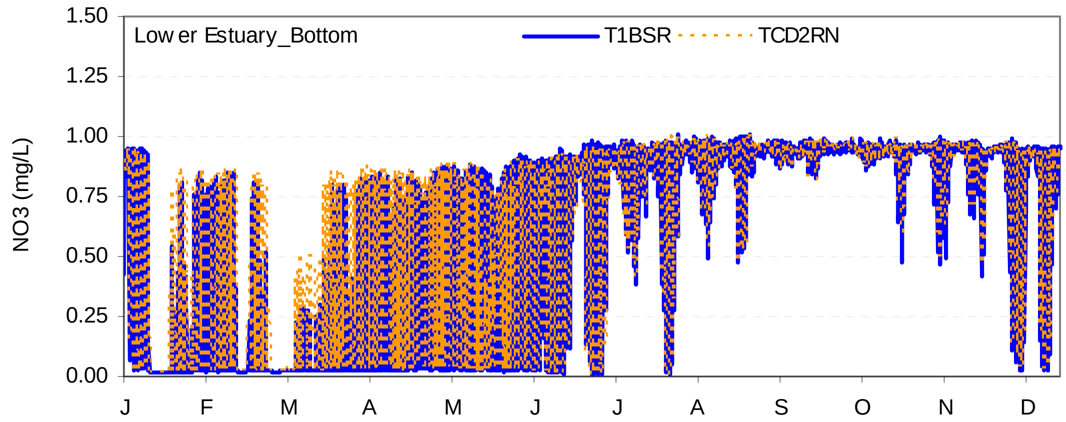

Low er Estuary_Top
MPH (mgChla/m2
T1BSR
TCD2RN
J F M A M J J A S O N D

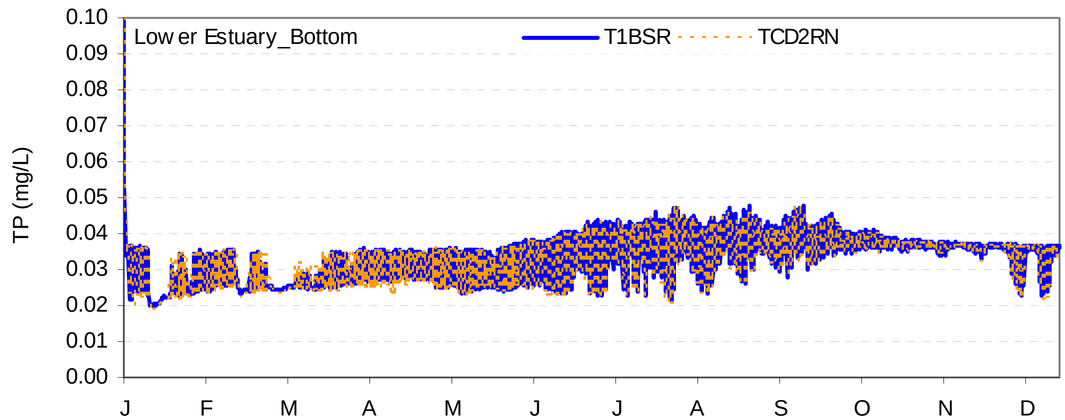
Lower Estuary - Bottom

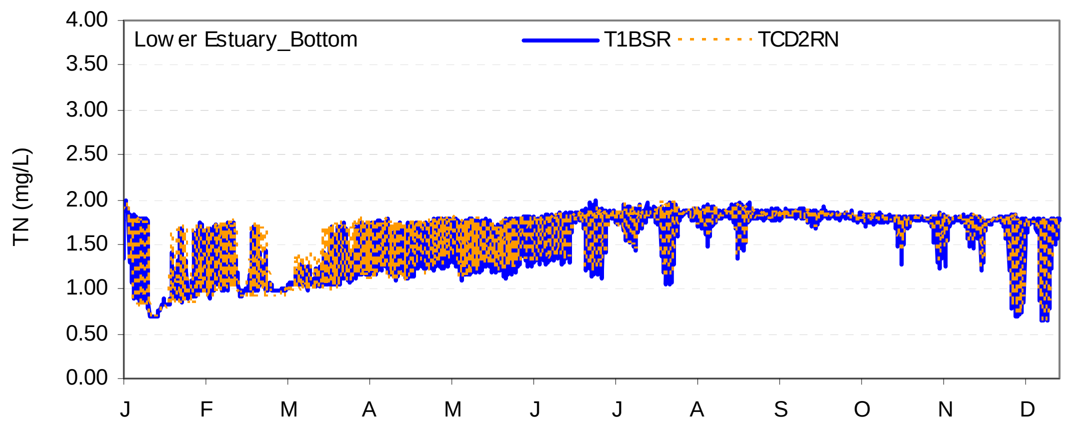


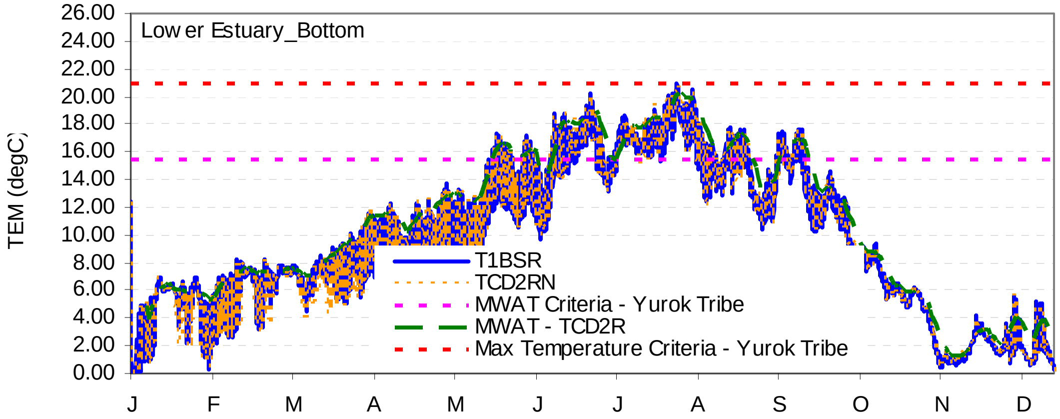




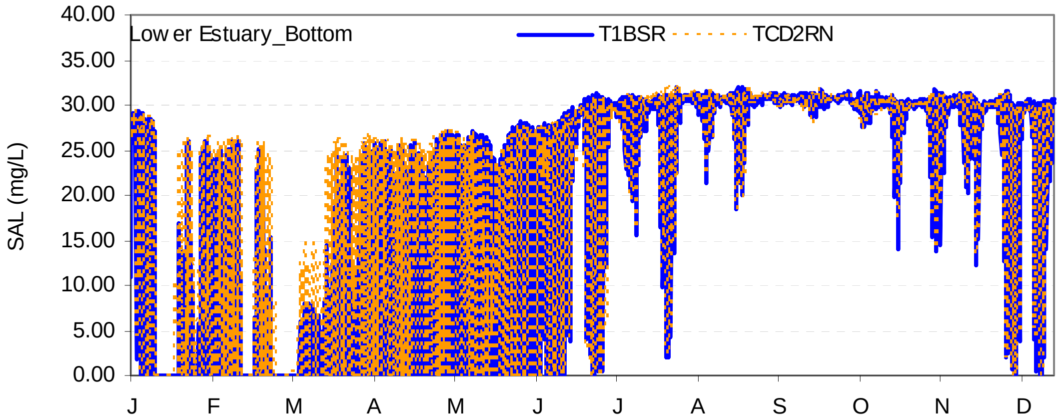

Low er Estuary_Bottom
T1BSR
TCD2RN
NO3 (mg/L)
1.50
1.25
1.00
0.75
0.50
0.25
0.00
J F M A M J J A S O N D


Low er Estuary_Bottom
T1BSR
TCD2RN
TP (mg/L)
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
J F M A M J J A S O N D

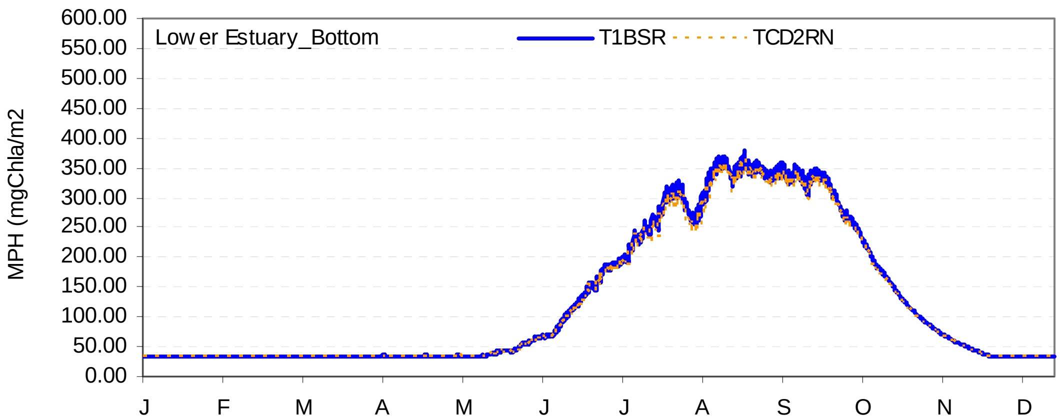

Low er Estuary_Bottom
T1BSR
TCD2RN
TN (mg/L)
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
J F M A M J J A S O N D



TEM (degC)
Low er Estuary_Bottom
T1BSR
TCD2RN
MWAT Criteria - Yurok Tribe
MWAT - TCD2R
Max Temperature Criteria - Yurok Tribe
26.00
24.00
22.00
20.00
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
J F M A M J J A S O N D



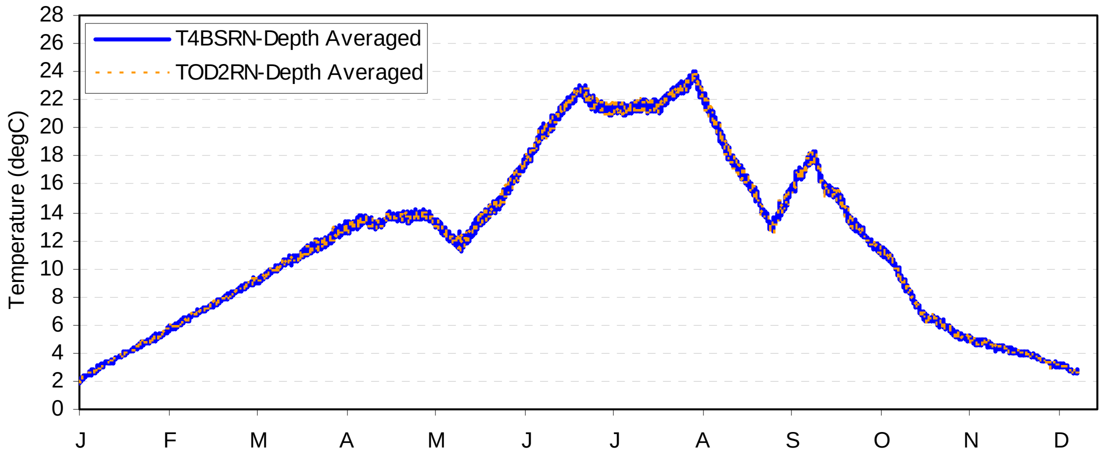
SAL (mg/L)
Low er Estuary_Bottom
T1BSR
TCD2RN
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
J F M A M J J A S O N D

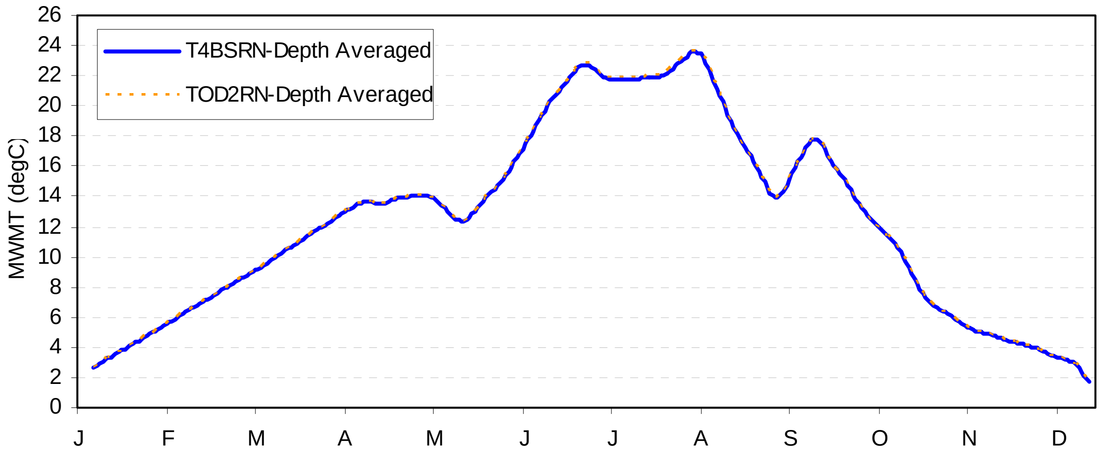


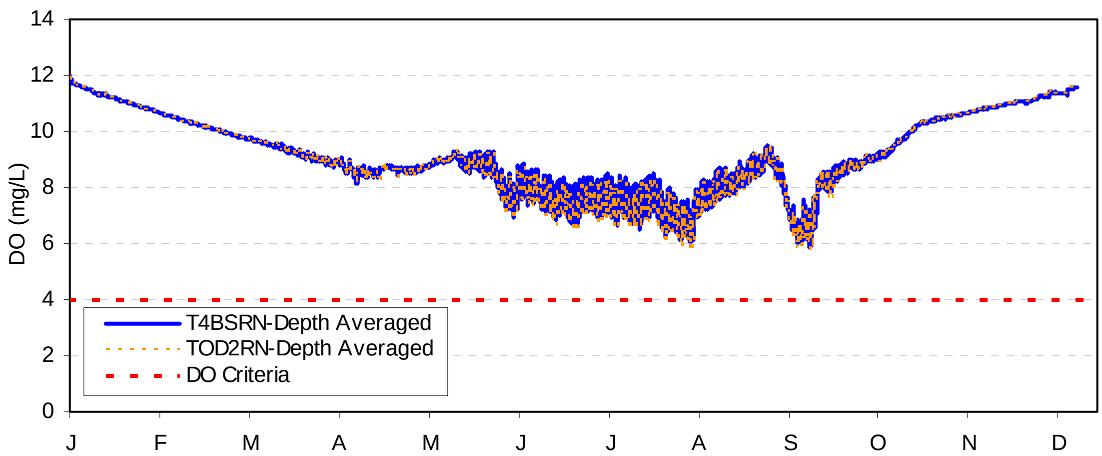
MPH (mgChla/m2
Low er Estuary_Bottom
T1BSR
TCD2RN
600.00
550.00
500.00
450.00
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
J F M A M J J A S O N D

Appendix C: T4BSRN and TOD2RN/TCD2RN Results

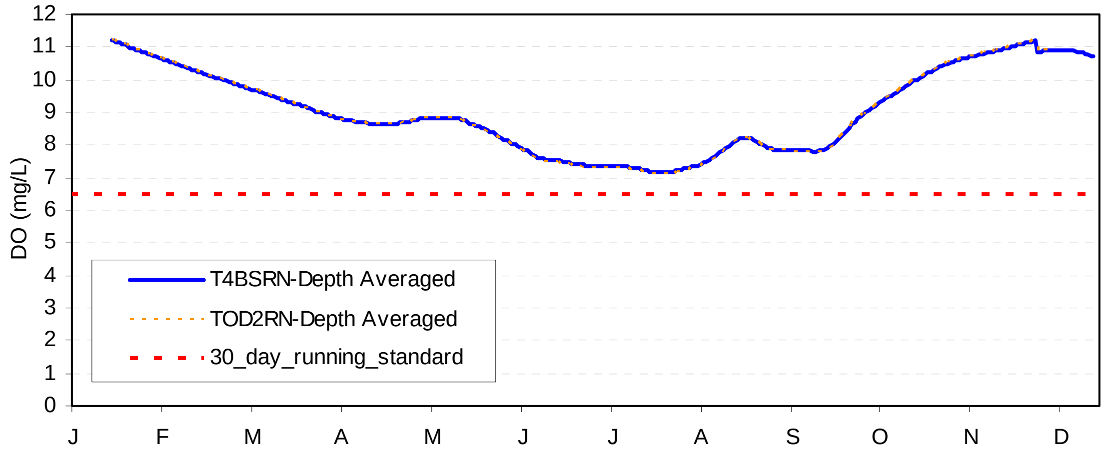
Klamath Falls STP

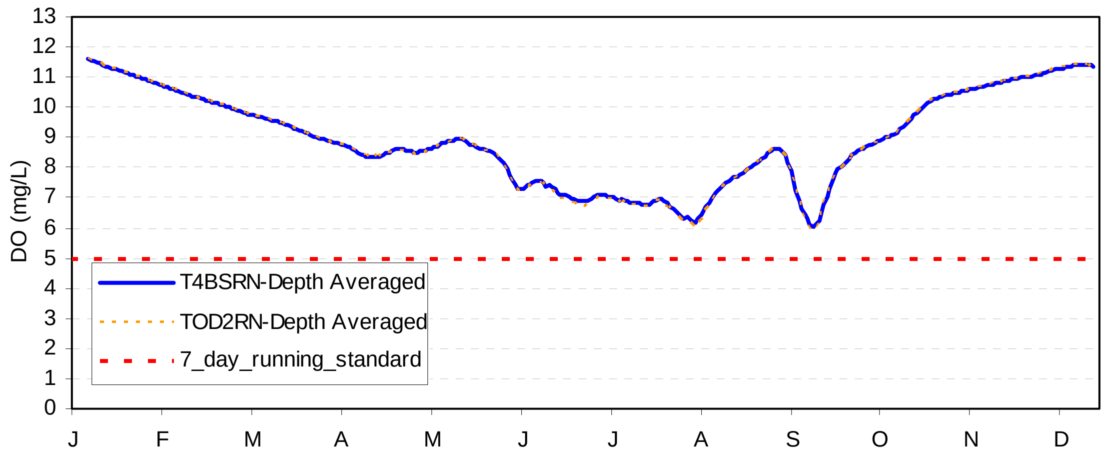


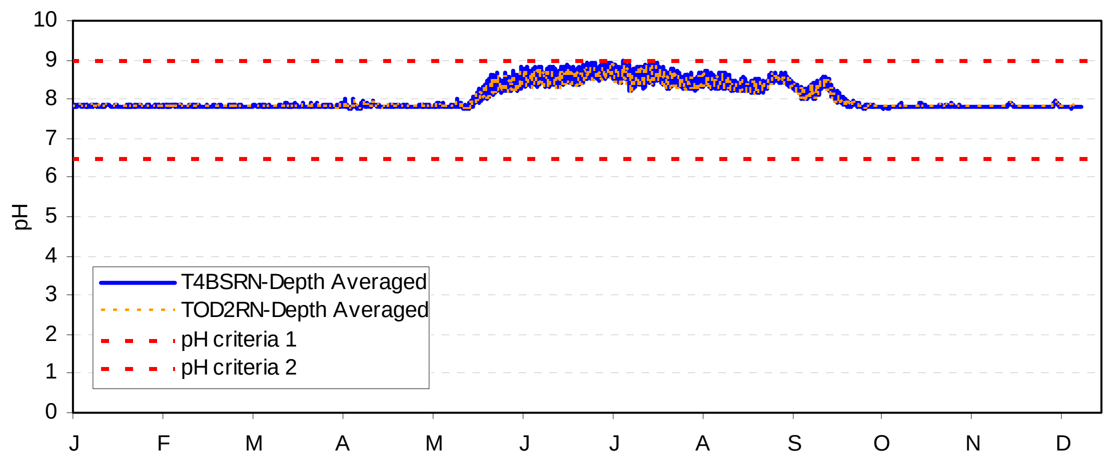




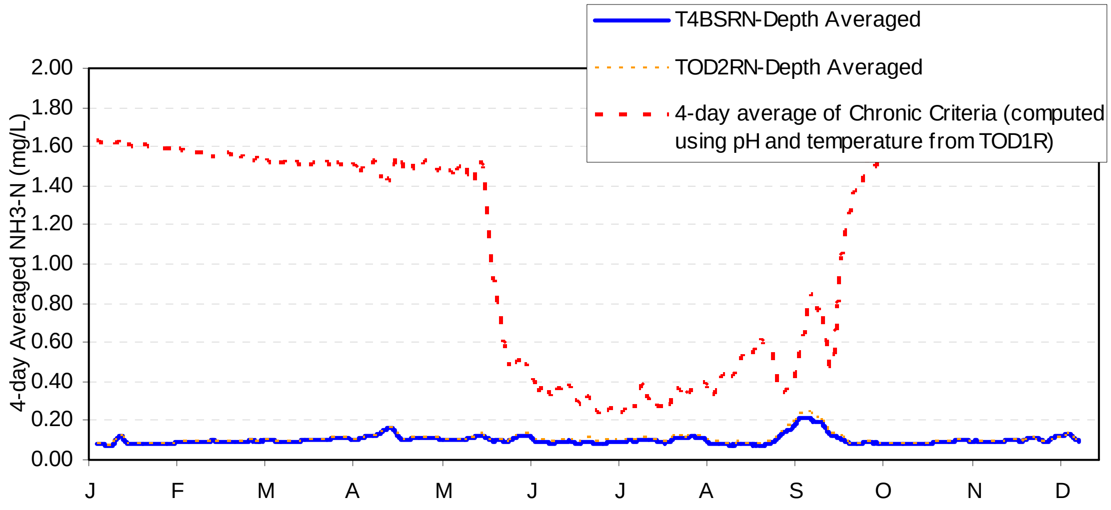
Klamath Falls STP

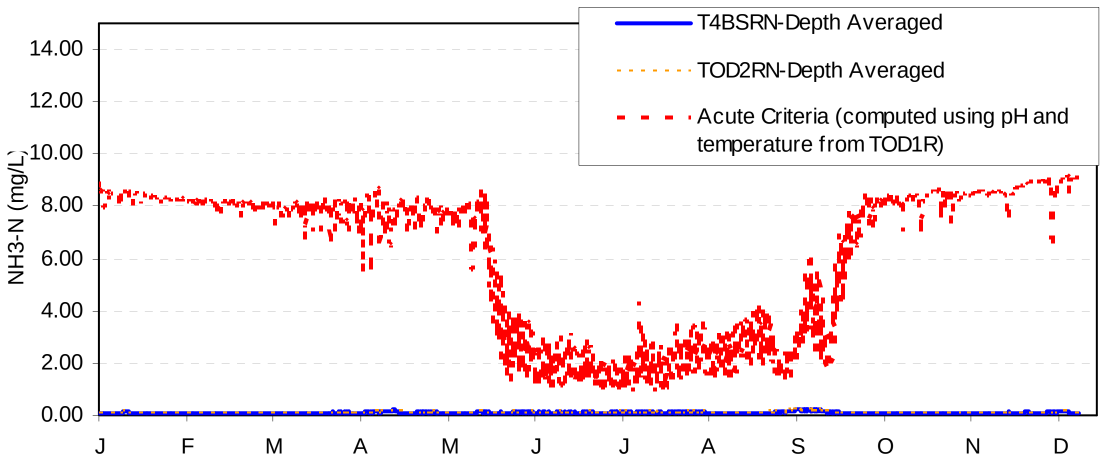


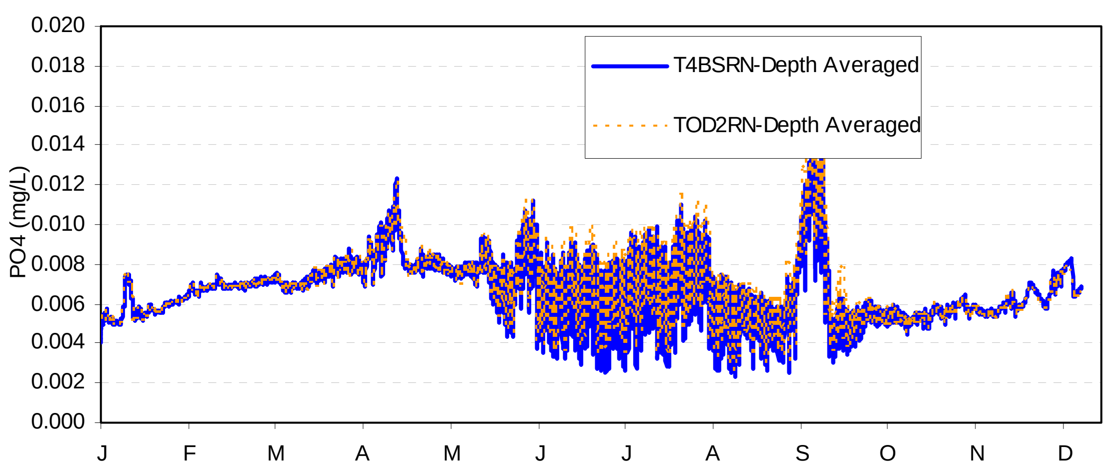




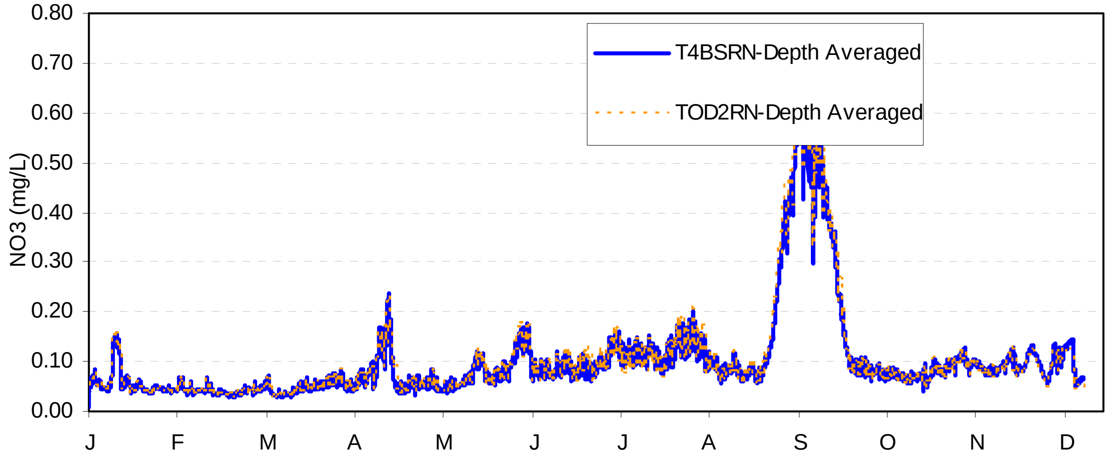
Klamath Falls STP

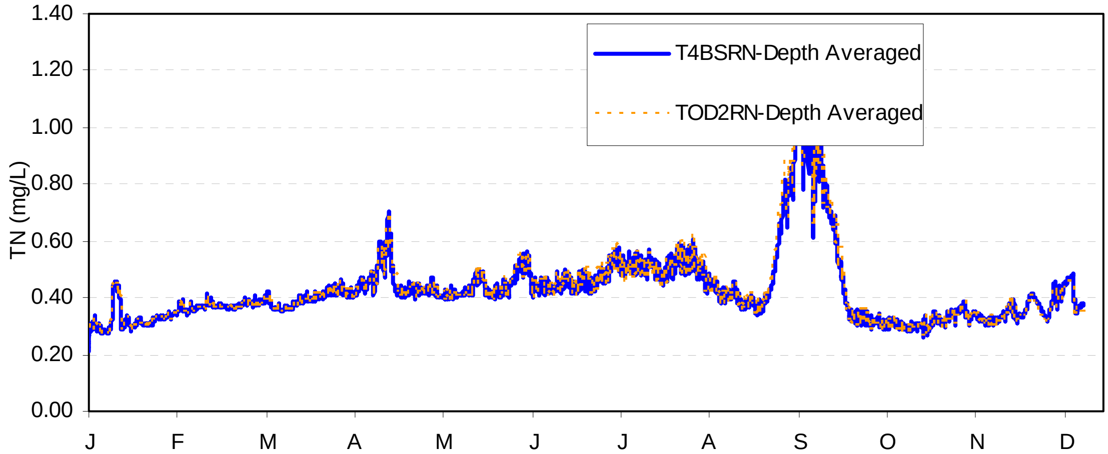


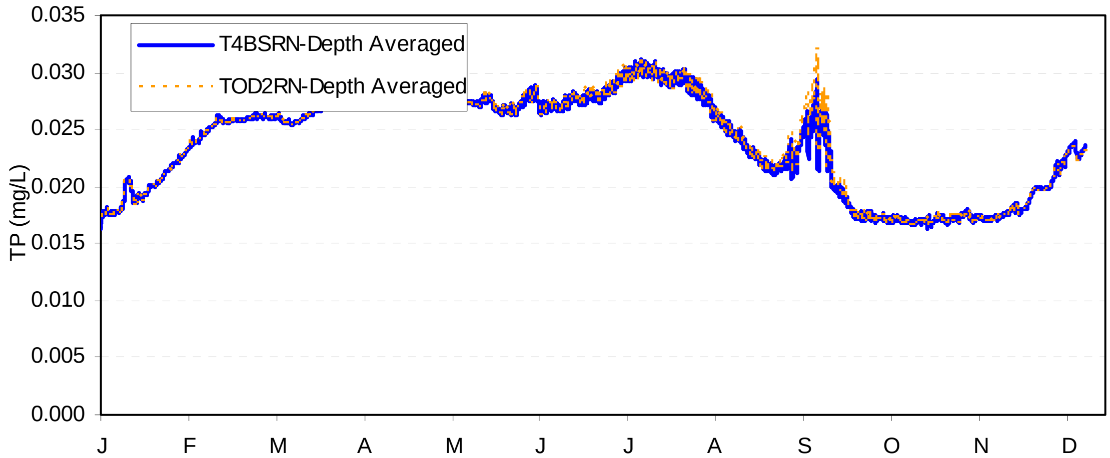




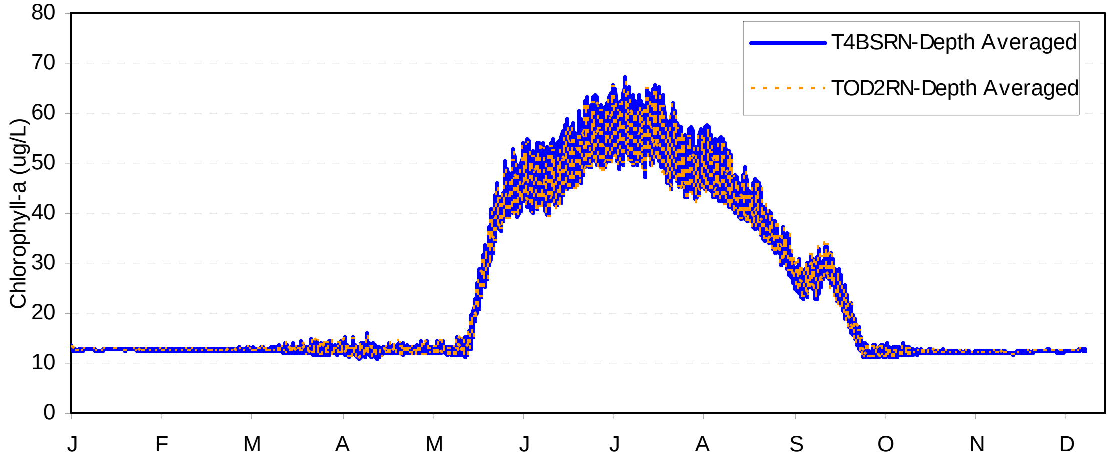
Klamath Falls STP

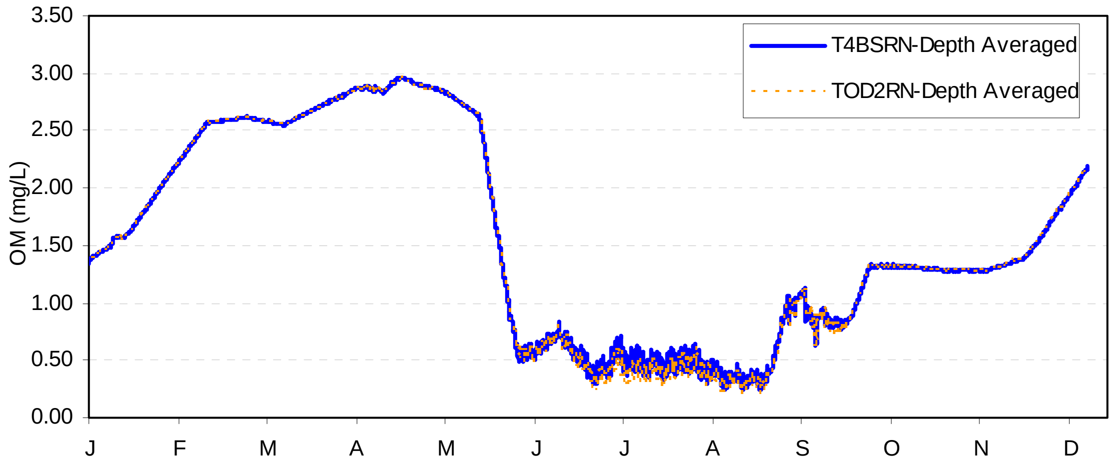




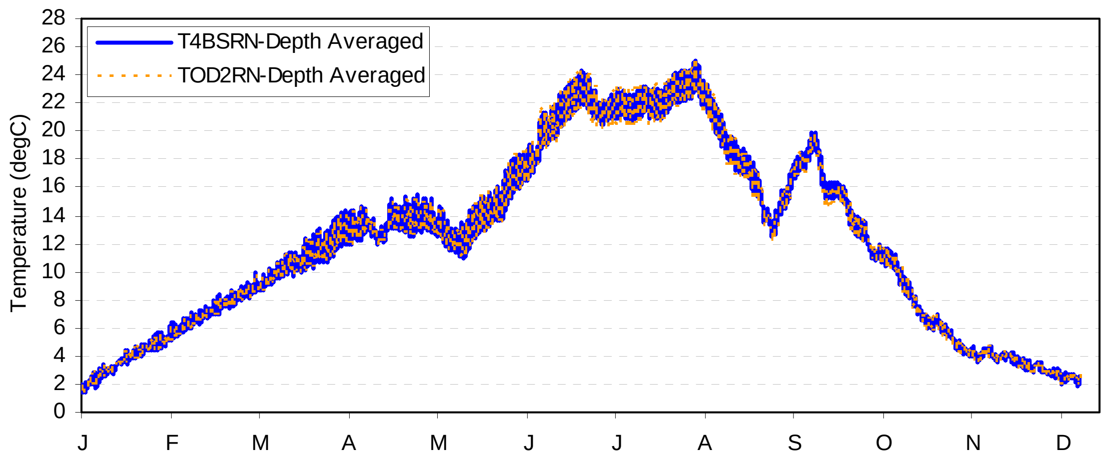


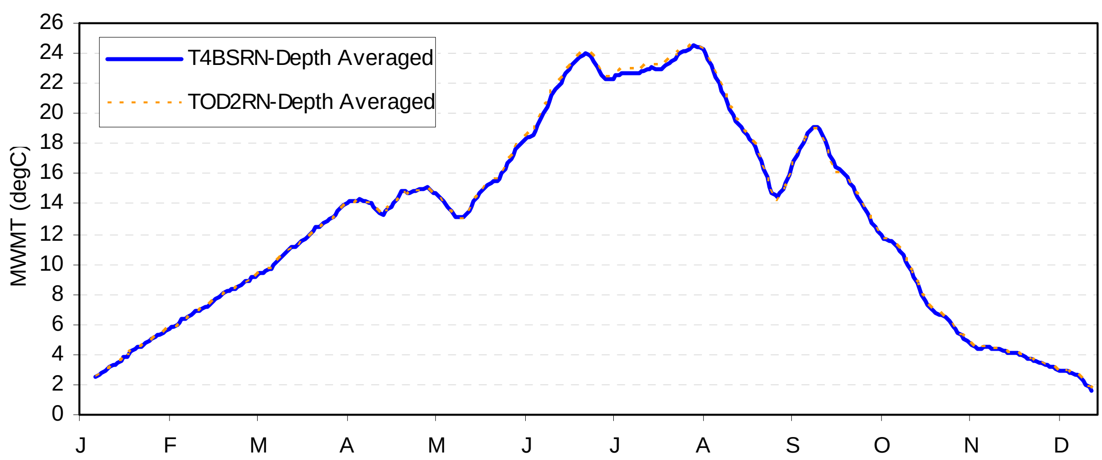
Klamath Falls STP

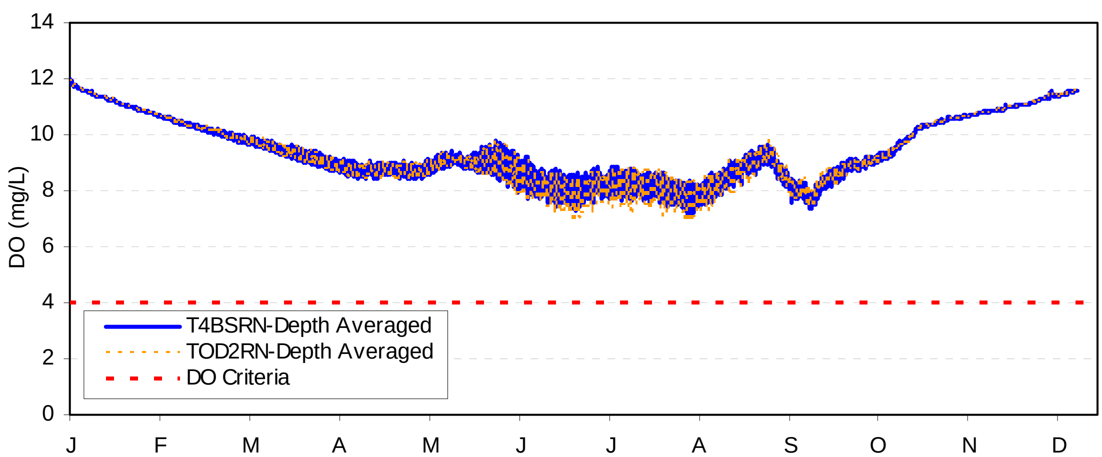




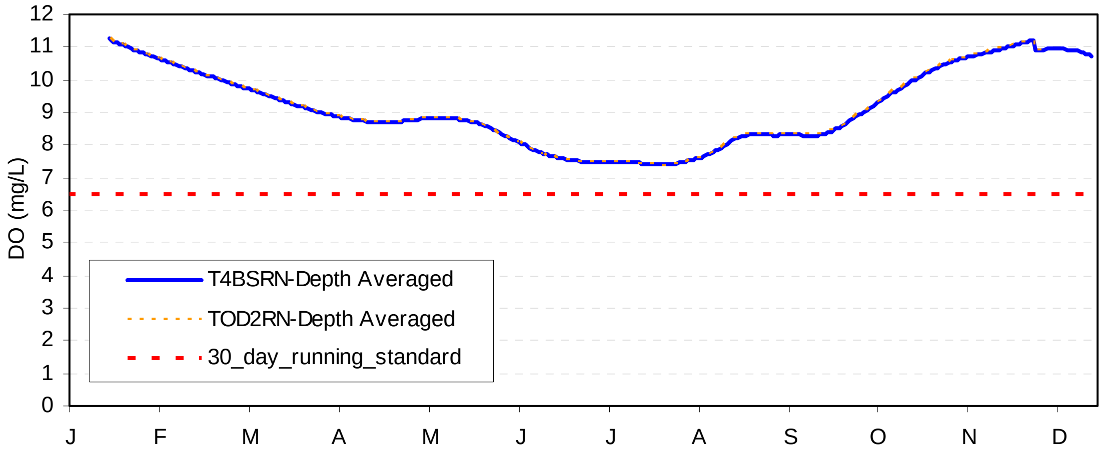
South Suburban Sanitary

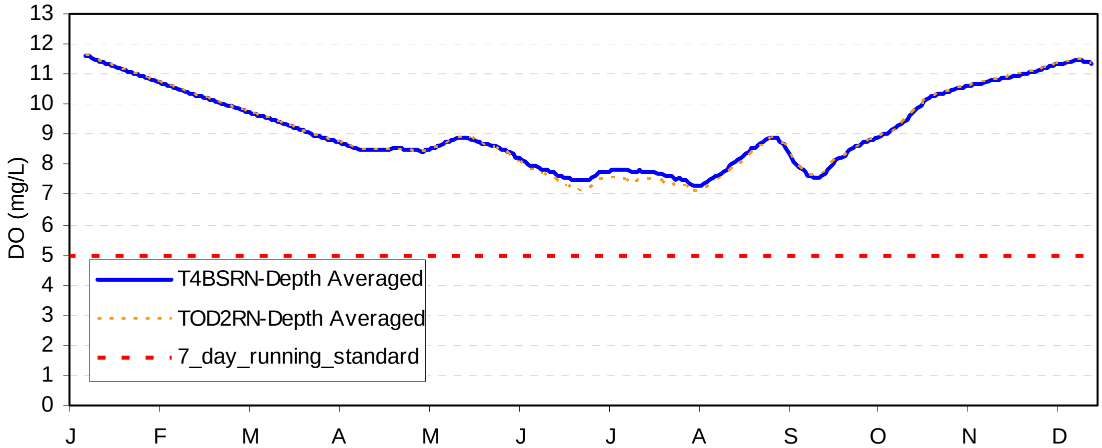


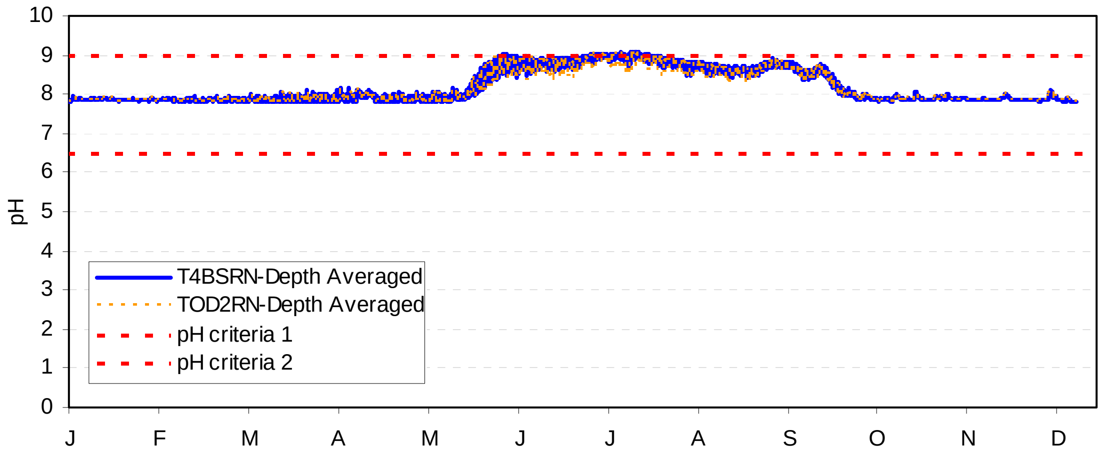




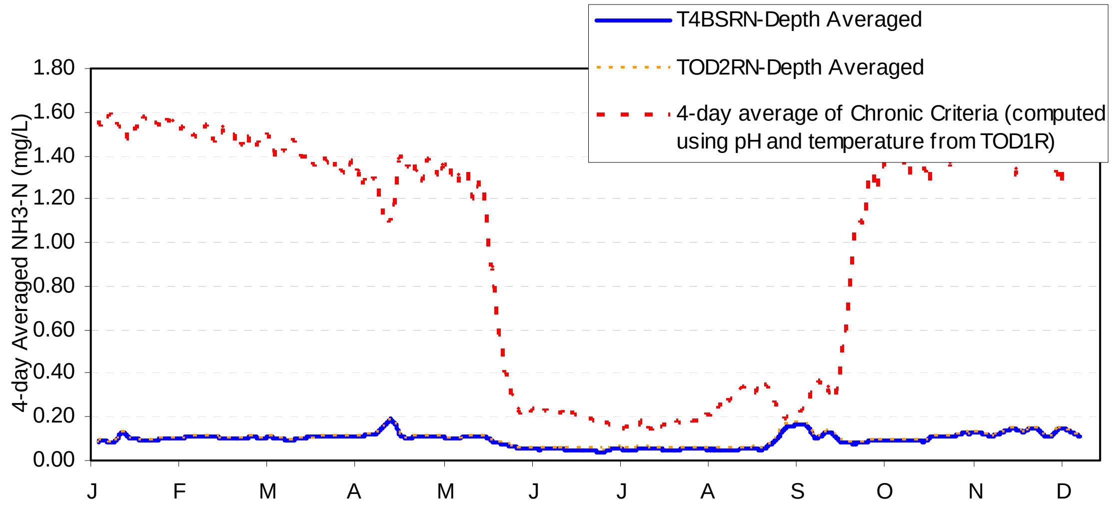
South Suburban Sanitary

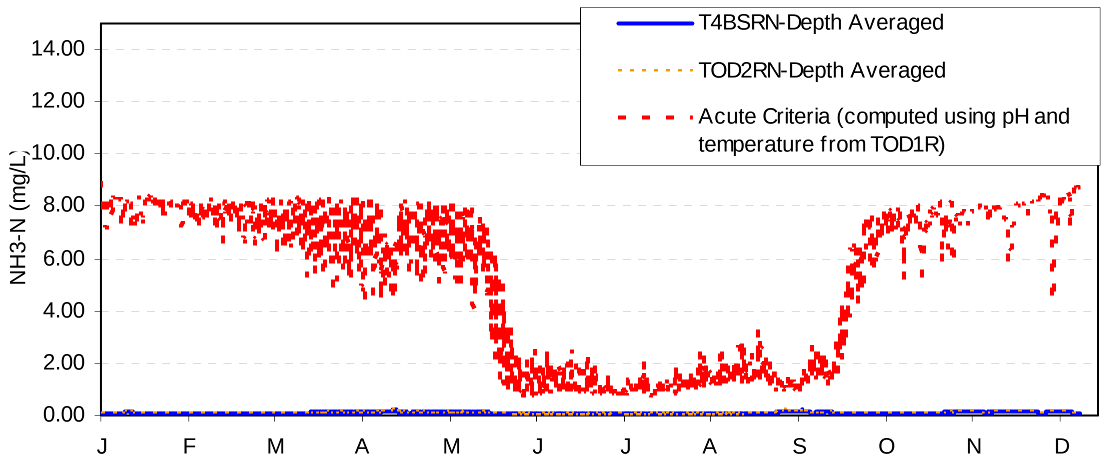


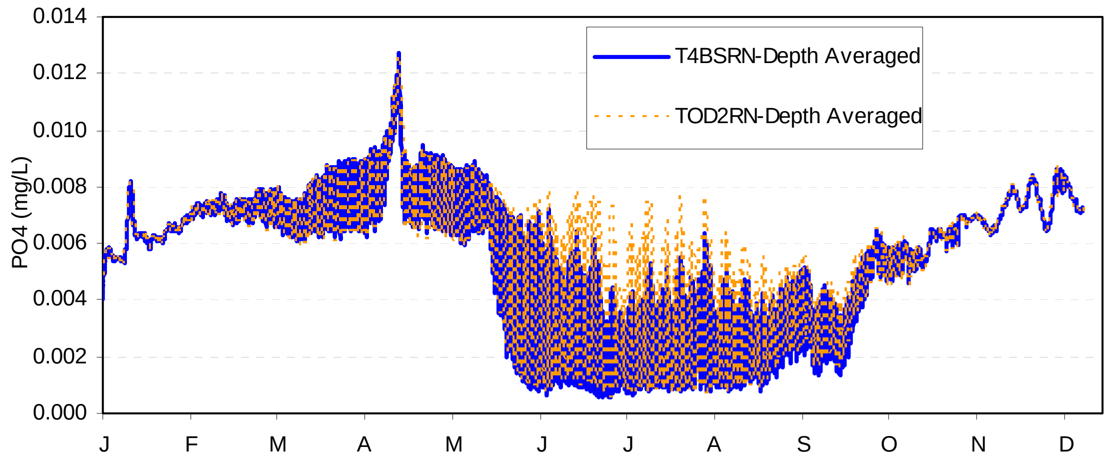




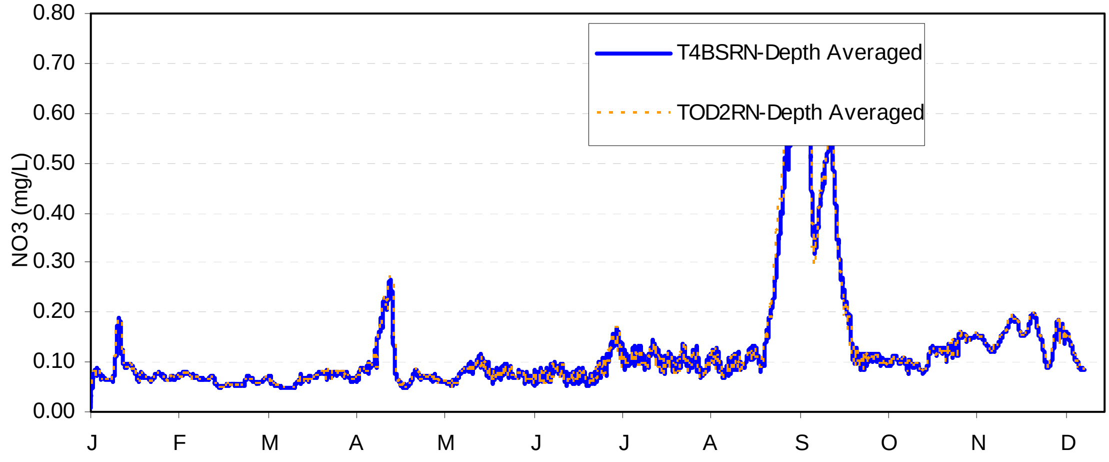
South Suburban Sanitary

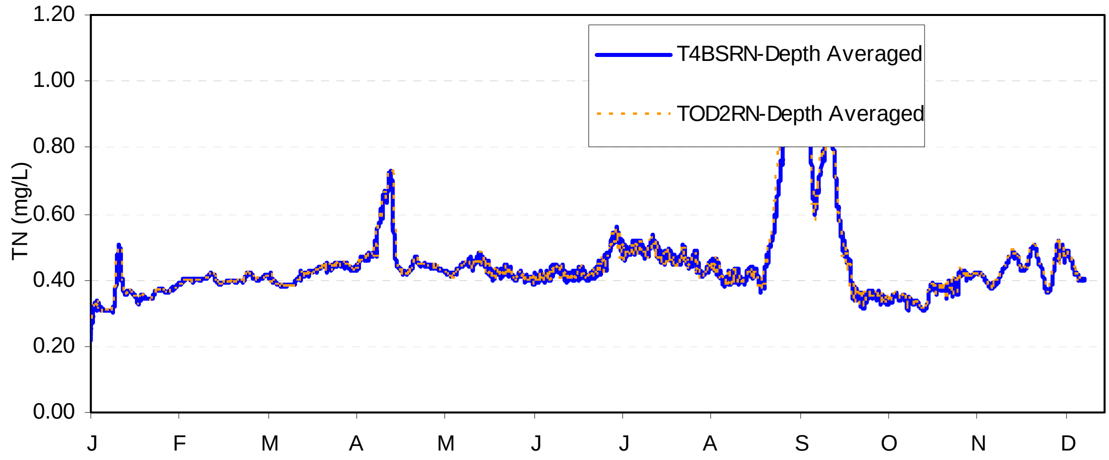


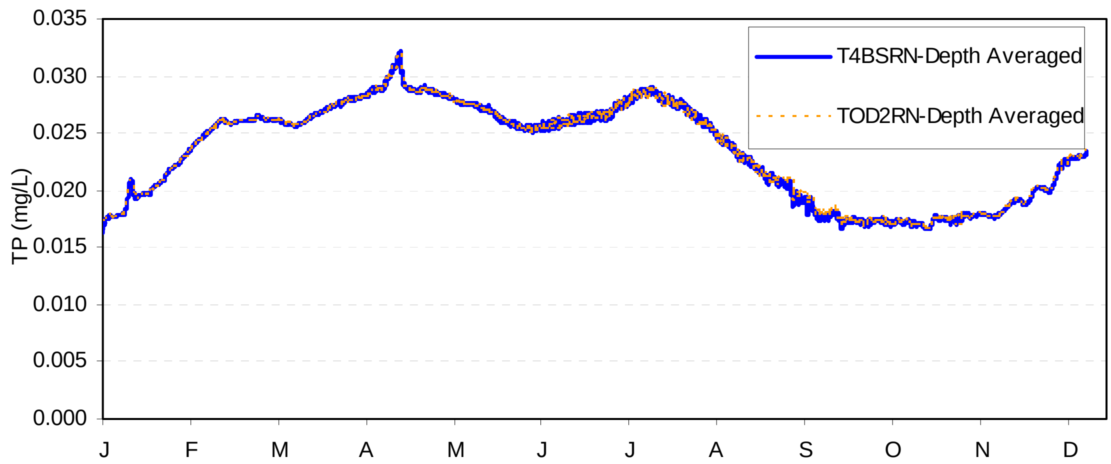




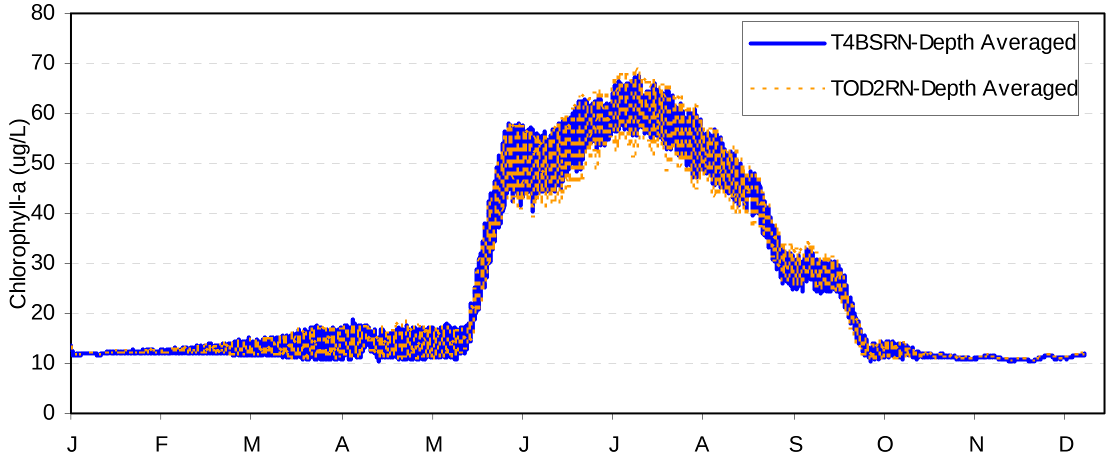
South Suburban Sanitary

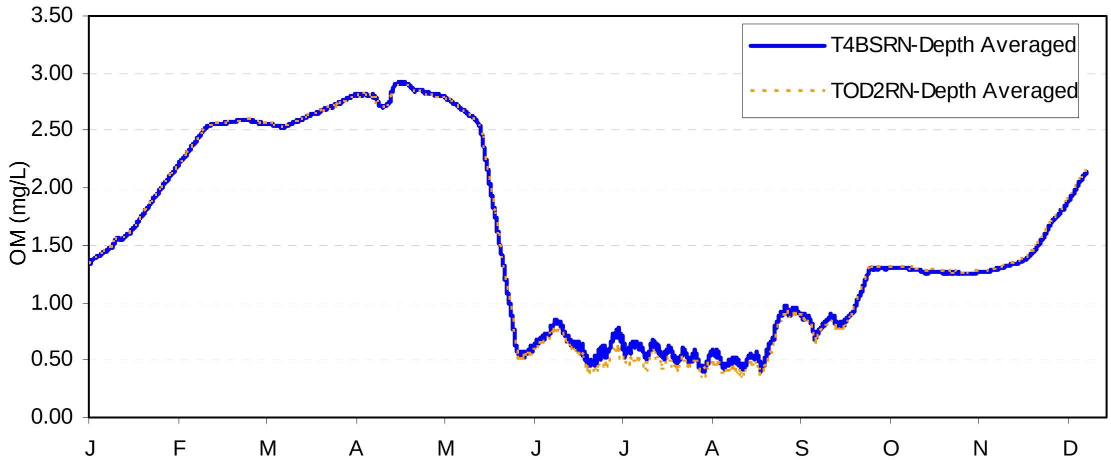




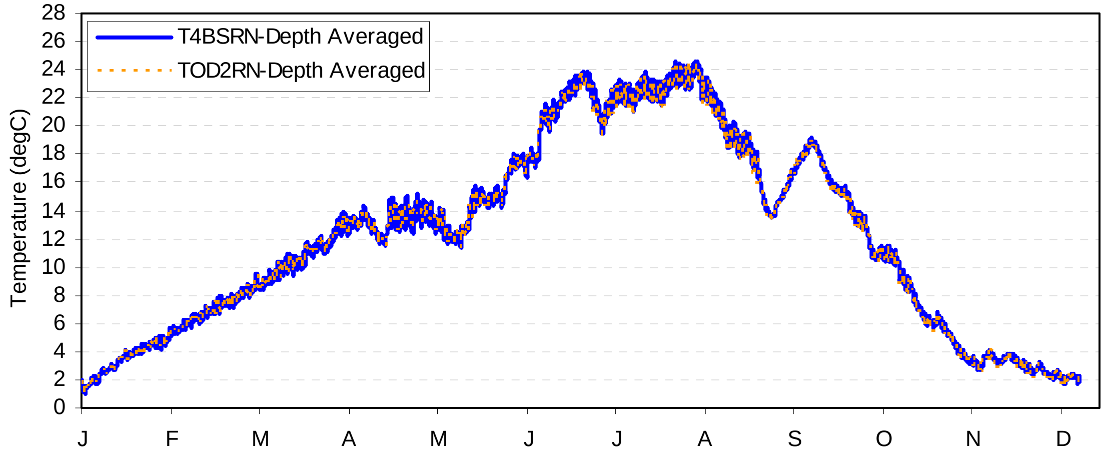


South Suburban Sanitary

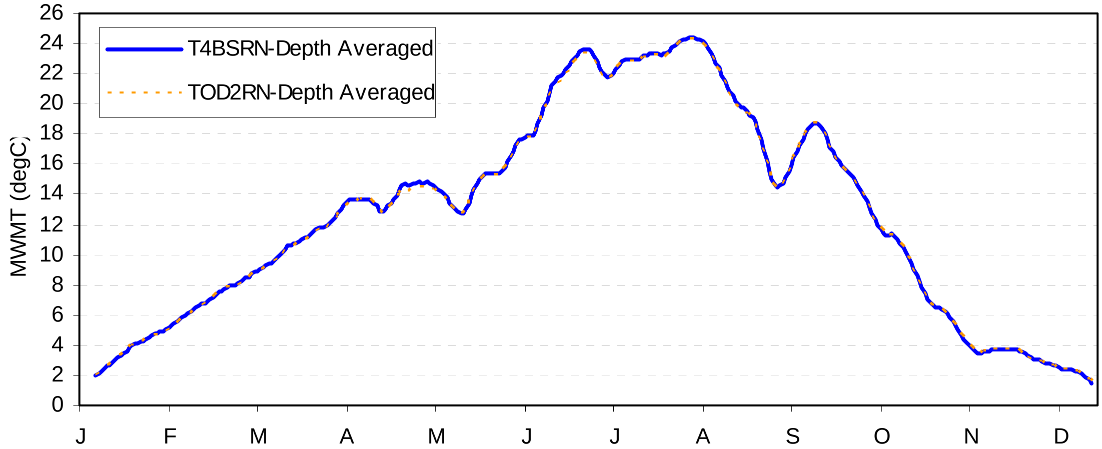




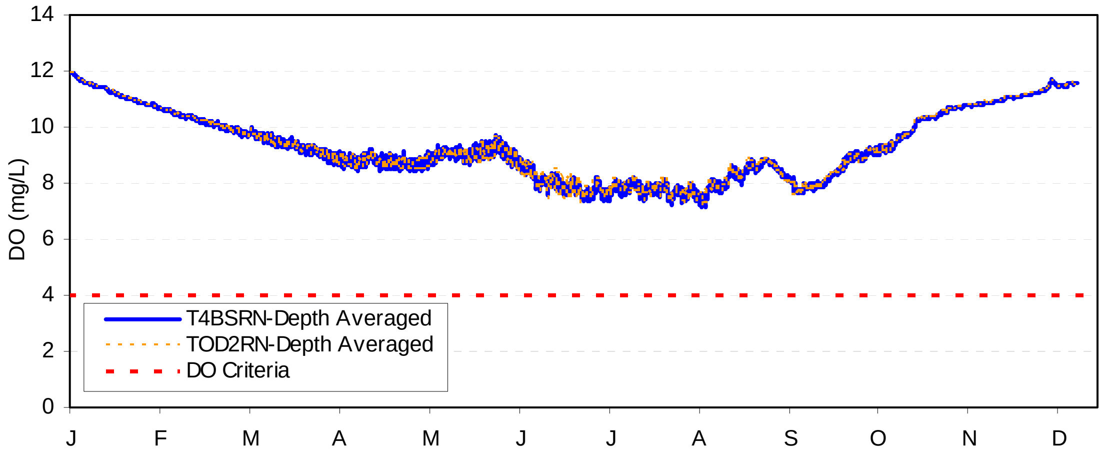
LRDC - CP



T4BSRN-Depth Averaged
TOD2RN-Depth Averaged
Temperature (degC)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
J
F
M
A
M
J
J
A
S
O
N
D

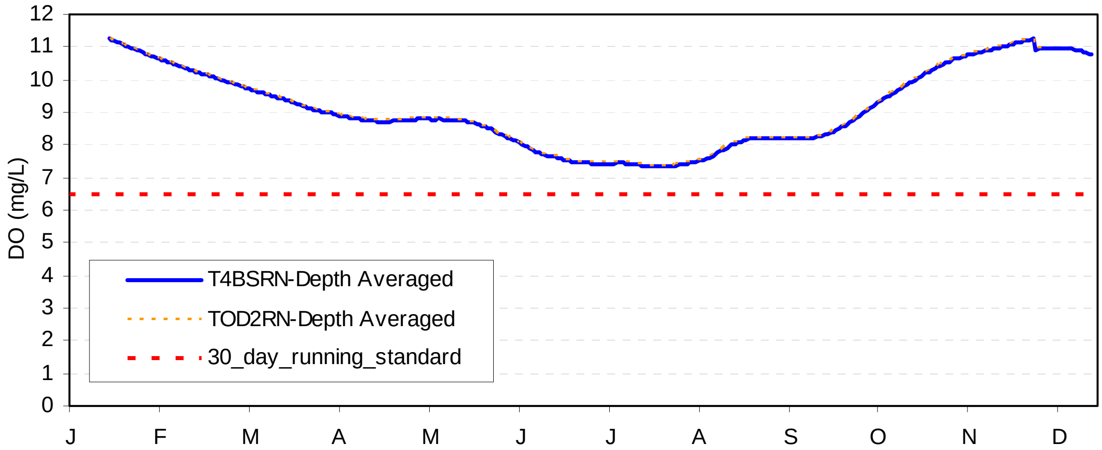


T4BSRN-Depth Averaged
TOD2RN-Depth Averaged
MWMT (degC)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
J
F
M
A
M
J
J
A
S
O
N
D

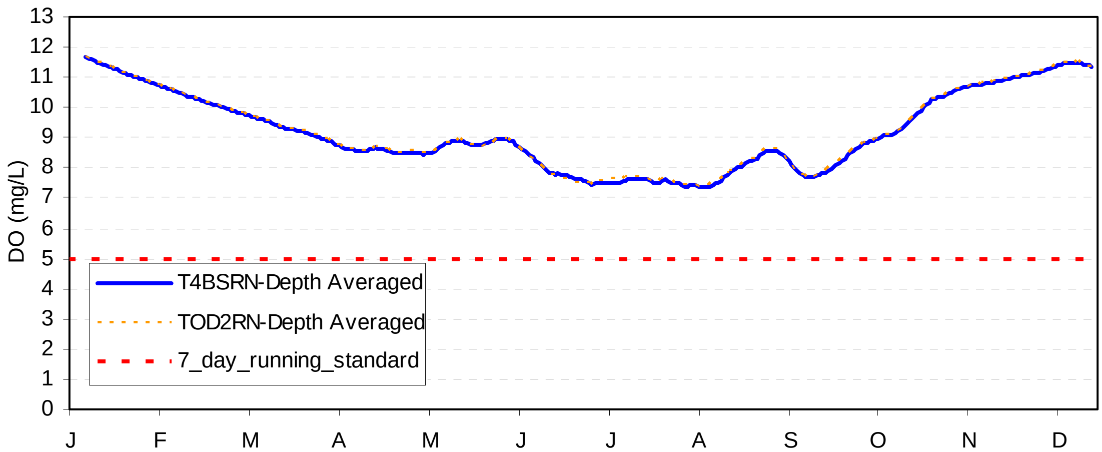


T4BSRN-Depth Averaged
TOD2RN-Depth Averaged
DO Criteria
DO (mg/L)
0
2
4
6
8
10
12
14
J
F
M
A
M
J
J
A
S
O
N
D

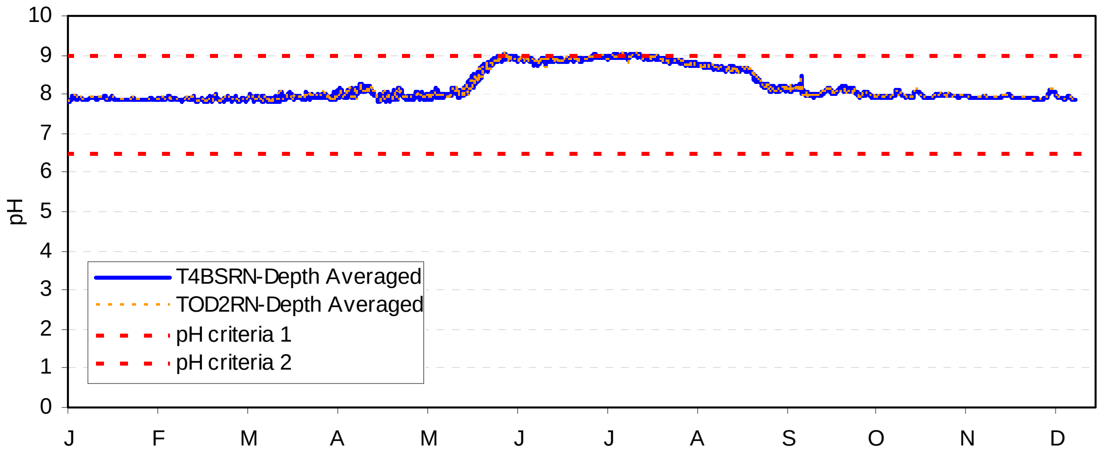
LRDC - CP



DO (mg/L)
T4BSRN-Depth Averaged
TOD2RN-Depth Averaged
30_day_running_standard
J F M A M J J A S O N D

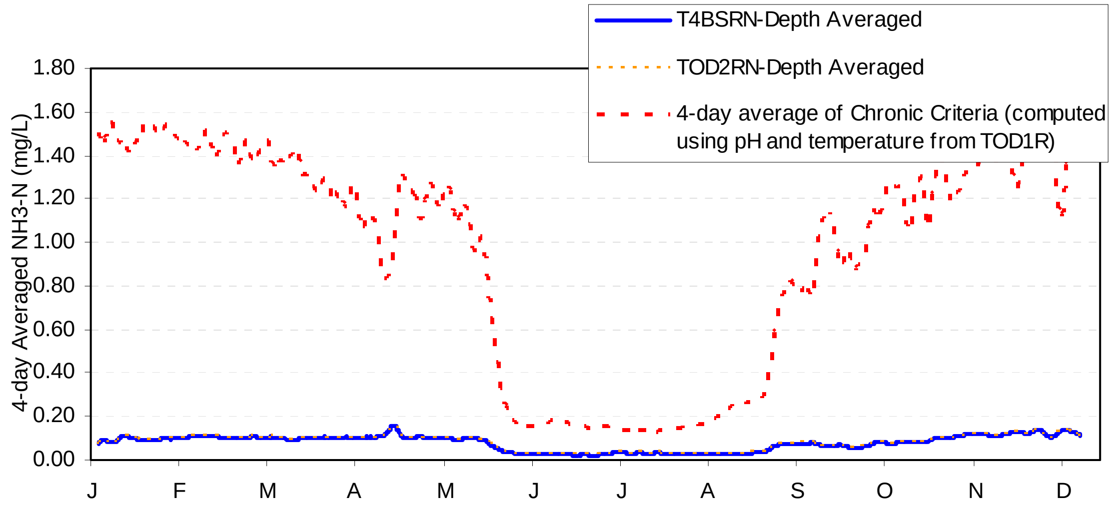


DO (mg/L)
T4BSRN-Depth Averaged
TOD2RN-Depth Averaged
7_day_running_standard
J F M A M J J A S O N D

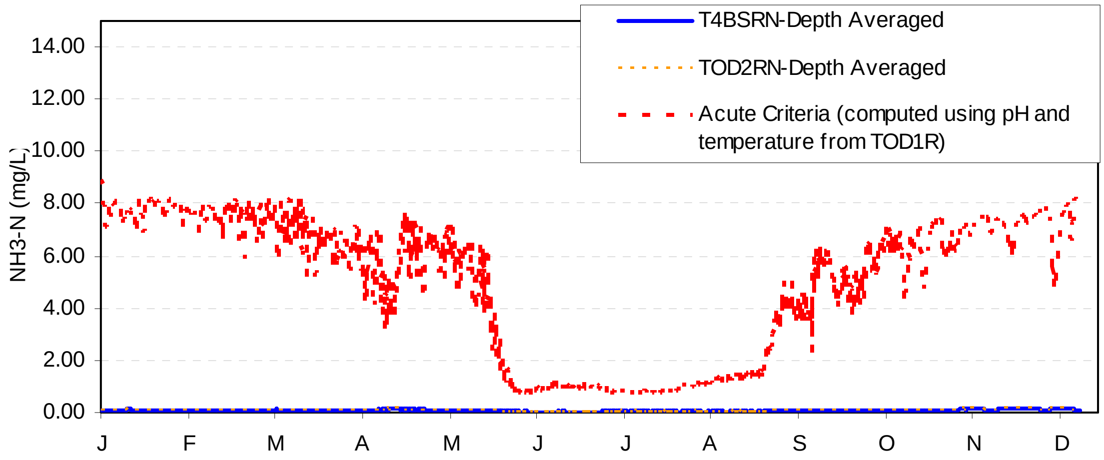


pH
T4BSRN-Depth Averaged
TOD2RN-Depth Averaged
pH criteria 1
pH criteria 2
J F M A M J J A S O N D

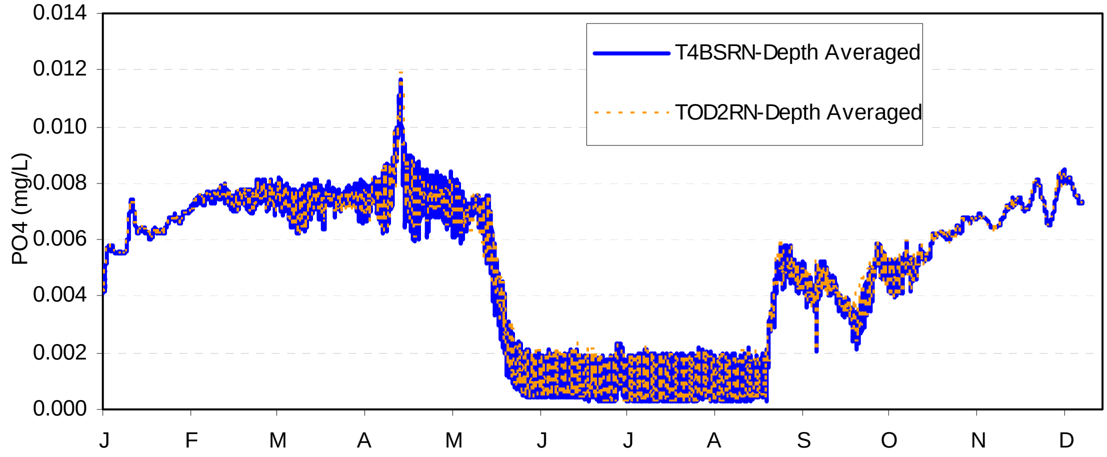
LRDC - CP



T4BSRN-Depth Averaged
TOD2RN-Depth Averaged
4-day average of Chronic Criteria (computed using pH and temperature from TOD1R)
4-day Averaged NH3-N (mg/L)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
J
F
M
A
M
J
J
A
S
O
N
D

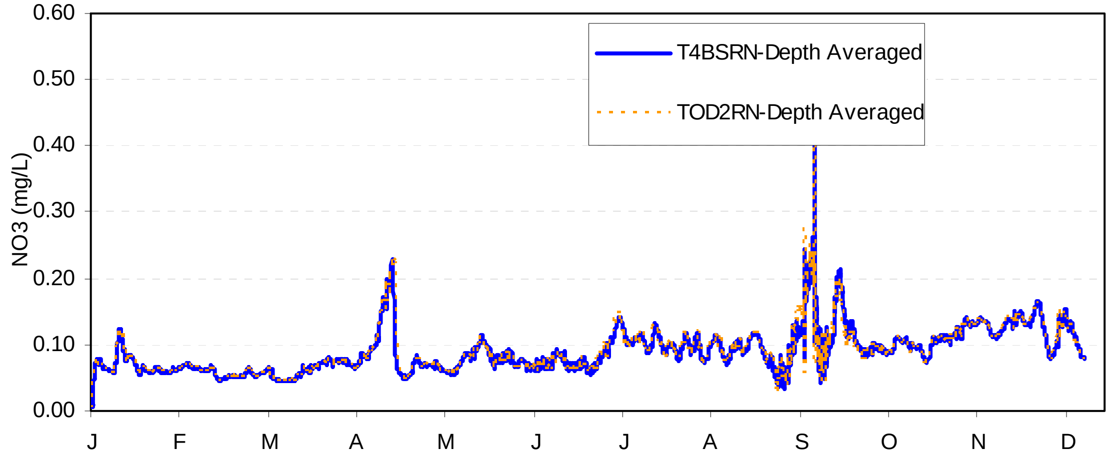


T4BSRN-Depth Averaged
TOD2RN-Depth Averaged
Acute Criteria (computed using pH and temperature from TOD1R)
NH3-N (mg/L)
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
J
F
M
A
M
J
J
A
S
O
N
D

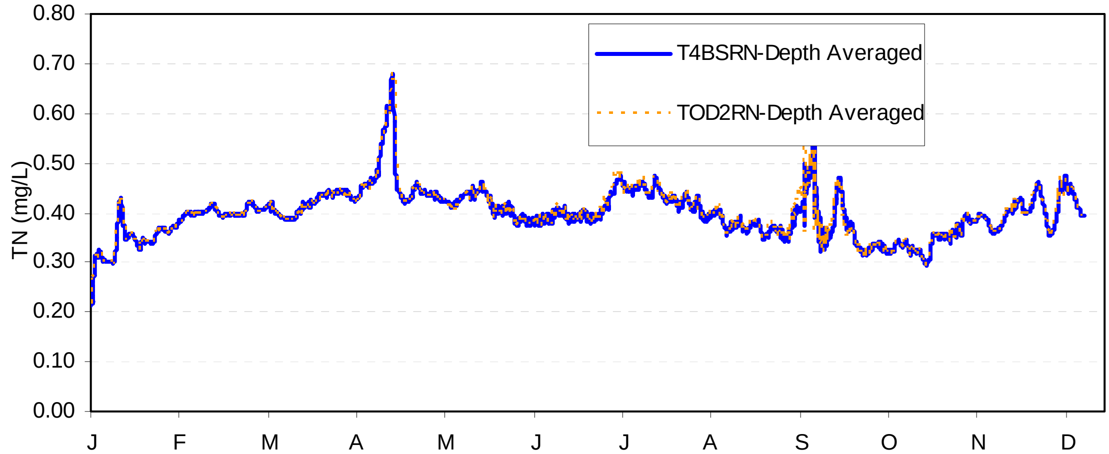


T4BSRN-Depth Averaged
TOD2RN-Depth Averaged
PO4 (mg/L)
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
J
F
M
A
M
J
J
A
S
O
N
D

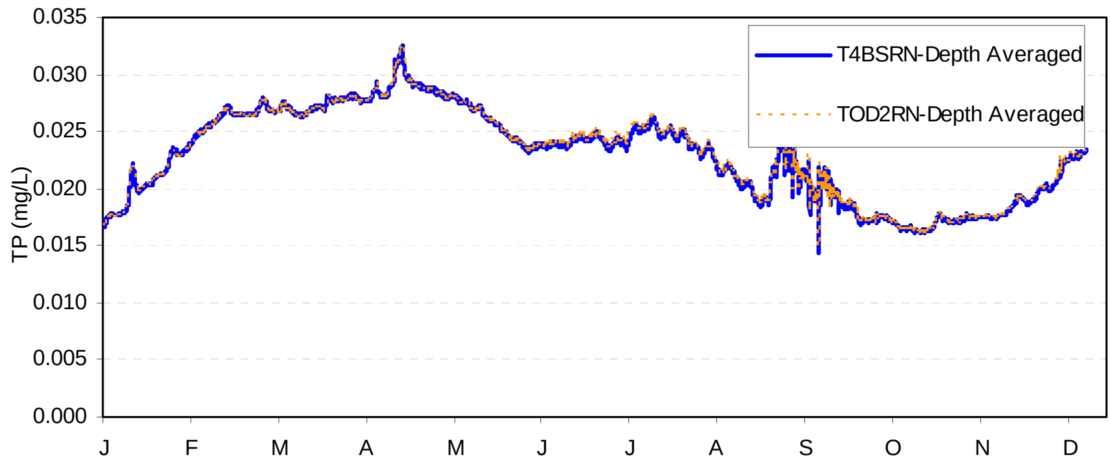
LRDC - CP



0.60
0.50
0.40
0.30
0.20
0.10
0.00
NO3 (mg/L)
J
F
M
A
M
J
J
A
S
O
N
D
T4BSRN-Depth Averaged
TOD2RN-Depth Averaged

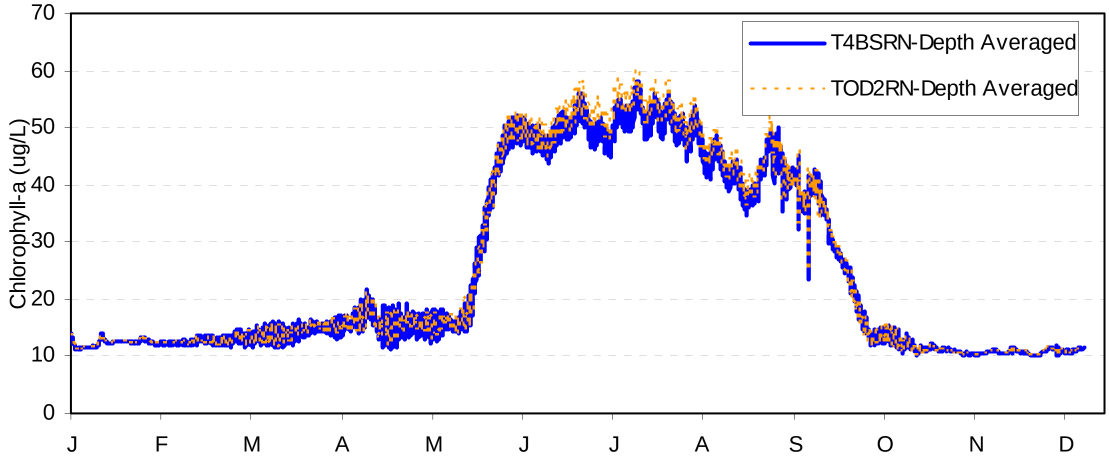


0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
TN (mg/L)
J
F
M
A
M
J
J
A
S
O
N
D
T4BSRN-Depth Averaged
TOD2RN-Depth Averaged

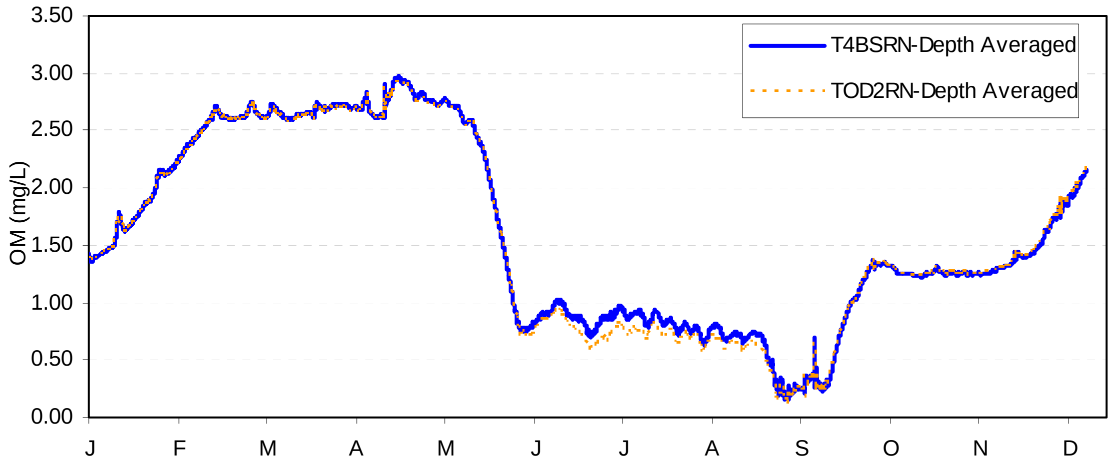


0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
TP (mg/L)
J
F
M
A
M
J
J
A
S
O
N
D
T4BSRN-Depth Averaged
TOD2RN-Depth Averaged

LRDC - CP

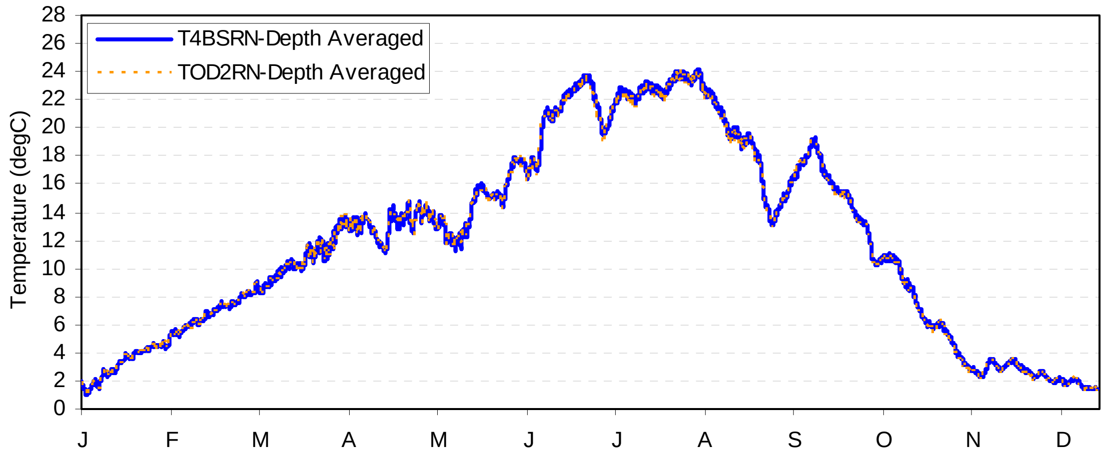


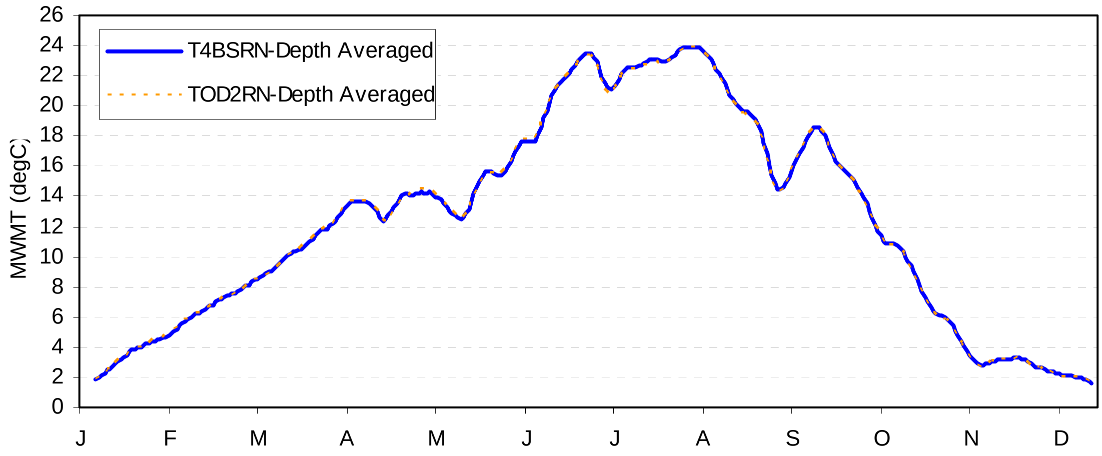
Chlorophyll-a (ug/L)
70
60
50
40
30
20
10
0
J
F
M
A
M
J
J
A
S
O
N
D
T4BSRN-Depth Averaged
TOD2RN-Depth Averaged

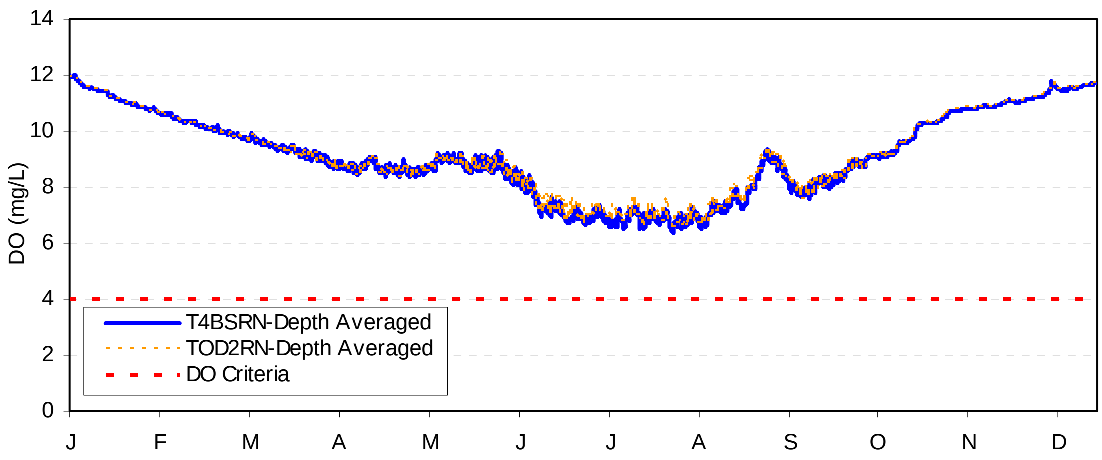


OM (mg/L)
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
J
F
M
A
M
J
J
A
S
O
N
D
T4BSRN-Depth Averaged
TOD2RN-Depth Averaged

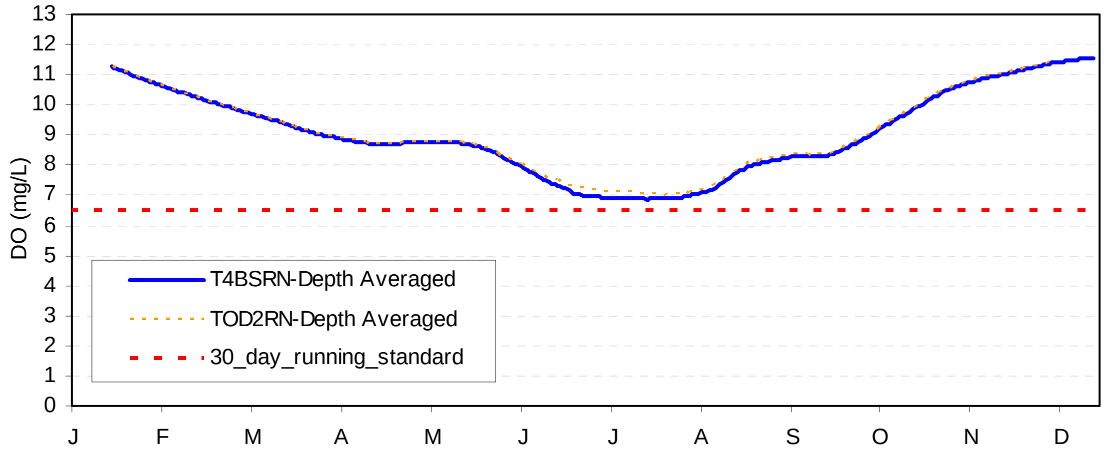
Miller Island

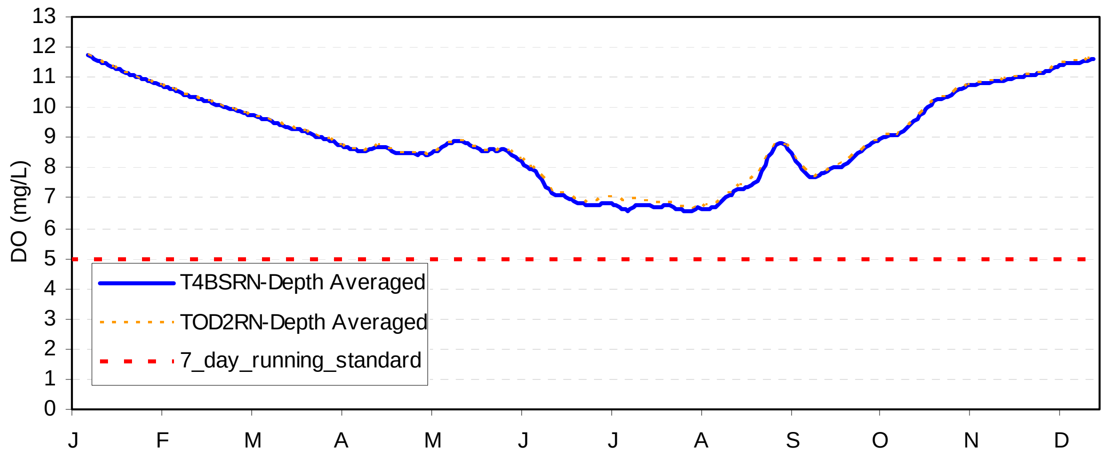


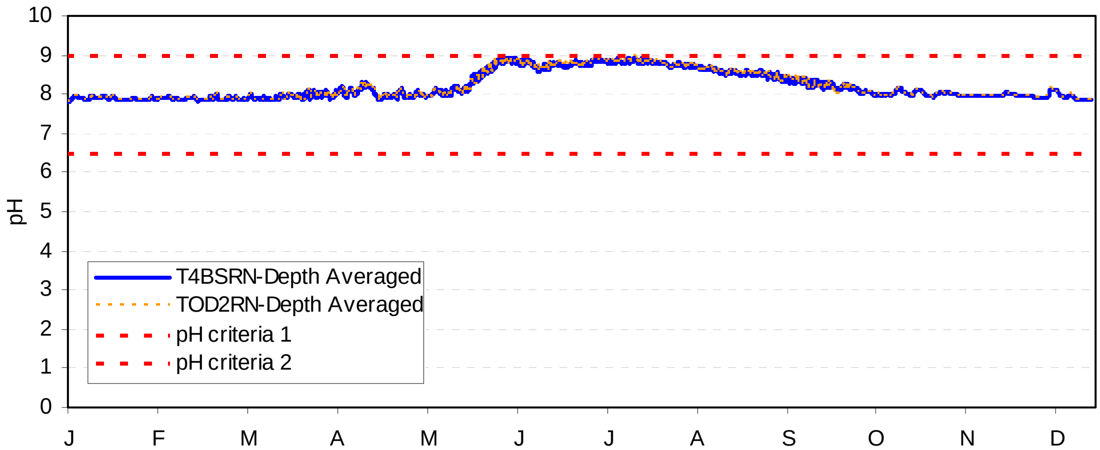




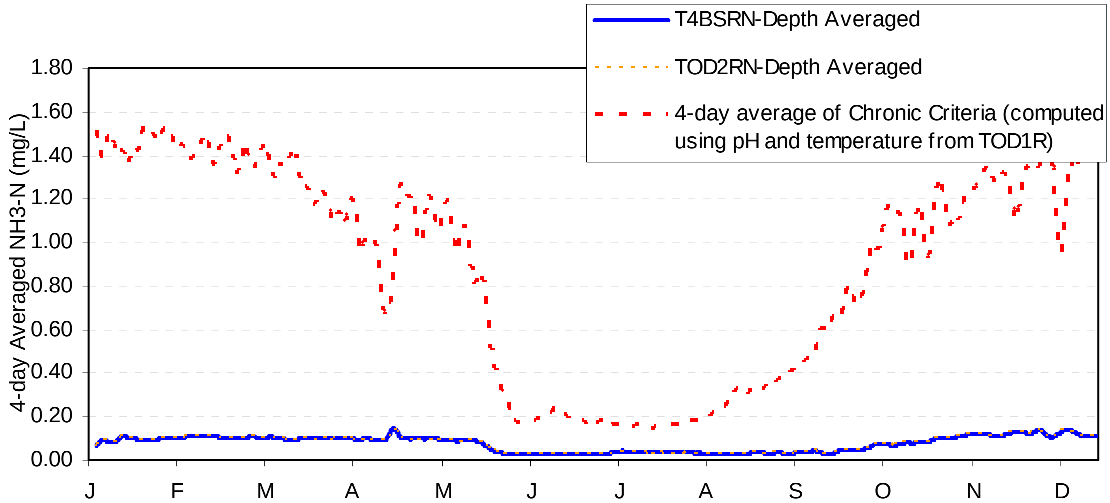
Miller Island

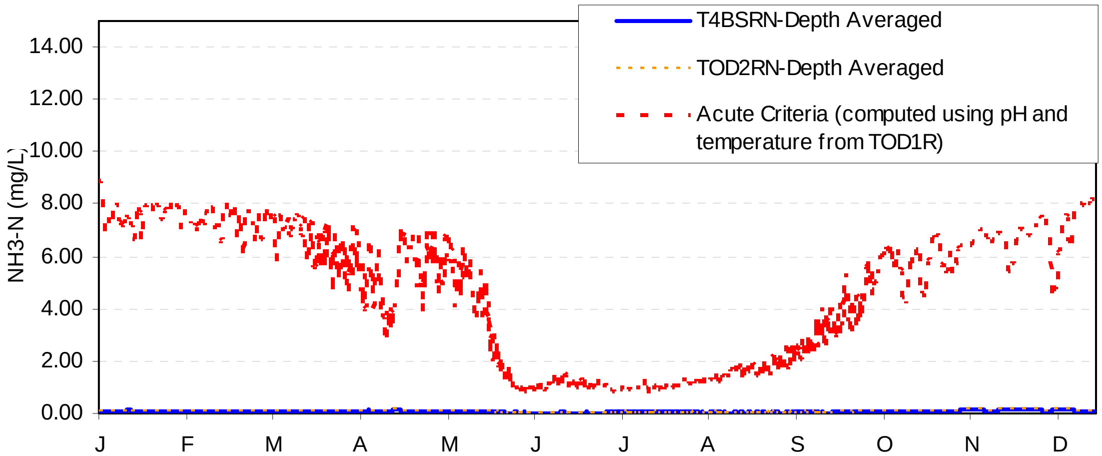


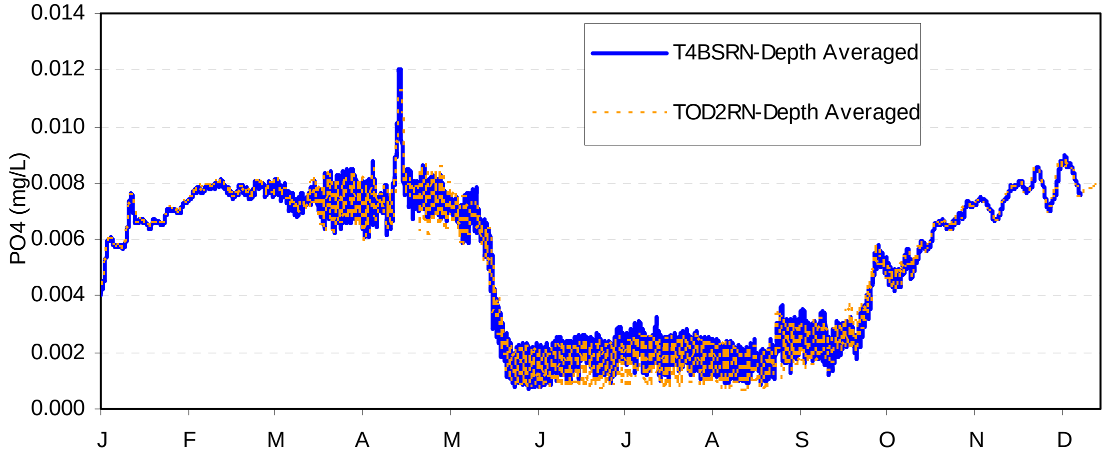




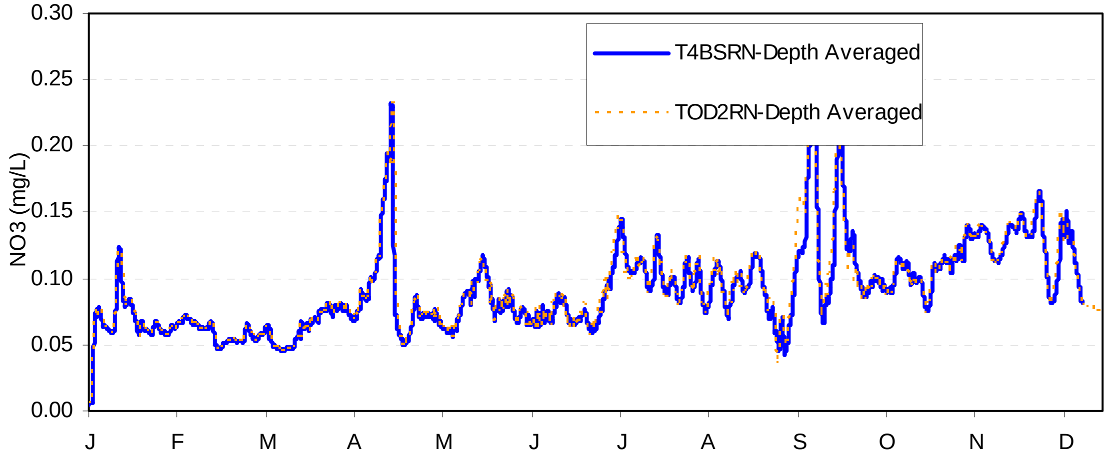
Miller Island

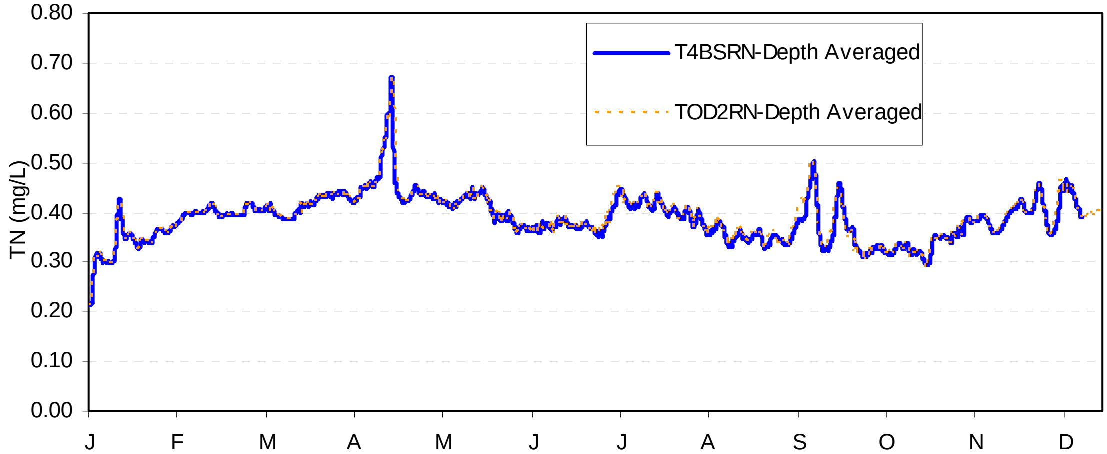


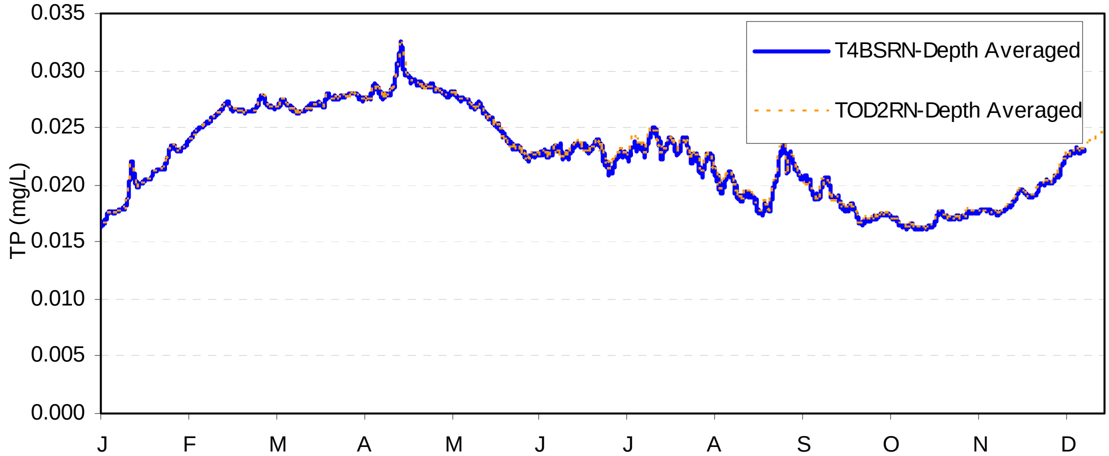




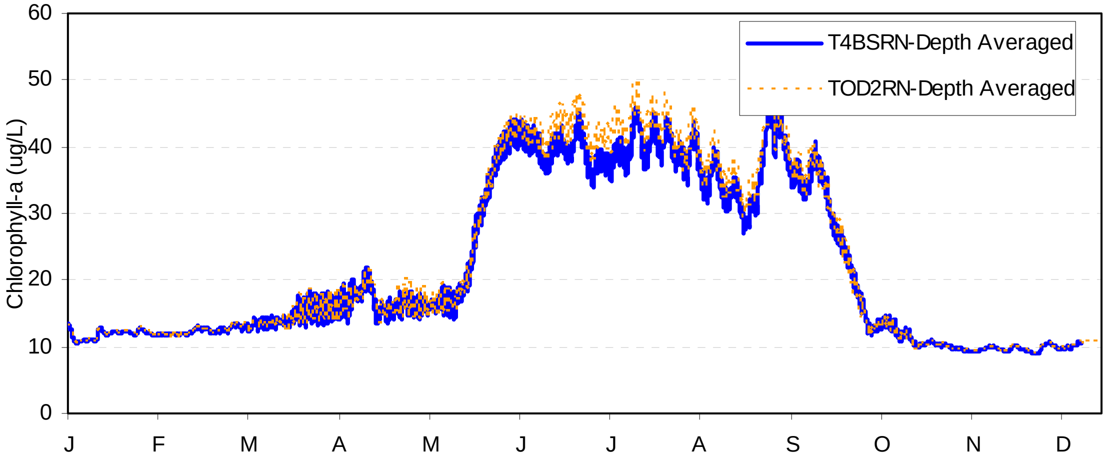
Miller Island

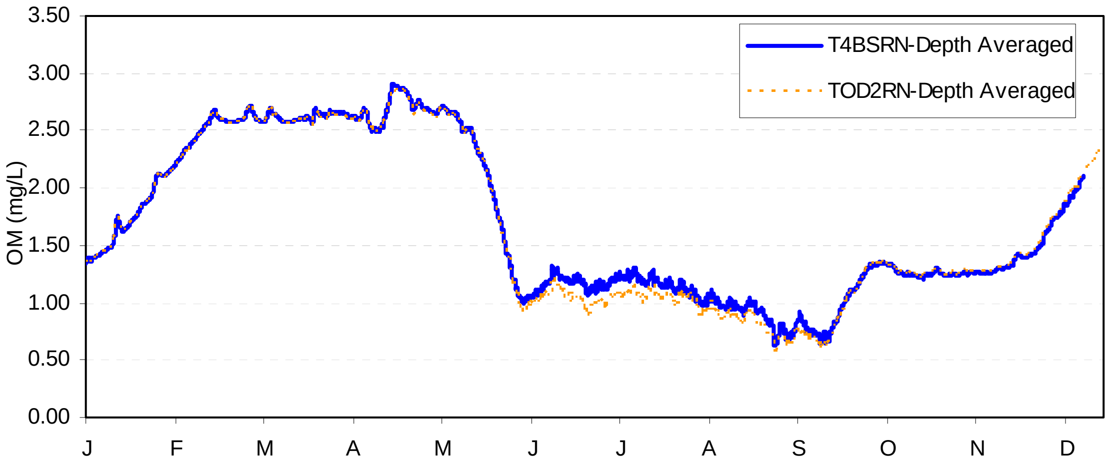




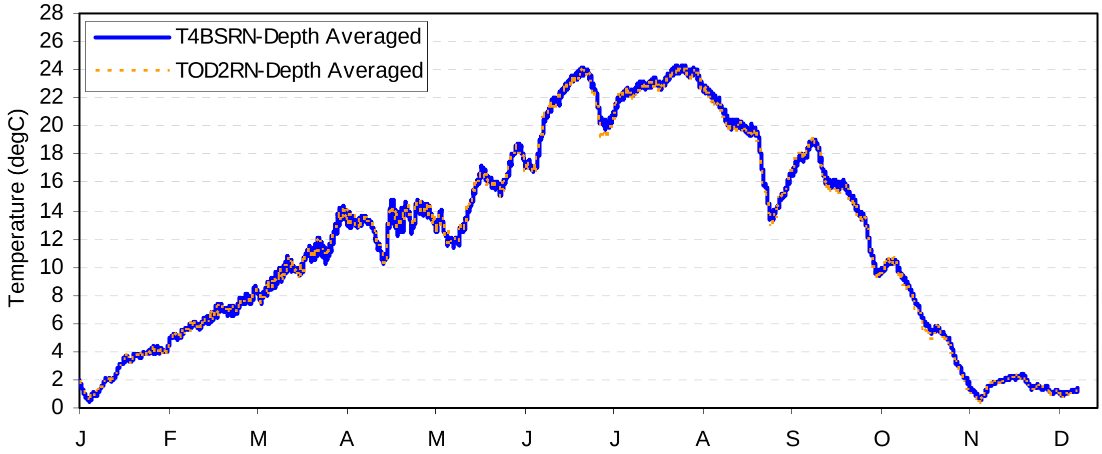


Miller Island

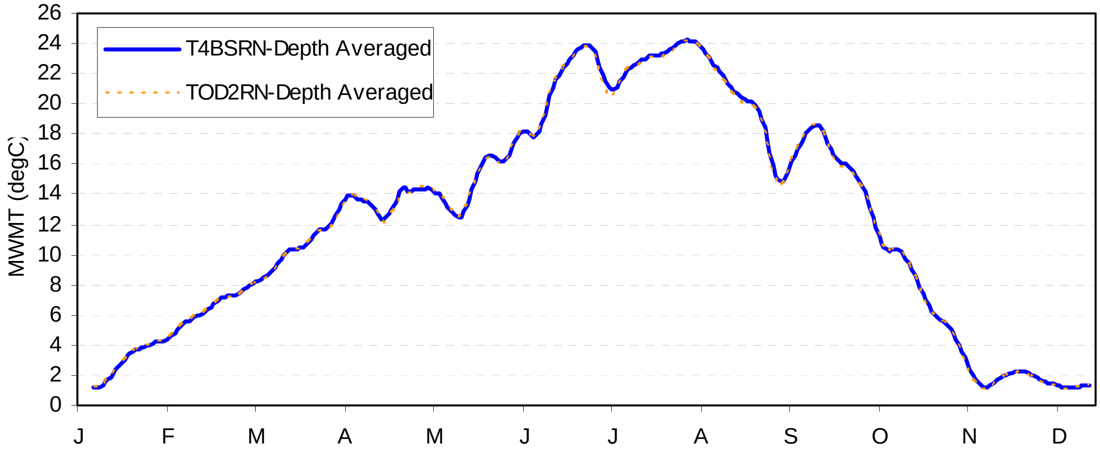




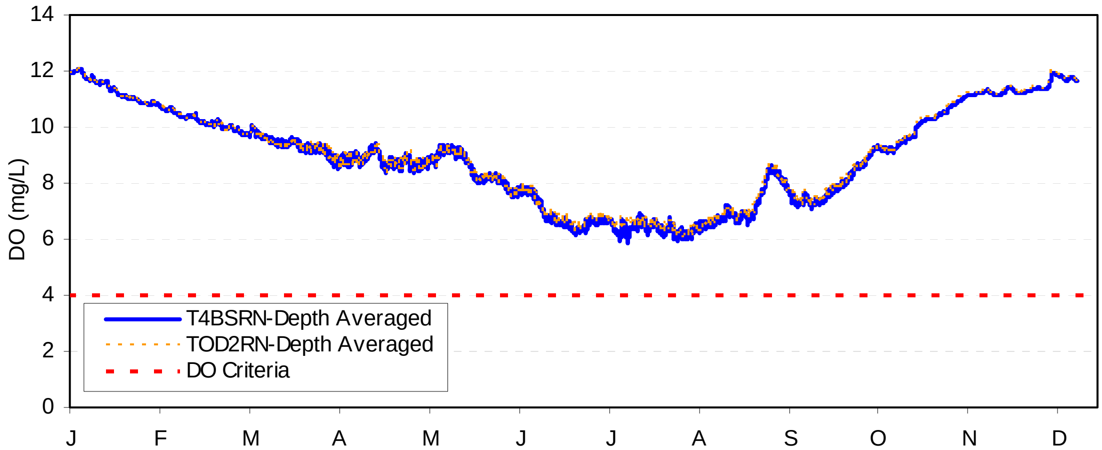
KSD



Temperature (degC)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
J F M A M J J A S O N D
T4BSRN-Depth Averaged
TOD2RN-Depth Averaged

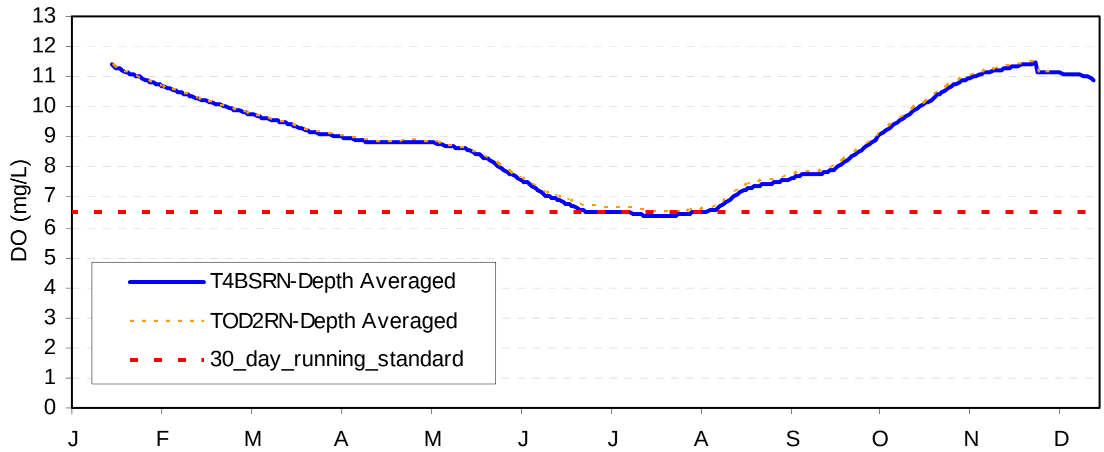


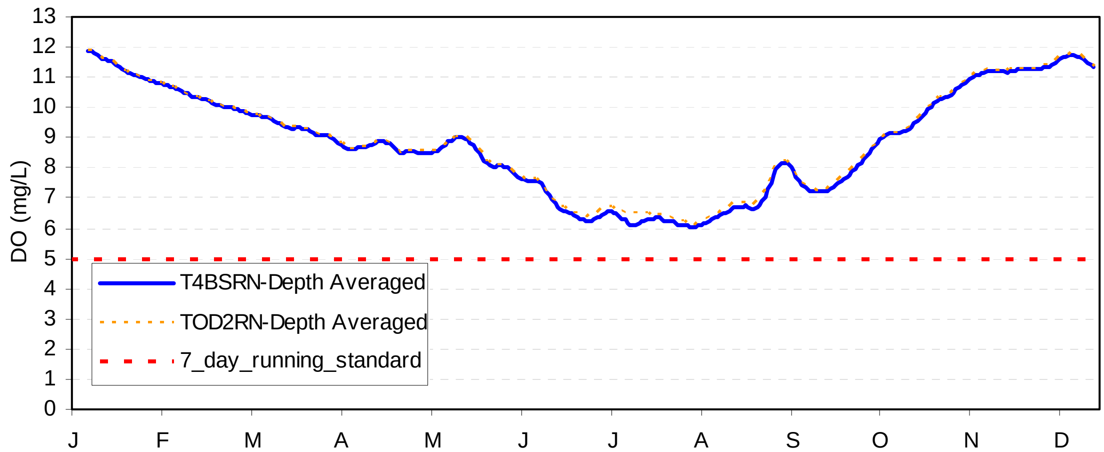
MWMT (degC)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
J F M A M J J A S O N D
T4BSRN-Depth Averaged
TOD2RN-Depth Averaged

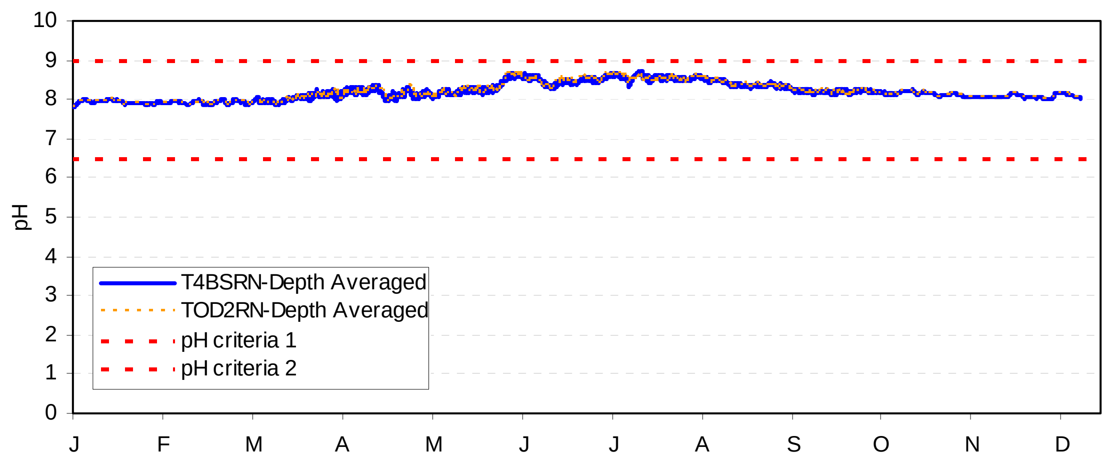


DO (mg/L)
0
2
4
6
8
10
12
14
J F M A M J J A S O N D
T4BSRN-Depth Averaged
TOD2RN-Depth Averaged
DO Criteria

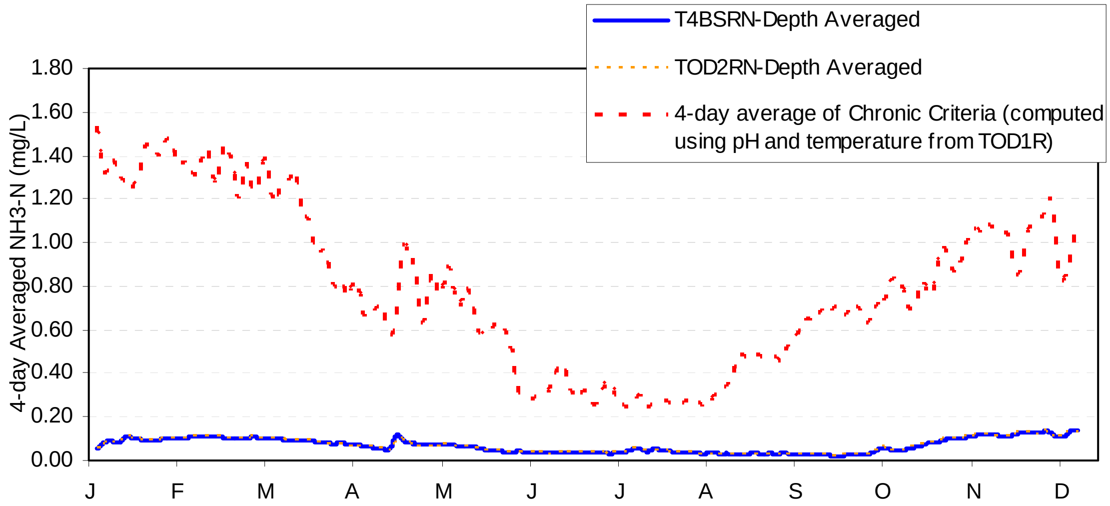
KSD


13
12
11
10
9
8
7
6
5
4
3
2
1
0
DO (mg/L)
T4BSRN-Depth Averaged
TOD2RN-Depth Averaged
30_day_running_standard
J
F
M
A
M
J
J
A
S
O
N
D

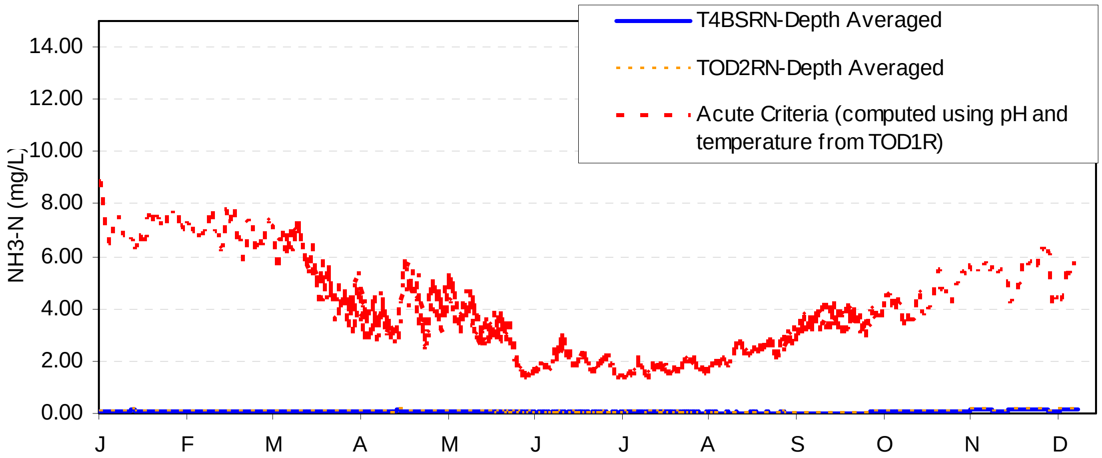

13
12
11
10
9
8
7
6
5
4
3
2
1
0
DO (mg/L)
T4BSRN-Depth Averaged
TOD2RN-Depth Averaged
7_day_running_standard
J
F
M
A
M
J
J
A
S
O
N
D


10
9
8
7
6
5
4
3
2
1
0
pH
T4BSRN-Depth Averaged
TOD2RN-Depth Averaged
pH criteria 1
pH criteria 2
J
F
M
A
M
J
J
A
S
O
N
D

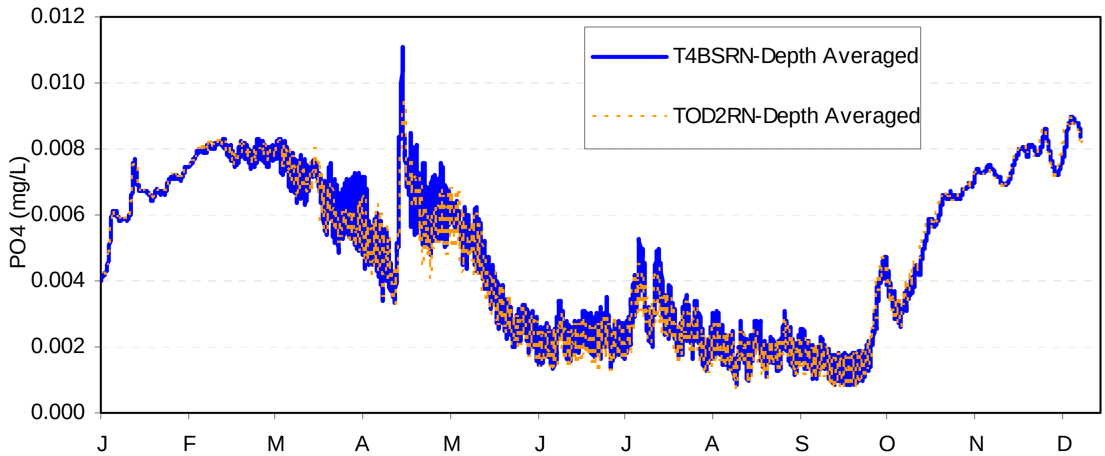
KSD



T4BSRN-Depth Averaged
TOD2RN-Depth Averaged
4-day average of Chronic Criteria (computed using pH and temperature from TOD1R)
4-day Averaged NH3-N (mg/L)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
J F M A M J J A S O N D

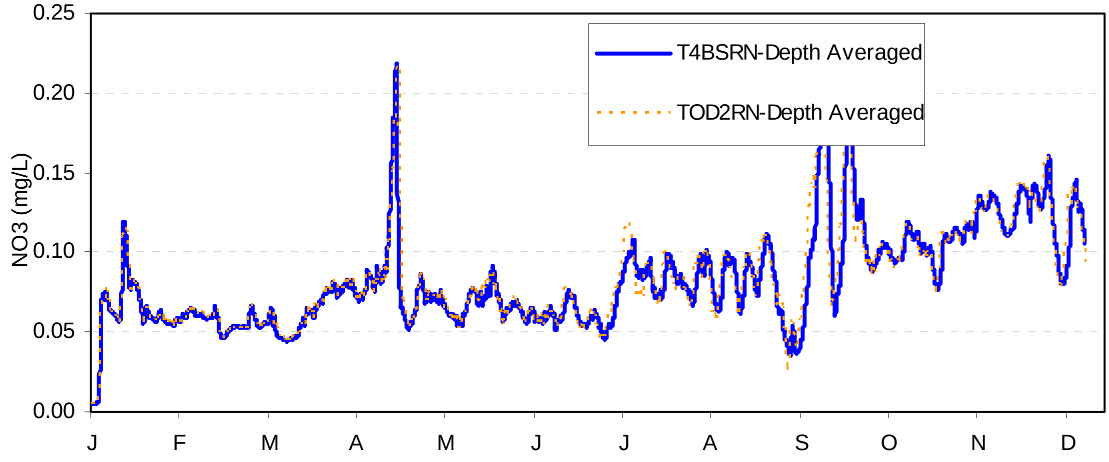


T4BSRN-Depth Averaged
TOD2RN-Depth Averaged
Acute Criteria (computed using pH and temperature from TOD1R)
NH3-N (mg/L)
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
J F M A M J J A S O N D

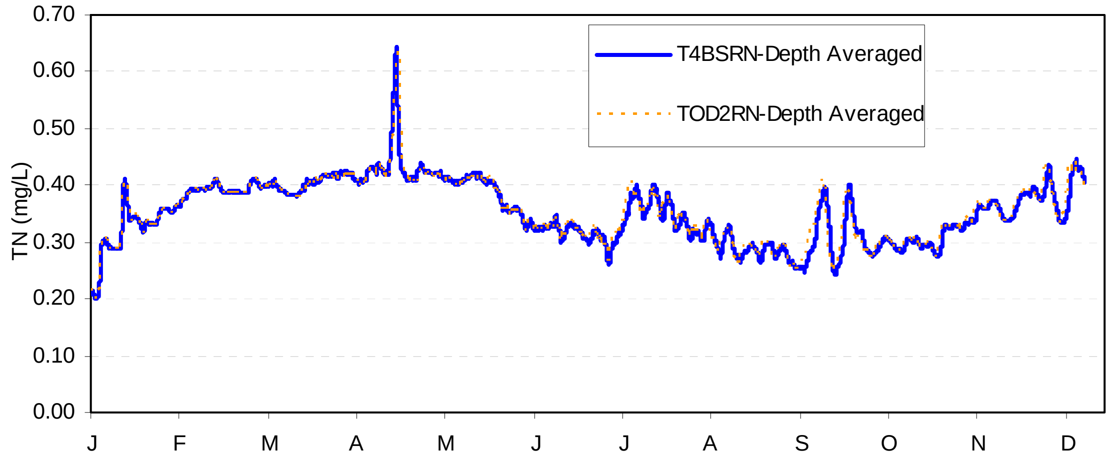


T4BSRN-Depth Averaged
TOD2RN-Depth Averaged
PO4 (mg/L)
0.012
0.010
0.008
0.006
0.004
0.002
0.000
J F M A M J J A S O N D

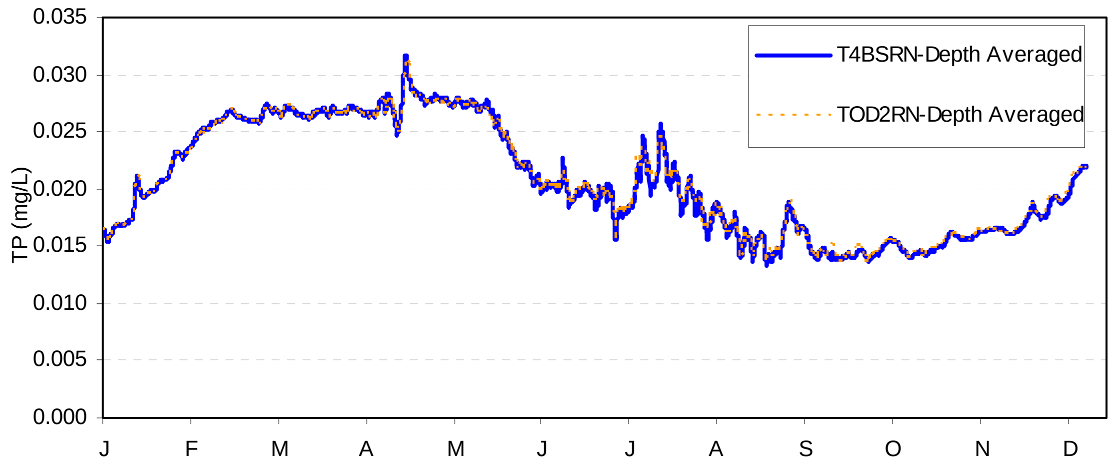
KSD



0.25
0.20
0.15
0.10
0.05
0.00
NO3 (mg/L)
J
F
M
A
M
J
J
A
S
O
N
D
T4BSRN-Depth Averaged
TOD2RN-Depth Averaged

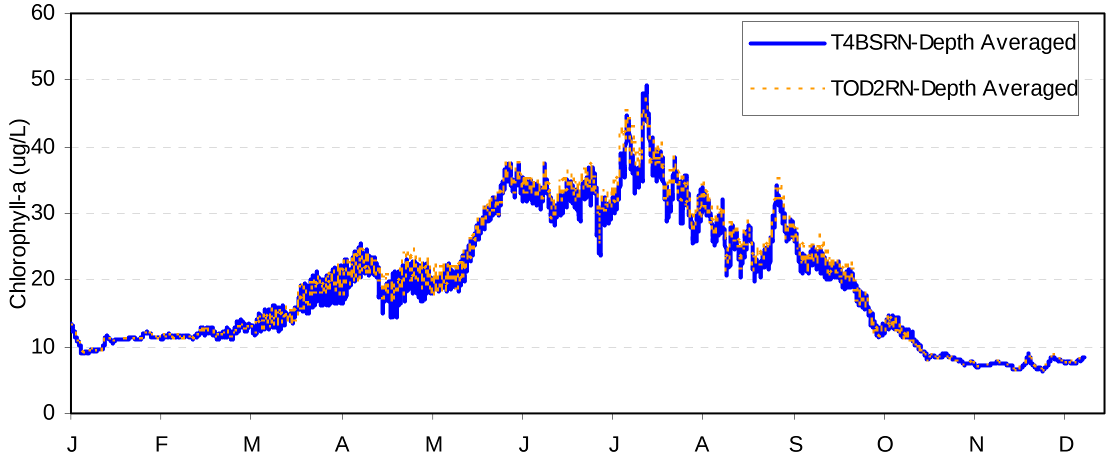


0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
TN (mg/L)
J
F
M
A
M
J
J
A
S
O
N
D
T4BSRN-Depth Averaged
TOD2RN-Depth Averaged

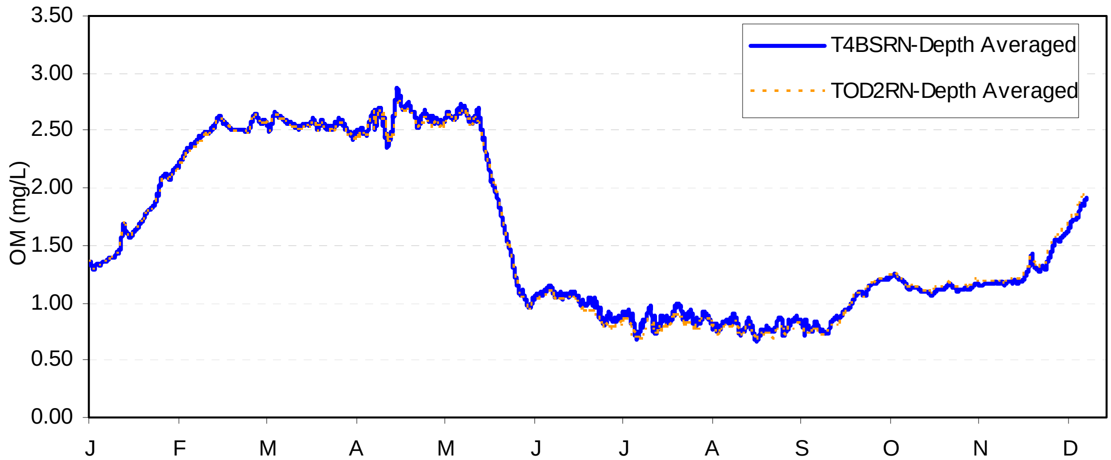


0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
TP (mg/L)
J
F
M
A
M
J
J
A
S
O
N
D
T4BSRN-Depth Averaged
TOD2RN-Depth Averaged

KSD

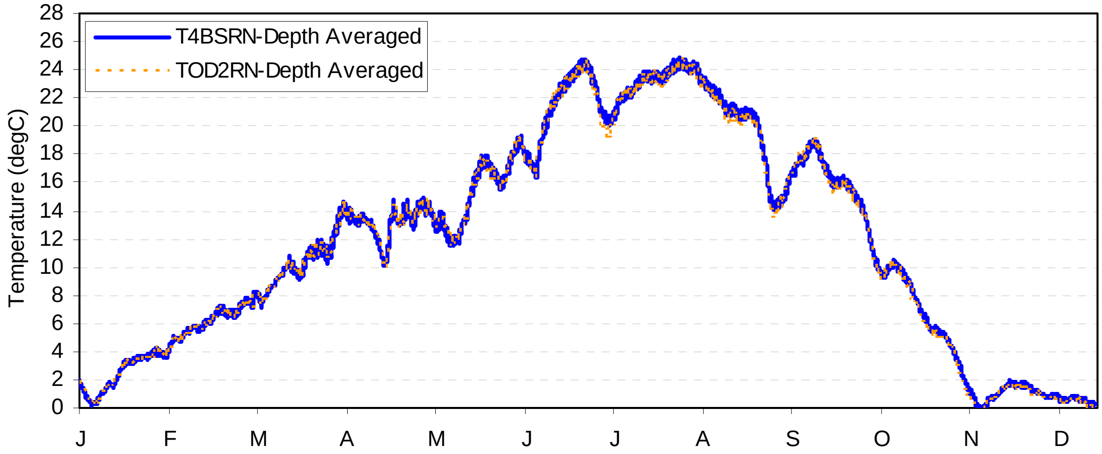


Chlorophyll-a (ug/L)
0
10
20
30
40
50
60
J
F
M
A
M
J
J
A
S
O
N
D
T4BSRN-Depth Averaged
TOD2RN-Depth Averaged

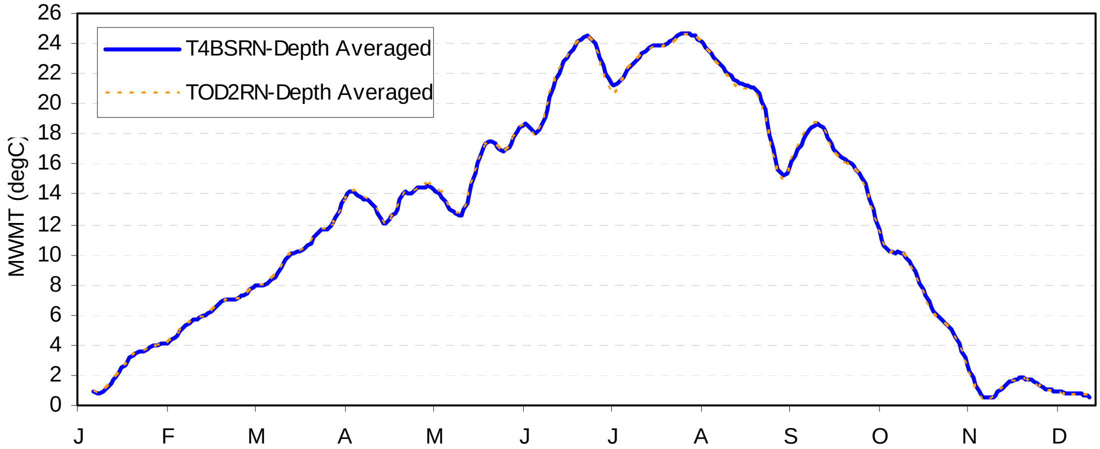


OM (mg/L)
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
J
F
M
A
M
J
J
A
S
O
N
D
T4BSRN-Depth Averaged
TOD2RN-Depth Averaged

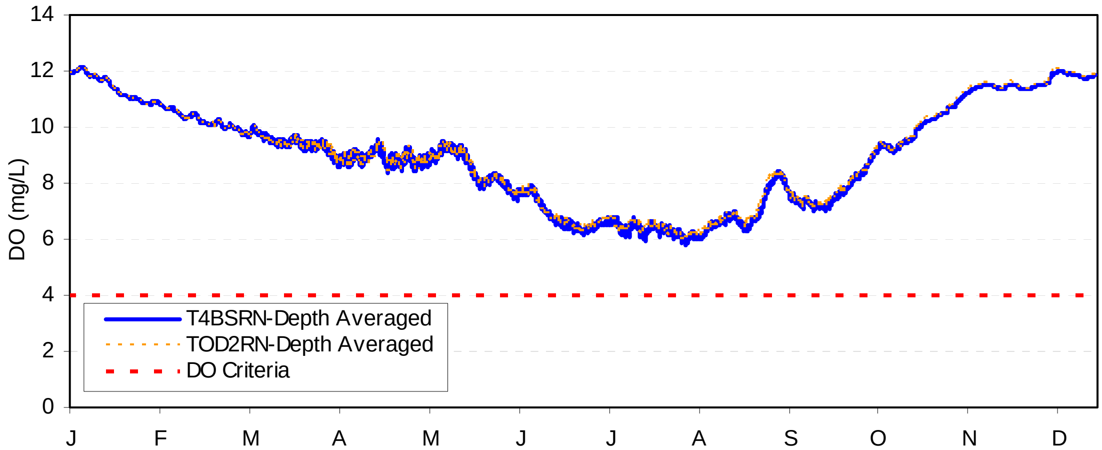
Hwy 66



T4BSRN-Depth Averaged
TOD2RN-Depth Averaged
Temperature (degC)
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
J F M A M J J A S O N D

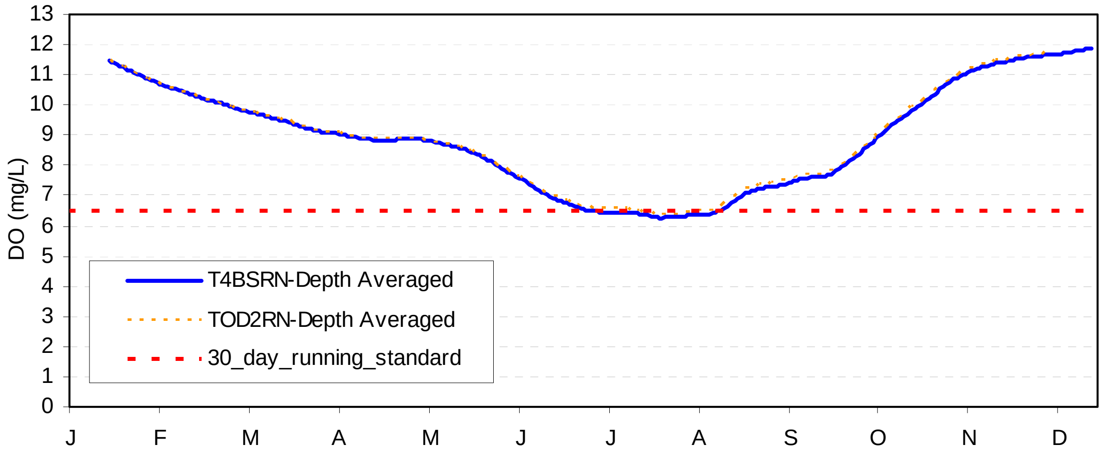


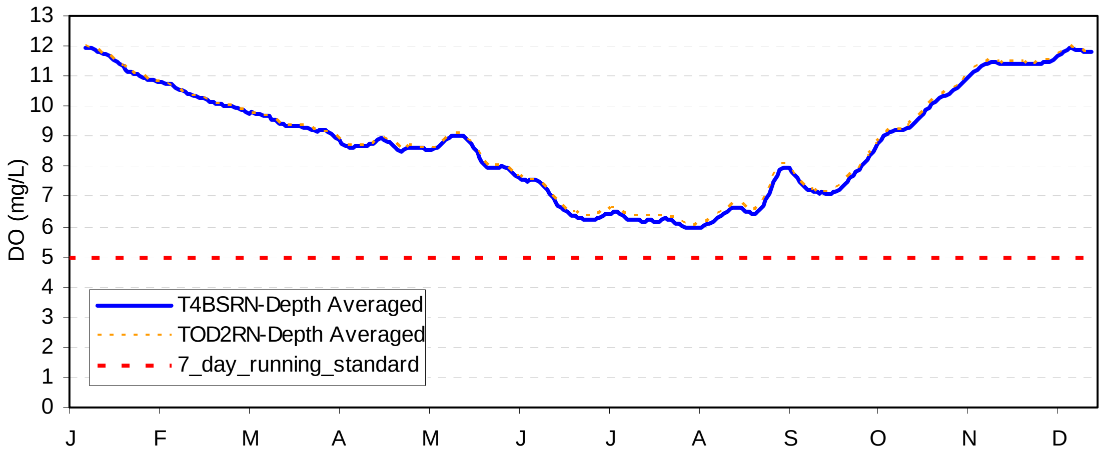
T4BSRN-Depth Averaged
TOD2RN-Depth Averaged
MWMT (degC)
26
24
22
20
18
16
14
12
10
8
6
4
2
0
J F M A M J J A S O N D

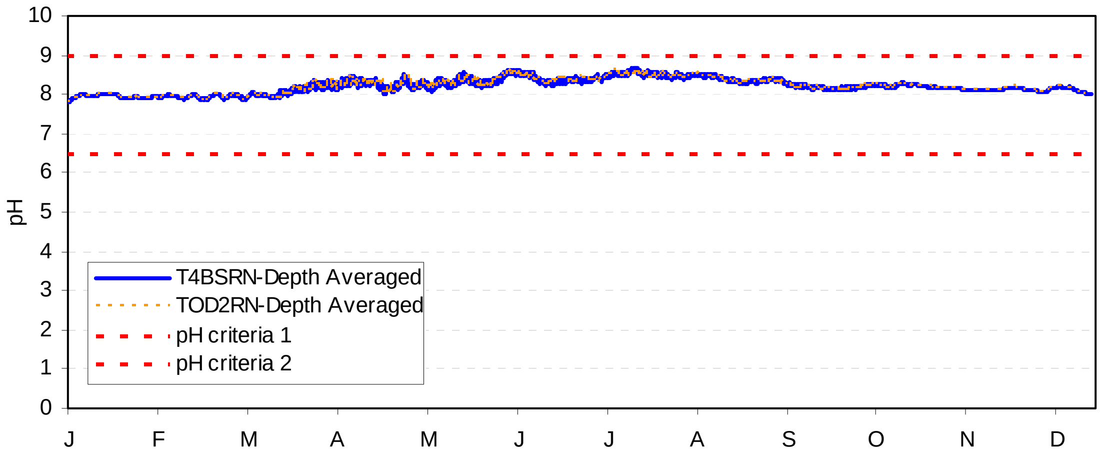


T4BSRN-Depth Averaged
TOD2RN-Depth Averaged
DO Criteria
DO (mg/L)
14
12
10
8
6
4
2
0
J F M A M J J A S O N D

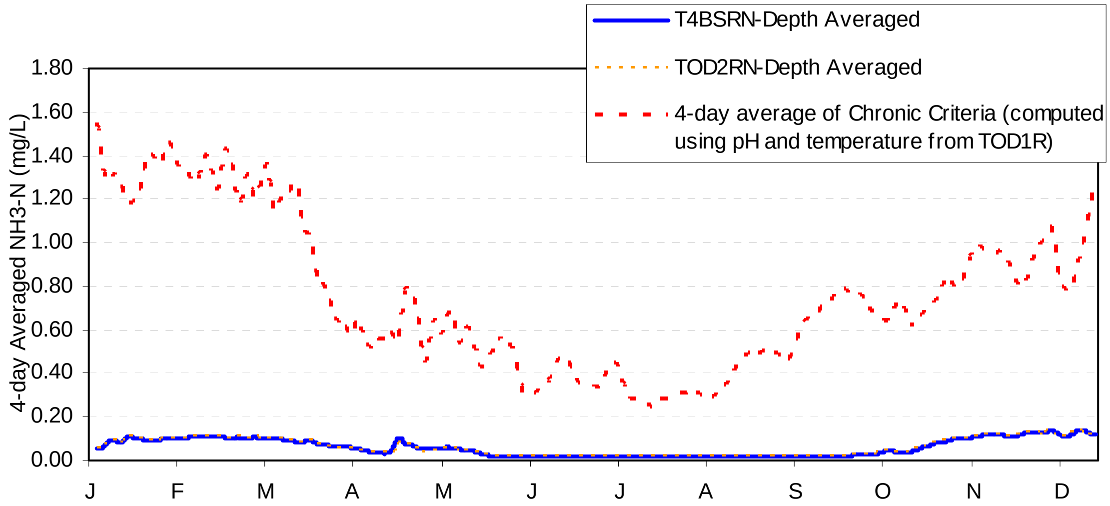
Hwy 66

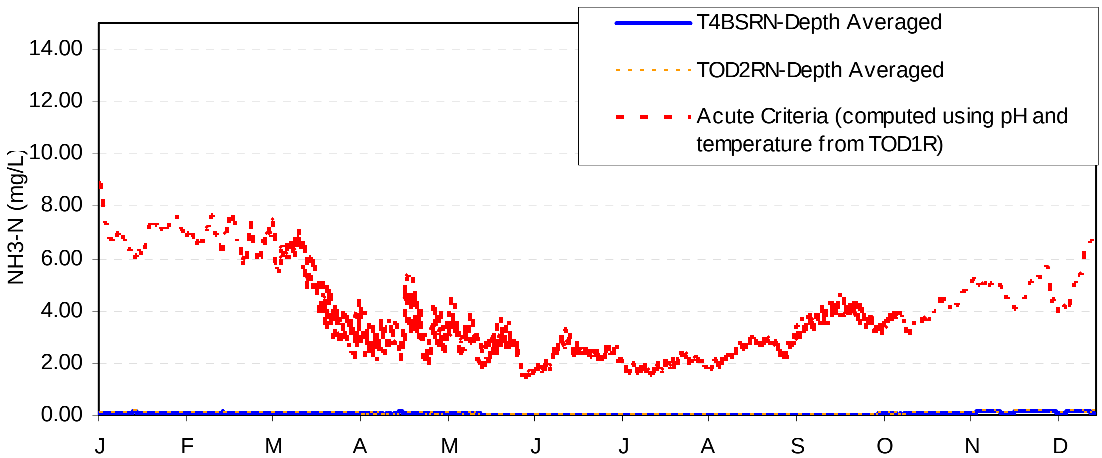

13
12
11
10
9
8
7
6
5
4
3
2
1
0
DO (mg/L)
T4BSRN-Depth Averaged
TOD2RN-Depth Averaged
30_day_running_standard
J
F
M
A
M
J
J
A
S
O
N
D

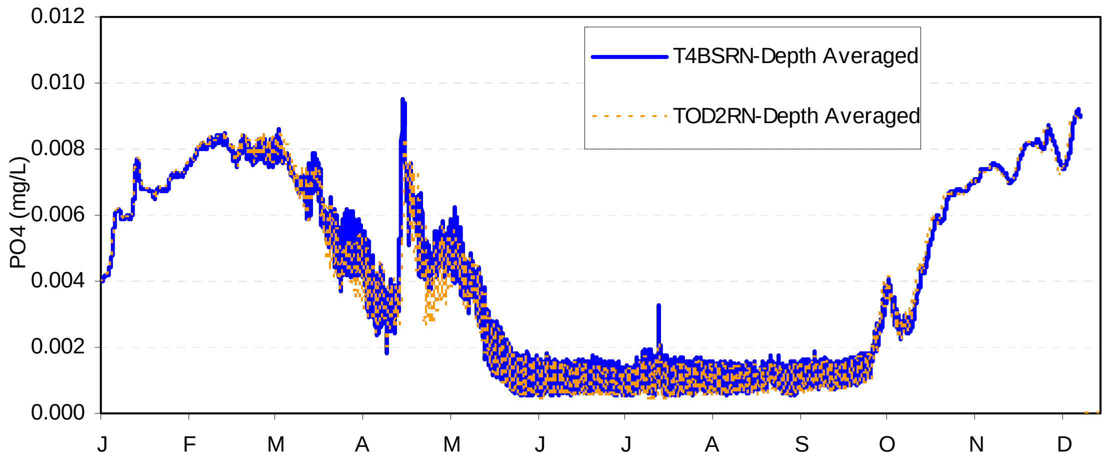

13
12
11
10
9
8
7
6
5
4
3
2
1
0
DO (mg/L)
T4BSRN-Depth Averaged
TOD2RN-Depth Averaged
7_day_running_standard
J
F
M
A
M
J
J
A
S
O
N
D


10
9
8
7
6
5
4
3
2
1
0
pH
T4BSRN-Depth Averaged
TOD2RN-Depth Averaged
pH criteria 1
pH criteria 2
J
F
M
A
M
J
J
A
S
O
N
D

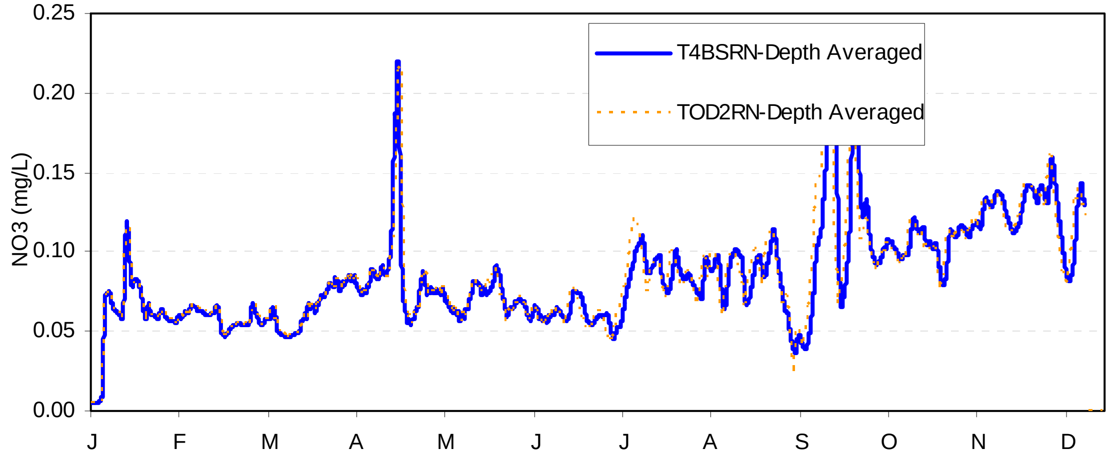
Hwy 66


T4BSRN-Depth Averaged
TOD2RN-Depth Averaged
4-day average of Chronic Criteria (computed using pH and temperature from TOD1R)
4-day Averaged NH3-N (mg/L)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
J F M A M J J A S O N D

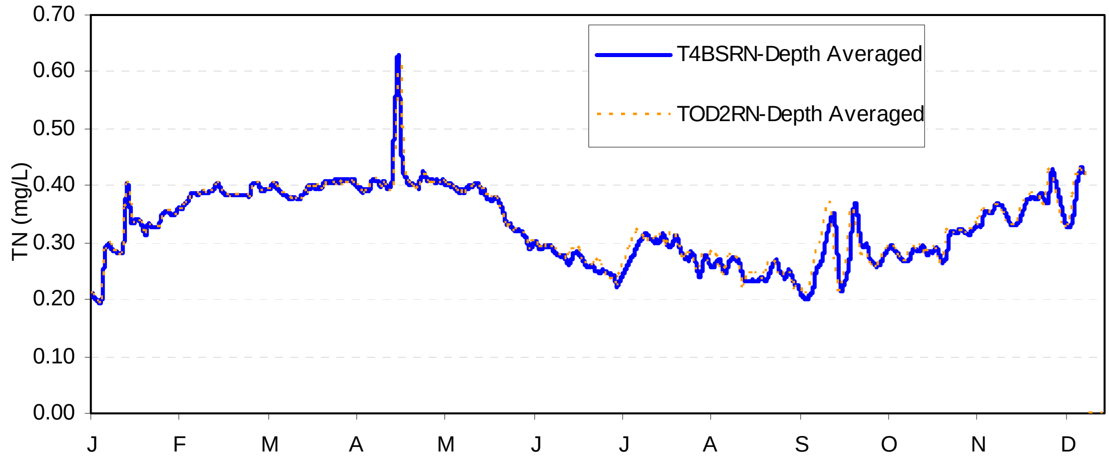

T4BSRN-Depth Averaged
TOD2RN-Depth Averaged
Acute Criteria (computed using pH and temperature from TOD1R)
NH3-N (mg/L)
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
J F M A M J J A S O N D


T4BSRN-Depth Averaged
TOD2RN-Depth Averaged
PO4 (mg/L)
0.012
0.010
0.008
0.006
0.004
0.002
0.000
J F M A M J J A S O N D

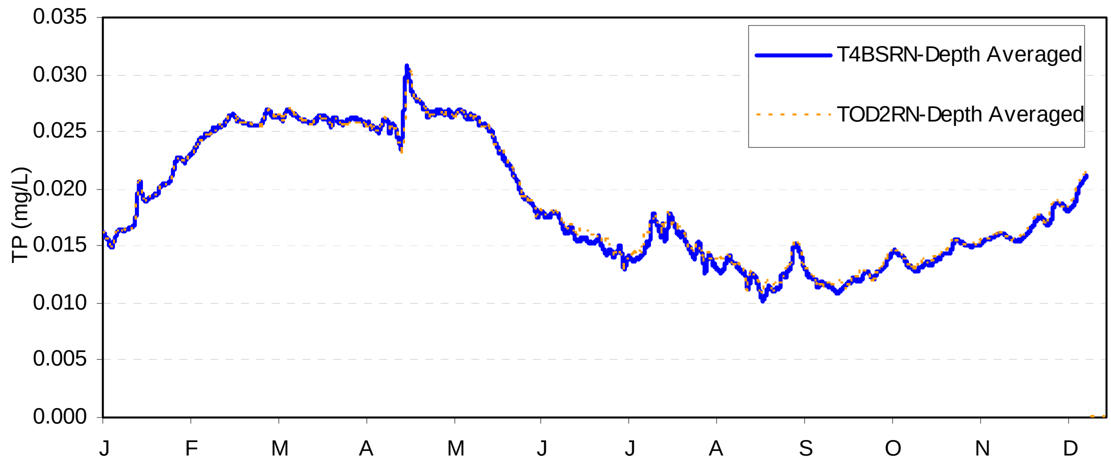
Hwy 66



0.25
0.20
0.15
0.10
0.05
0.00
NO3 (mg/L)
J
F
M
A
M
J
J
A
S
O
N
D
T4BSRN-Depth Averaged
TOD2RN-Depth Averaged

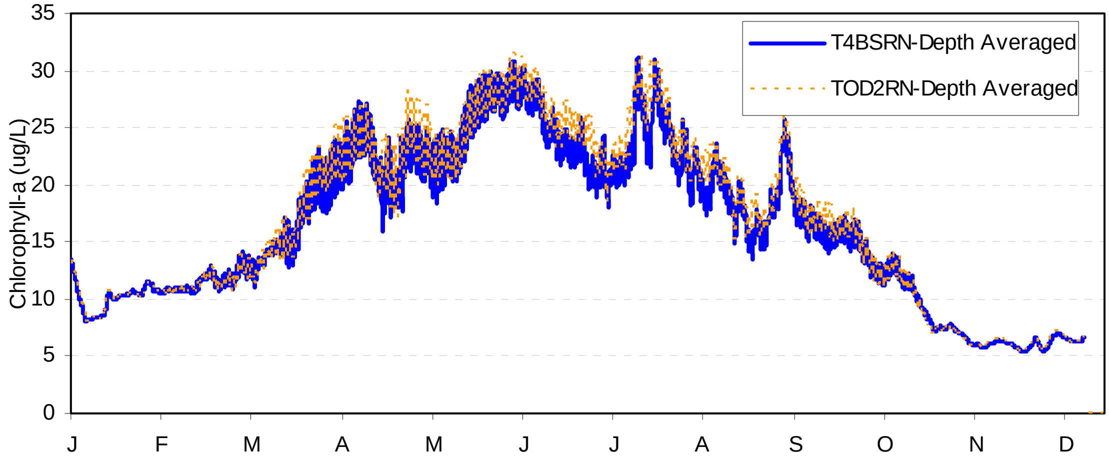


0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
TN (mg/L)
J
F
M
A
M
J
J
A
S
O
N
D
T4BSRN-Depth Averaged
TOD2RN-Depth Averaged

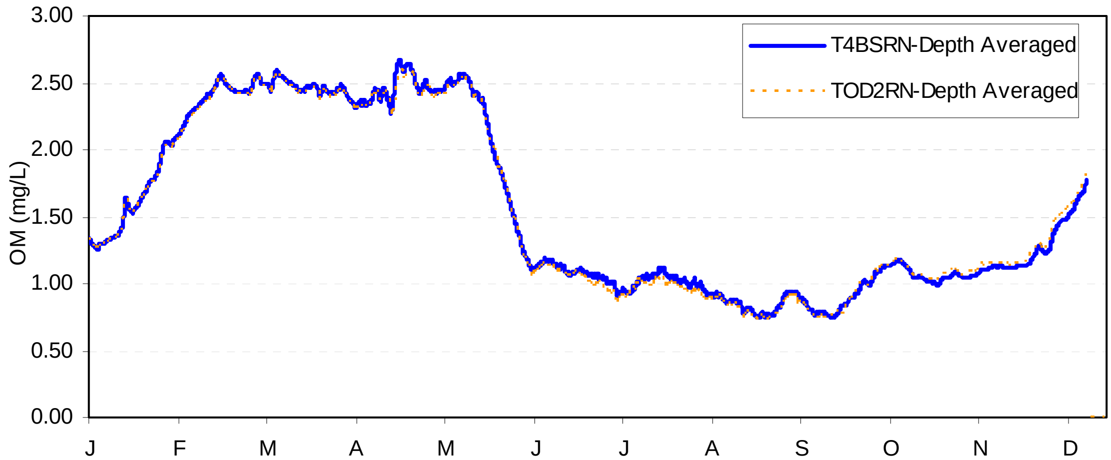


0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
TP (mg/L)
J
F
M
A
M
J
J
A
S
O
N
D
T4BSRN-Depth Averaged
TOD2RN-Depth Averaged

Hwy 66

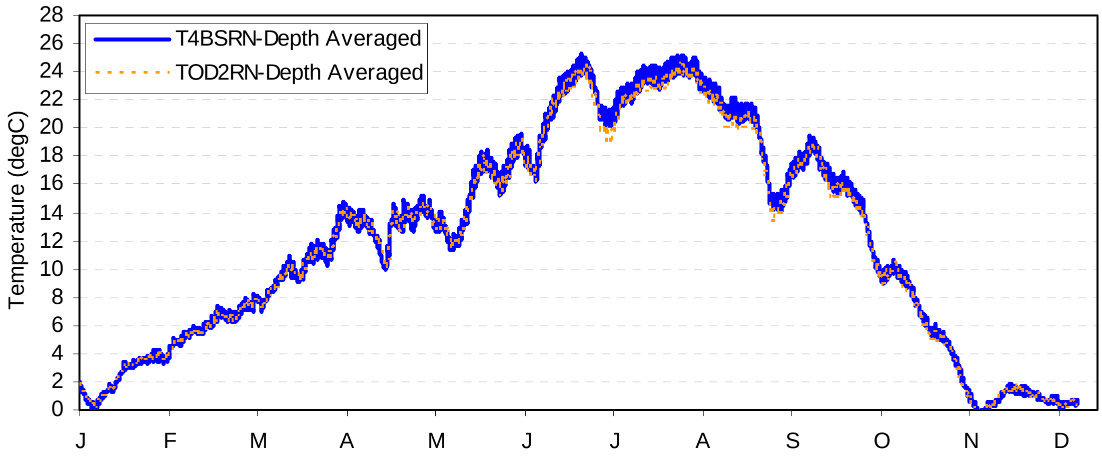


Chlorophyll-a (ug/L)
35
30
25
20
15
10
5
0
J
F
M
A
M
J
J
A
S
O
N
D
T4BSRN-Depth Averaged
TOD2RN-Depth Averaged

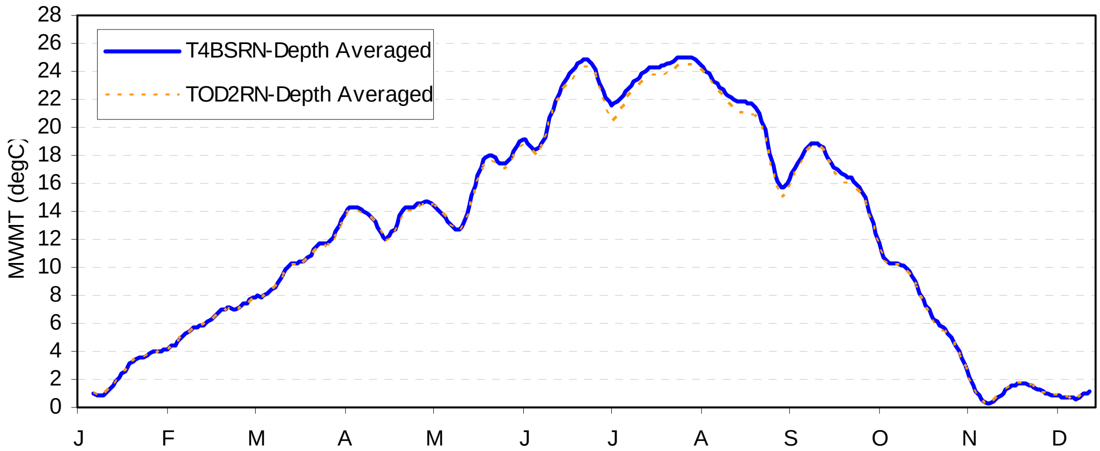


OM (mg/L)
3.00
2.50
2.00
1.50
1.00
0.50
0.00
J
F
M
A
M
J
J
A
S
O
N
D
T4BSRN-Depth Averaged
TOD2RN-Depth Averaged

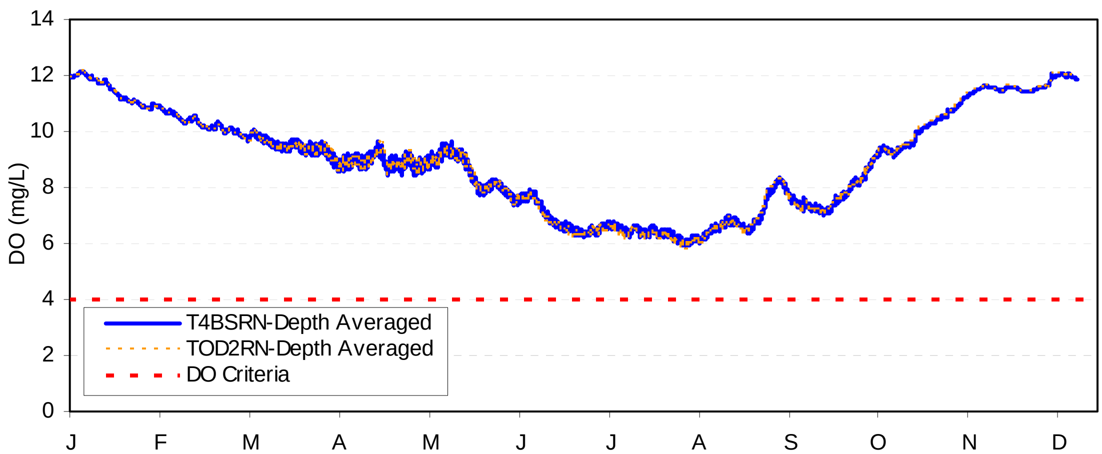
Keno Dam



T4BSRN-Depth Averaged
TOD2RN-Depth Averaged
Temperature (degC)
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
J F M A M J J A S O N D

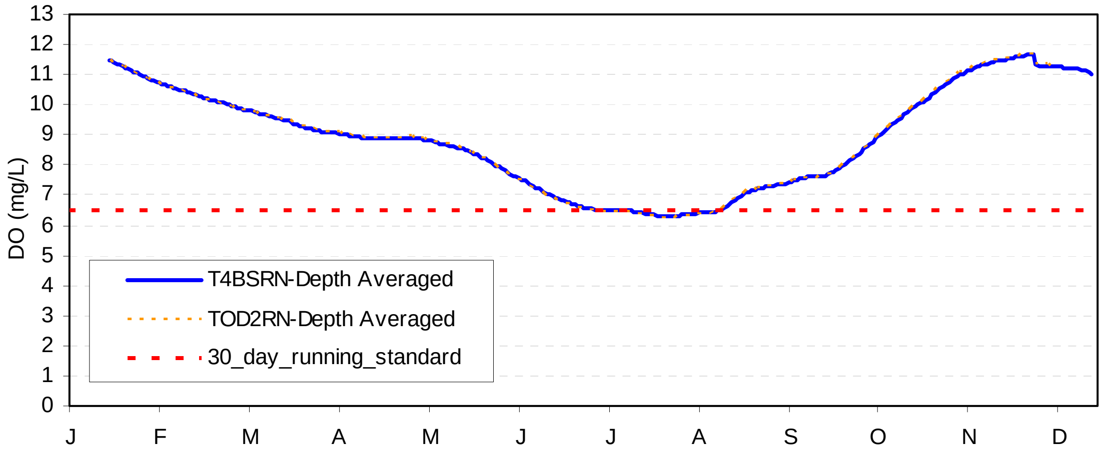


T4BSRN-Depth Averaged
TOD2RN-Depth Averaged
MWMT (degC)
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
J F M A M J J A S O N D

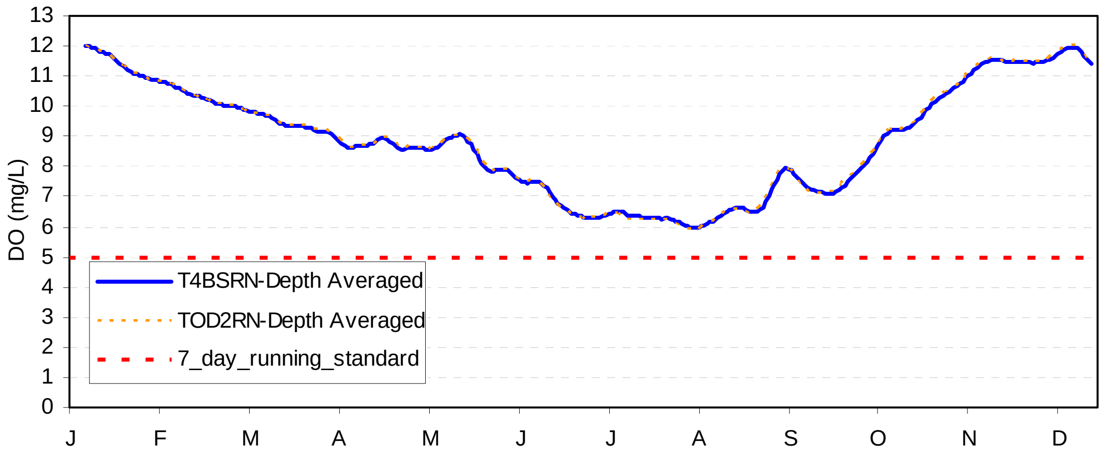


T4BSRN-Depth Averaged
TOD2RN-Depth Averaged
DO Criteria
DO (mg/L)
14
12
10
8
6
4
2
0
J F M A M J J A S O N D

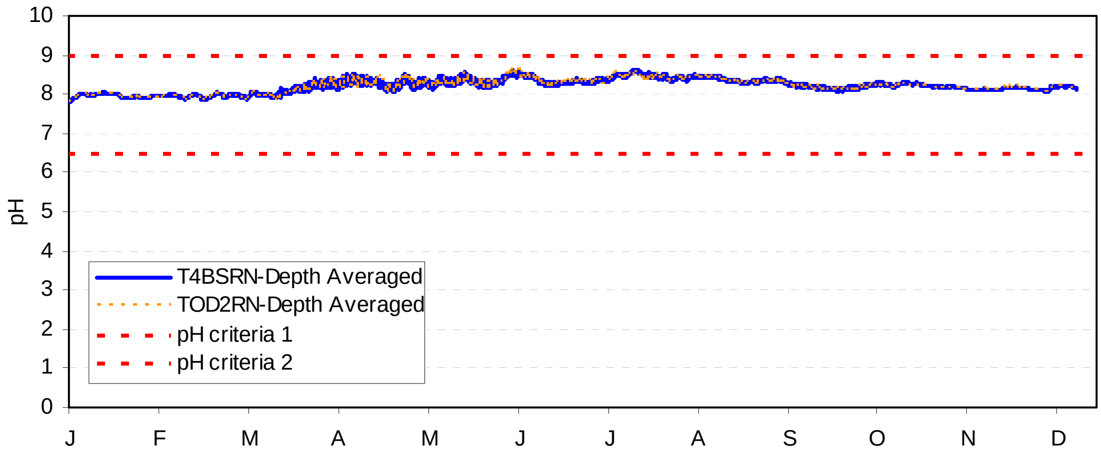
Keno Dam



DO (mg/L)
13
12
11
10
9
8
7
6
5
4
3
2
1
0
T4BSRN-Depth Averaged
TOD2RN-Depth Averaged
30_day_running_standard
J F M A M J J A S O N D

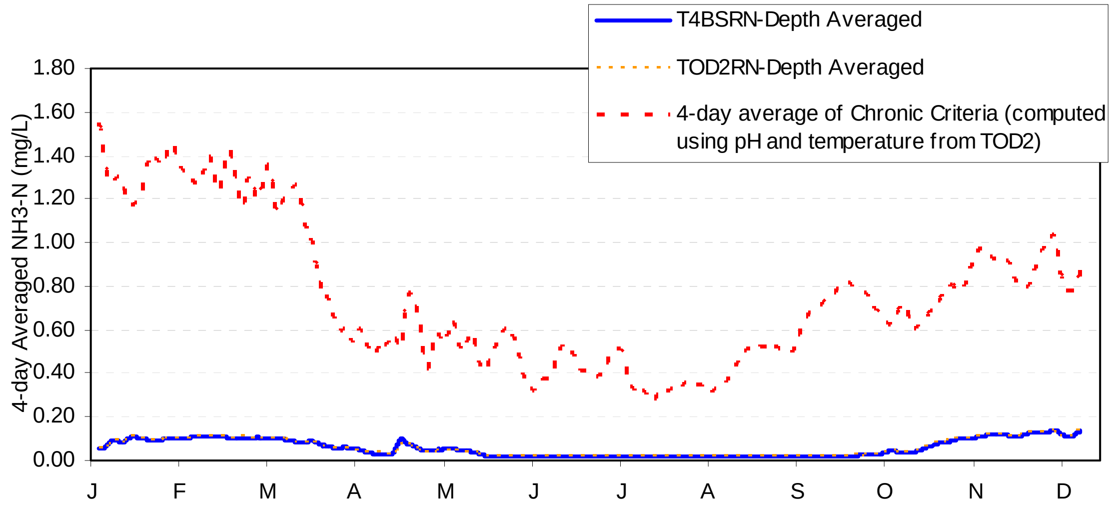


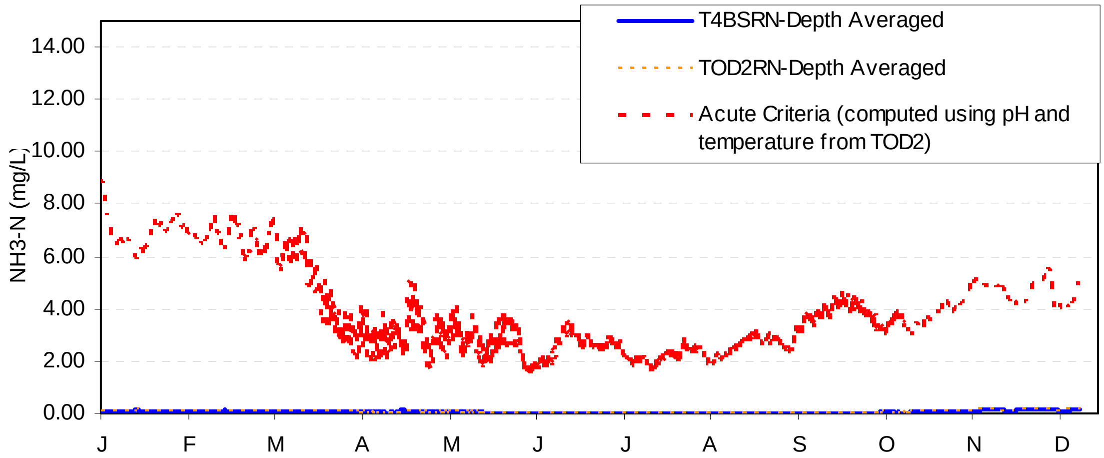
DO (mg/L)
13
12
11
10
9
8
7
6
5
4
3
2
1
0
T4BSRN-Depth Averaged
TOD2RN-Depth Averaged
7_day_running_standard
J F M A M J J A S O N D

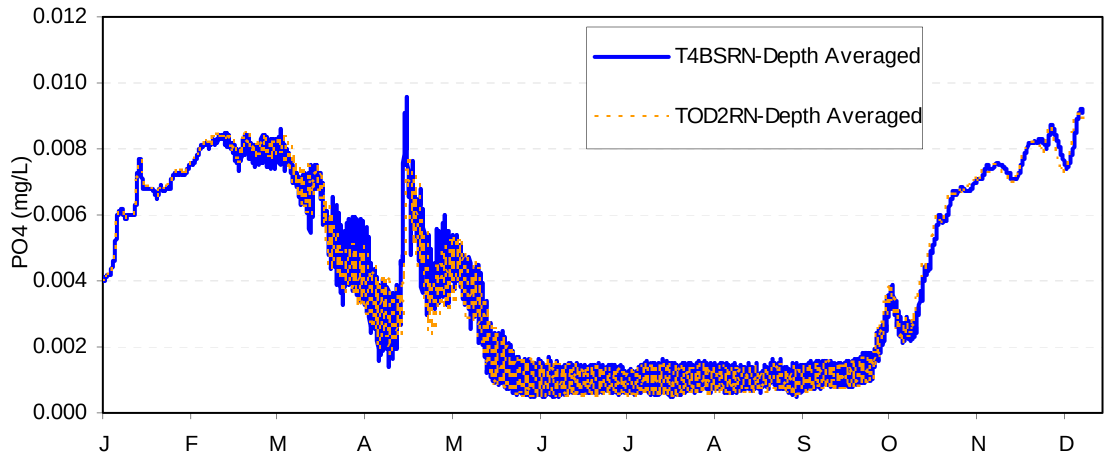


pH
10
9
8
7
6
5
4
3
2
1
0
T4BSRN-Depth Averaged
TOD2RN-Depth Averaged
pH criteria 1
pH criteria 2
J F M A M J J A S O N D

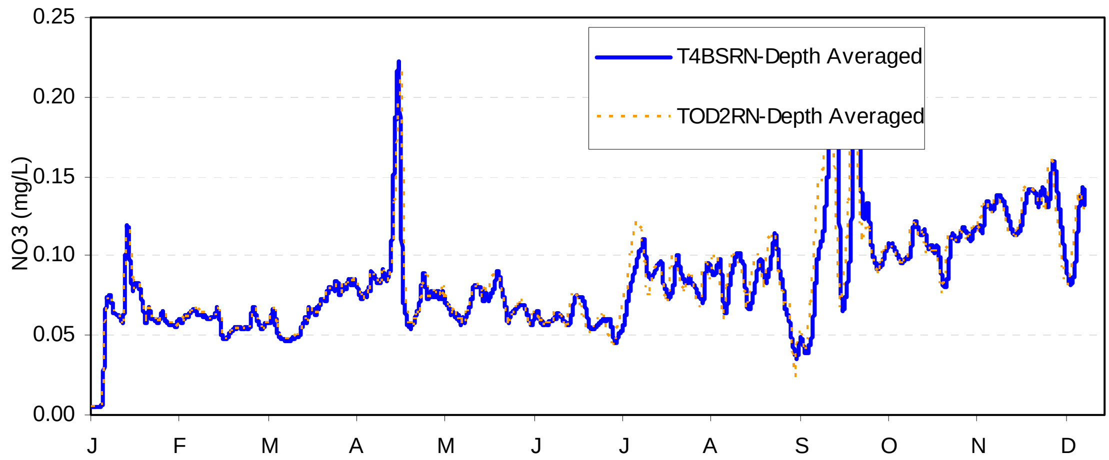
Keno Dam

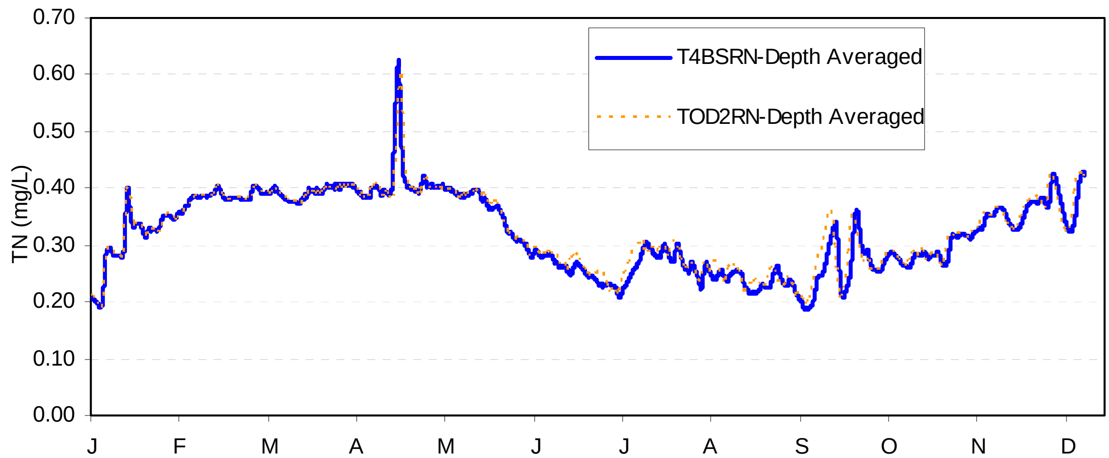

T4BSRN-Depth Averaged
TOD2RN-Depth Averaged
4-day average of Chronic Criteria (computed using pH and temperature from TOD2)
4-day Averaged NH3-N (mg/L)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
J F M A M J J A S O N D

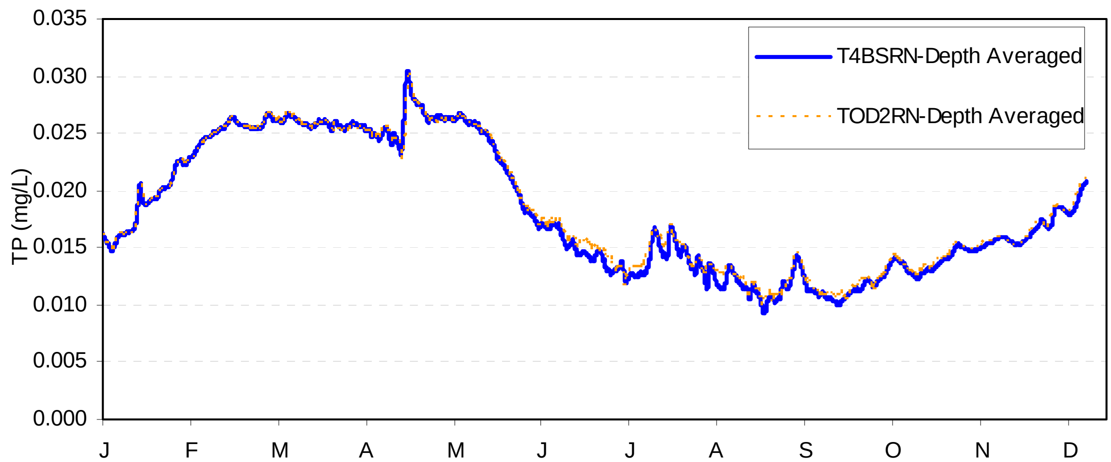

T4BSRN-Depth Averaged
TOD2RN-Depth Averaged
Acute Criteria (computed using pH and temperature from TOD2)
NH3-N (mg/L)
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
J F M A M J J A S O N D


T4BSRN-Depth Averaged
TOD2RN-Depth Averaged
PO4 (mg/L)
0.012
0.010
0.008
0.006
0.004
0.002
0.000
J F M A M J J A S O N D

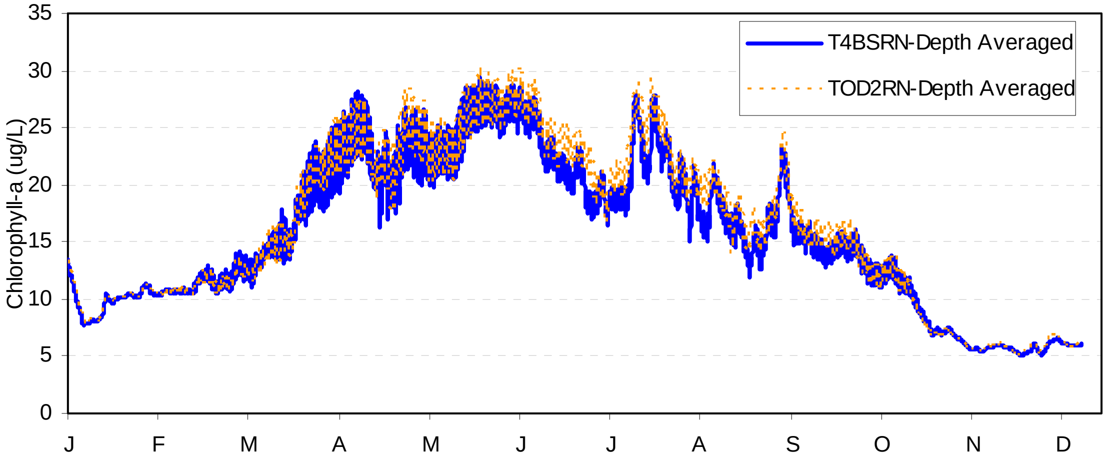
Keno Dam


0.25
0.20
0.15
0.10
0.05
0.00
NO3 (mg/L)
J
F
M
A
M
J
J
A
S
O
N
D
T4BSRN-Depth Averaged
TOD2RN-Depth Averaged

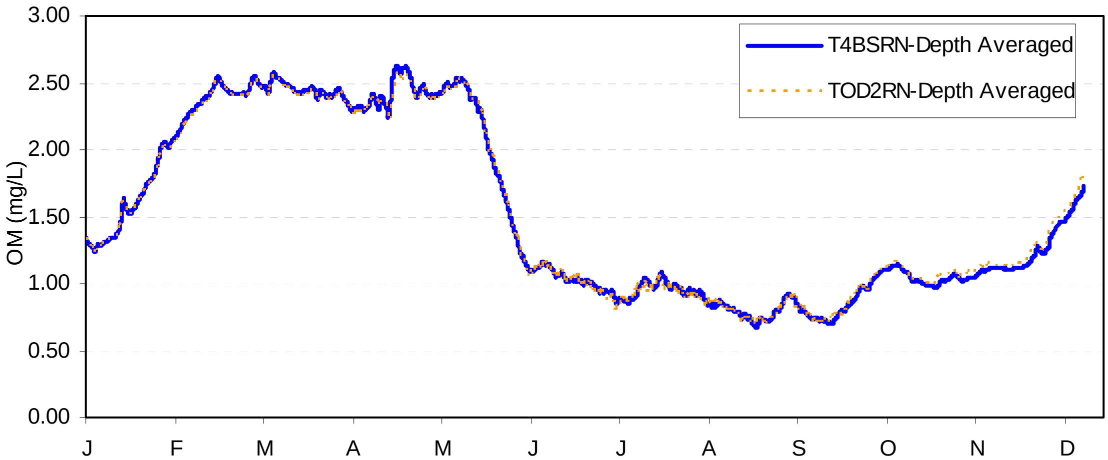

0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
TN (mg/L)
J
F
M
A
M
J
J
A
S
O
N
D
T4BSRN-Depth Averaged
TOD2RN-Depth Averaged


0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
TP (mg/L)
J
F
M
A
M
J
J
A
S
O
N
D
T4BSRN-Depth Averaged
TOD2RN-Depth Averaged

Keno Dam

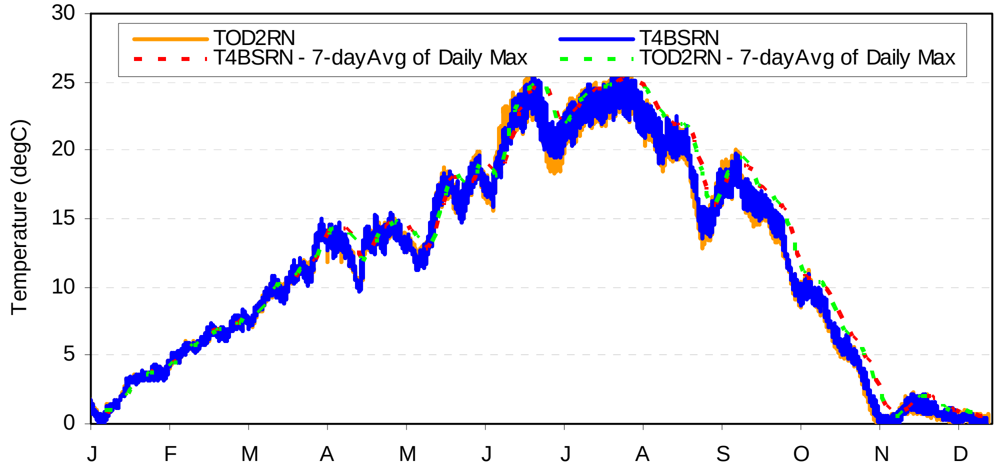


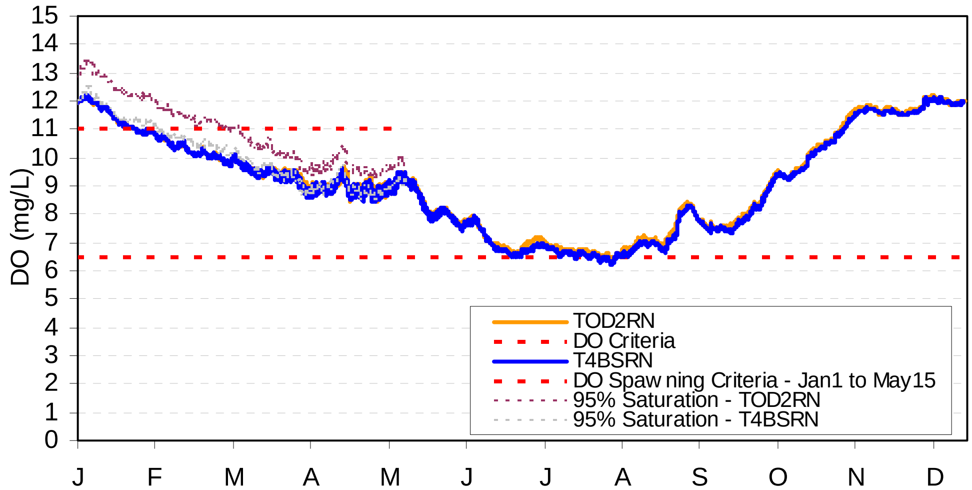
35
30
25
20
15
10
5
0
Chlorophyll-a (ug/L)
J
F
M
A
M
J
J
A
S
O
N
D
T4BSRN-Depth Averaged
TOD2RN-Depth Averaged

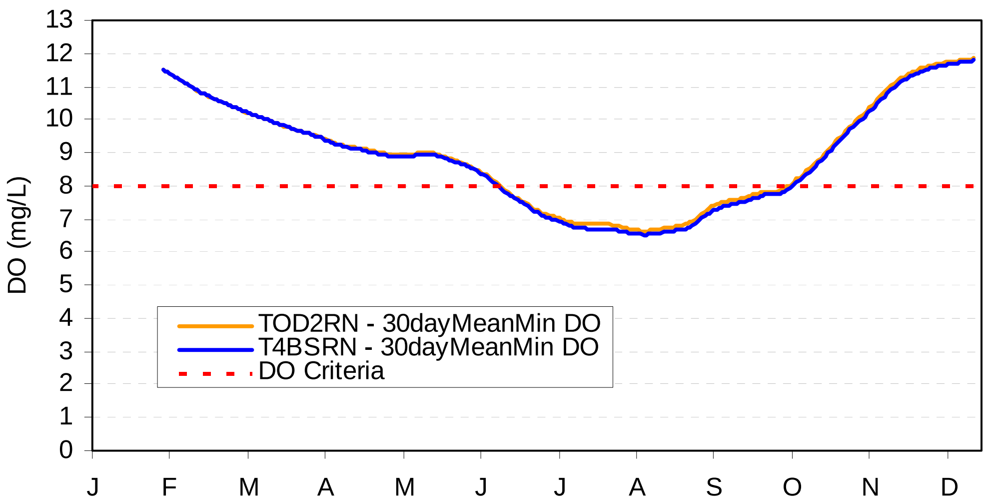


3.00
2.50
2.00
1.50
1.00
0.50
0.00
OM (mg/L)
J
F
M
A
M
J
J
A
S
O
N
D
T4BSRN-Depth Averaged
TOD2RN-Depth Averaged

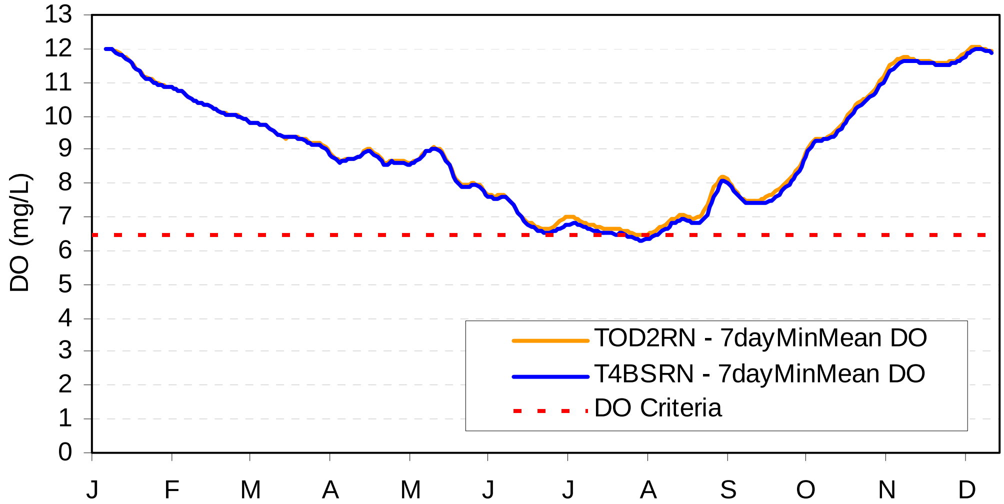
T4BSRN_USGS_DS_KENO

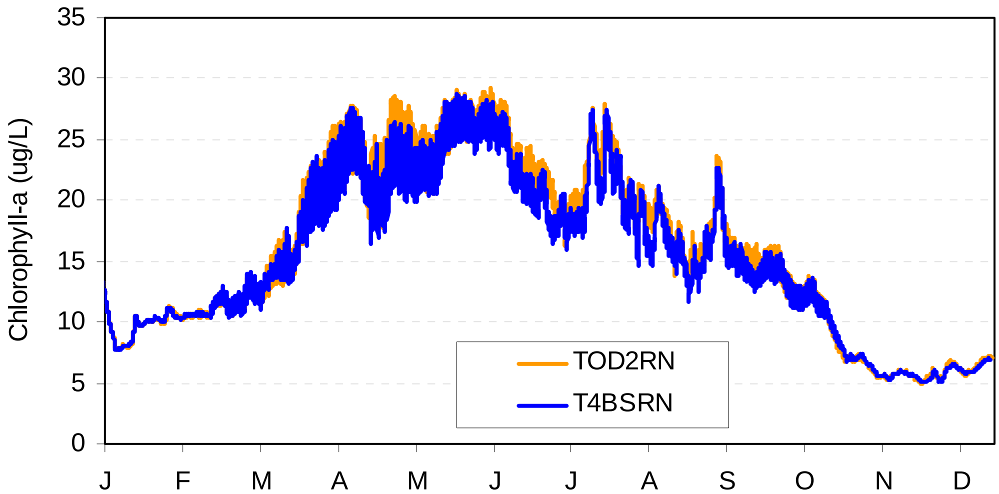


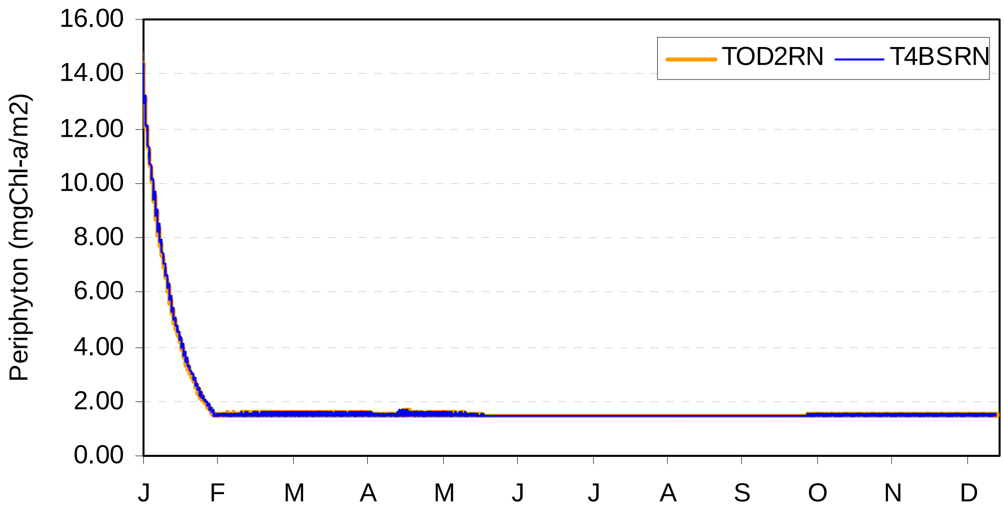




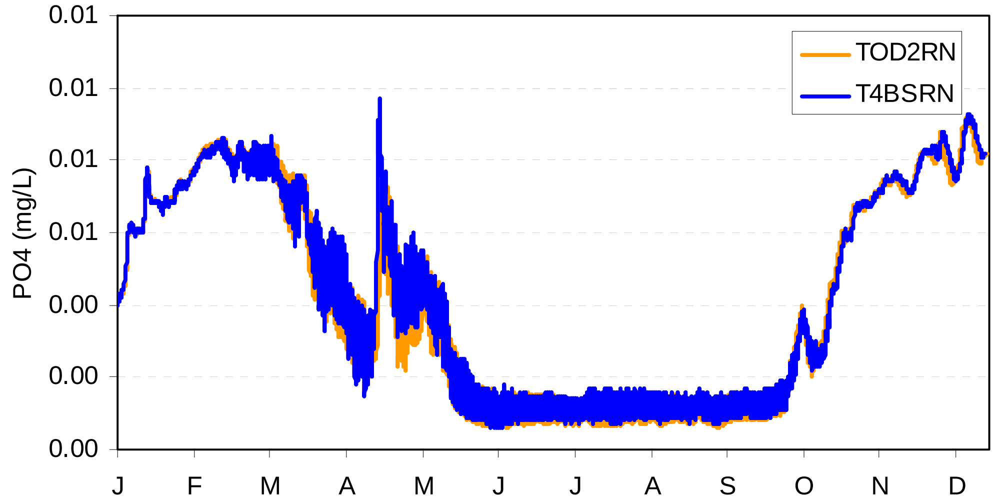
T4BSRN_USGS_DS_KENO

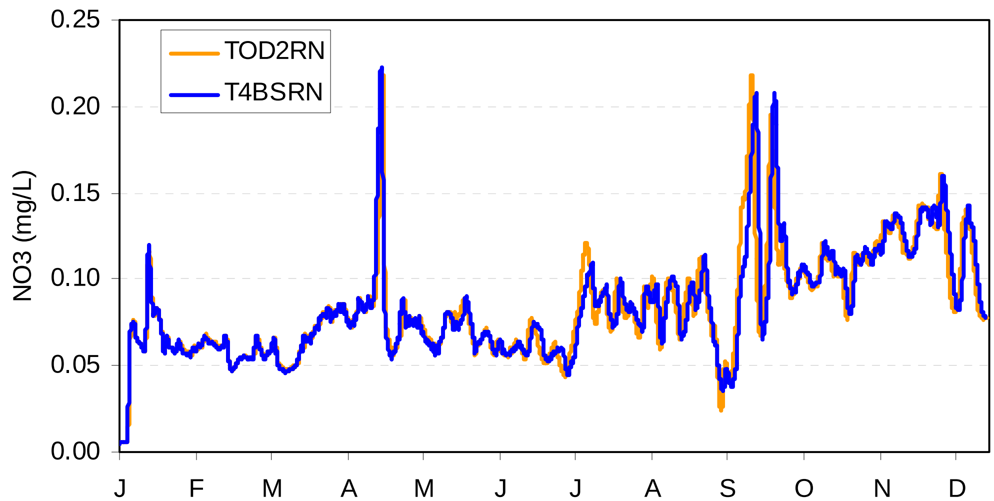


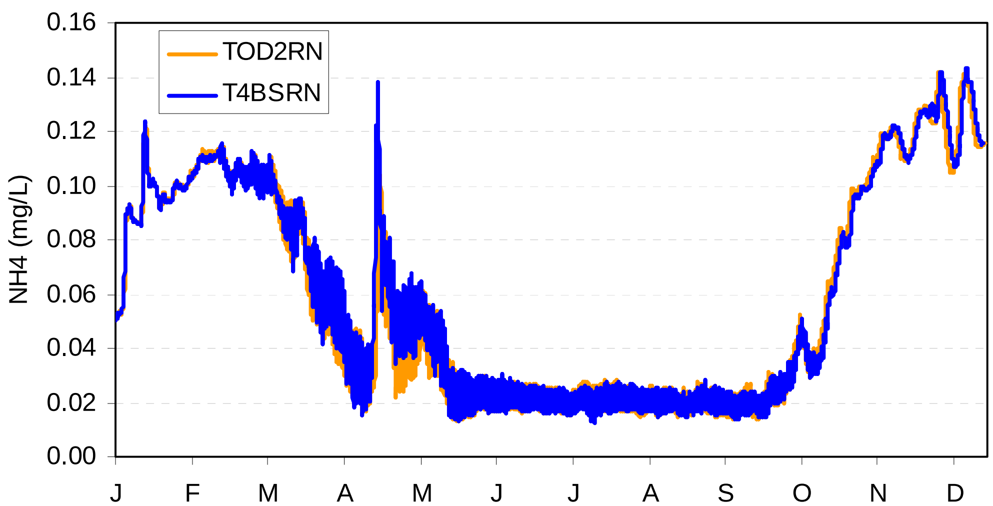




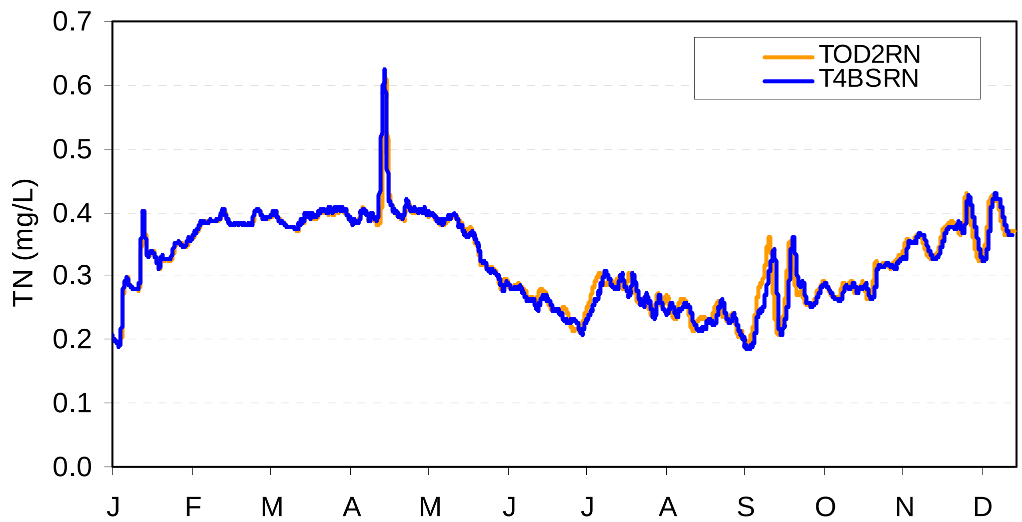
T4BSRN_USGS_DS_KENO



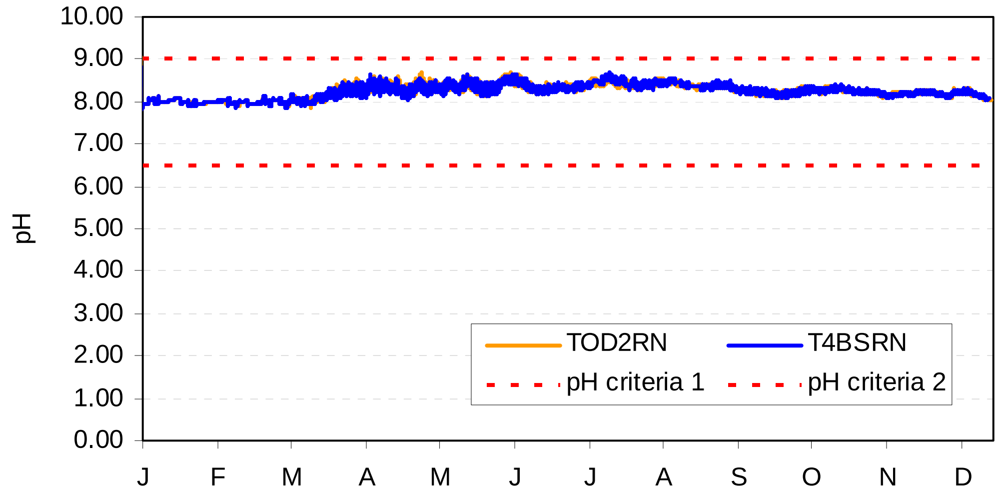


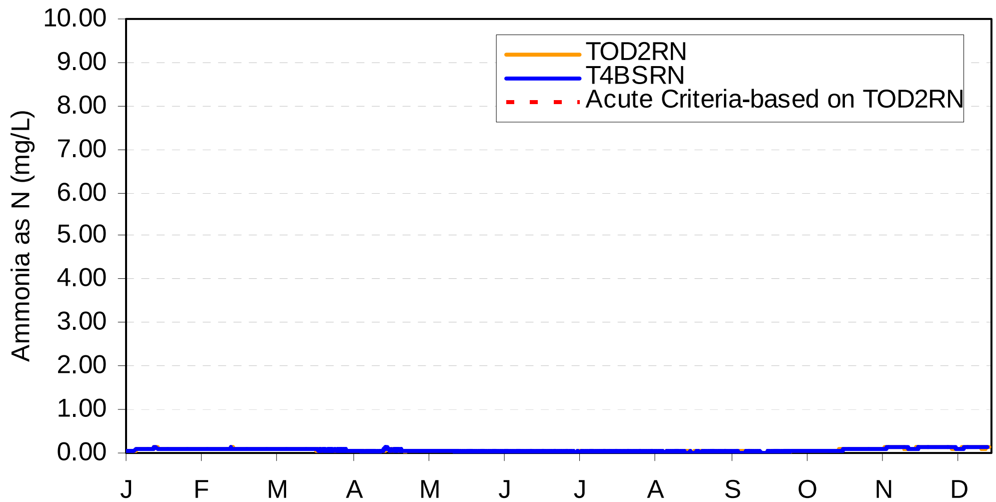


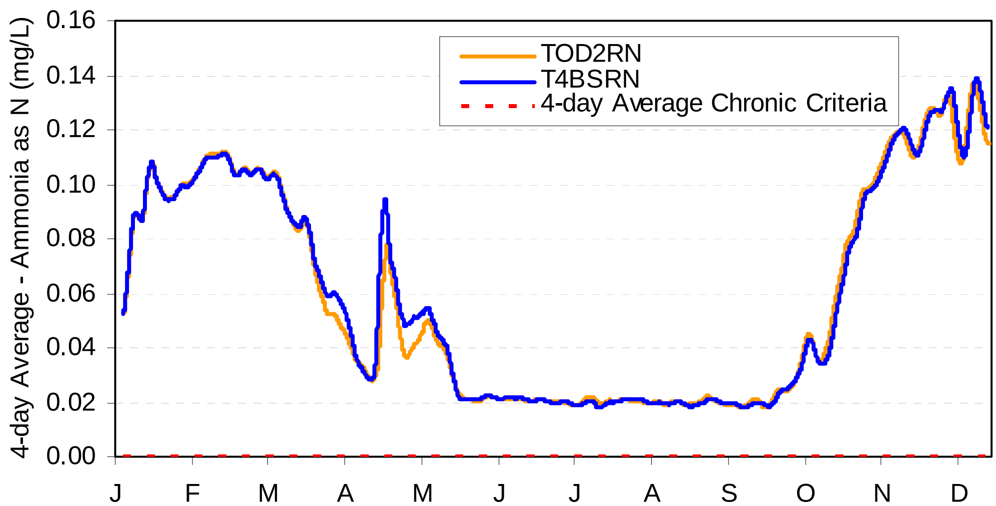
T4BSRN_USGS_DS_KENO



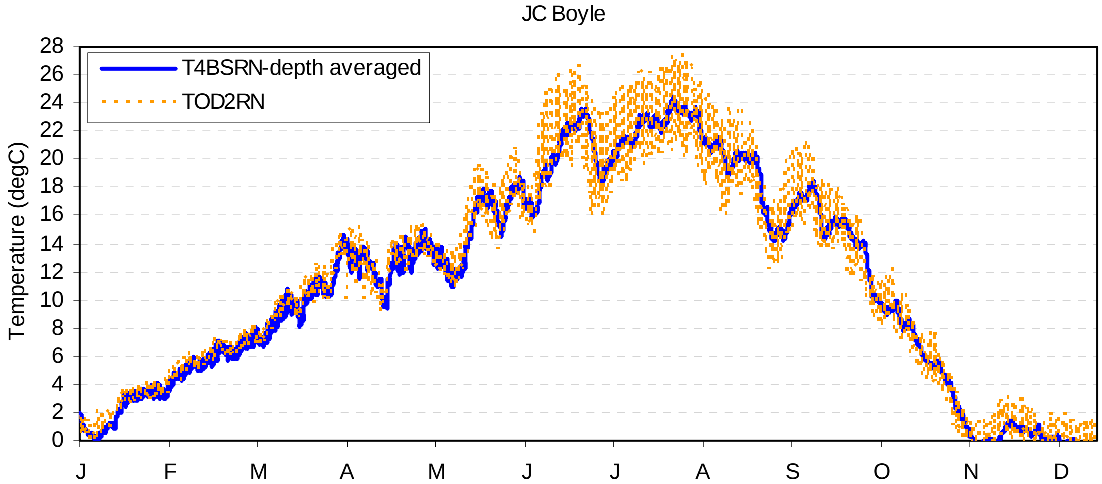
T4BSRN_USGS_DS_KENO

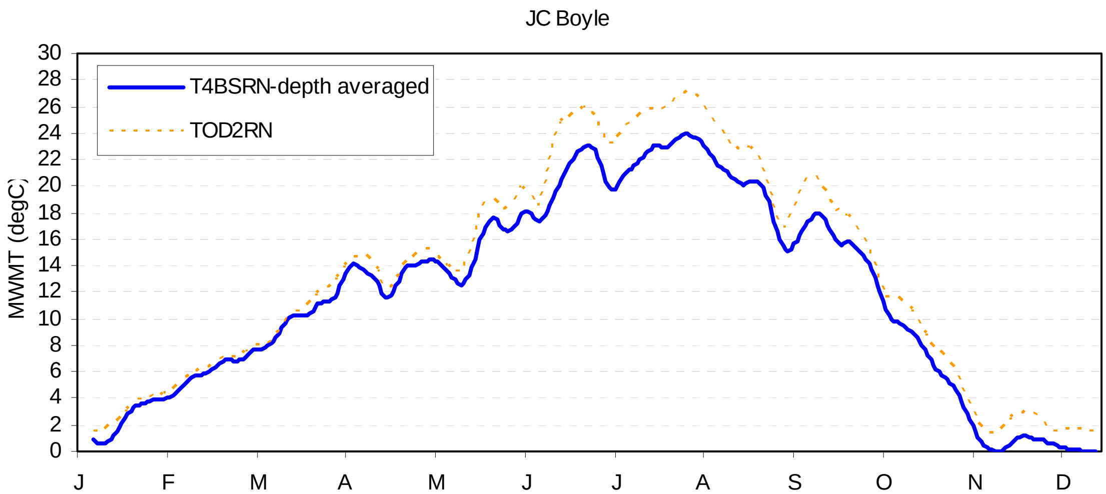


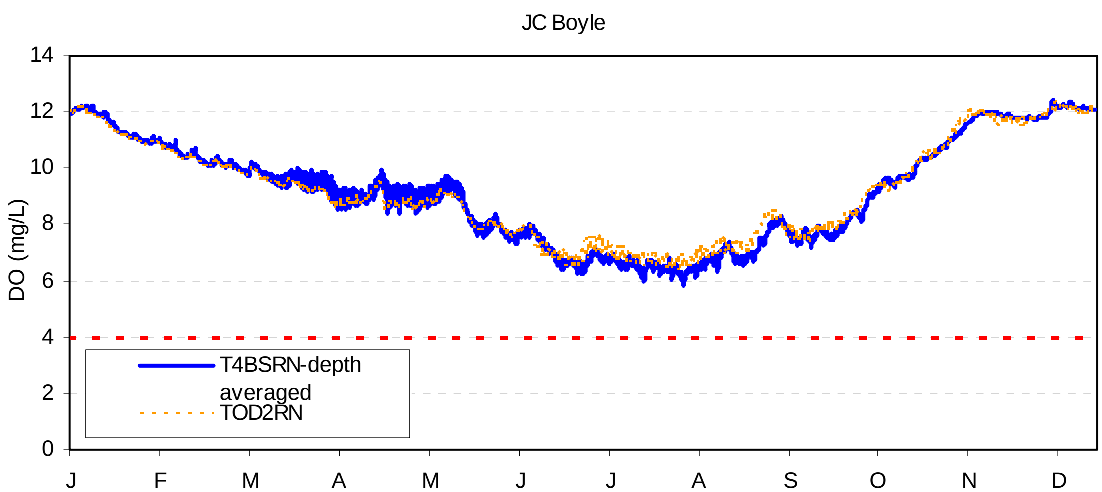




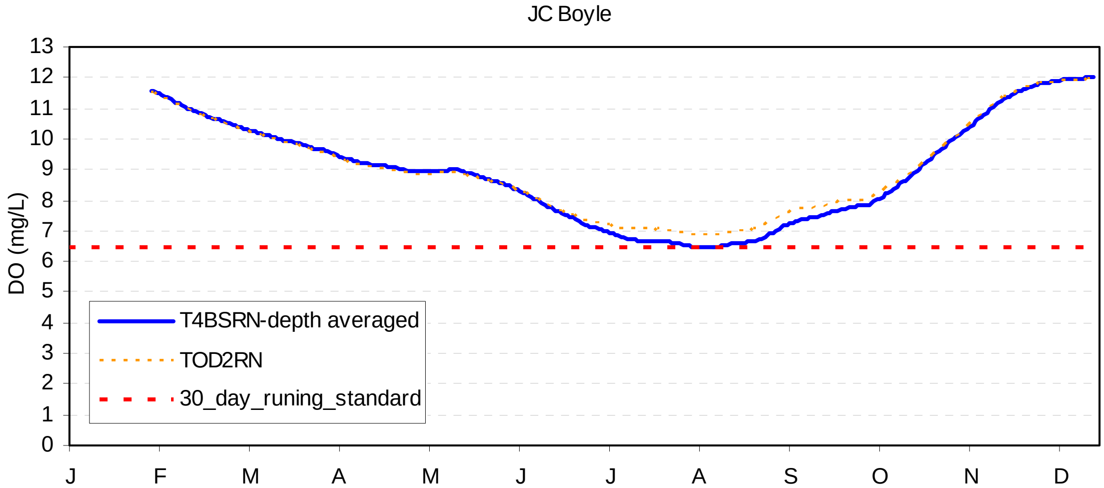
JC Boyle

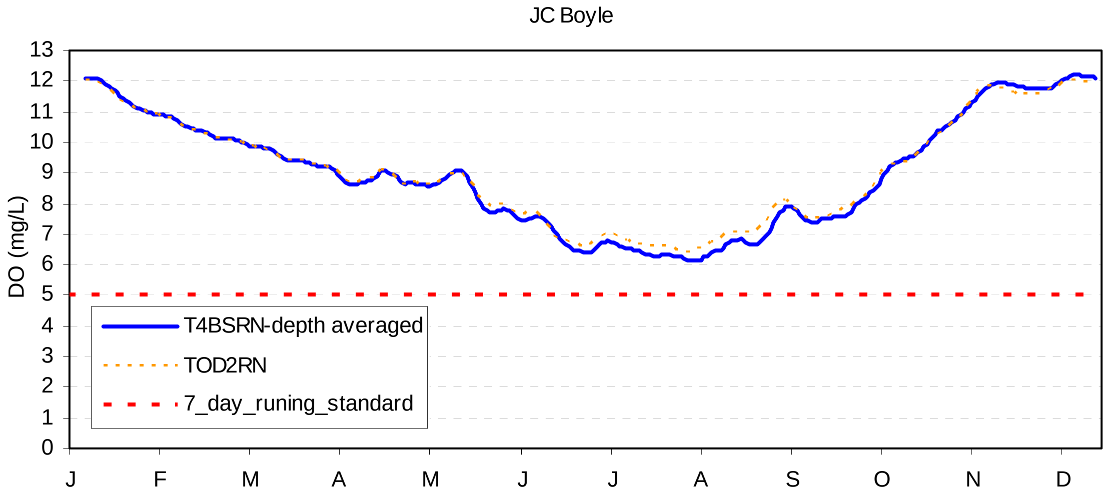

JC Boyle
T4BSRN-depth averaged
TOD2RN
Temperature (degC)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
J
F
M
A
M
J
J
A
S
O
N
D

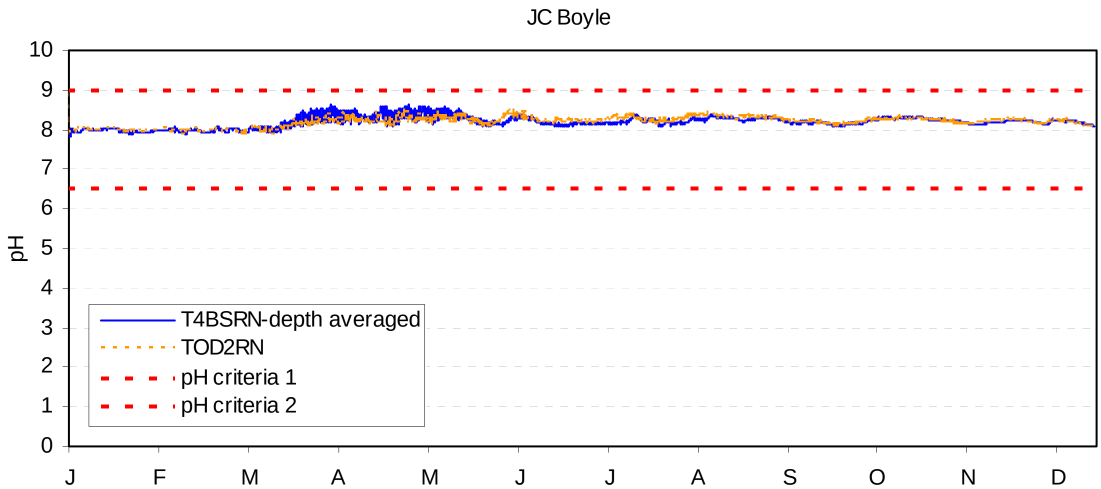

JC Boyle
T4BSRN-depth averaged
TOD2RN
MWMT (degC)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
J
F
M
A
M
J
J
A
S
O
N
D


JC Boyle
T4BSRN-depth averaged
TOD2RN
DO (mg/L)
0
2
4
6
8
10
12
14
J
F
M
A
M
J
J
A
S
O
N
D

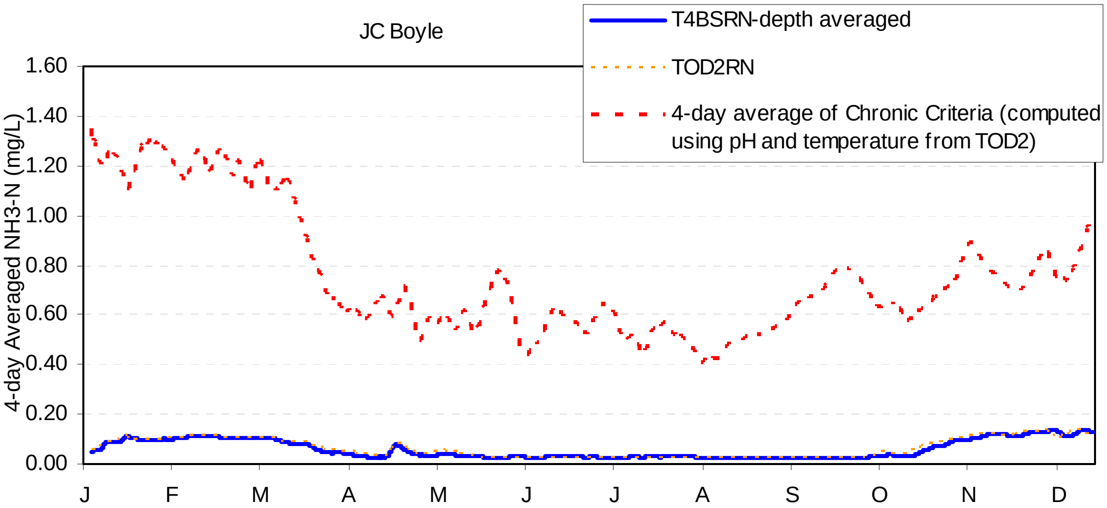
JC Boyle

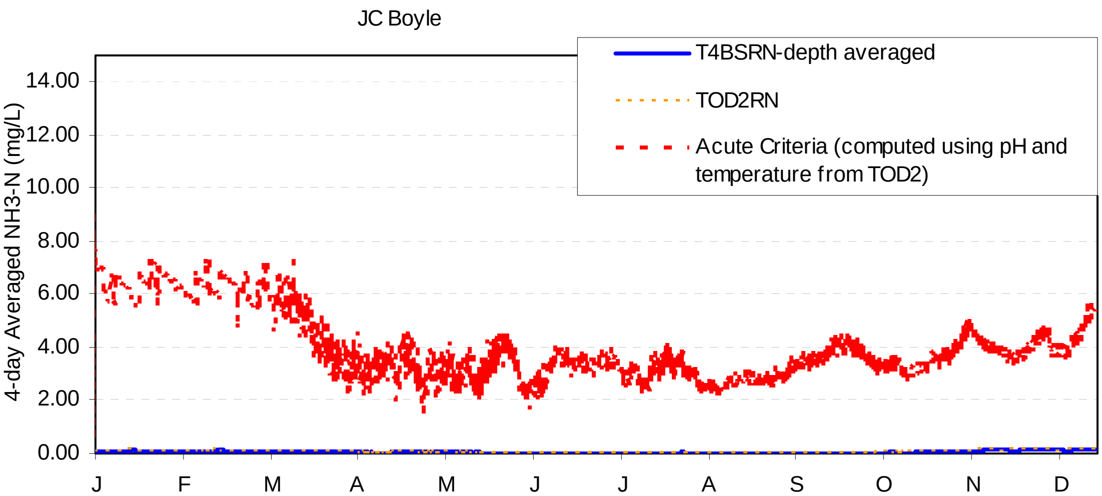

JC Boyle
DO (mg/L)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
J
F
M
A
M
J
J
A
S
O
N
D
T4BSRN-depth averaged
TOD2RN
30_day_runing_standard

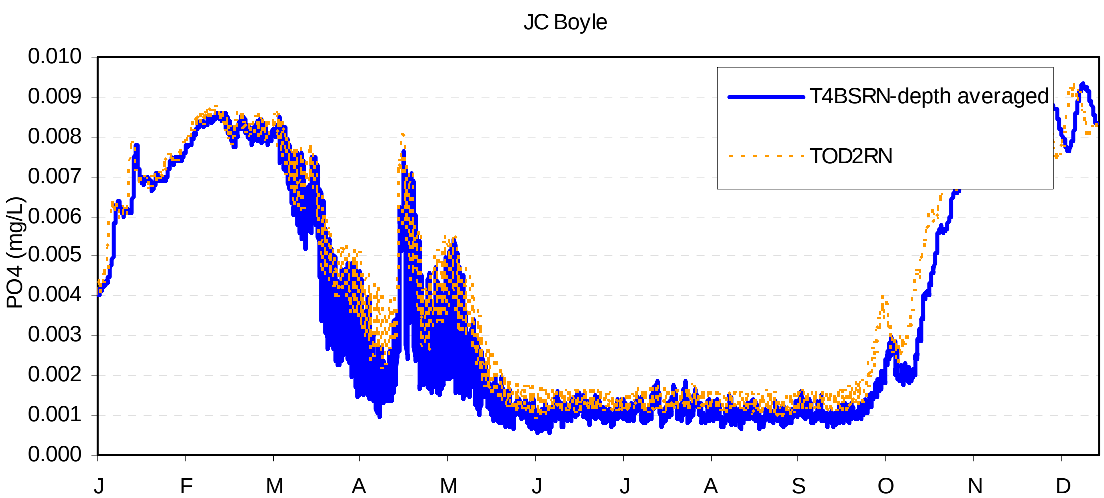

JC Boyle
DO (mg/L)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
J
F
M
A
M
J
J
A
S
O
N
D
T4BSRN-depth averaged
TOD2RN
7_day_runing_standard


JC Boyle
pH
0
1
2
3
4
5
6
7
8
9
10
J
F
M
A
M
J
J
A
S
O
N
D
T4BSRN-depth averaged
TOD2RN
pH criteria 1
pH criteria 2

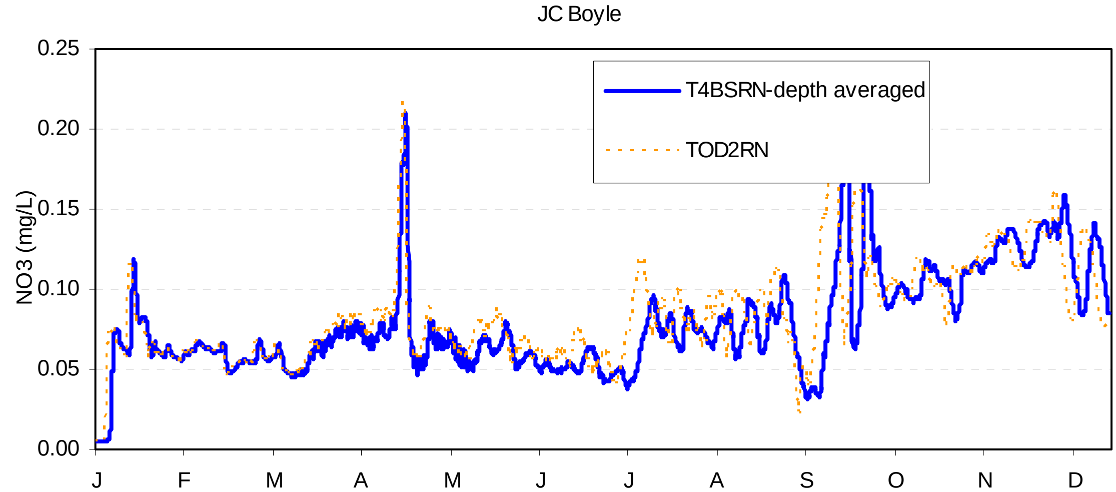
JC Boyle


JC Boyle
T4BSRN-depth averaged
TOD2RN
4-day average of Chronic Criteria (computed using pH and temperature from TOD2)
4-day Averaged NH3-N (mg/L)
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
J F M A M J J A S O N D

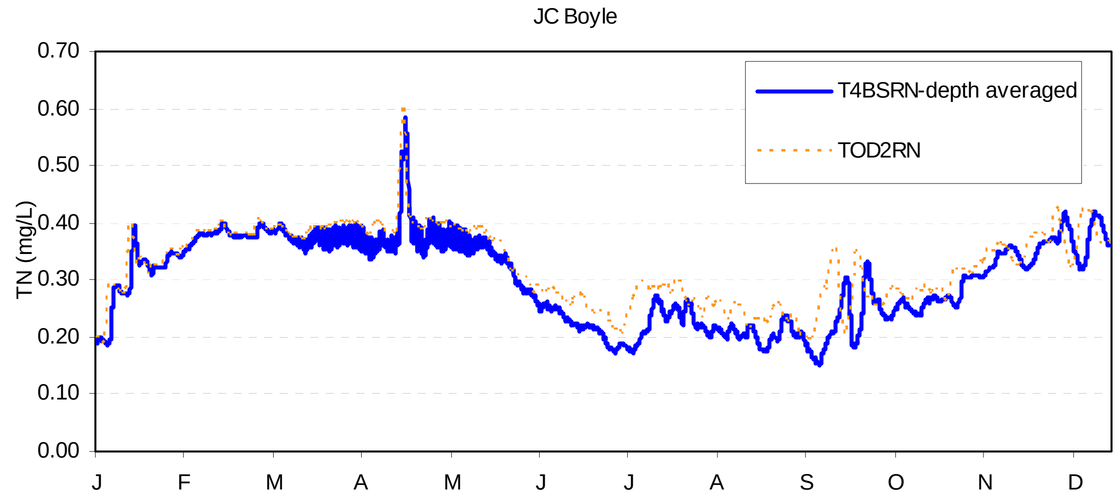

JC Boyle
T4BSRN-depth averaged
TOD2RN
Acute Criteria (computed using pH and temperature from TOD2)
4-day Averaged NH3-N (mg/L)
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
J F M A M J J A S O N D


JC Boyle
T4BSRN-depth averaged
TOD2RN
PO4 (mg/L)
0.010
0.009
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0.000
J F M A M J J A S O N D

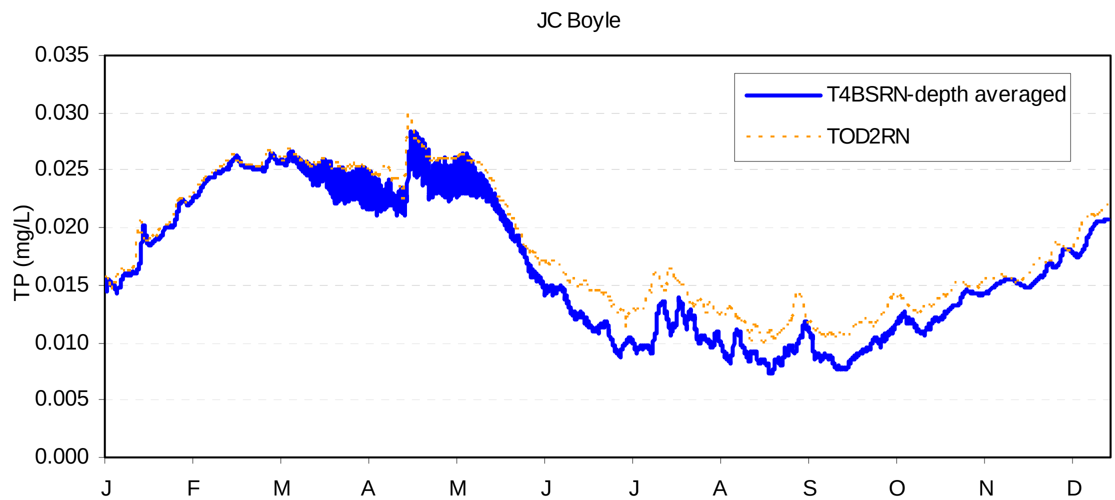
JC Boyle



JC Boyle
NO3 (mg/L)
0.25
0.20
0.15
0.10
0.05
0.00
J F M A M J J A S O N D
T4BSRN-depth averaged
TOD2RN

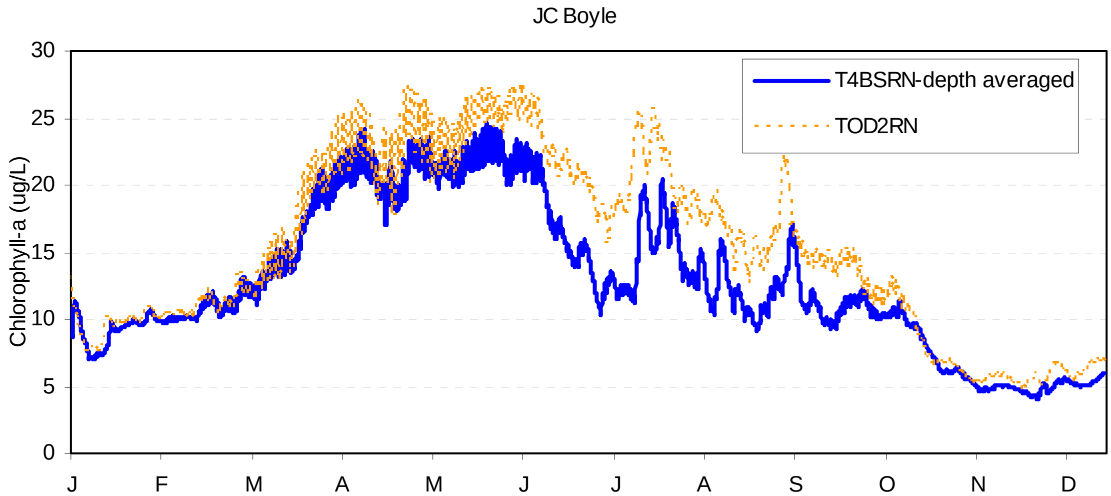


JC Boyle
TN (mg/L)
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
J F M A M J J A S O N D
T4BSRN-depth averaged
TOD2RN

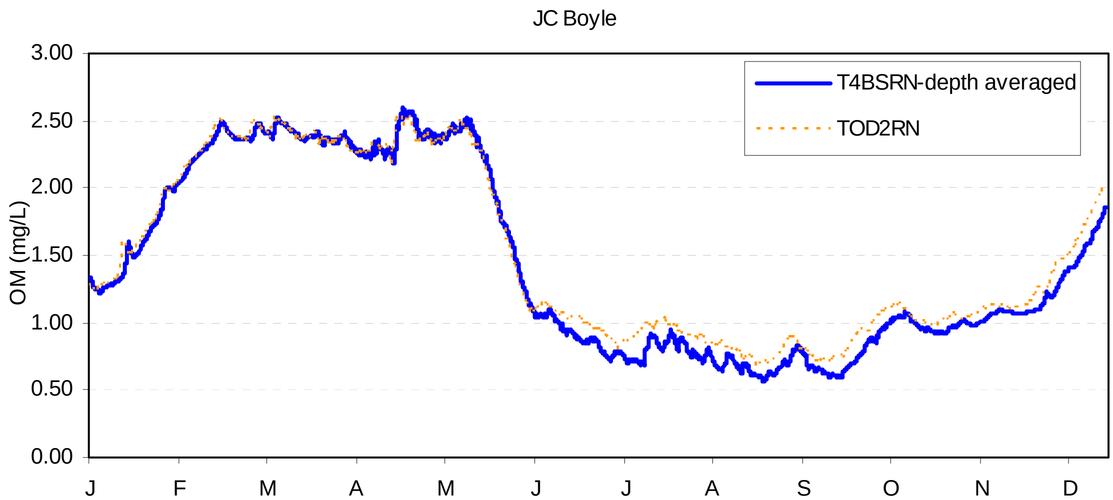


JC Boyle
TP (mg/L)
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
J F M A M J J A S O N D
T4BSRN-depth averaged
TOD2RN

JC Boyle

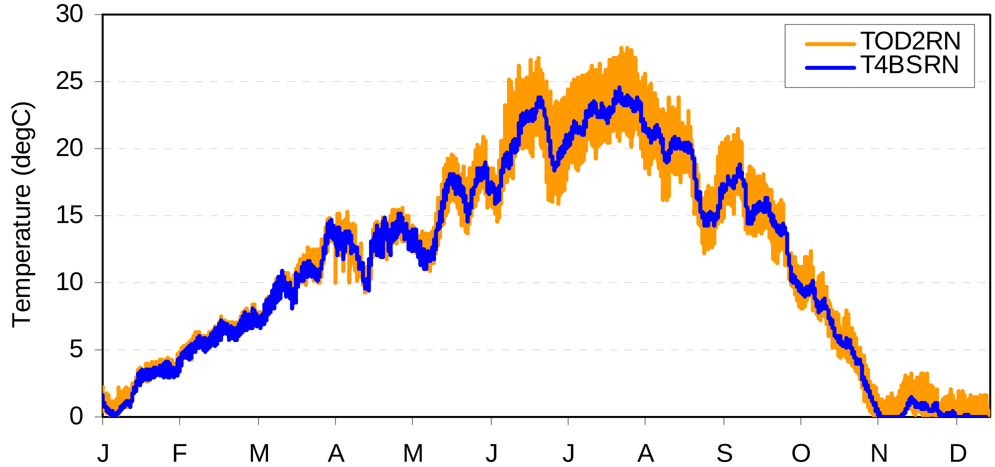


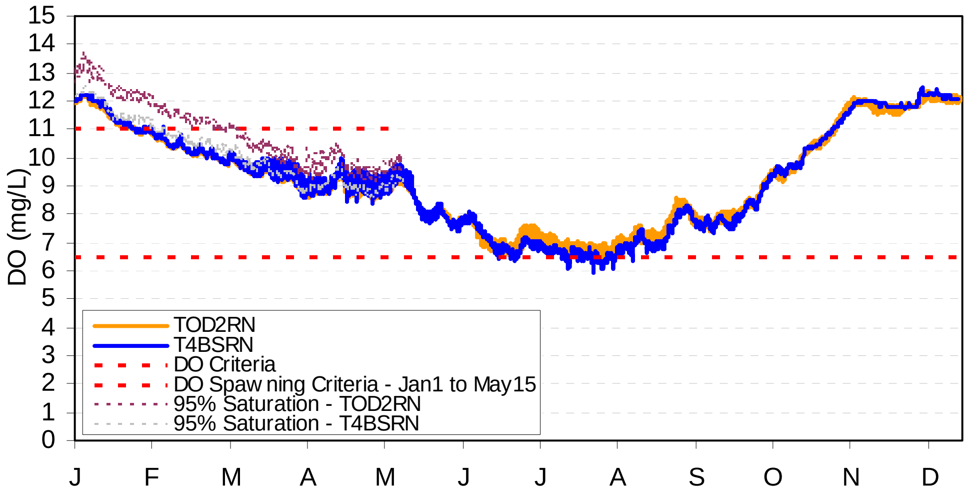
JC Boyle
30
25
20
15
10
5
0
Chlorophyll-a (ug/L)
J
F
M
A
M
J
J
A
S
O
N
D
T4BSRN-depth averaged
TOD2RN

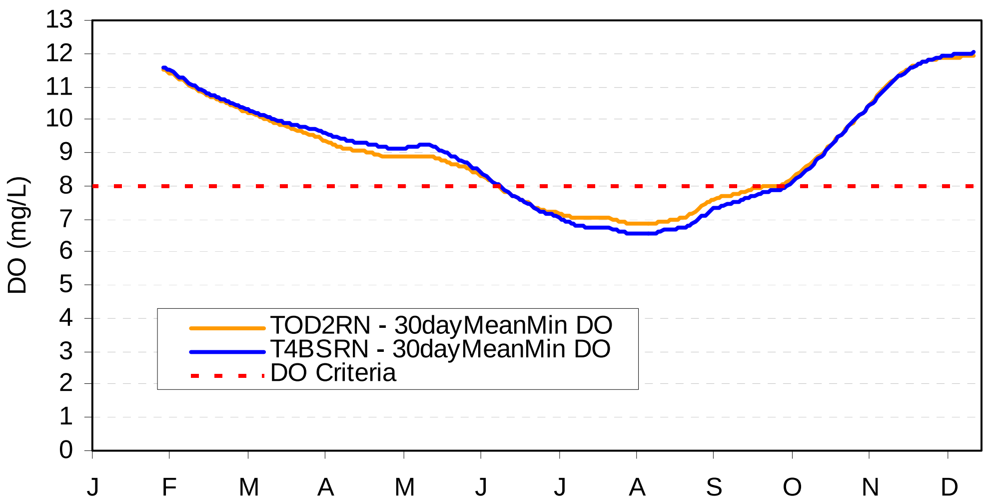


JC Boyle
3.00
2.50
2.00
1.50
1.00
0.50
0.00
OM (mg/L)
J
F
M
A
M
J
J
A
S
O
N
D
T4BSRN-depth averaged
TOD2RN

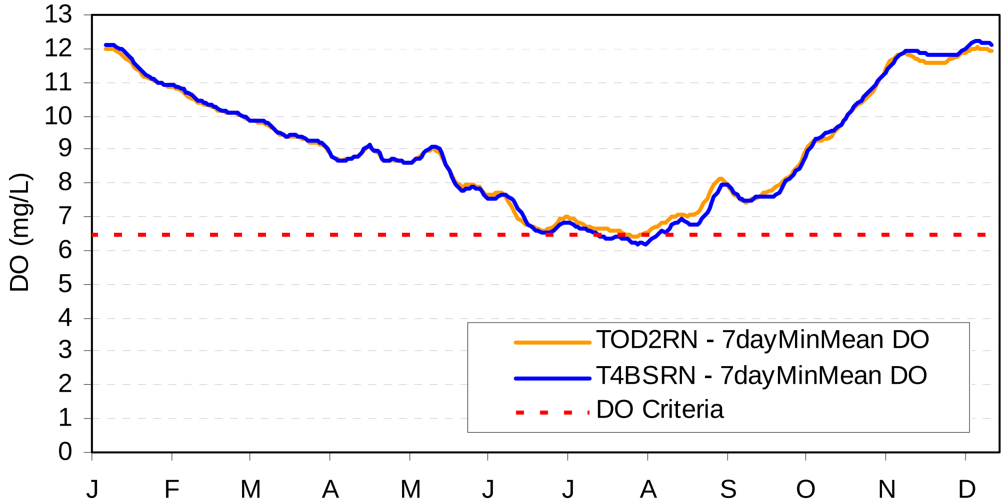
T4BSRN_ND1_DS_JCBDAM

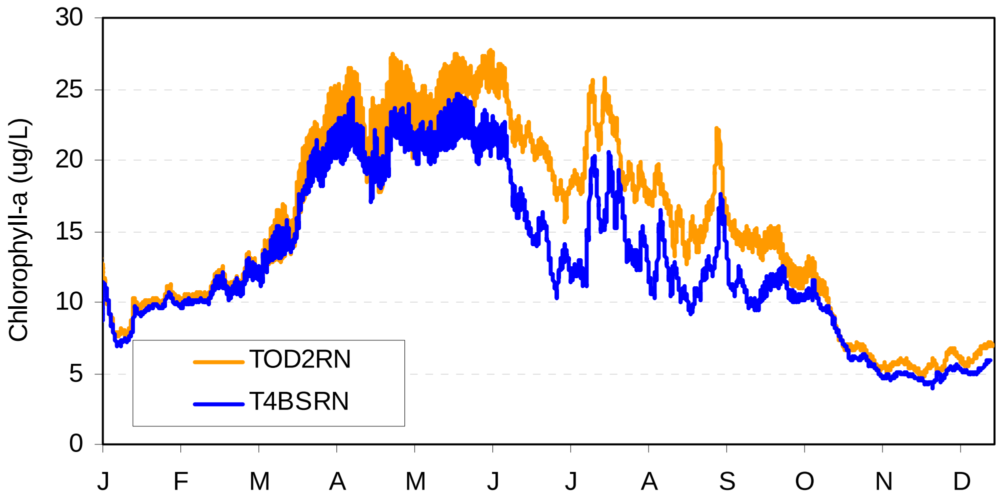


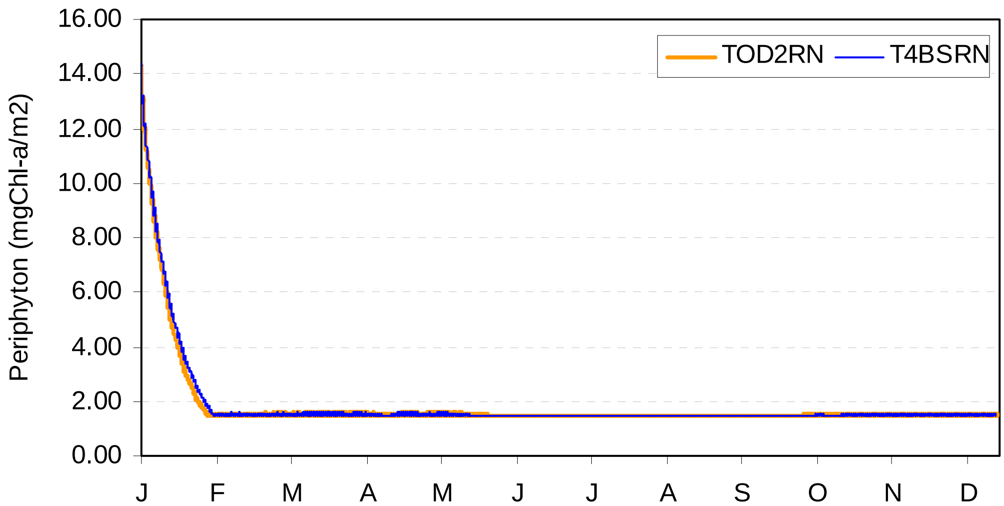




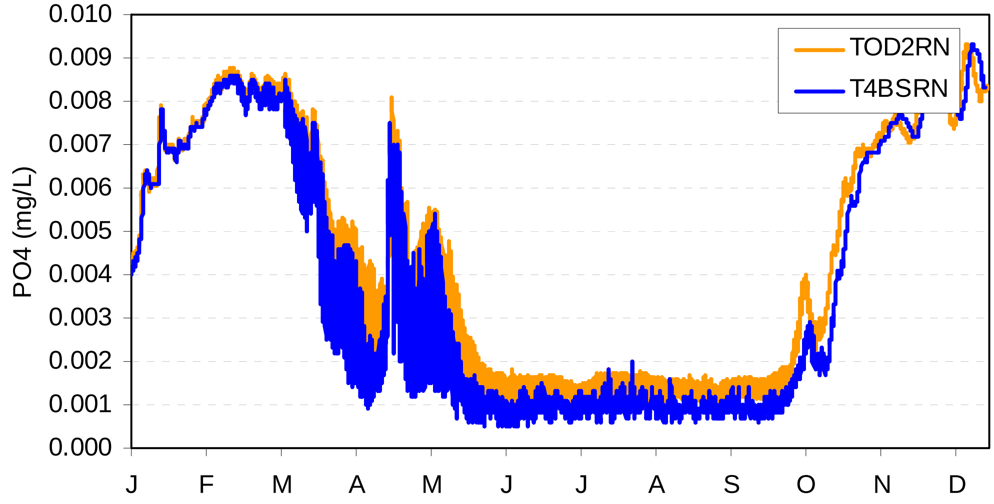
T4BSRN_ND1_DS_JCBDAM

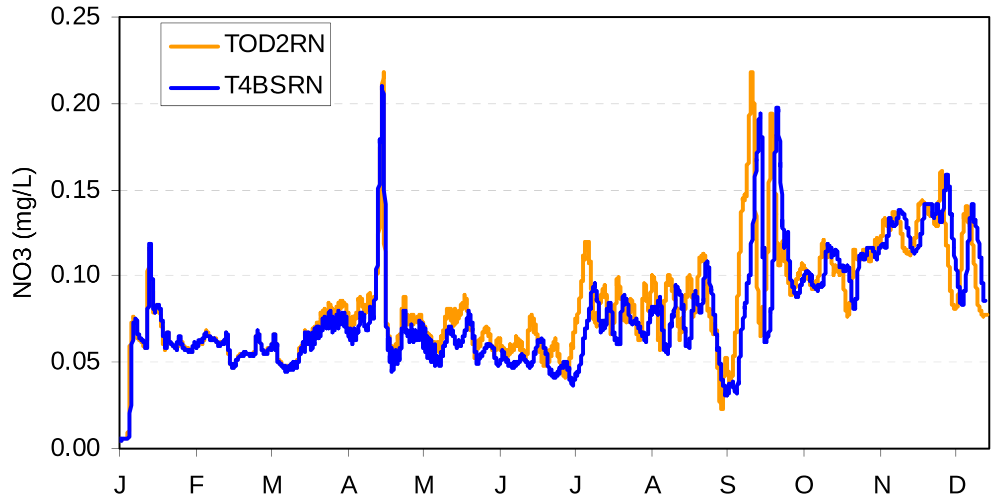


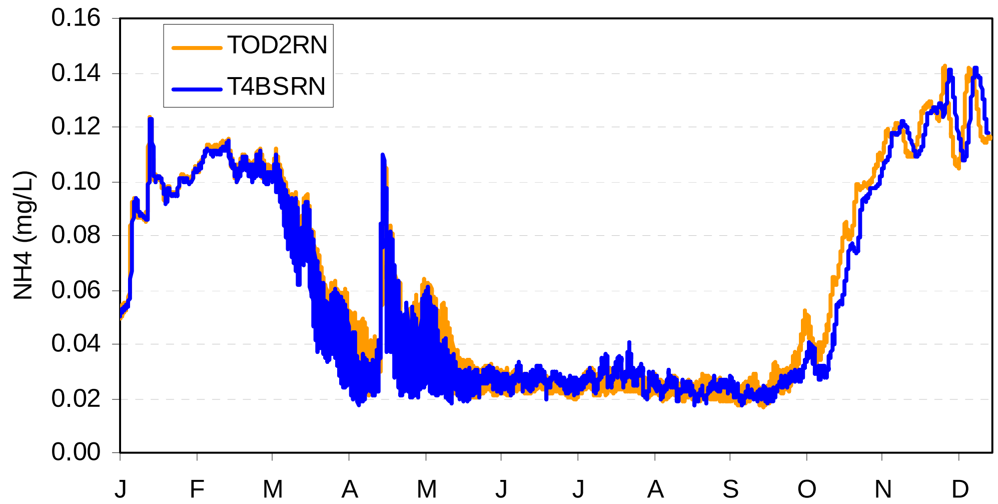




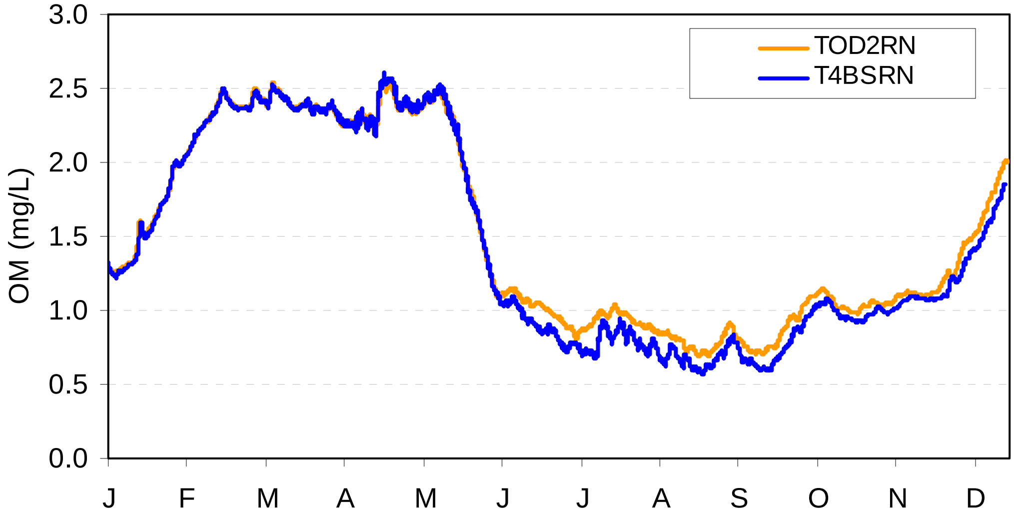
T4BSRN_ND1_DS_JCBDAM

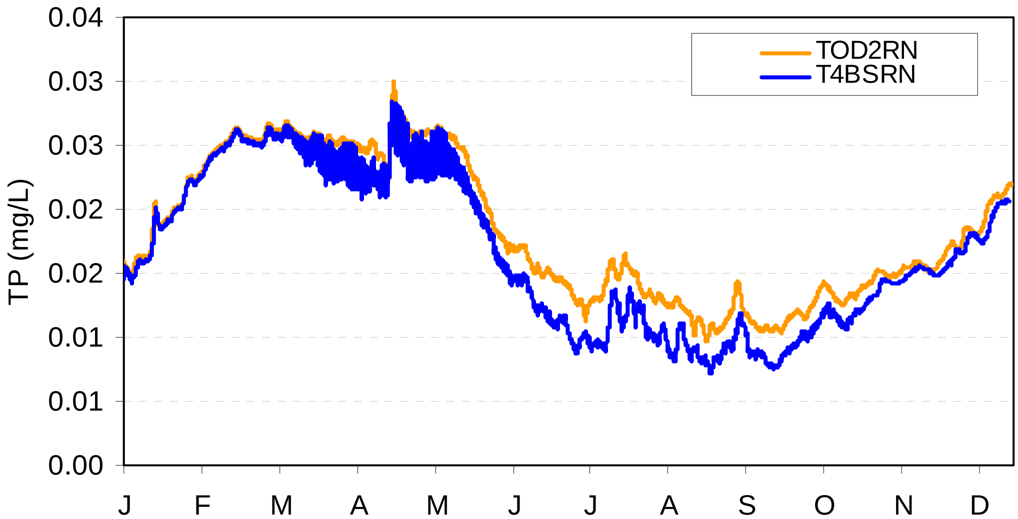


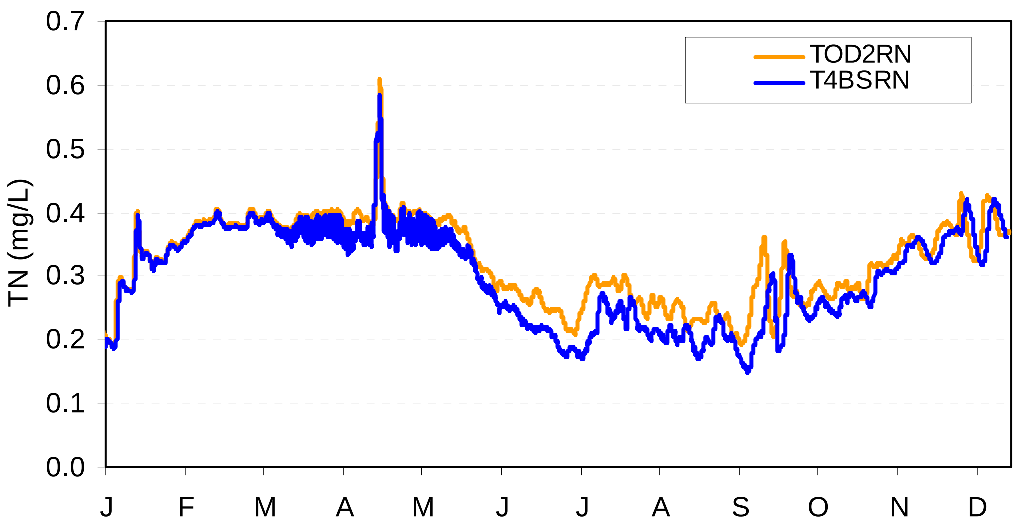




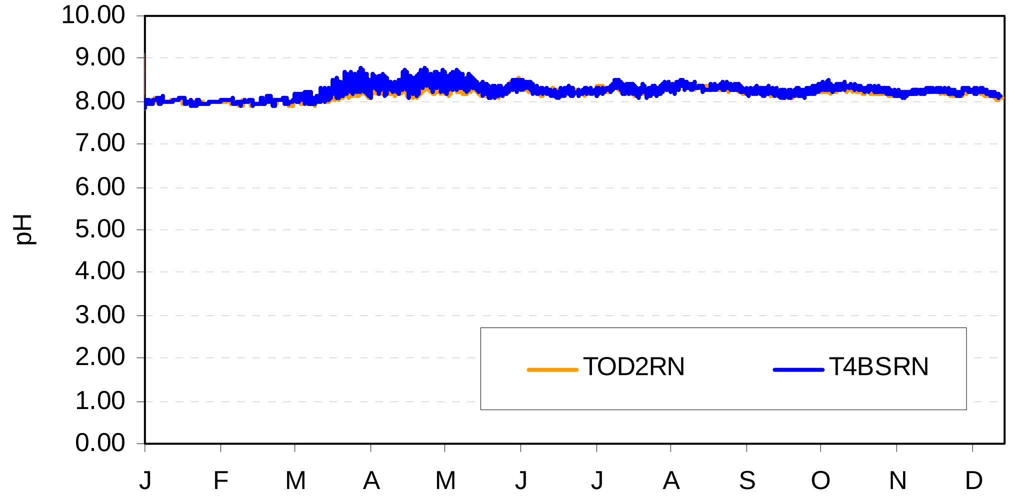
T4BSRN_ND1_DS_JCBDAM



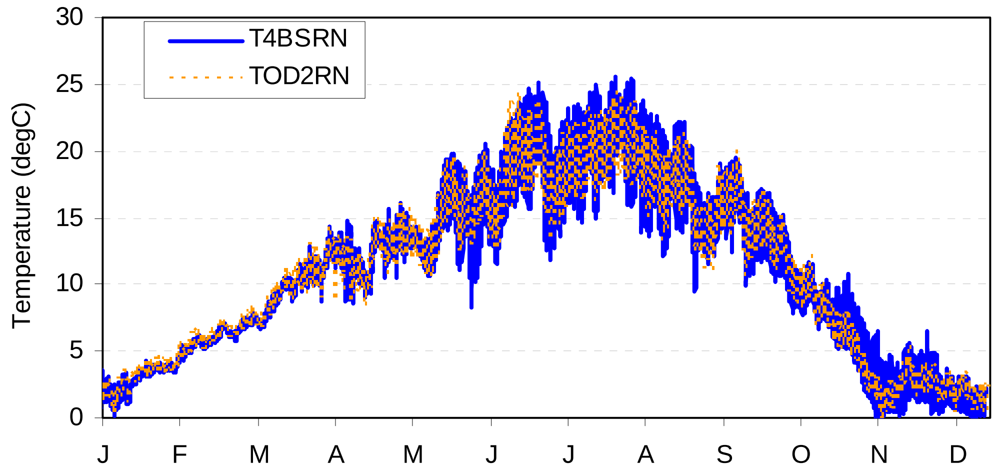


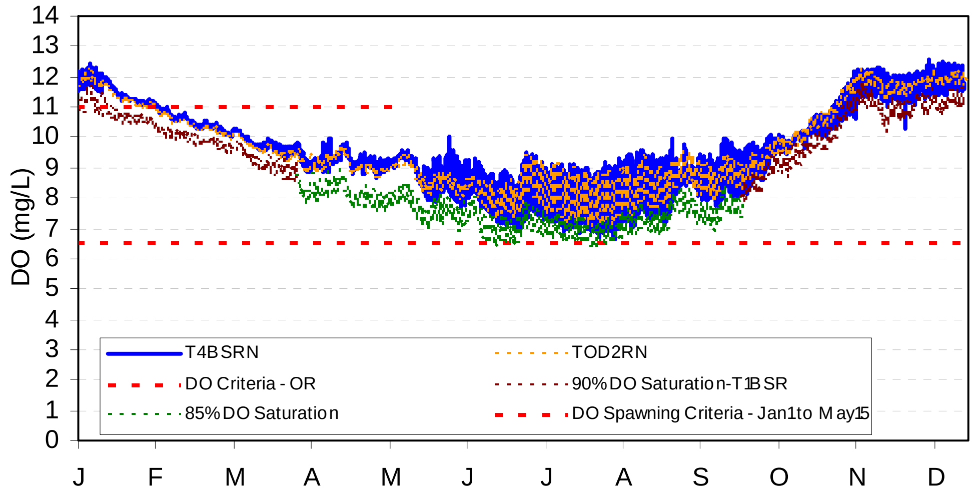


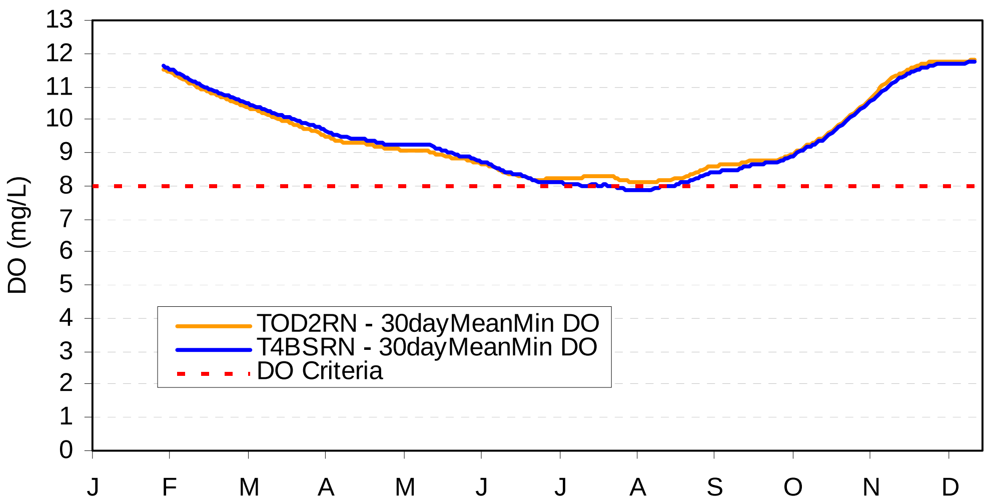
T4BSRN_ND1_DS_JCBDAM



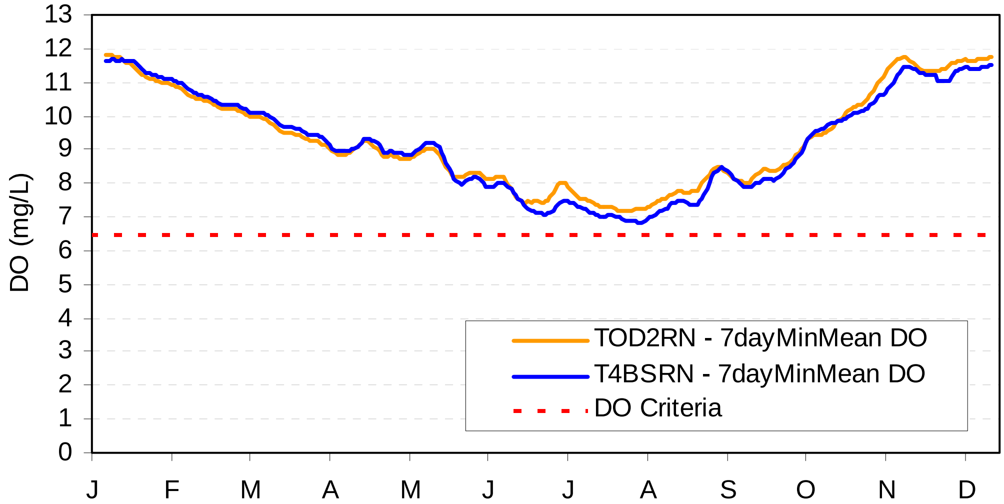
T4BSRN_ND331_STATELINE

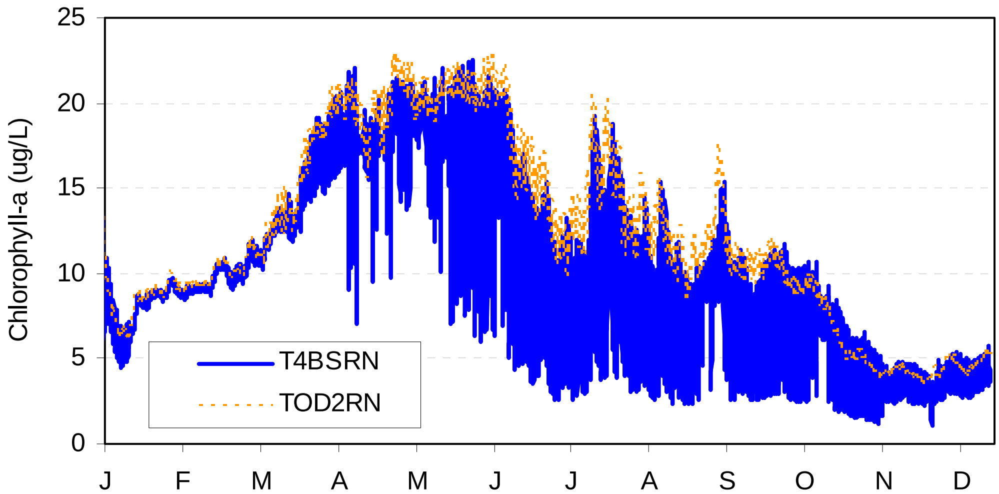


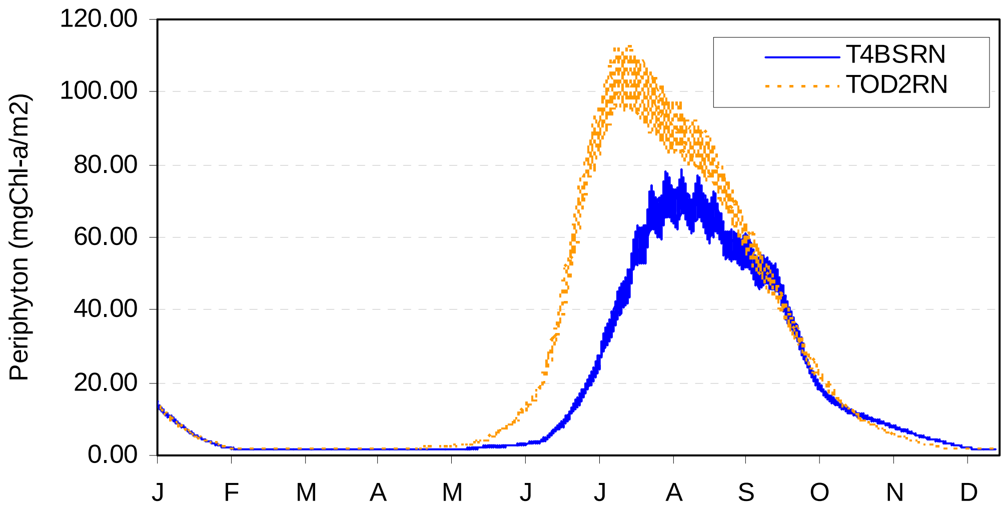




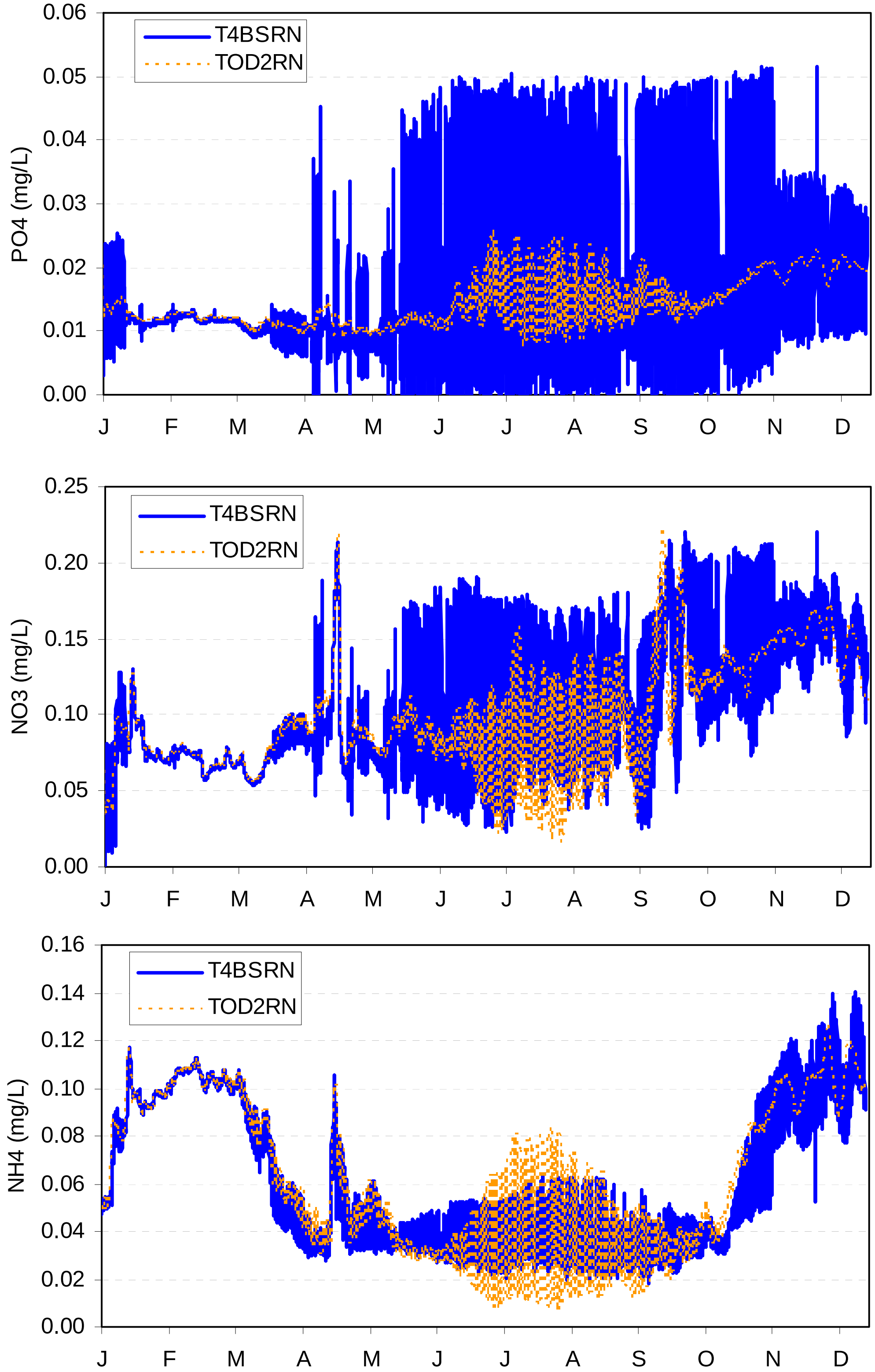
T4BSRN_ND331_STATELINE



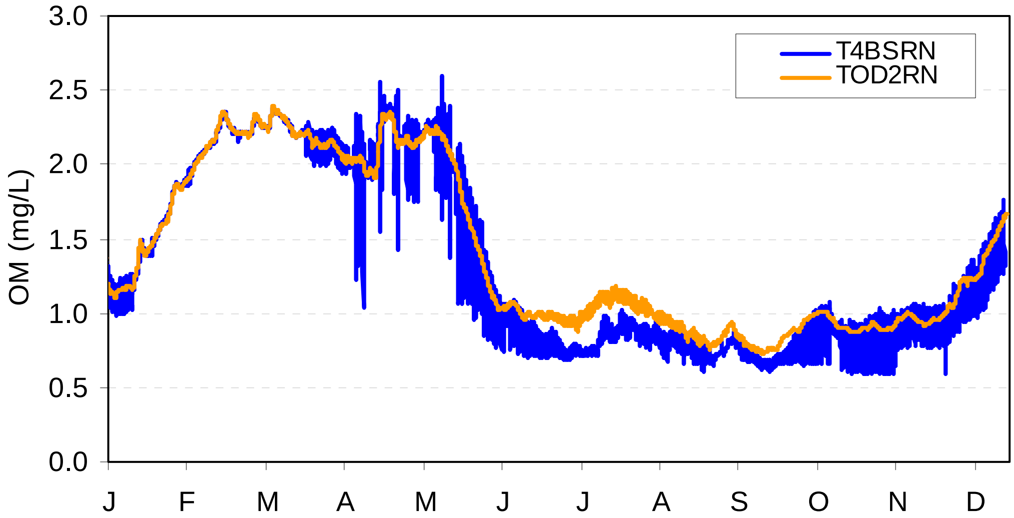


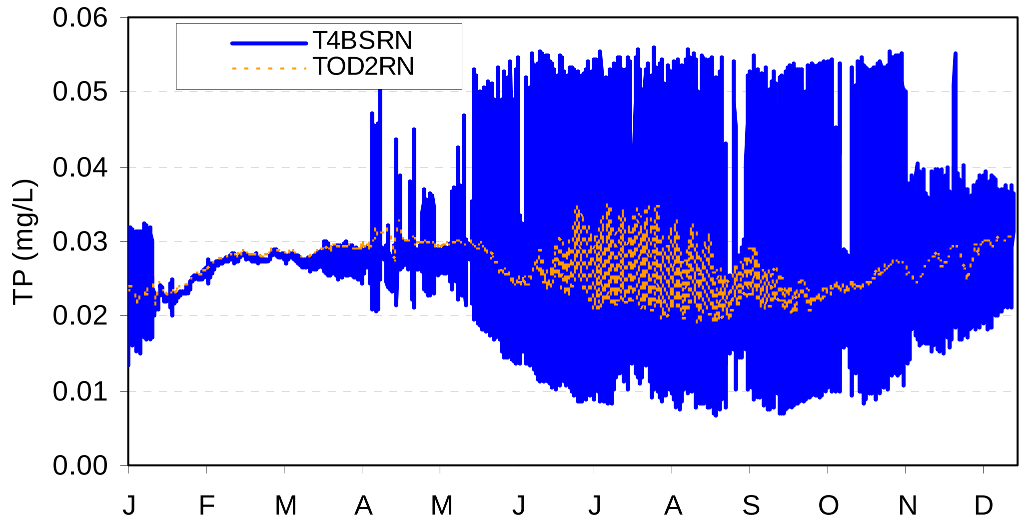


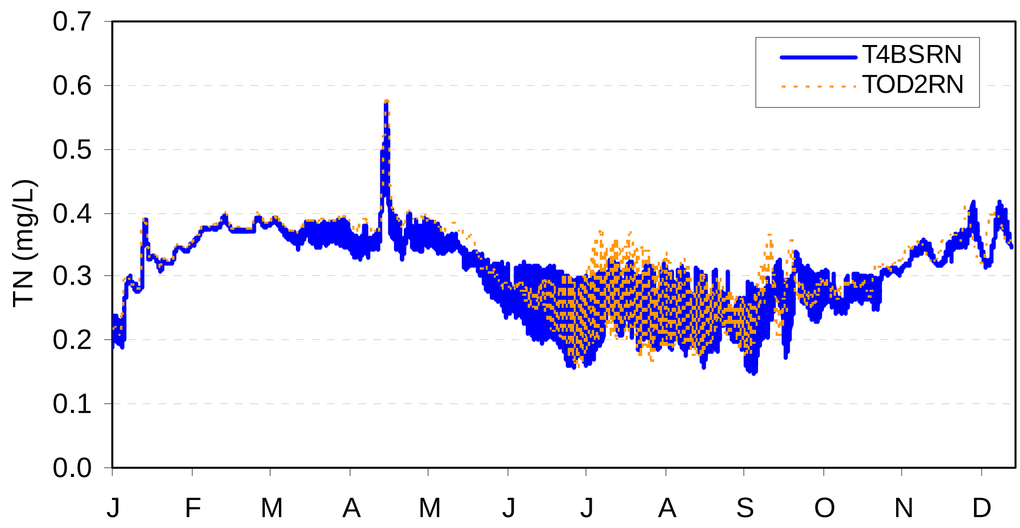
T4BSRN_ND331_STATELINE



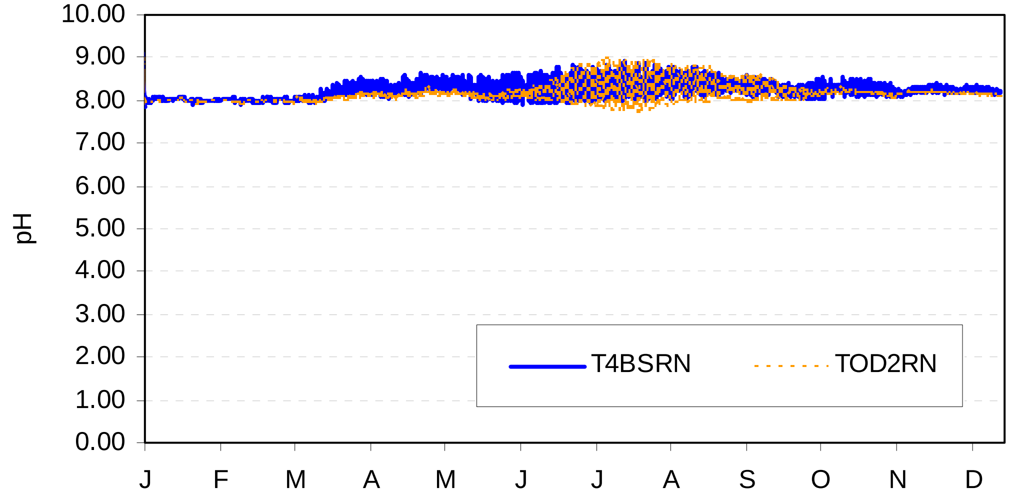
T4BSRN_ND331_STATELINE







T4BSRN_ND331_STATELINE



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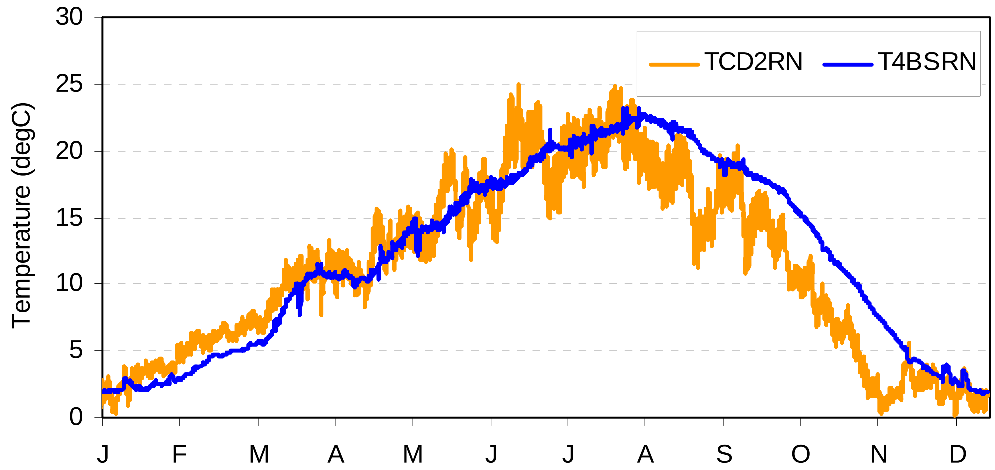

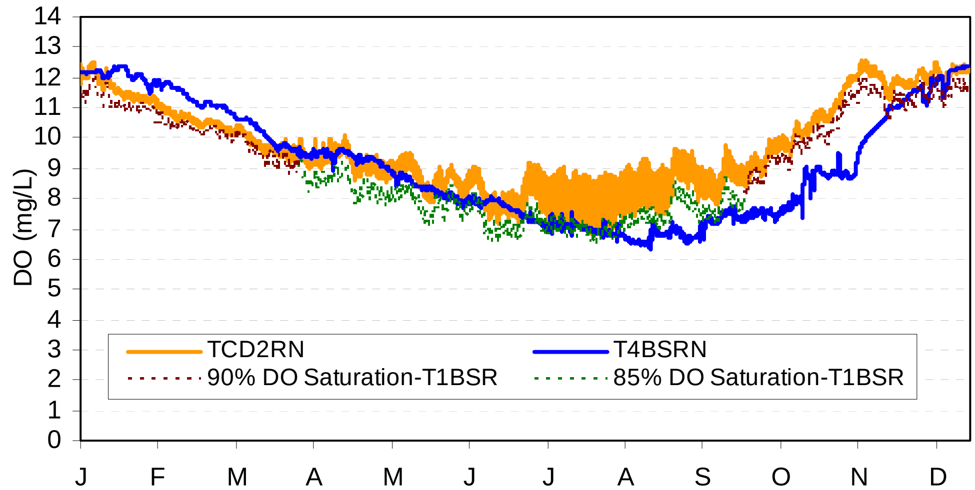

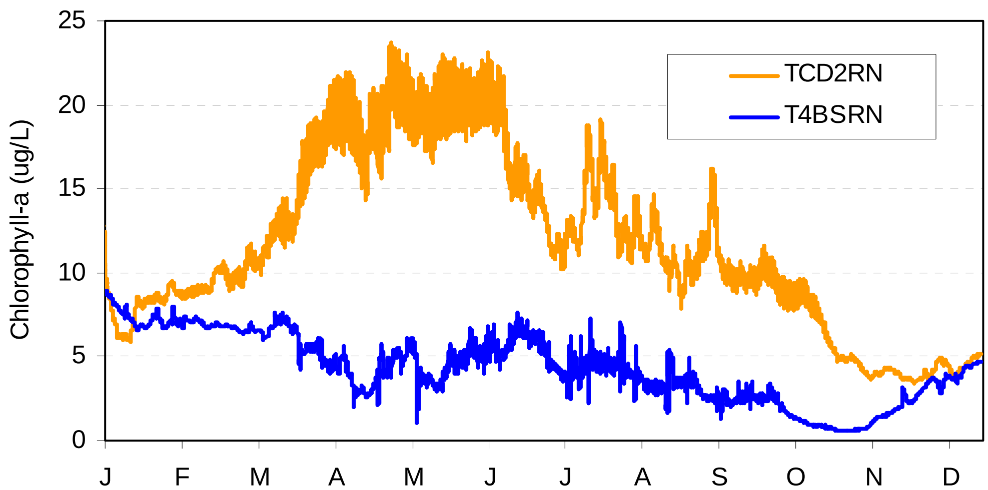

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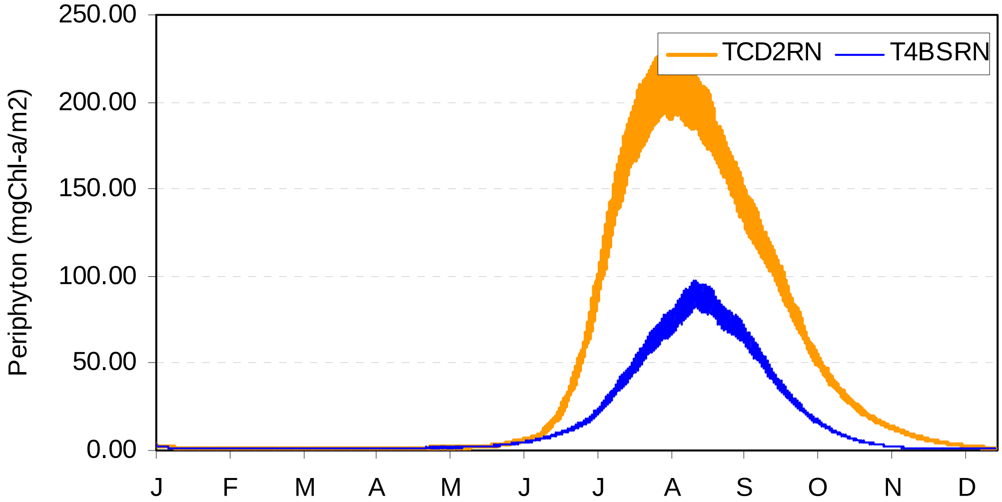

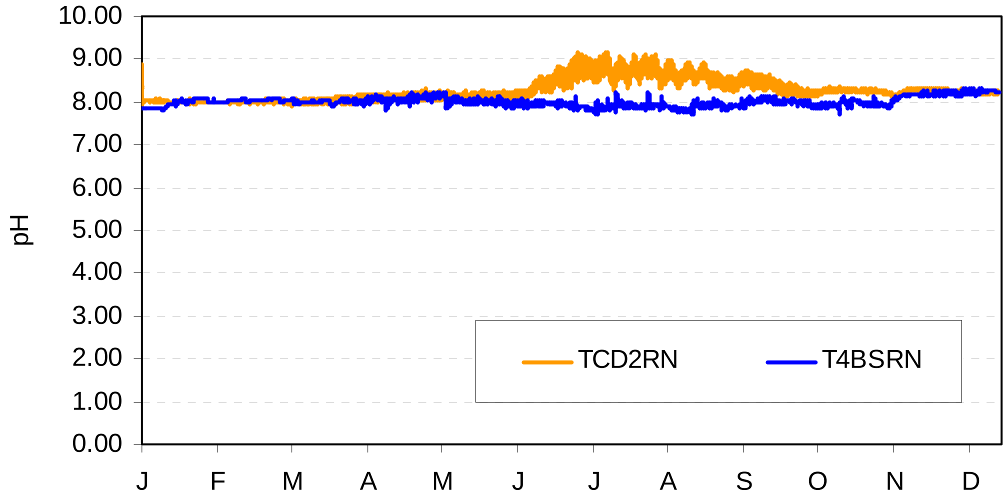

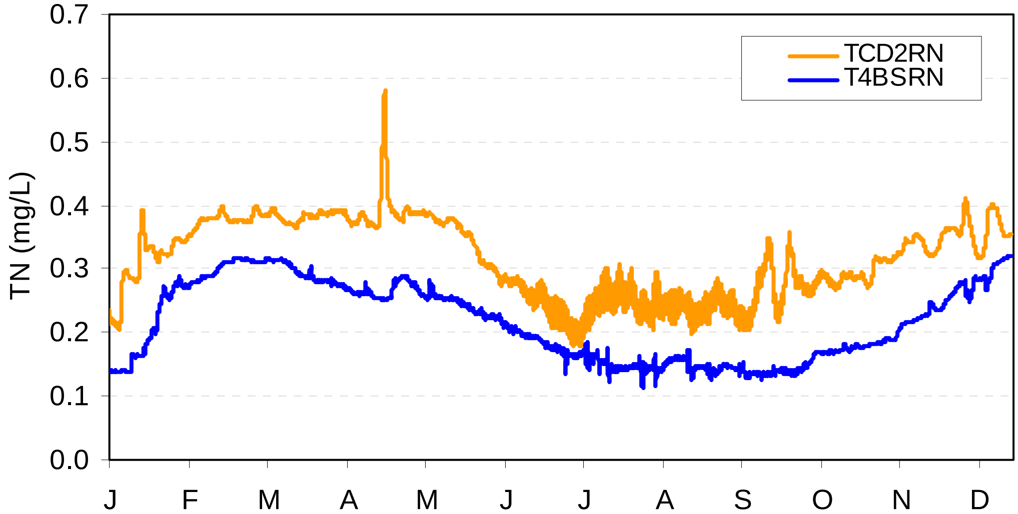

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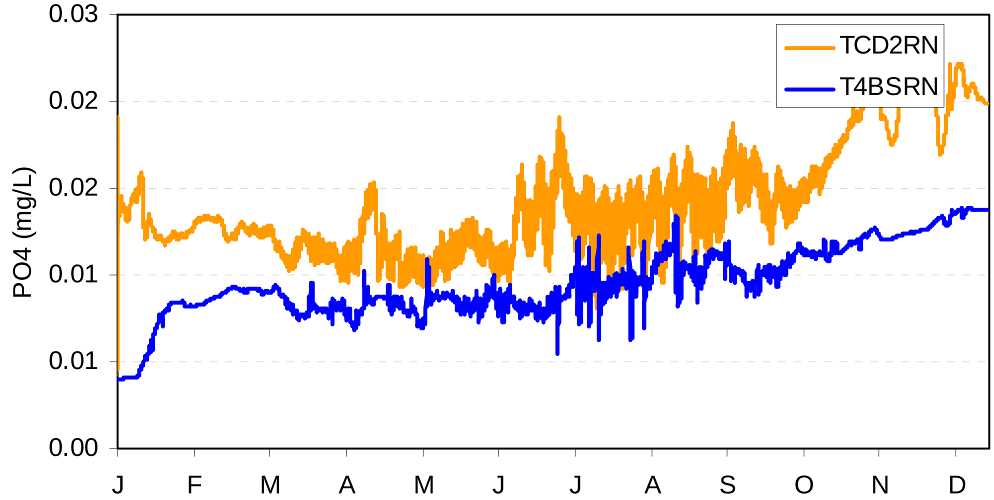

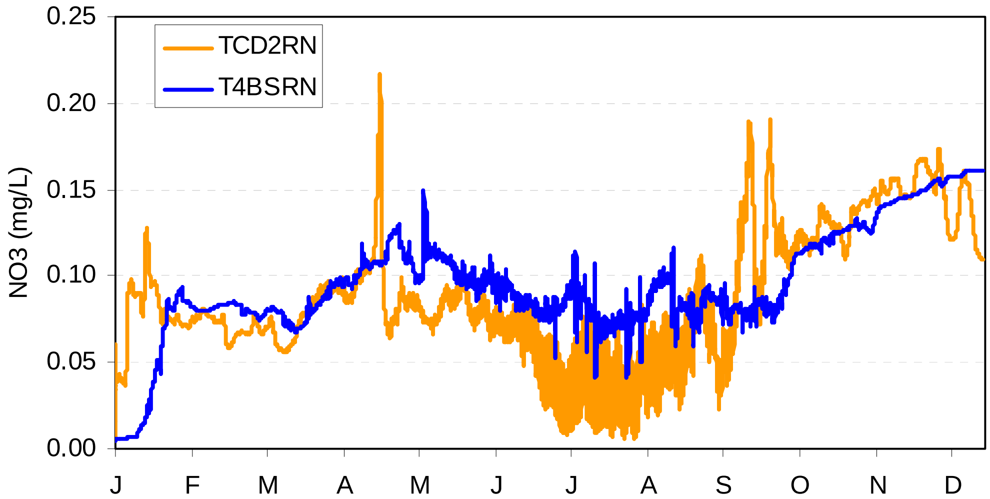

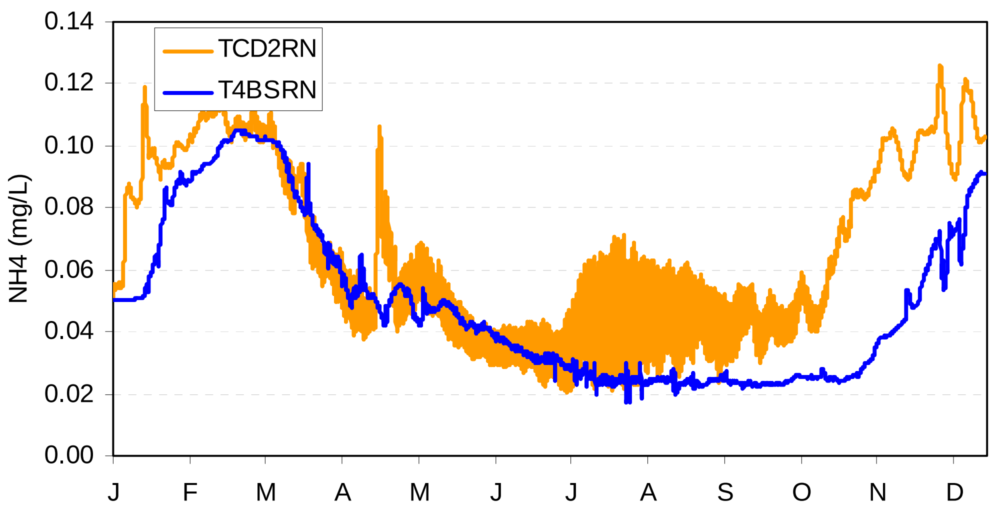

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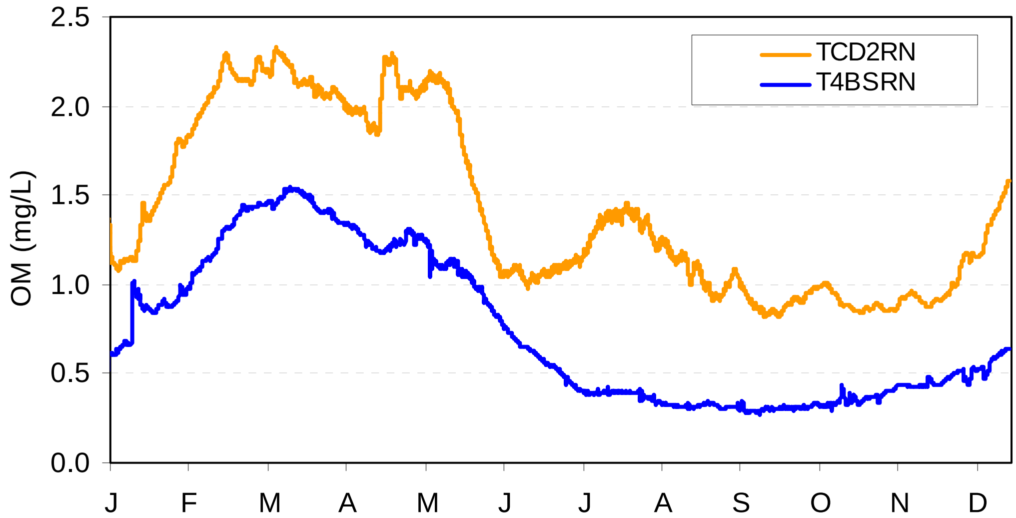

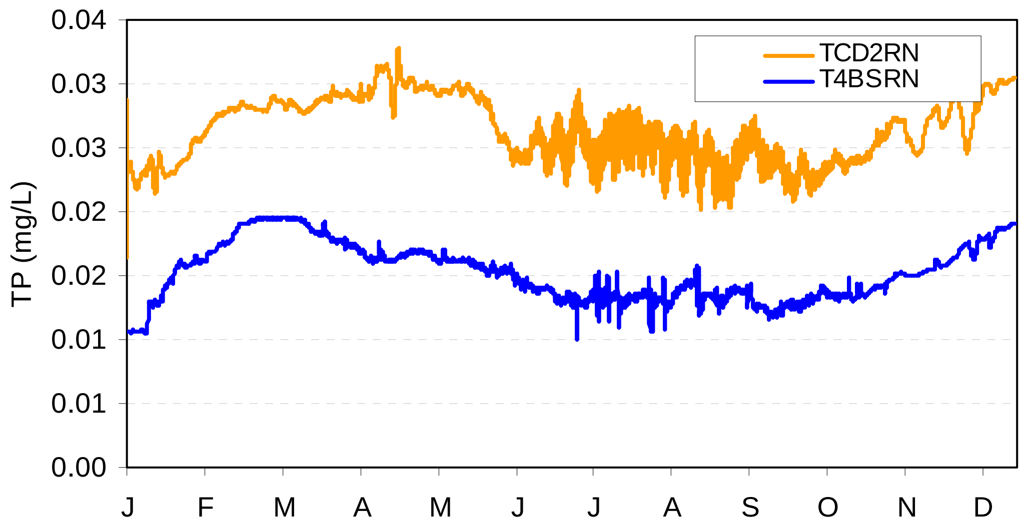

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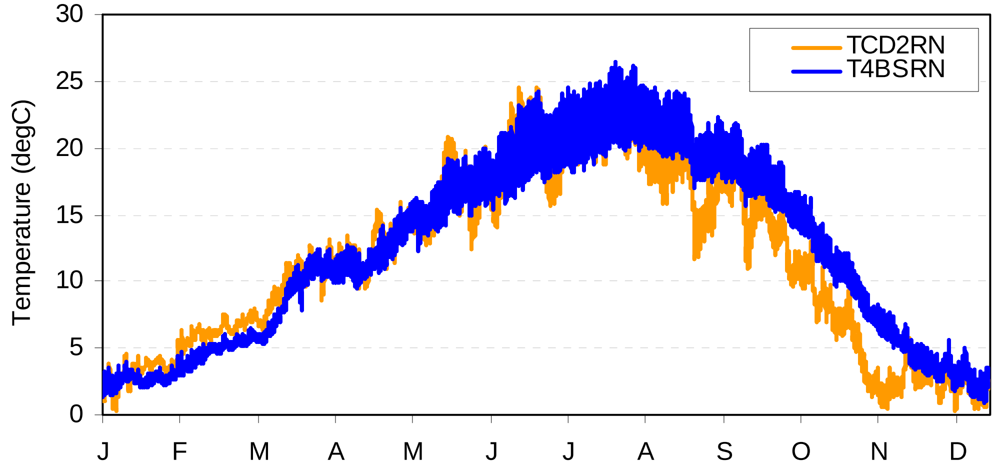

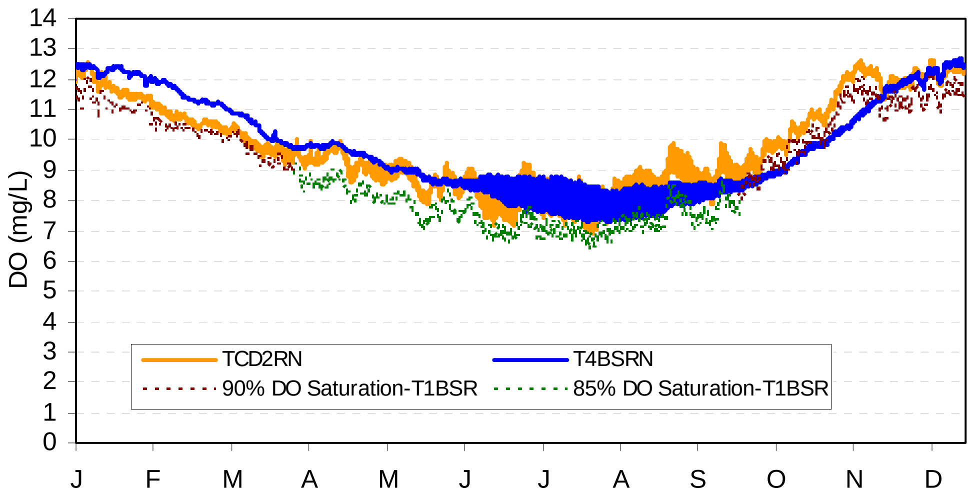

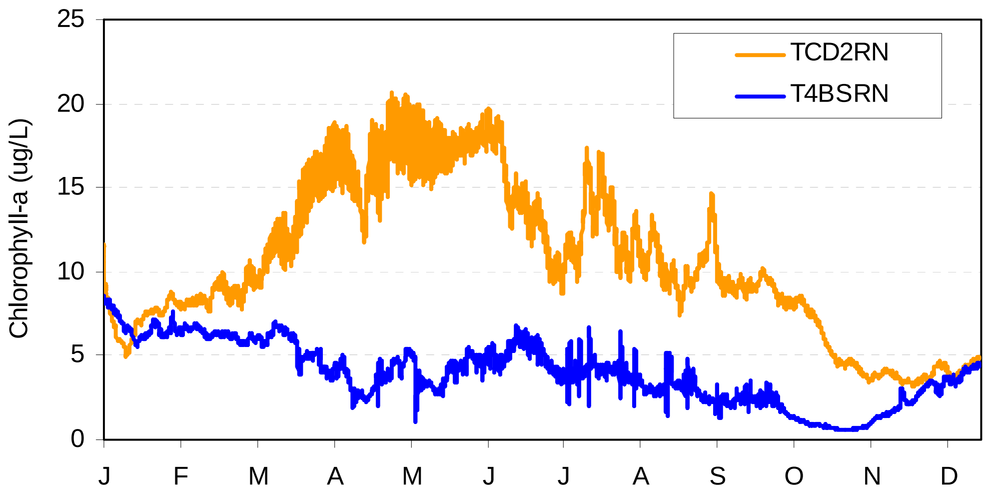

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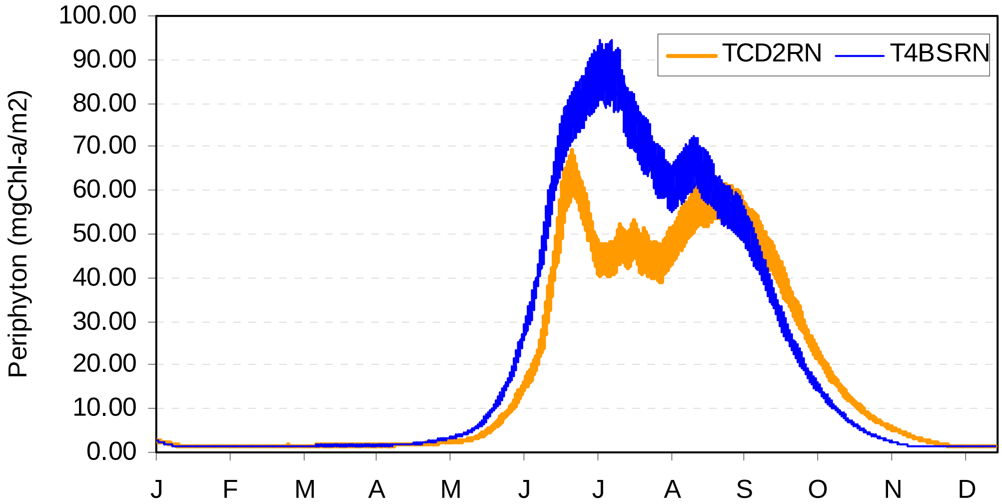

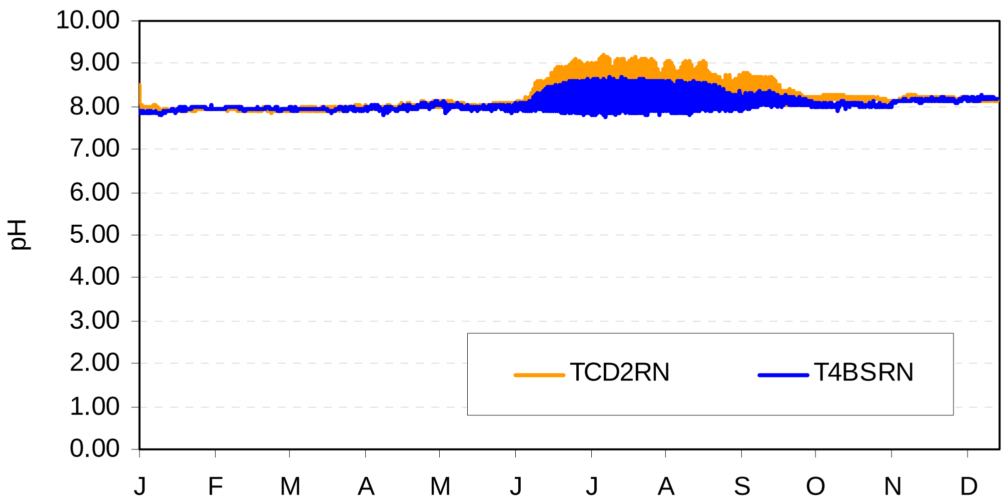

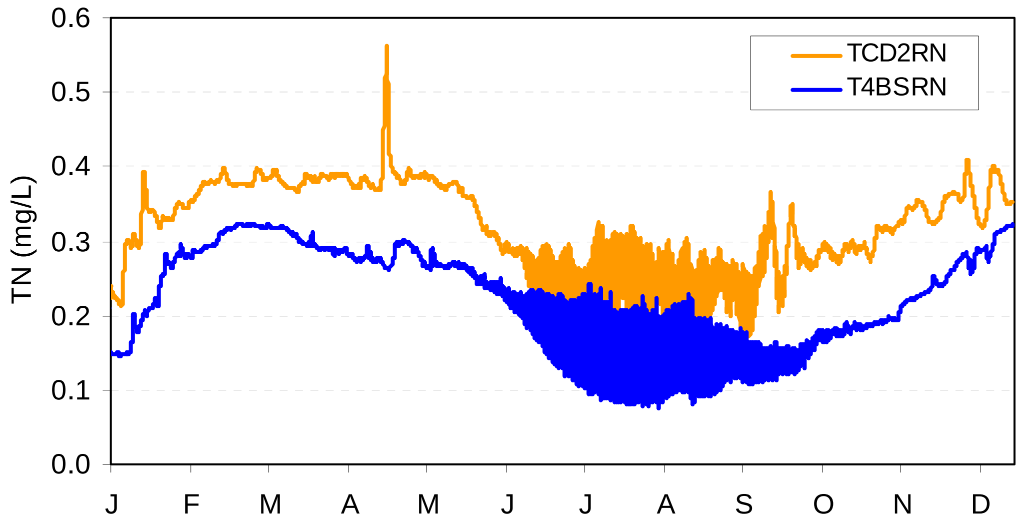

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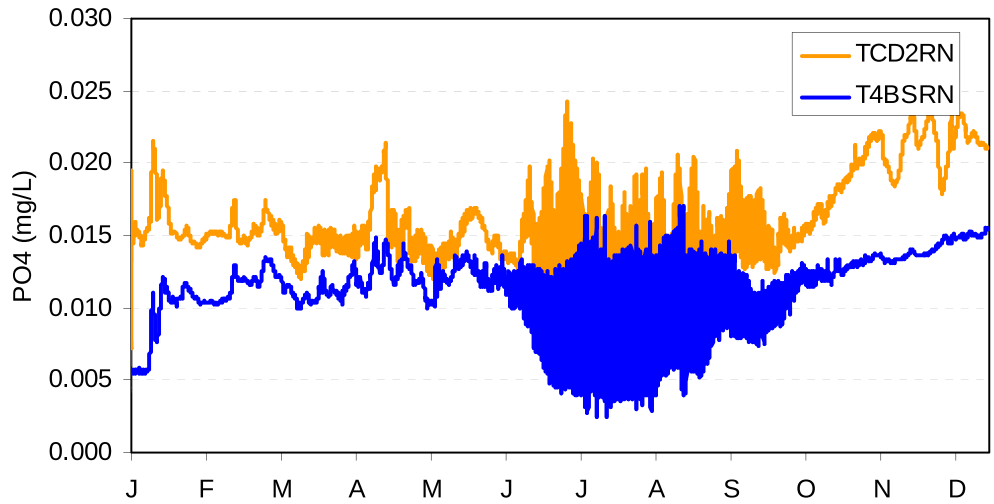

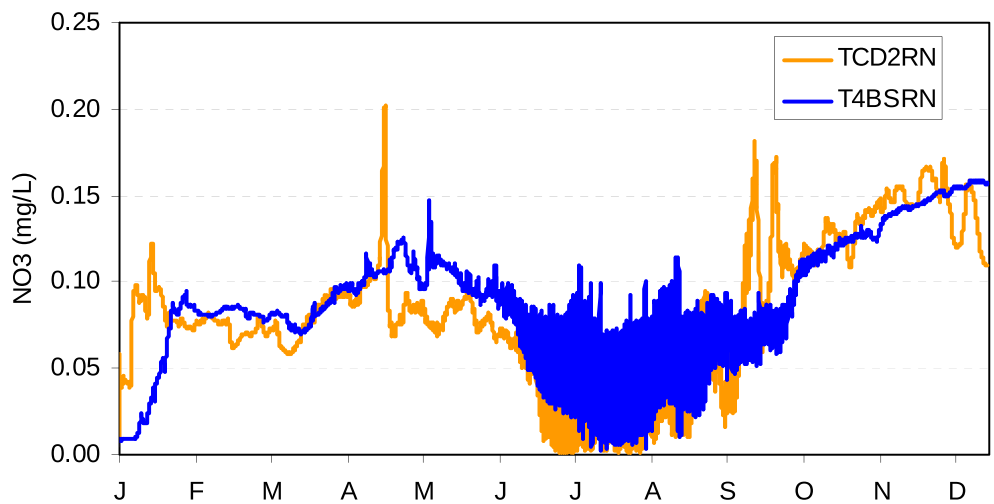

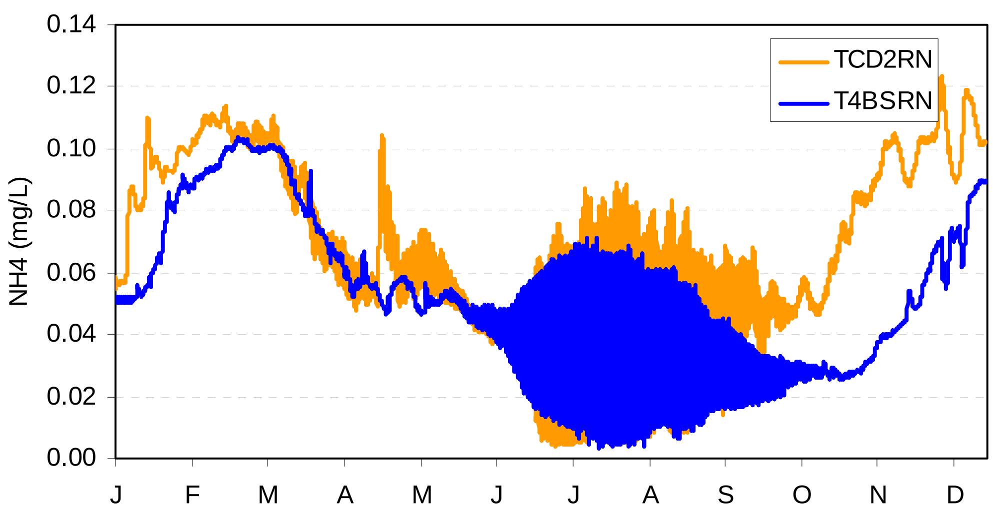

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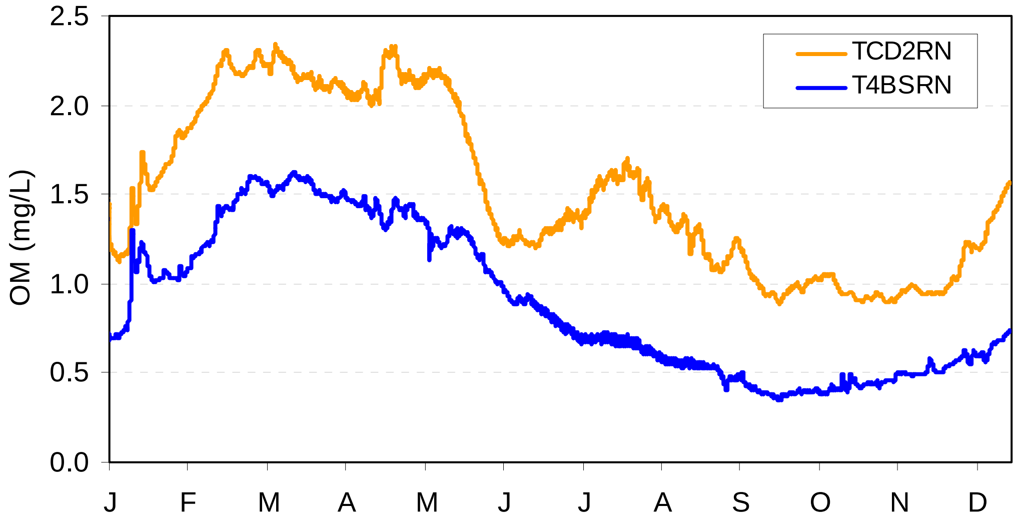

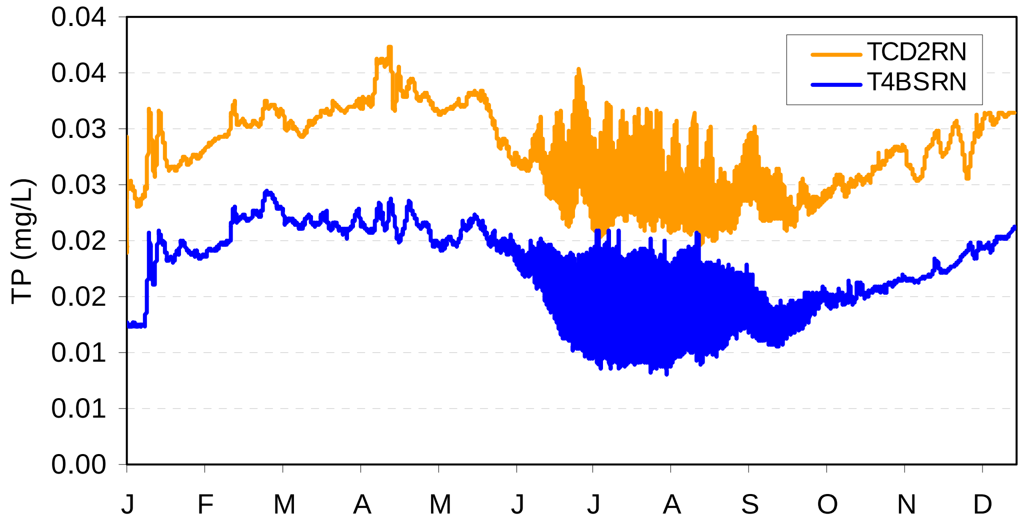

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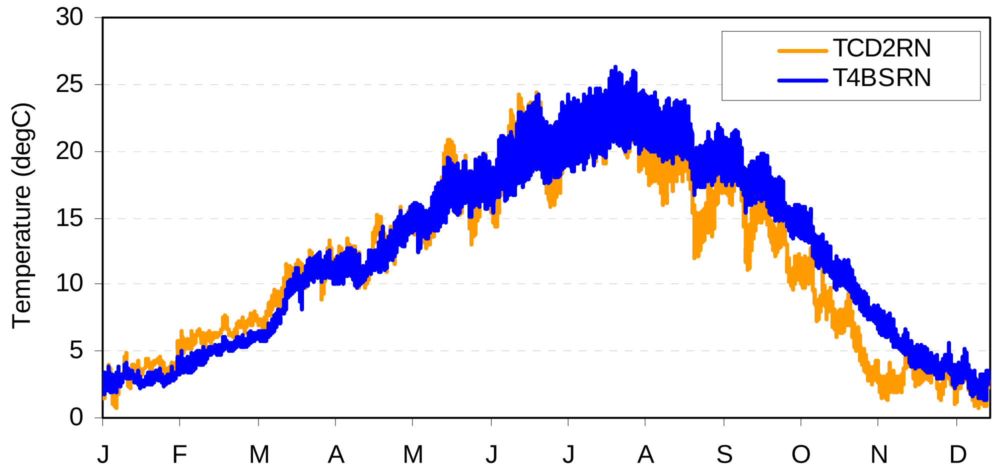

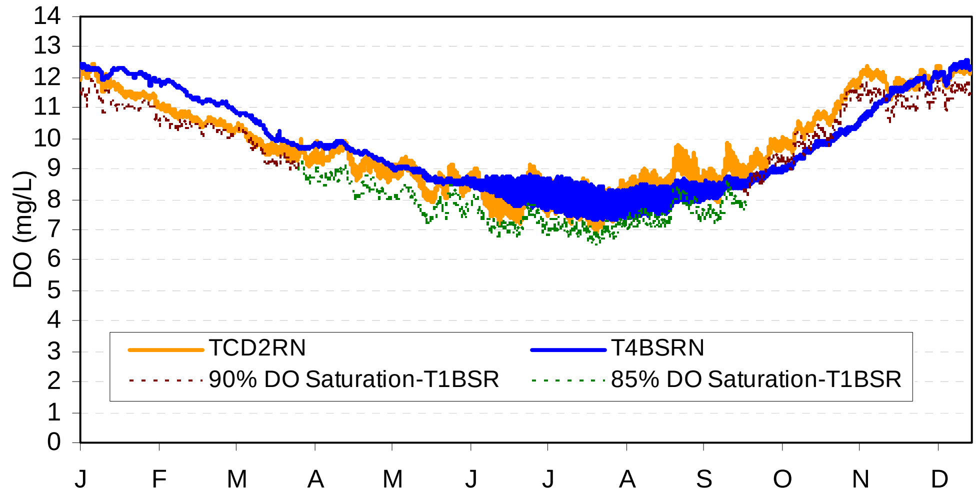

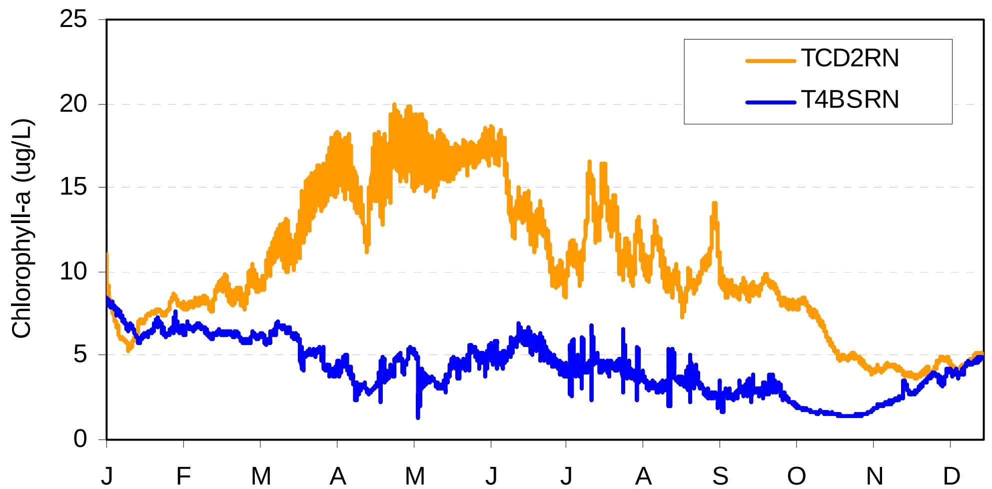

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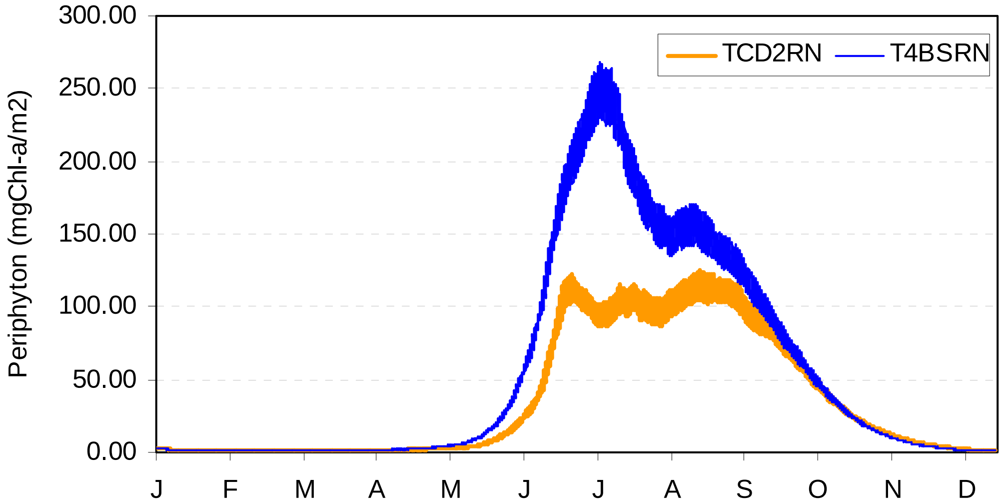

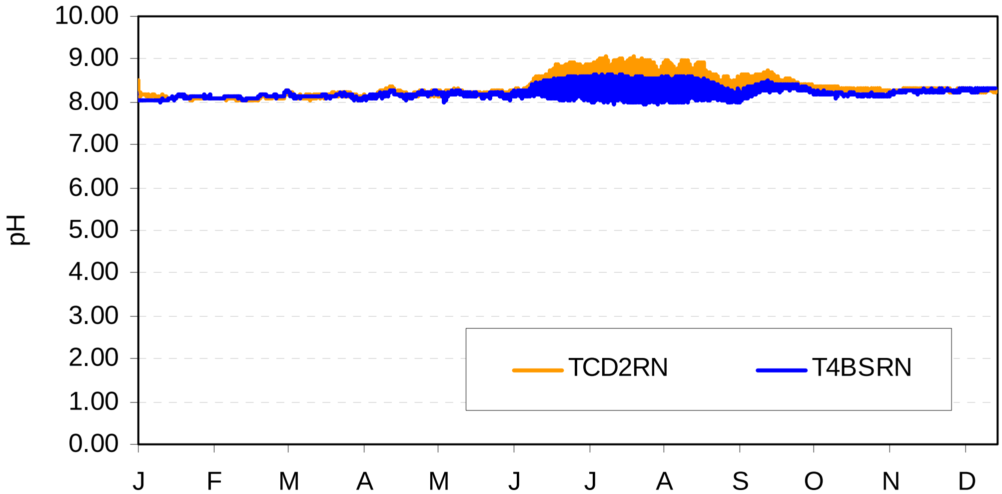

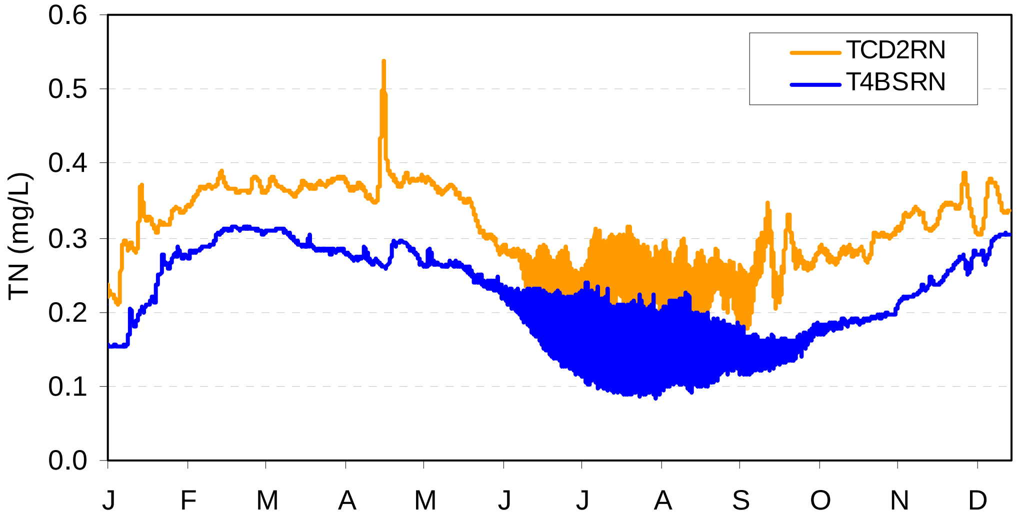

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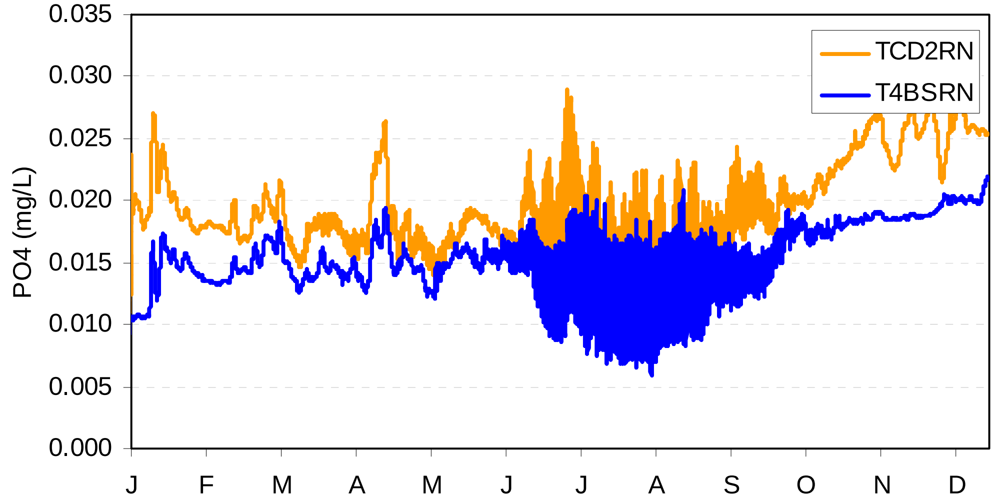

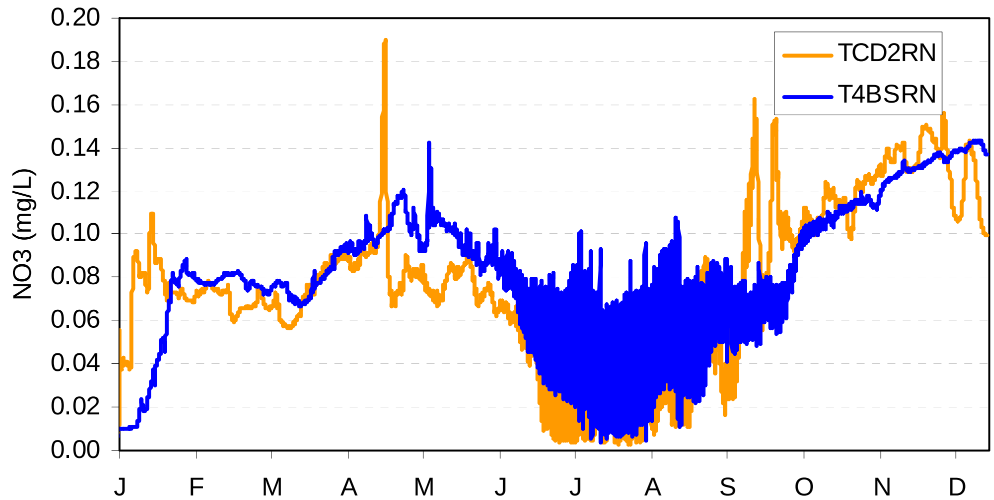

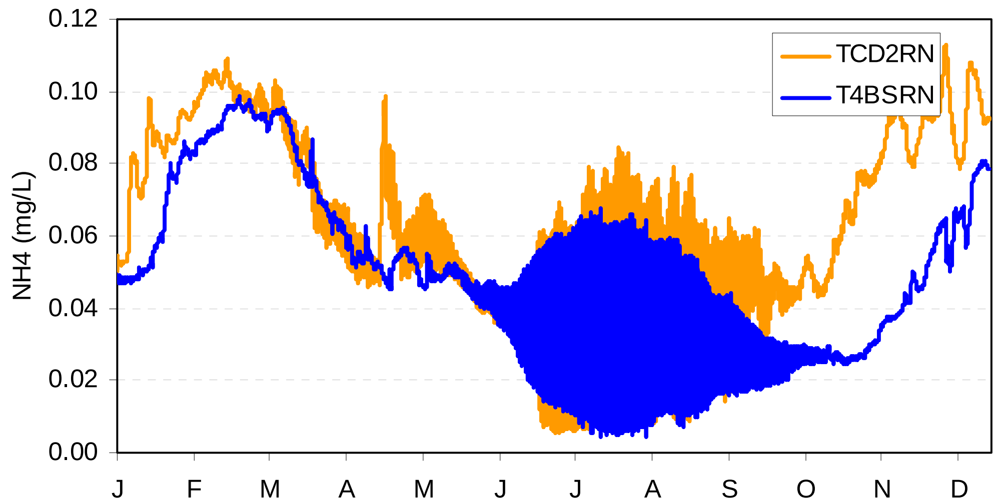

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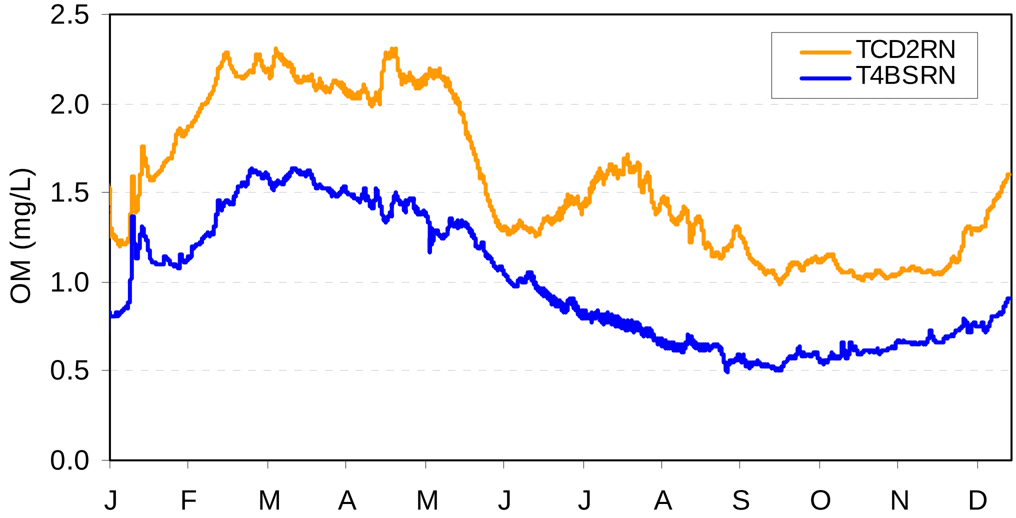

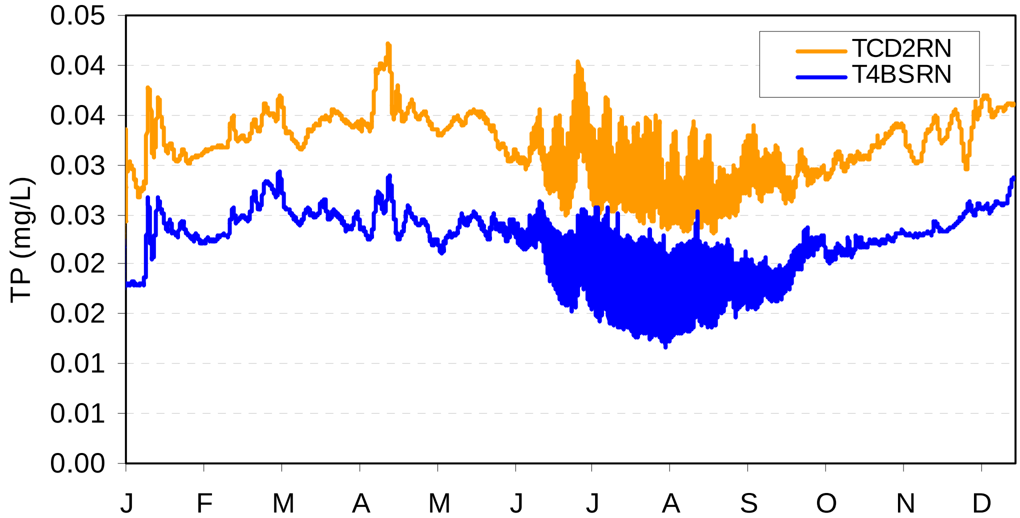

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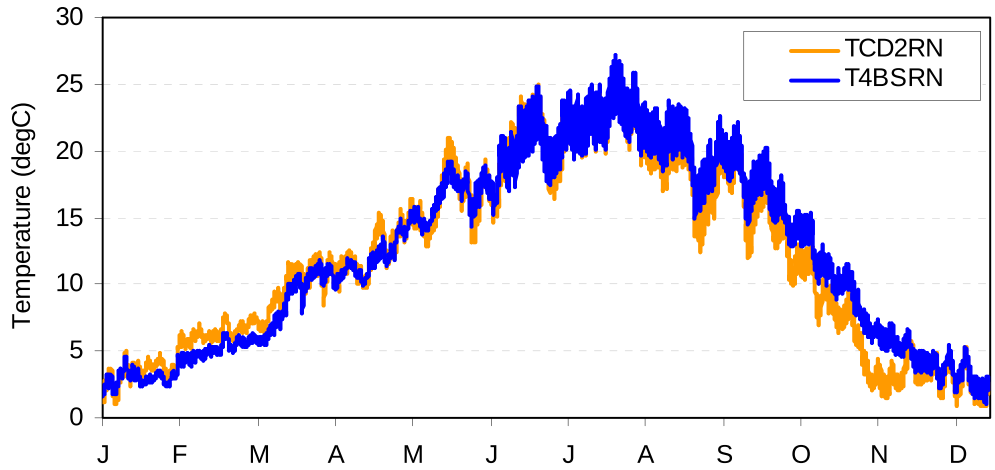

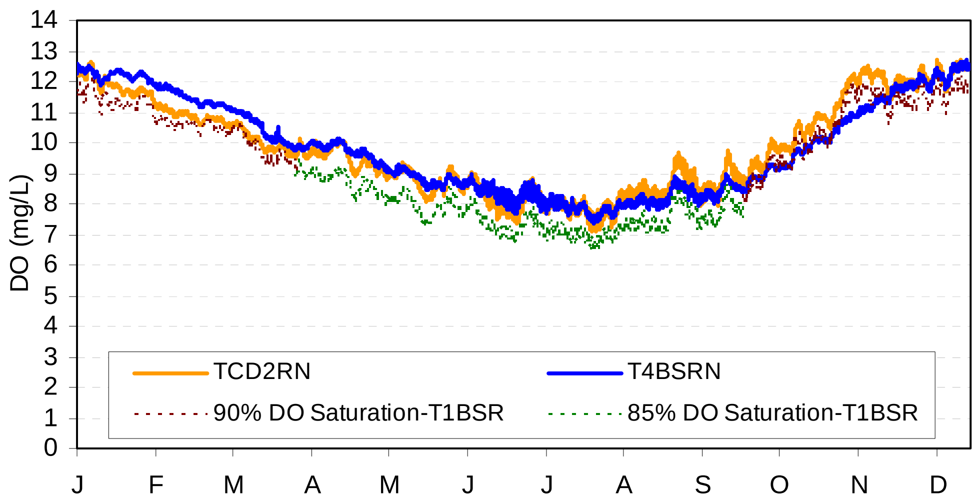

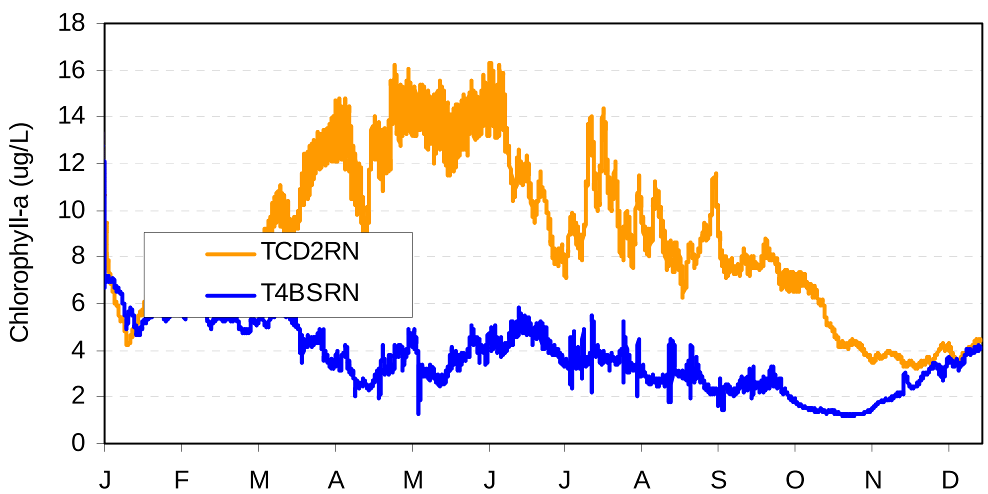

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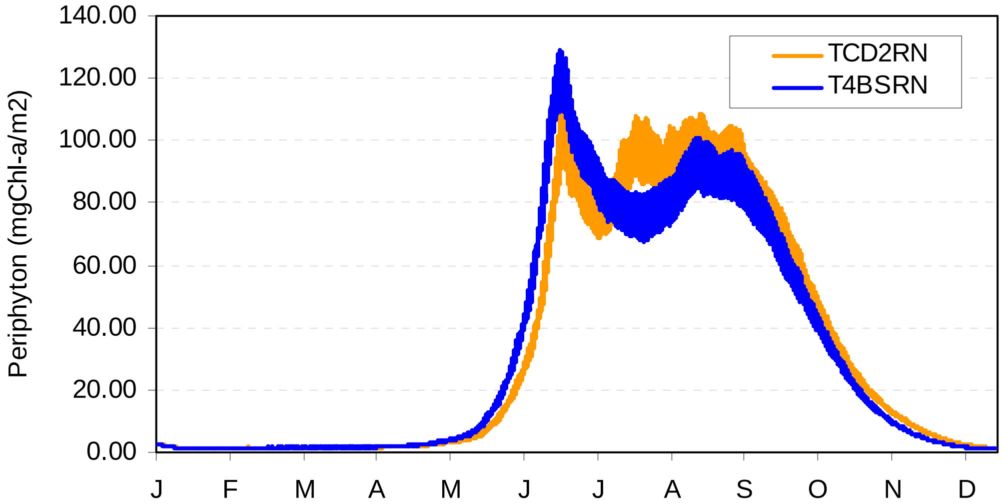

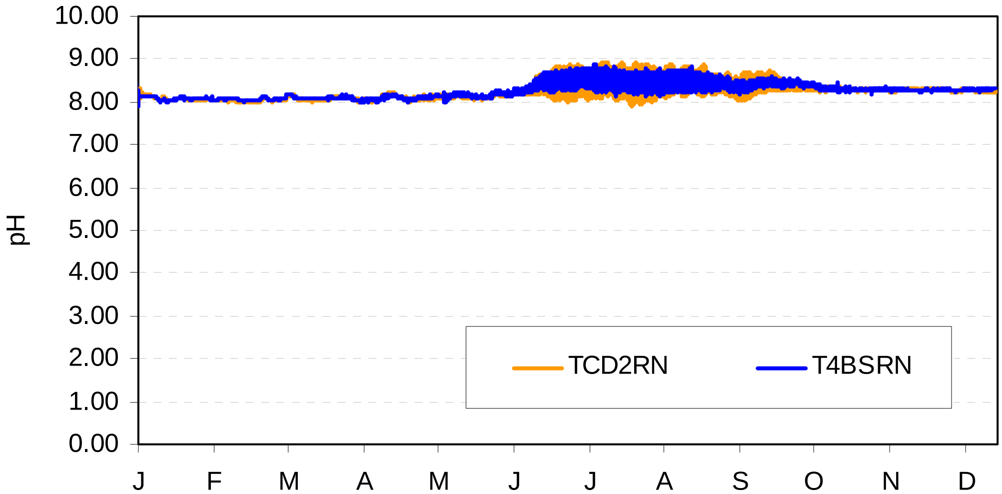

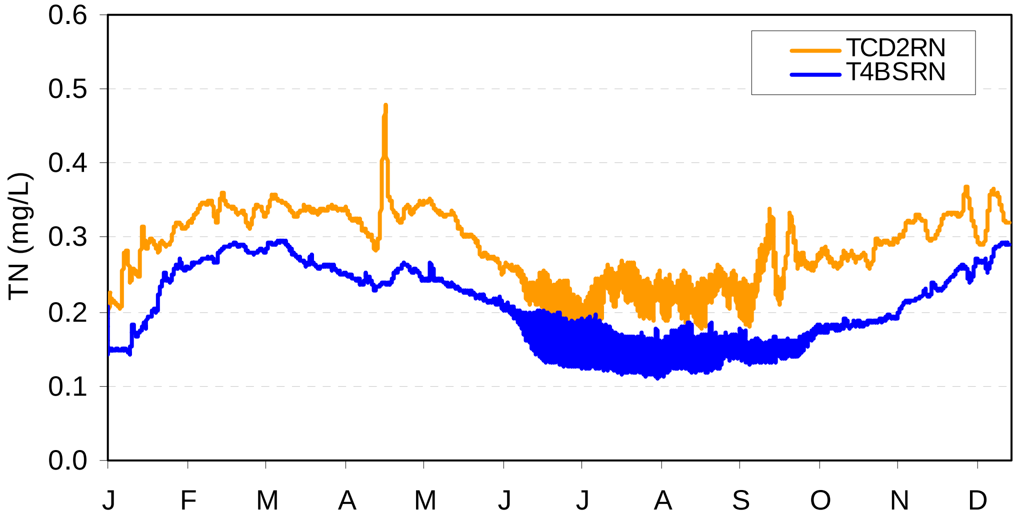

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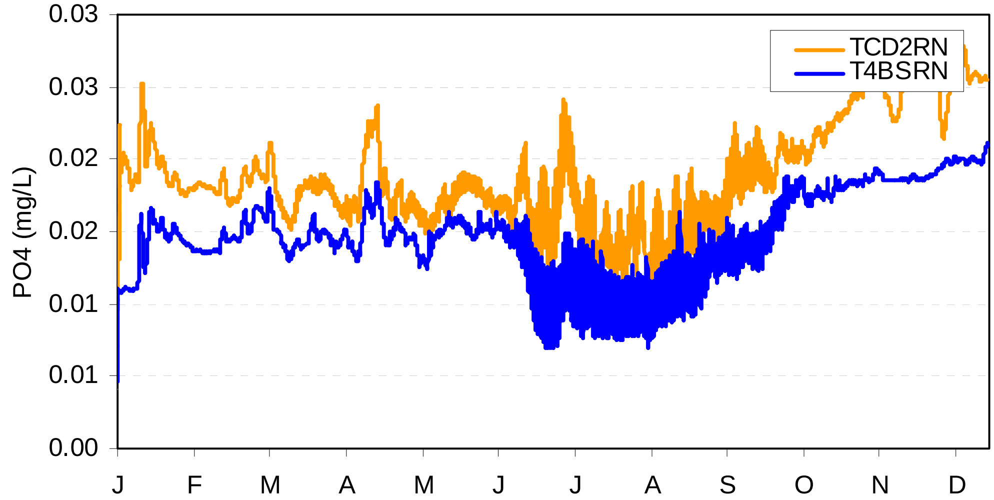

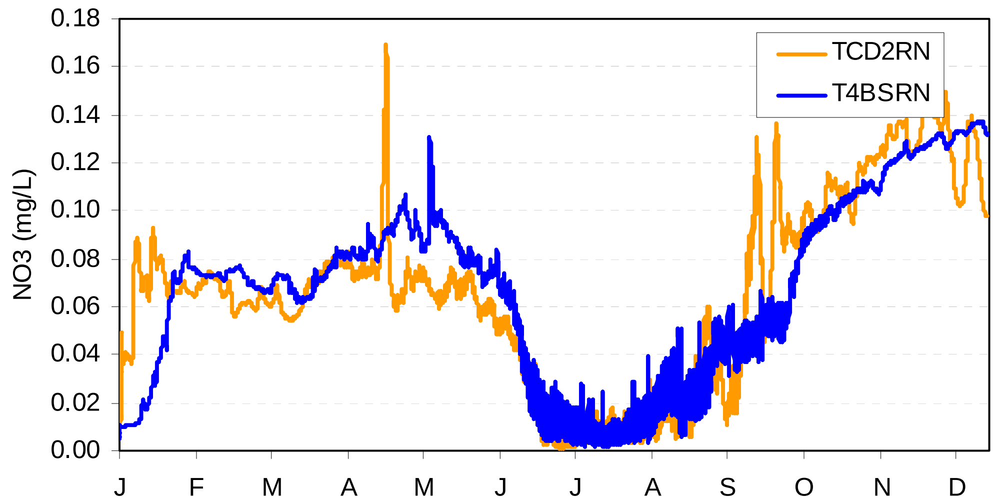

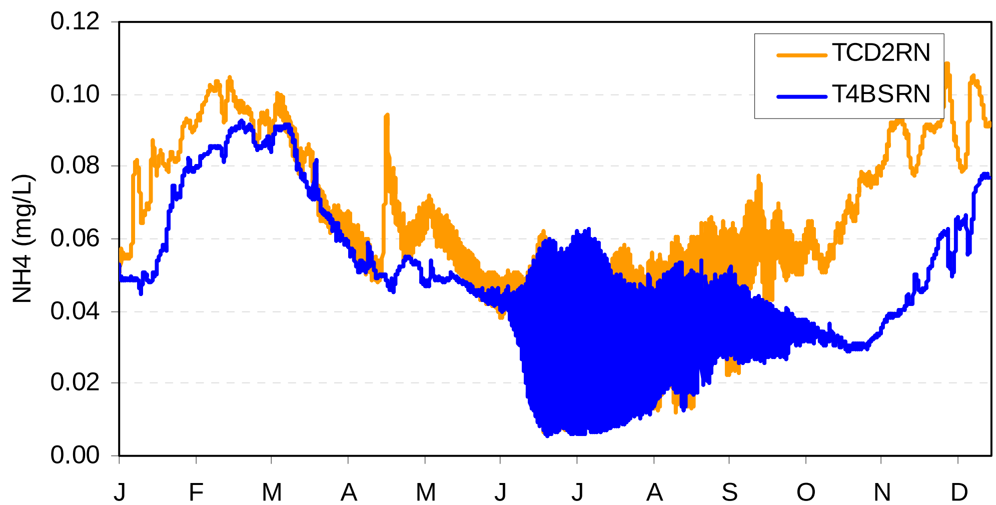

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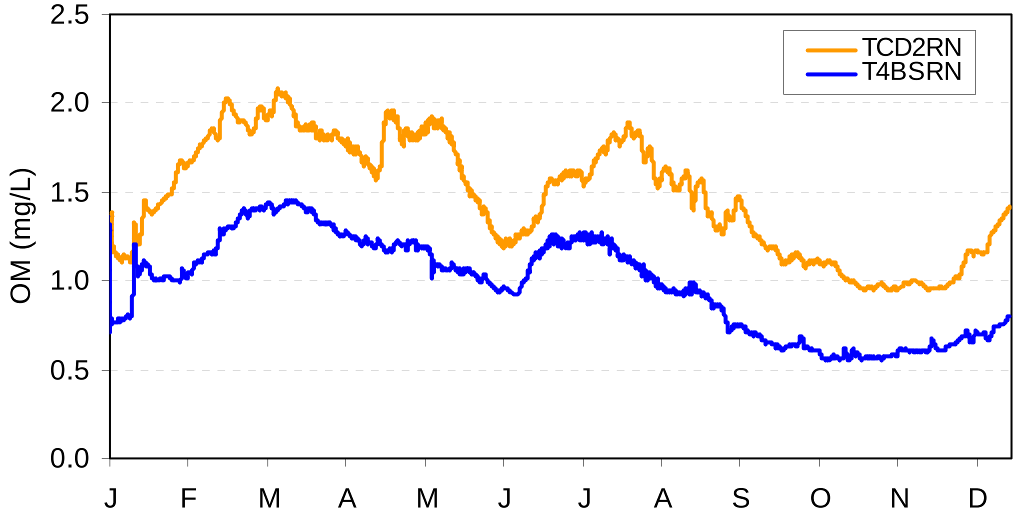

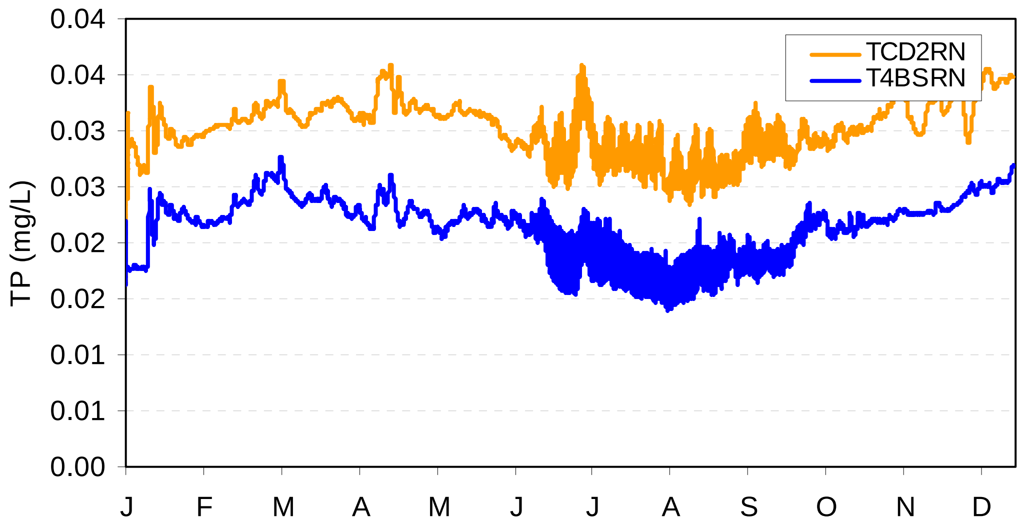

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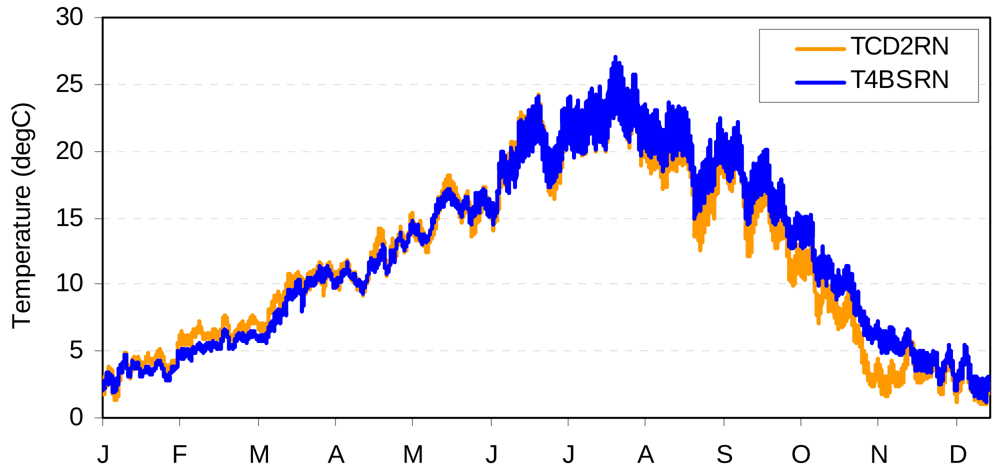

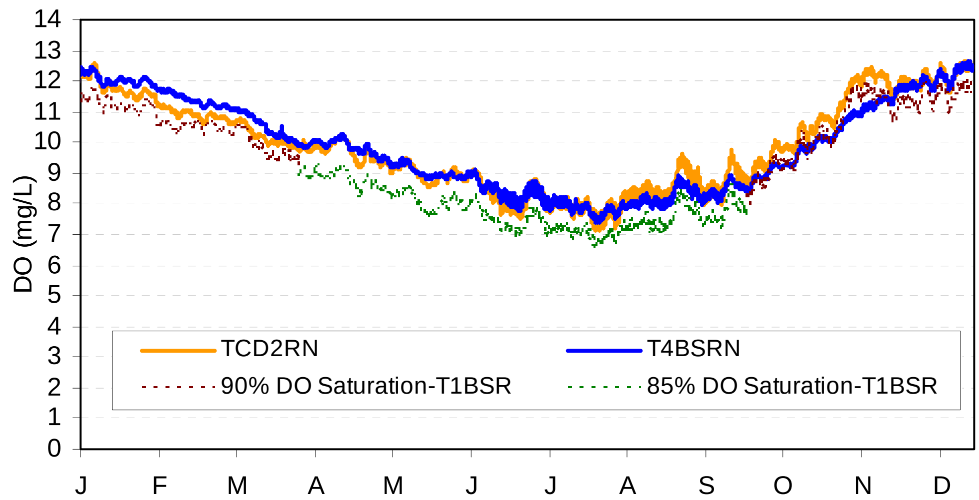

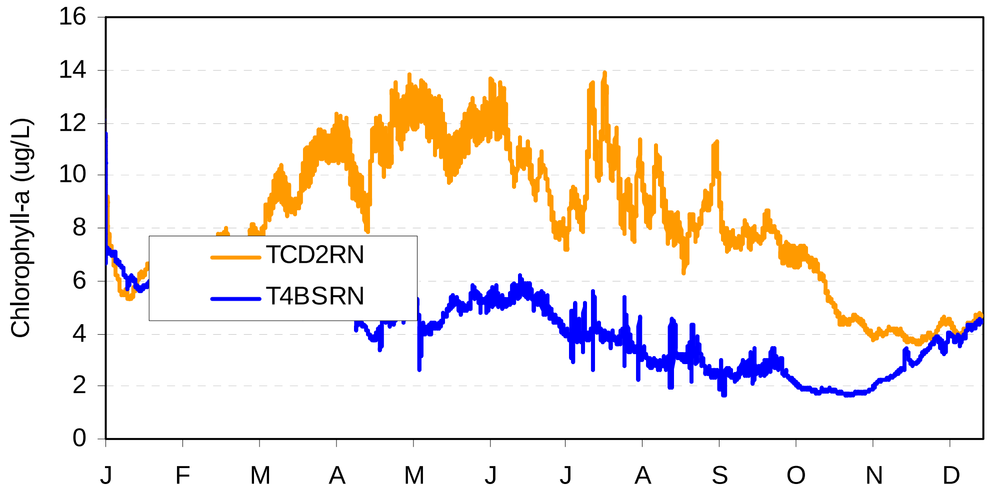

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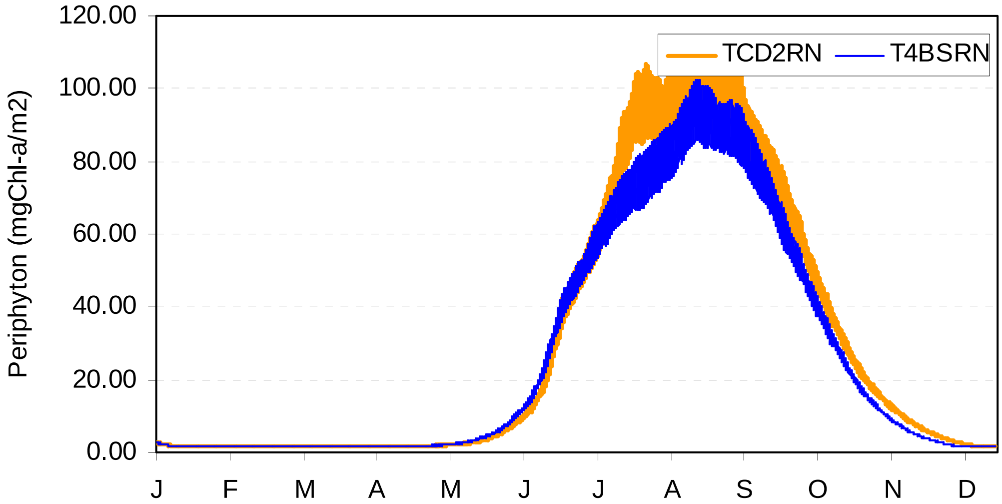

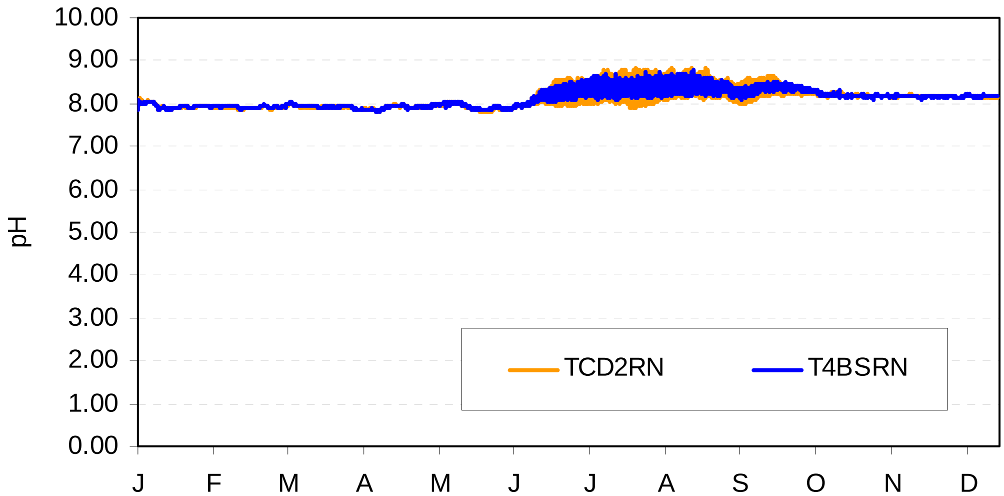

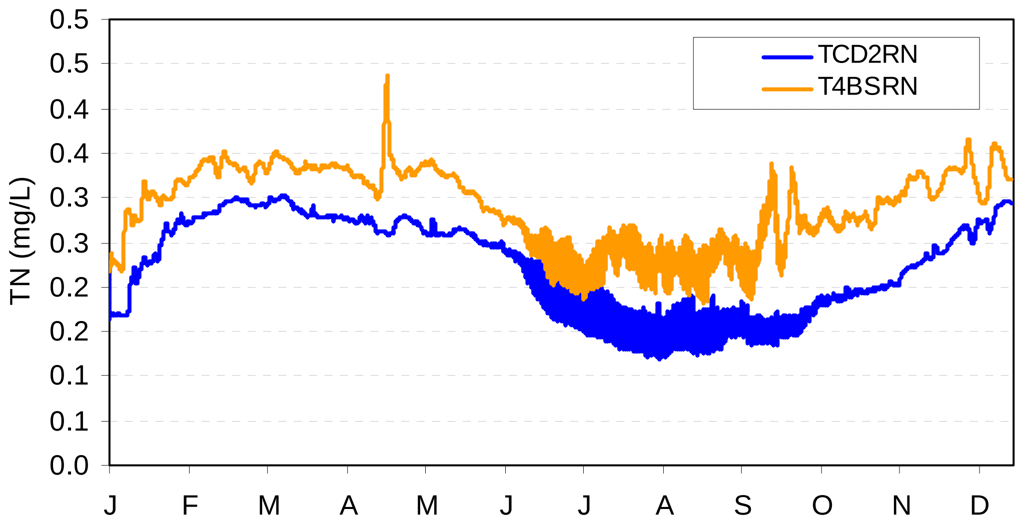

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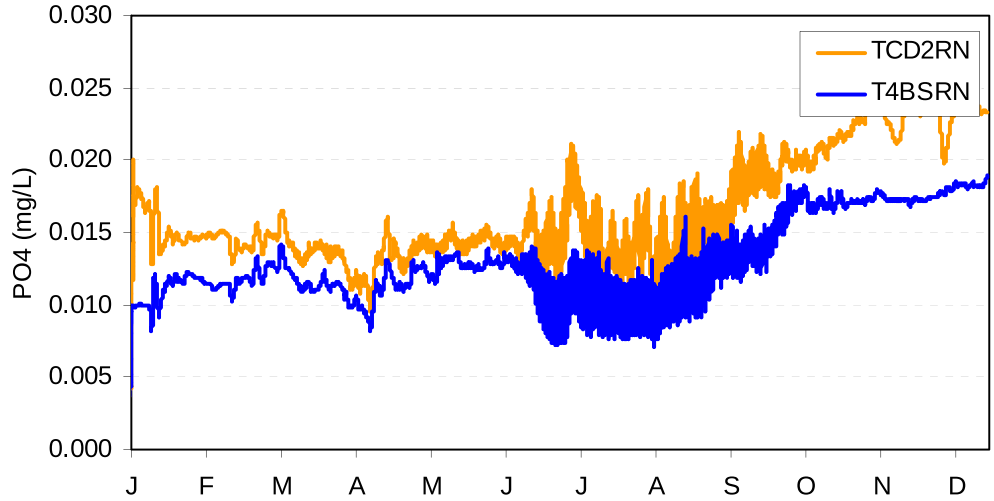

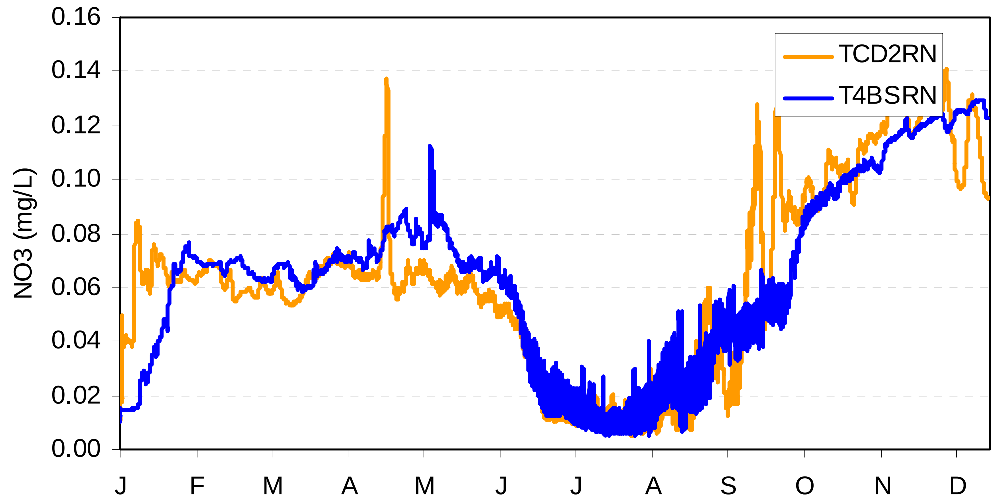

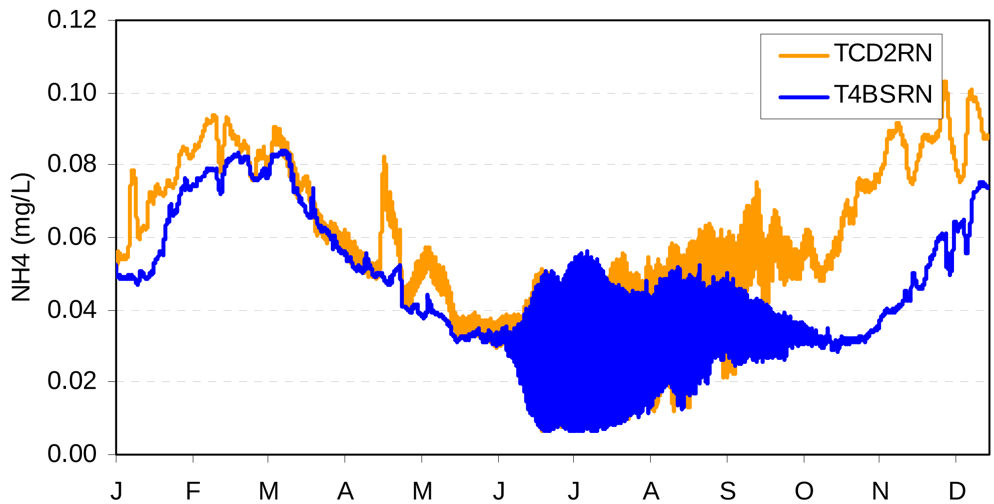

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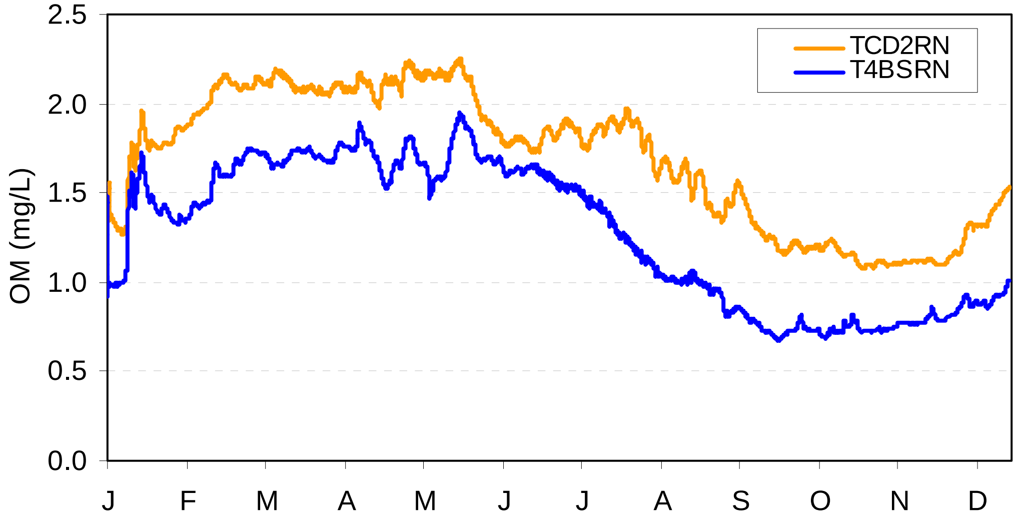

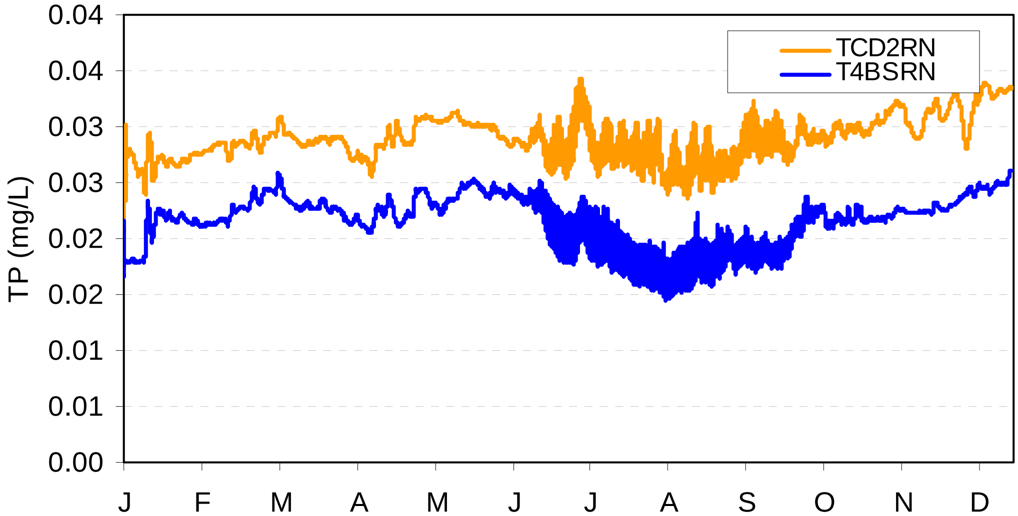

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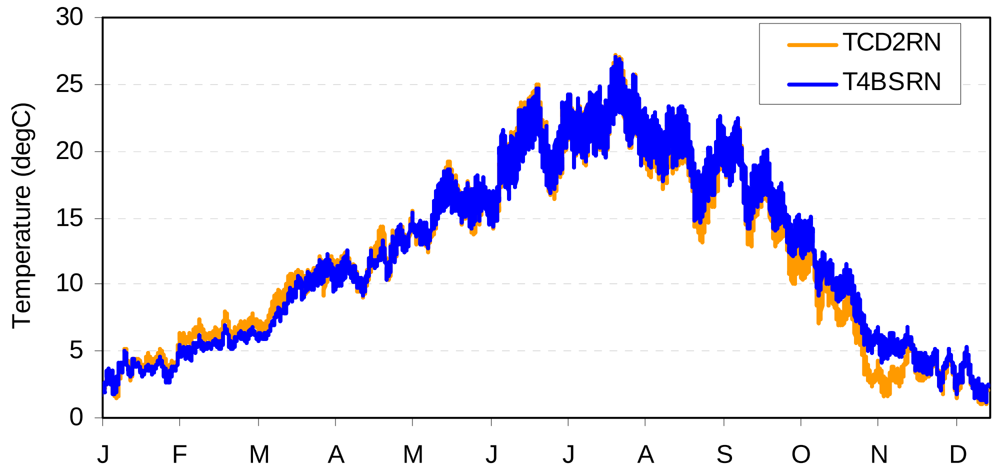

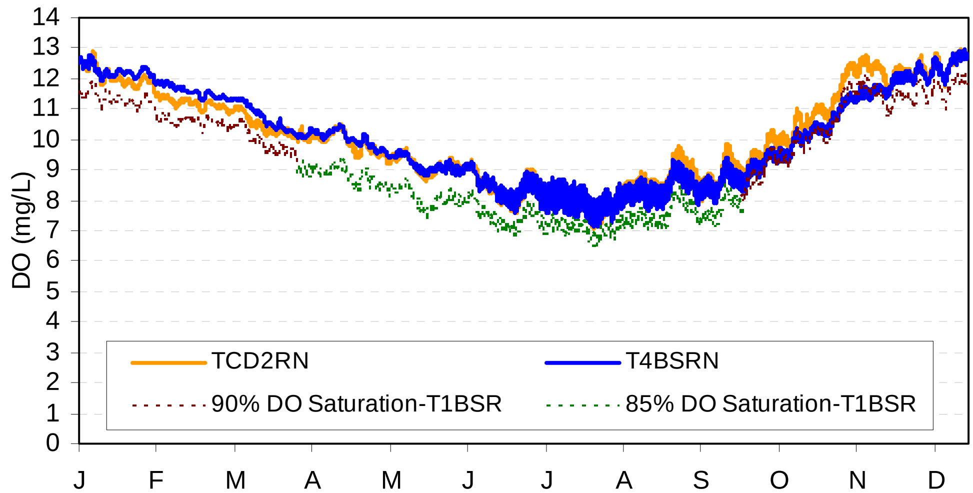

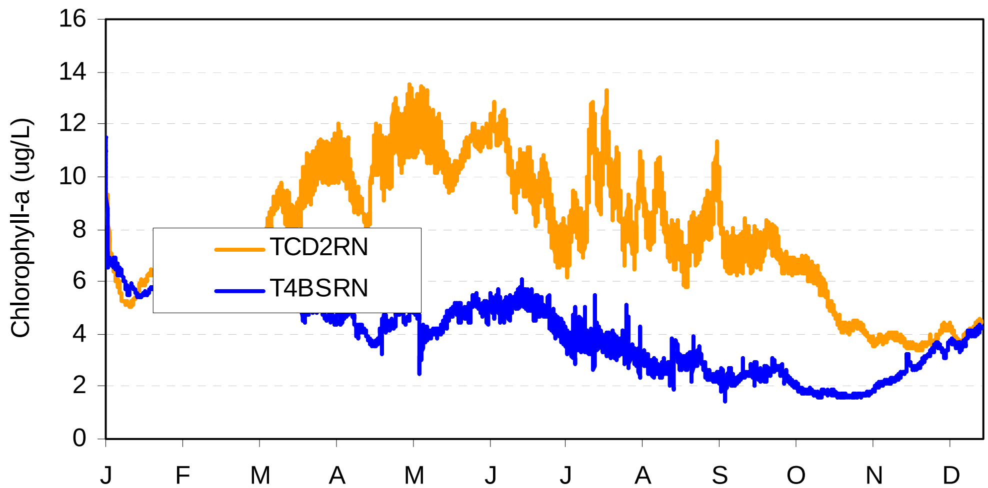

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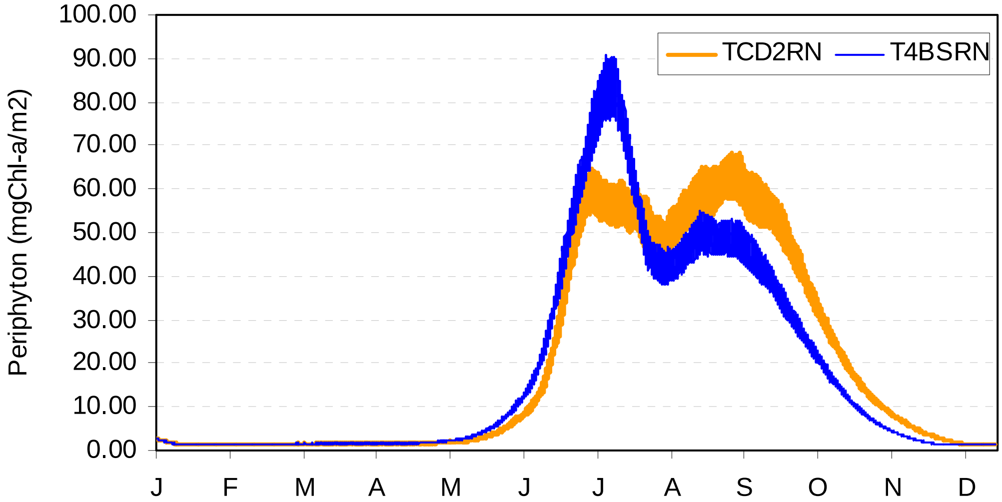

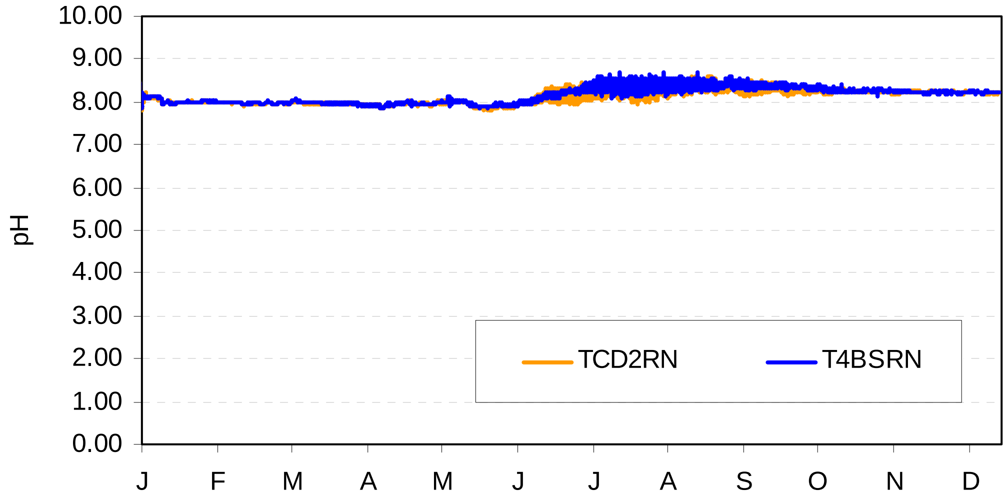

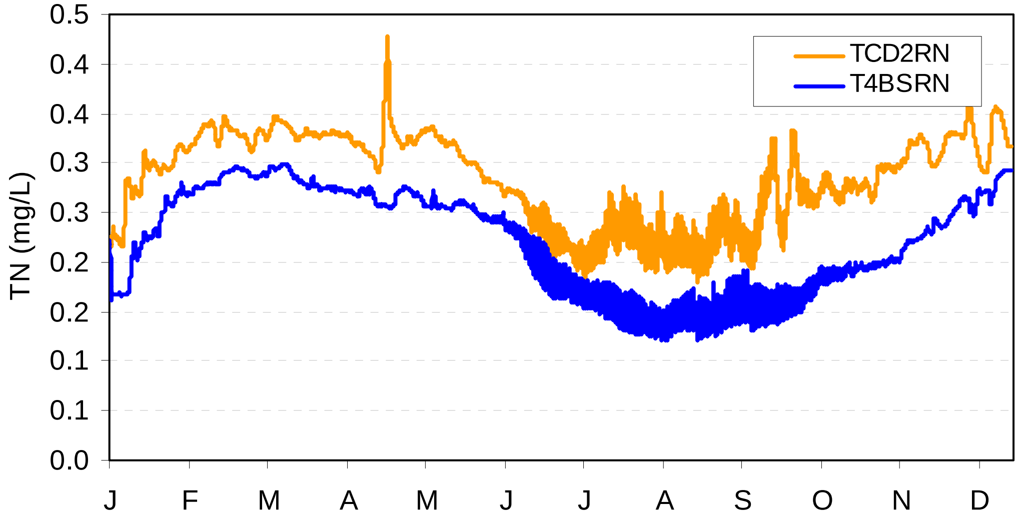

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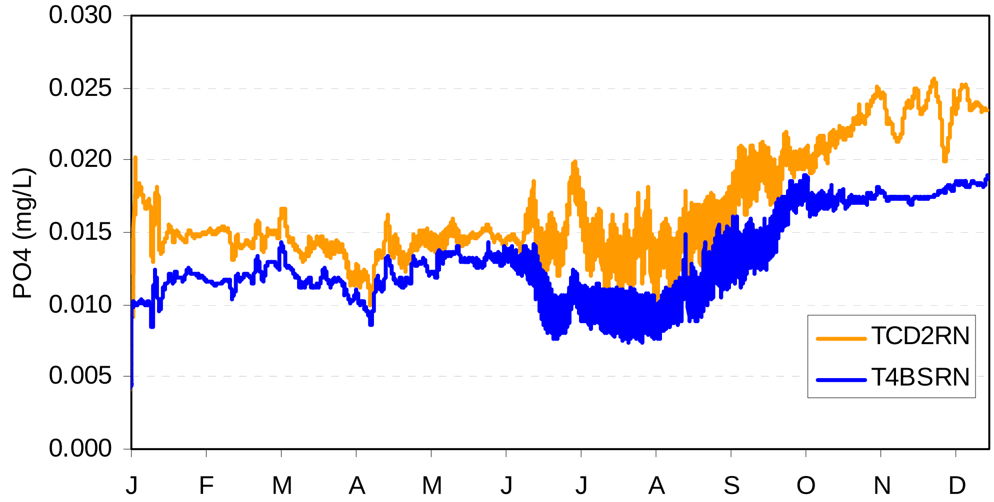

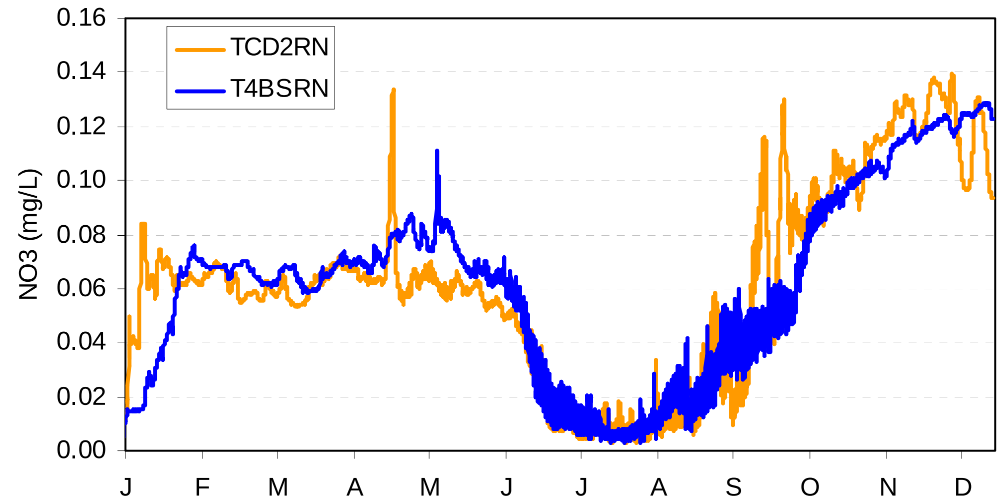

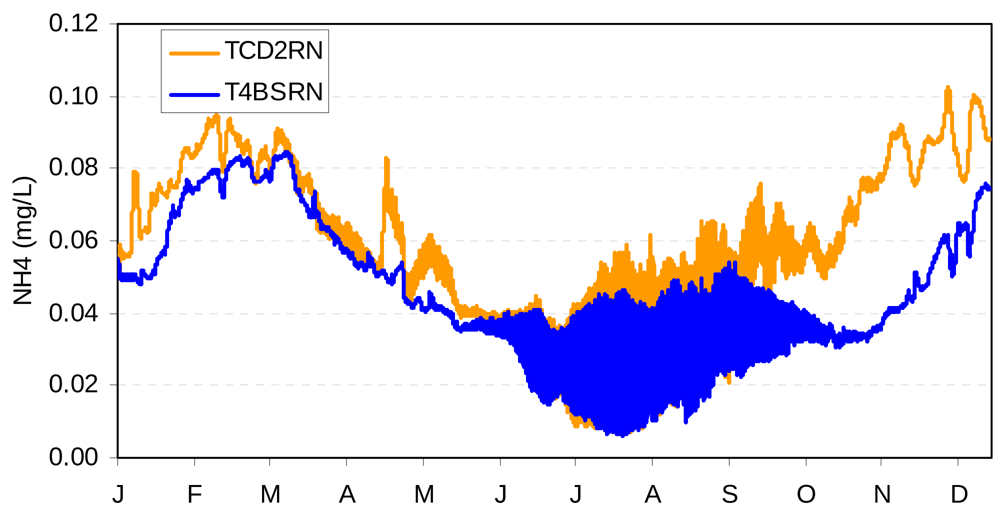

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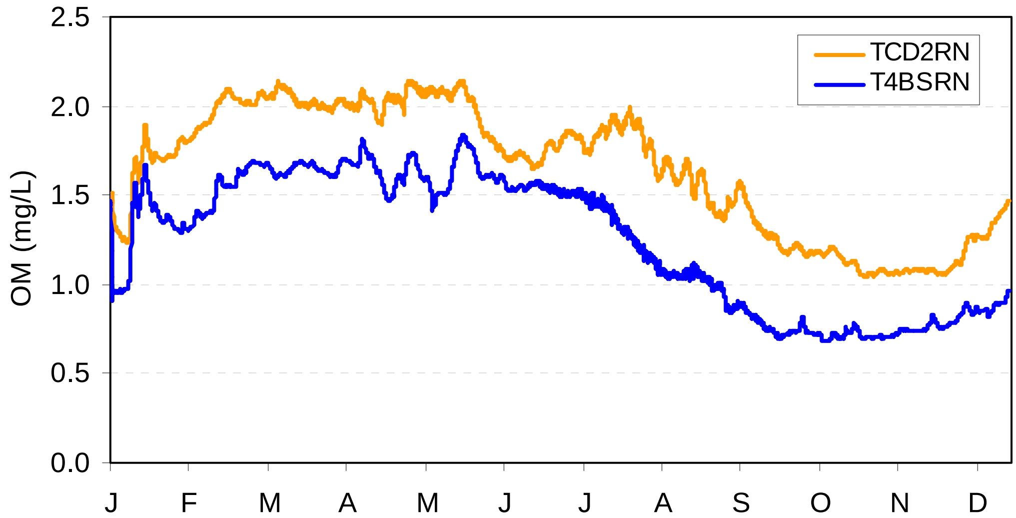

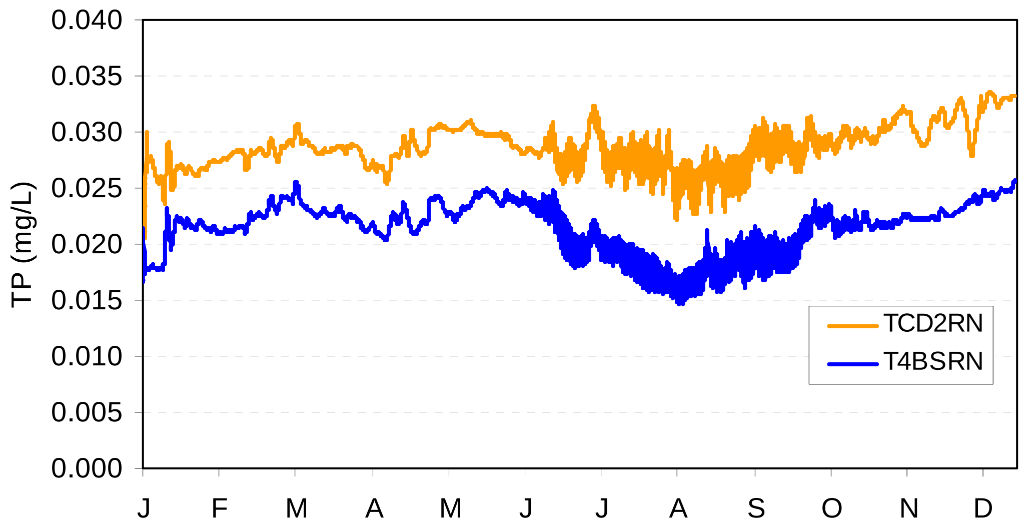

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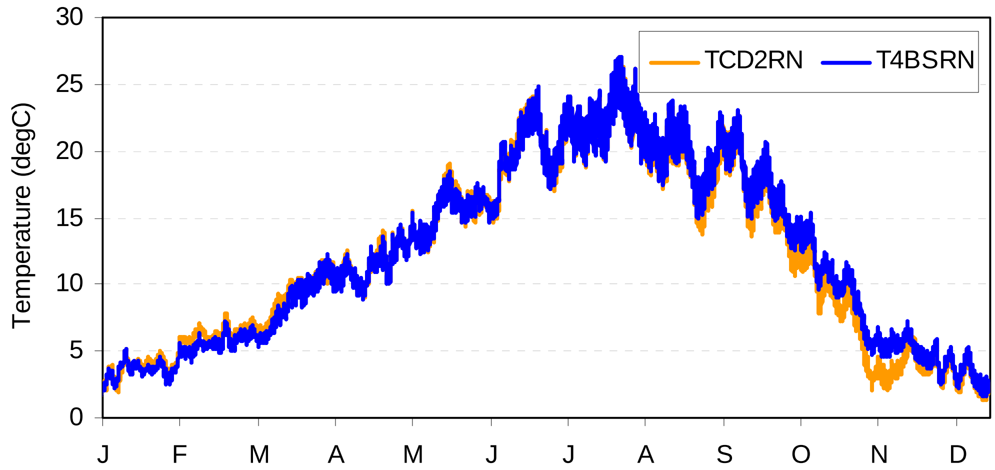

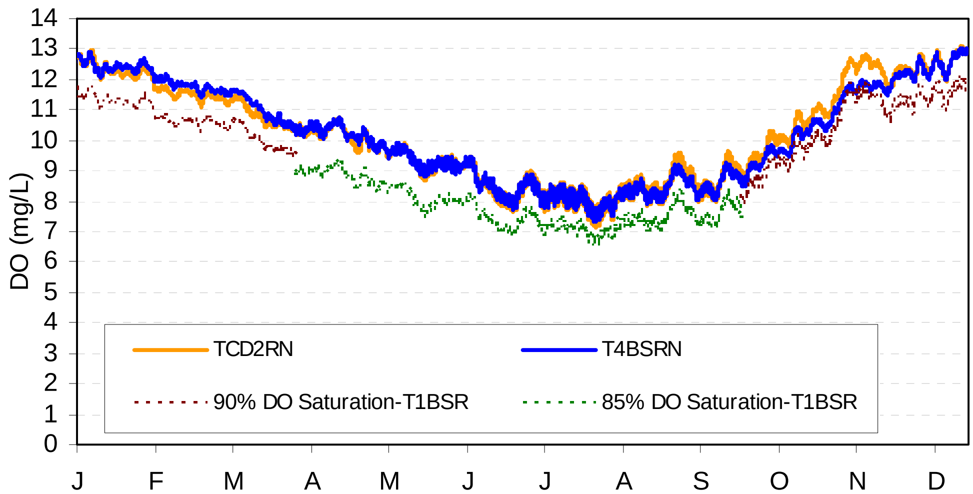

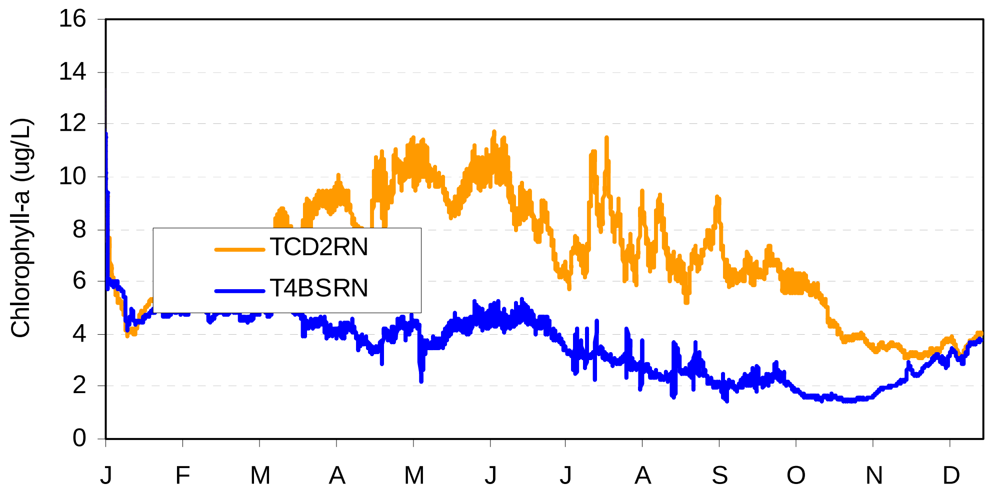

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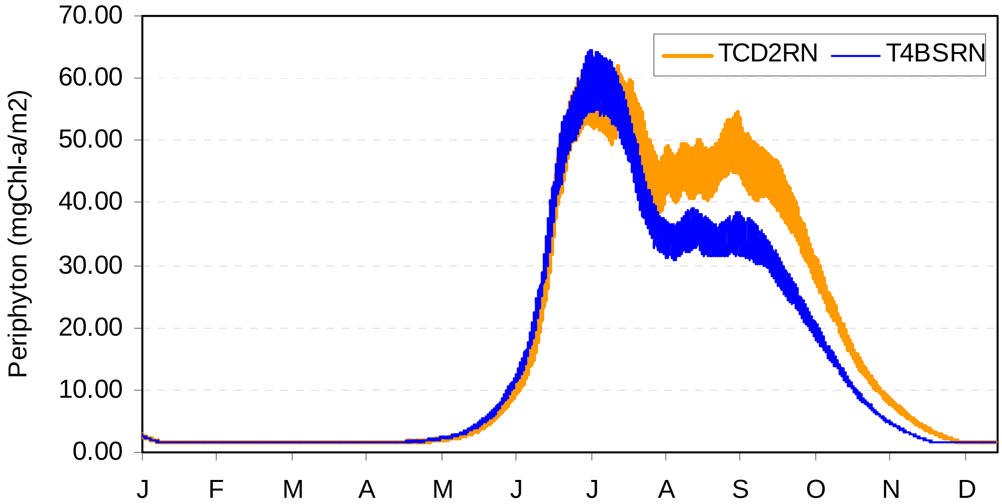

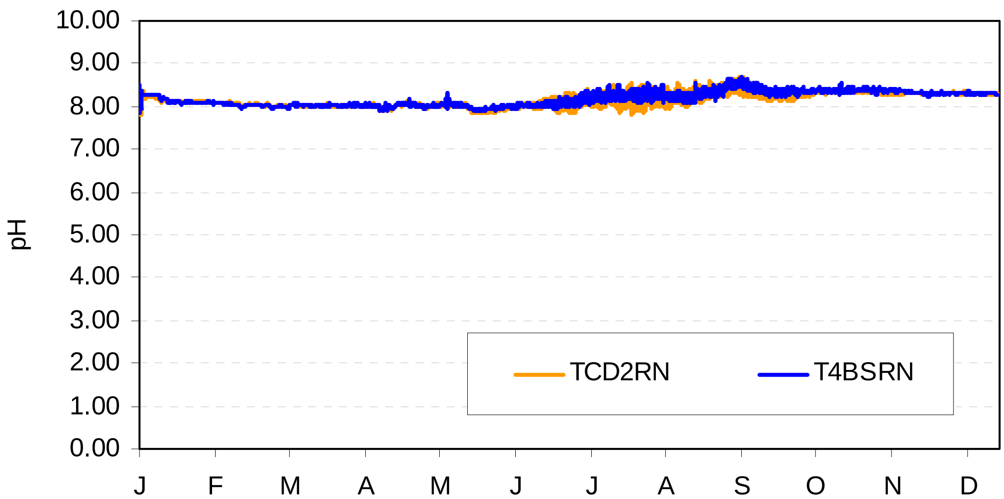

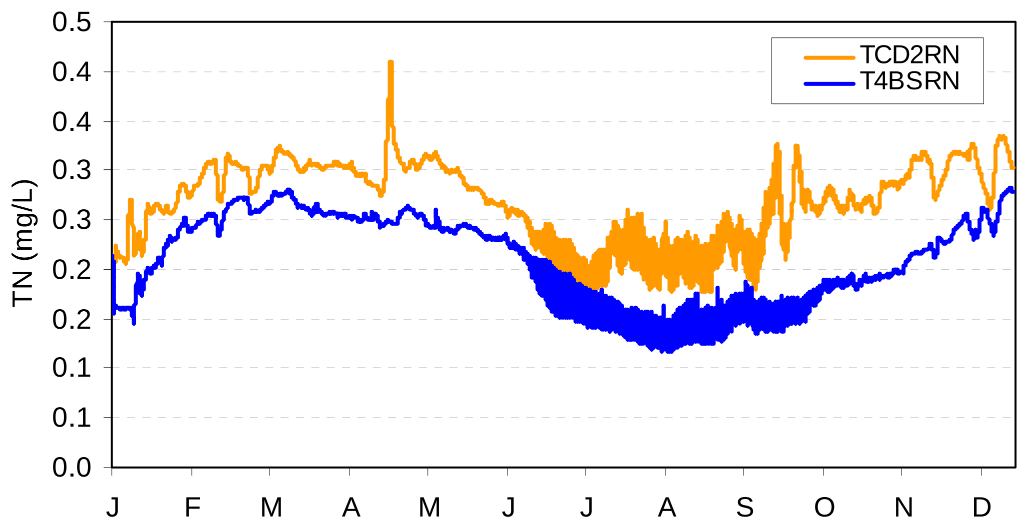

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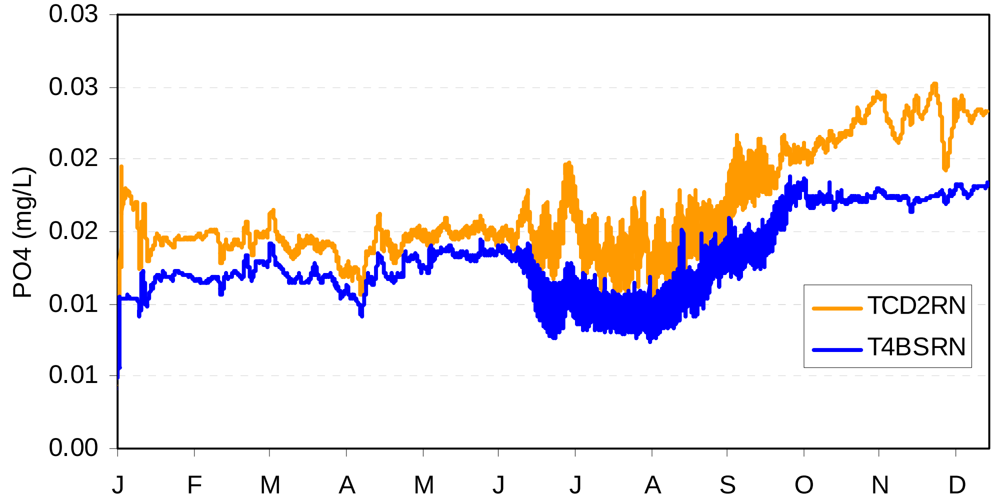

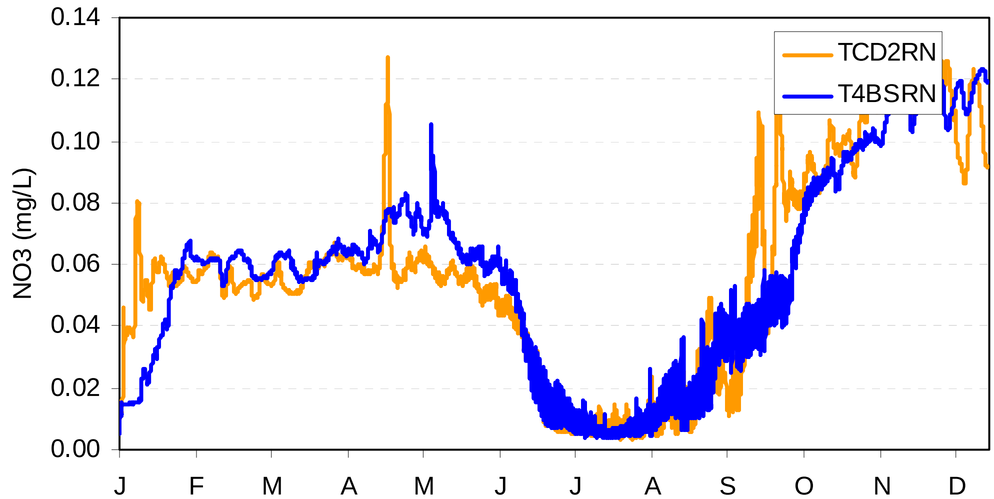

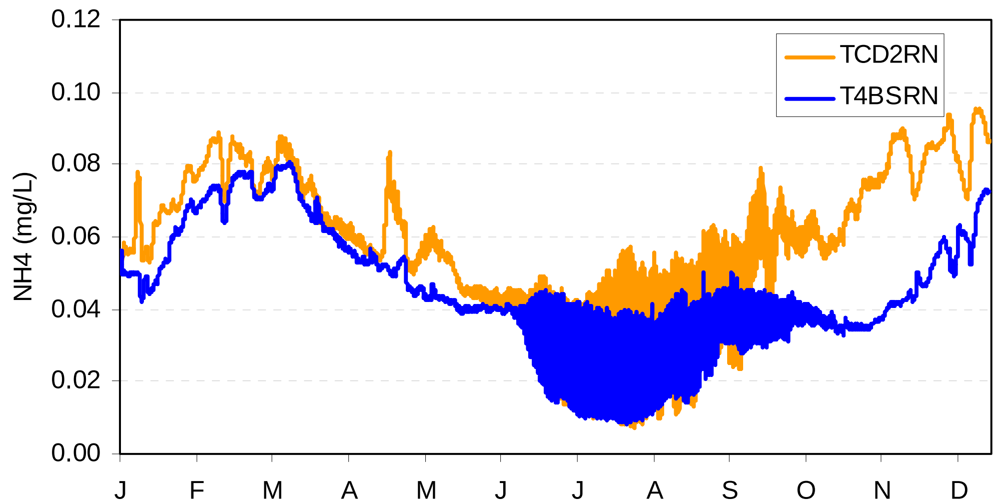

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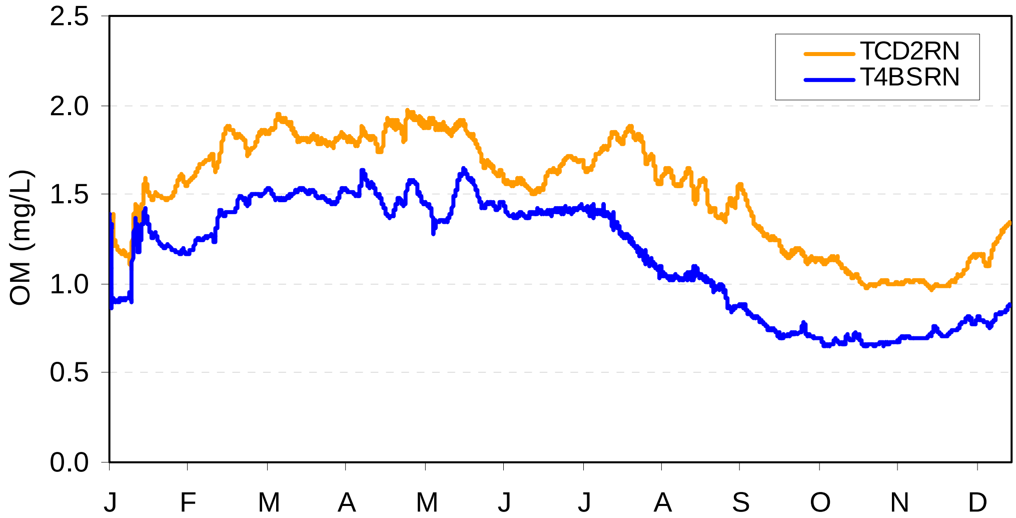

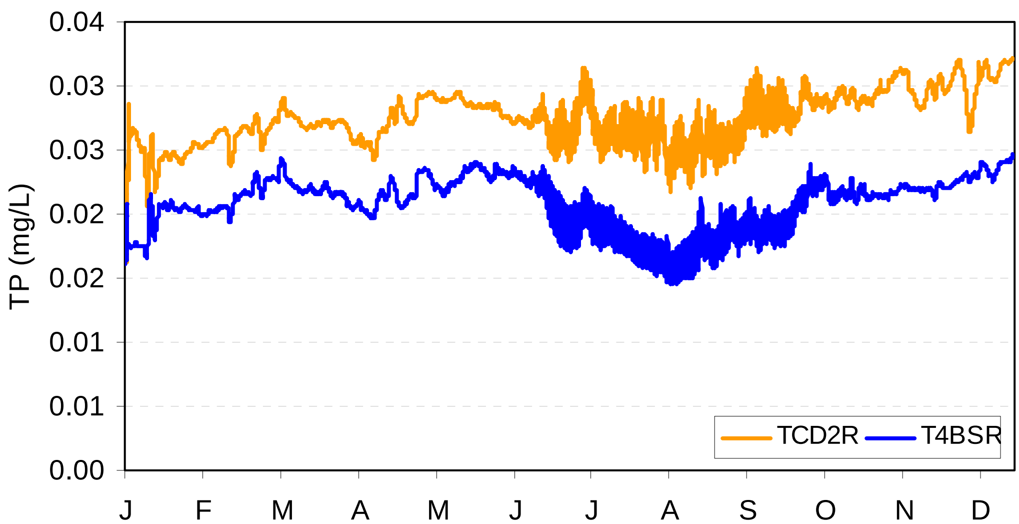

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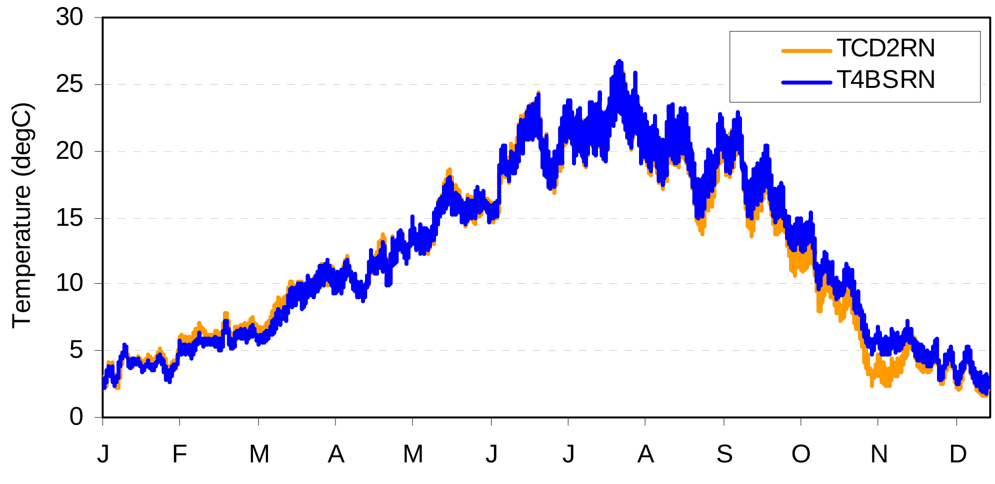

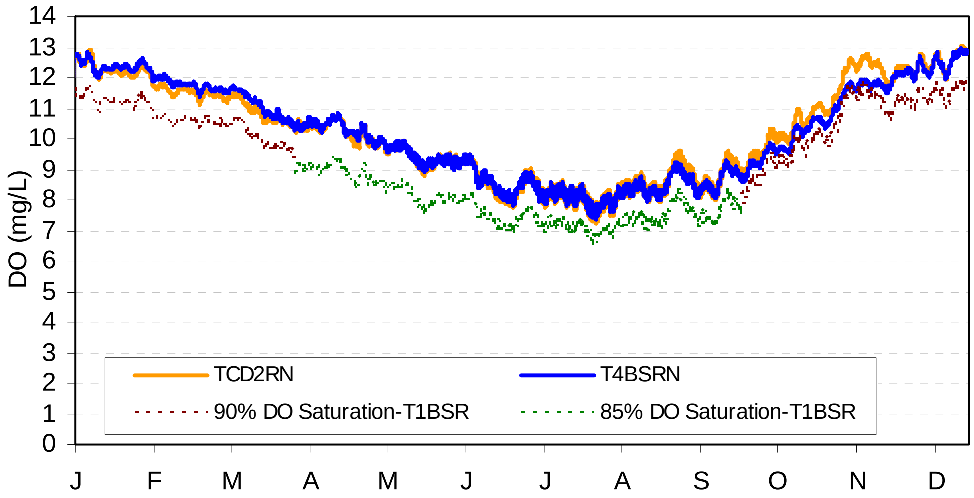

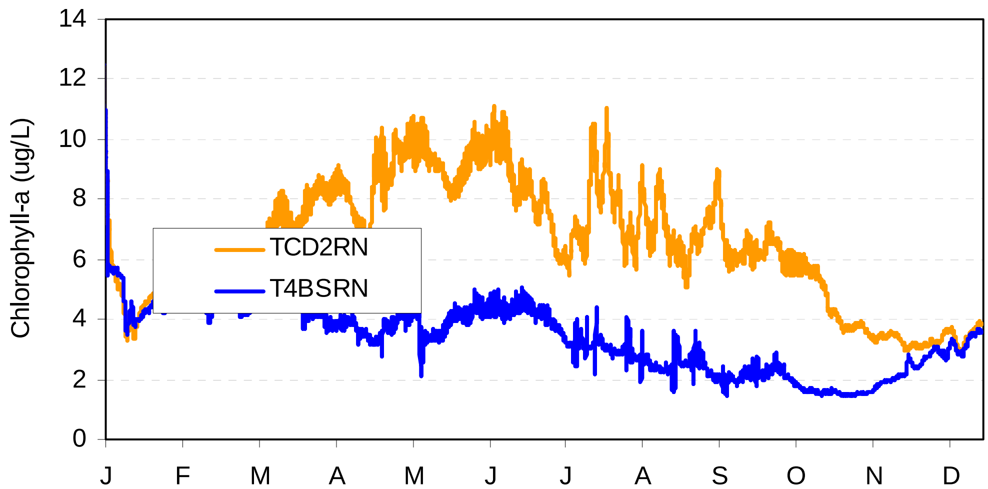

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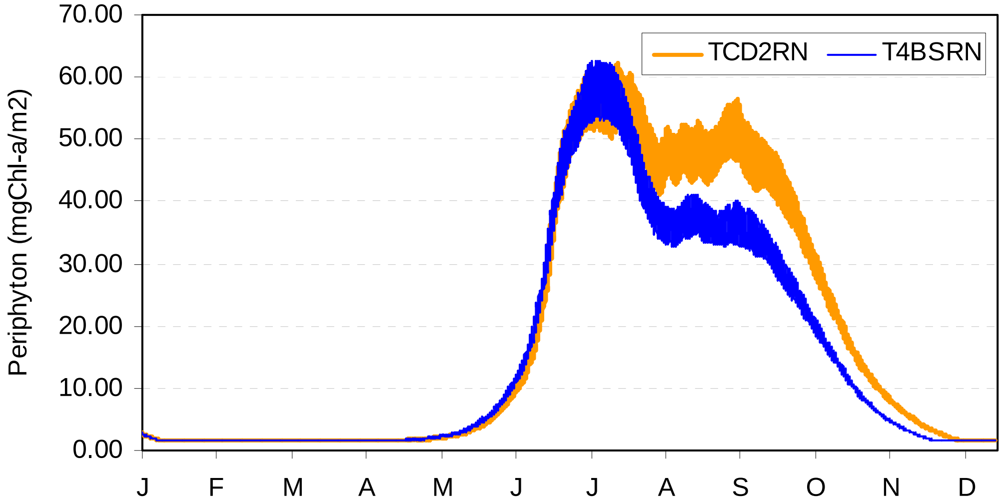

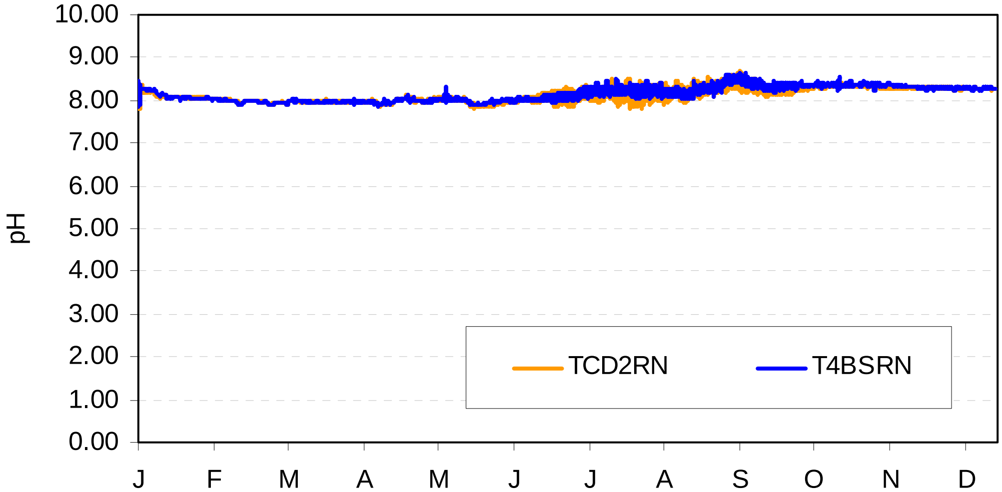

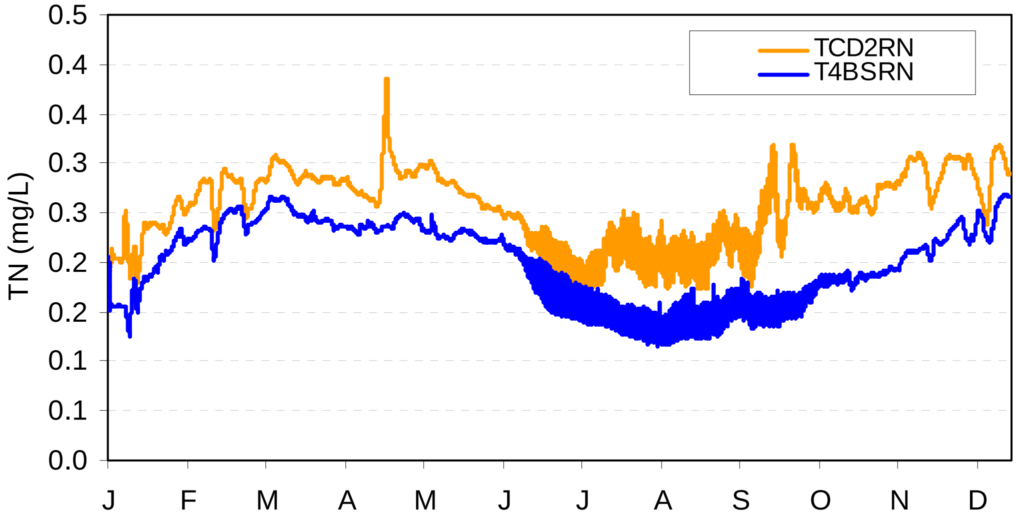

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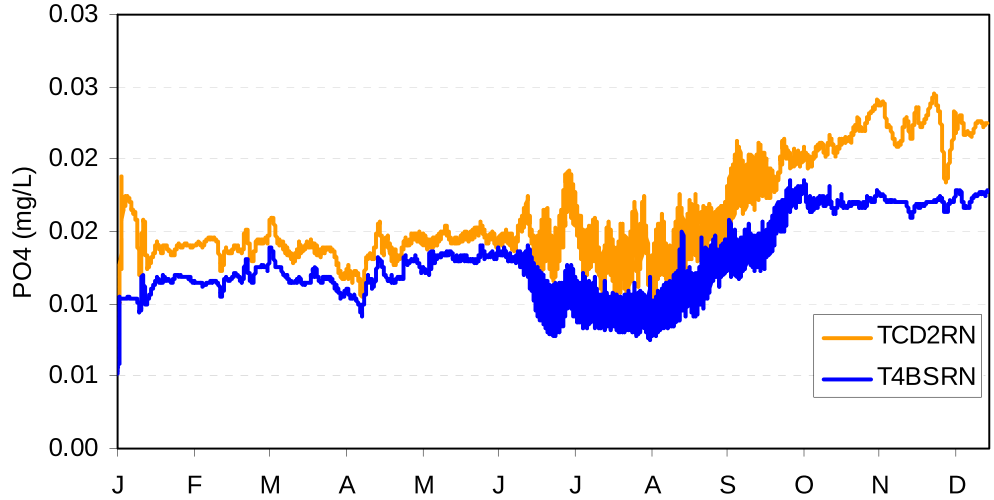

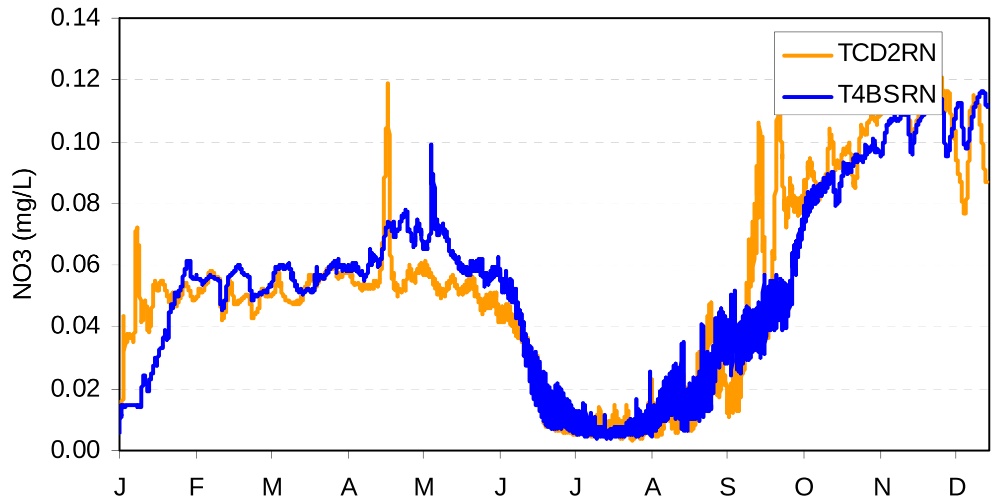

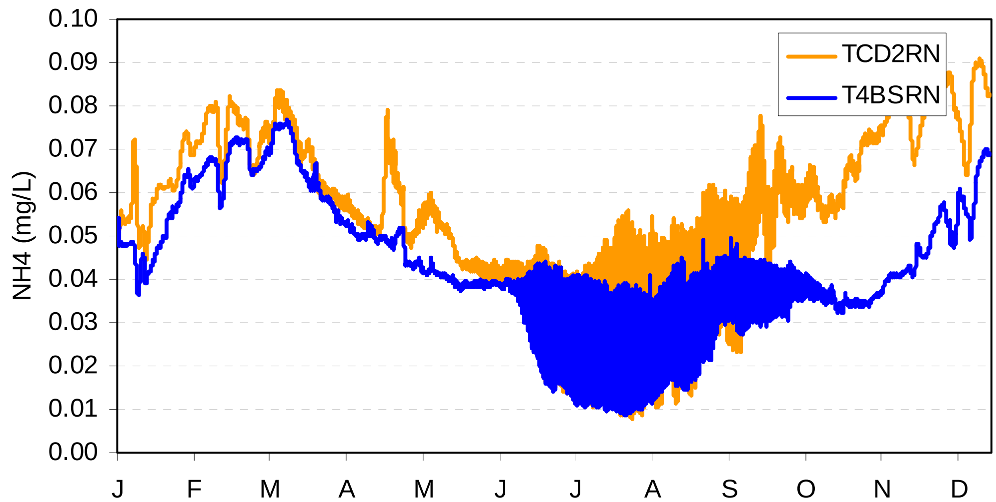

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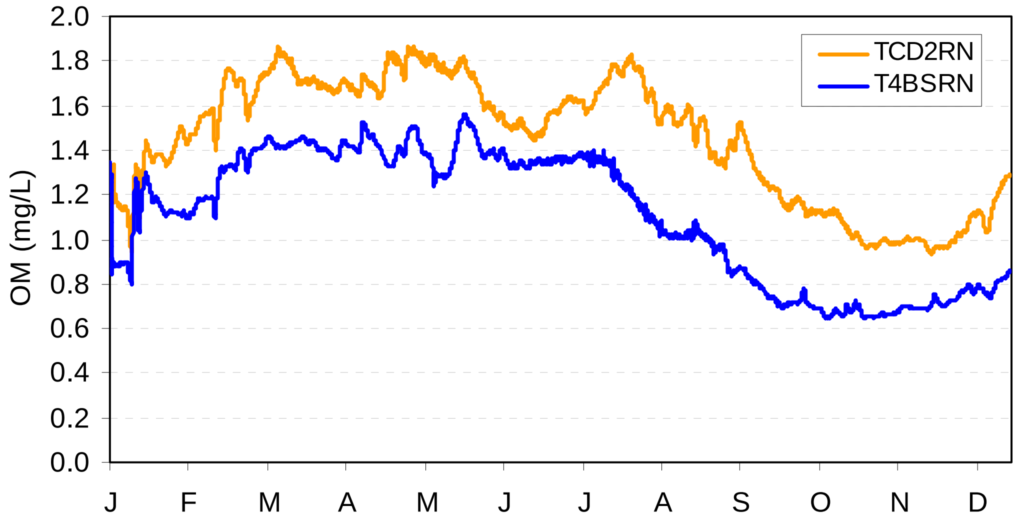

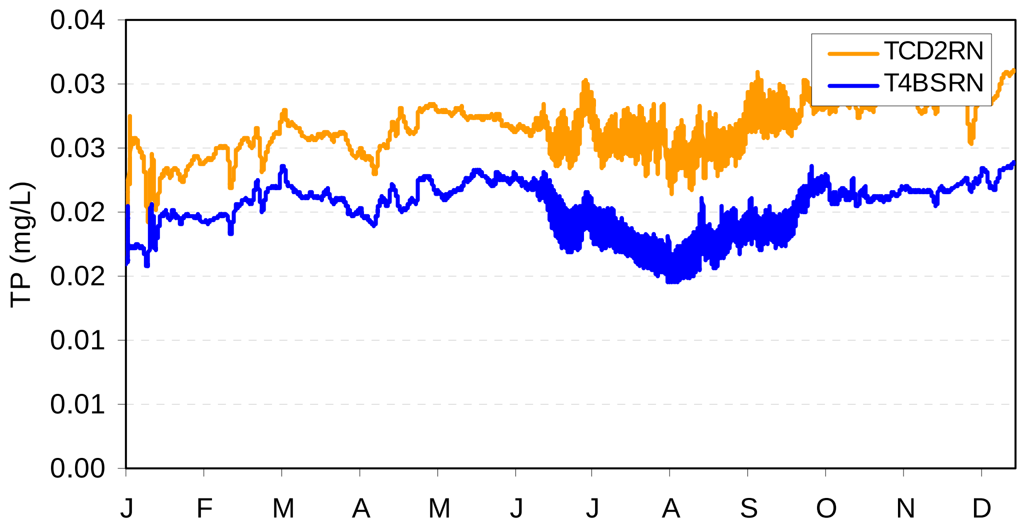

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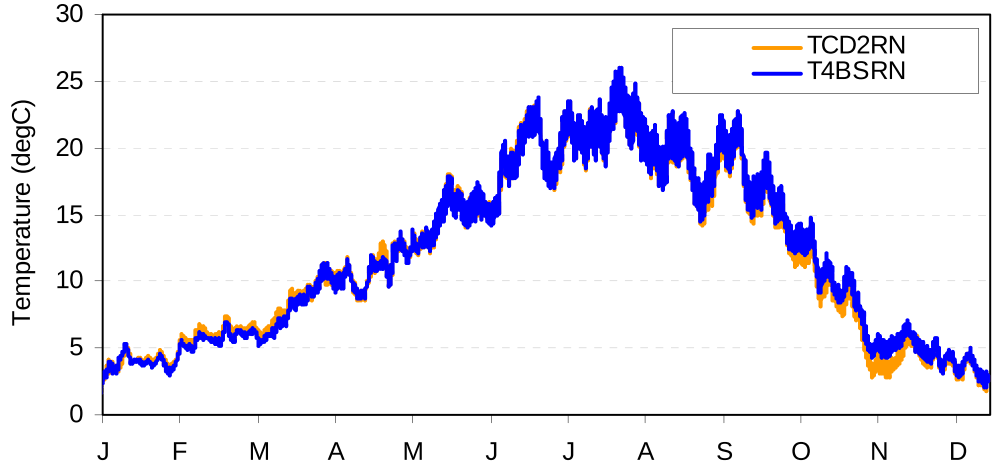

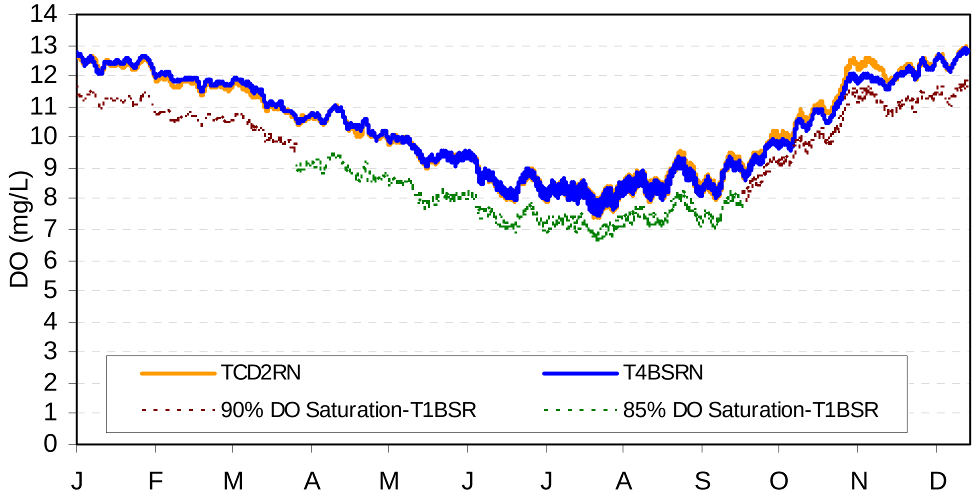

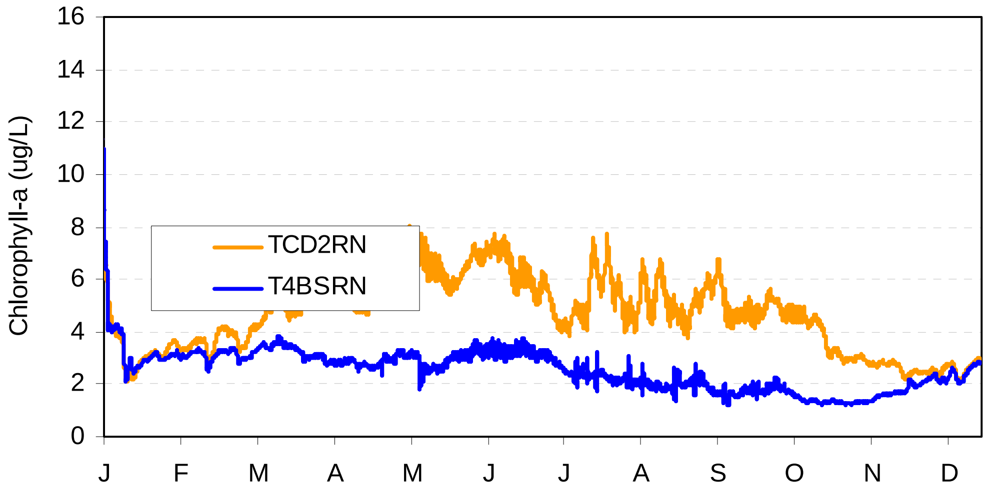

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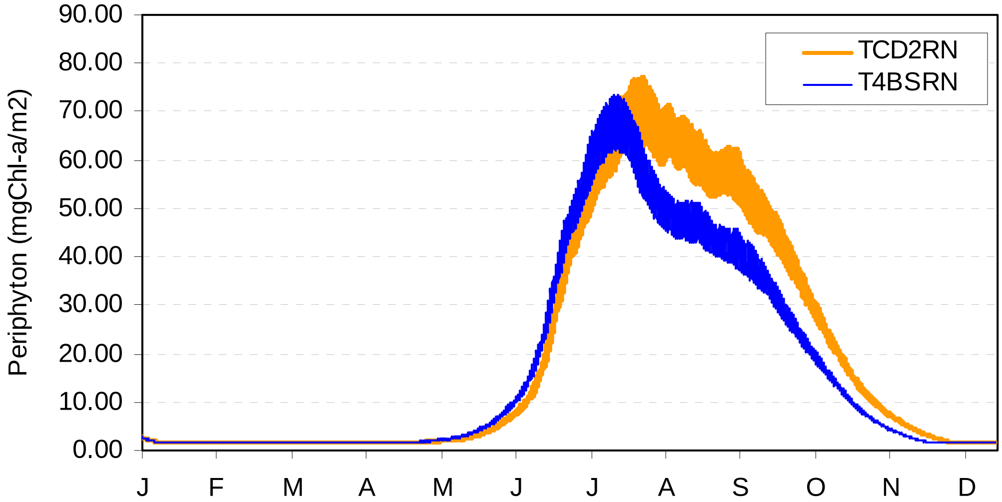

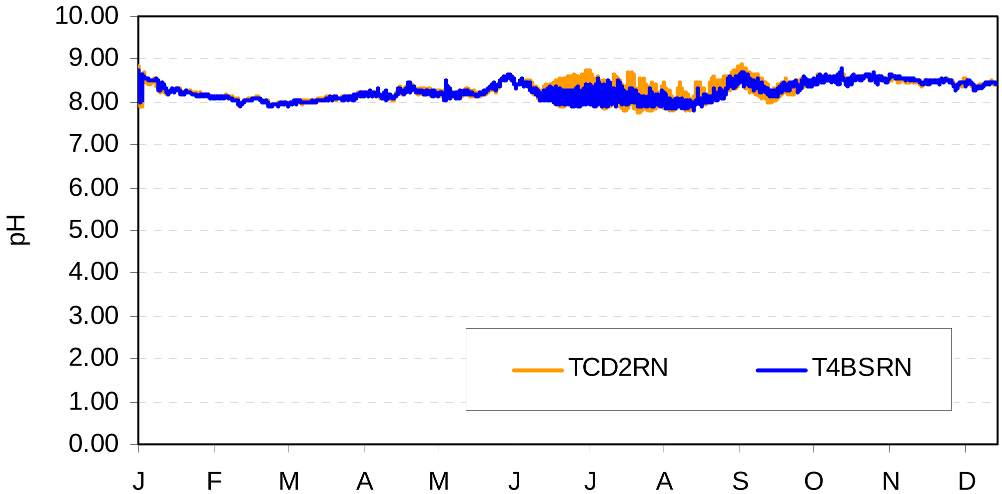

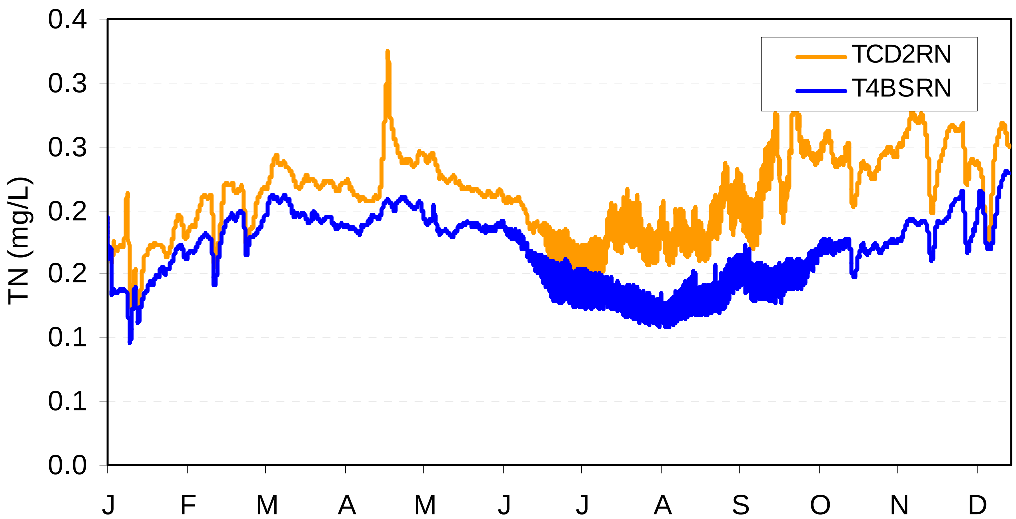

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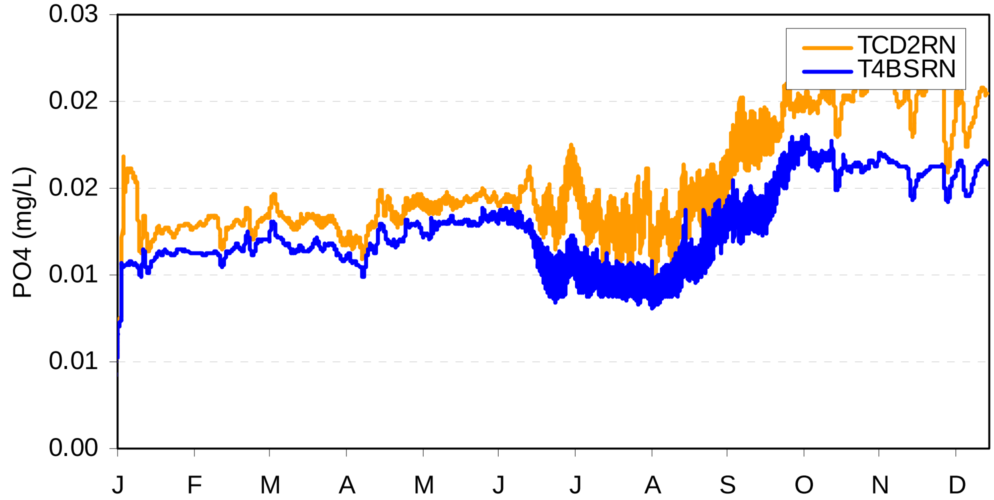

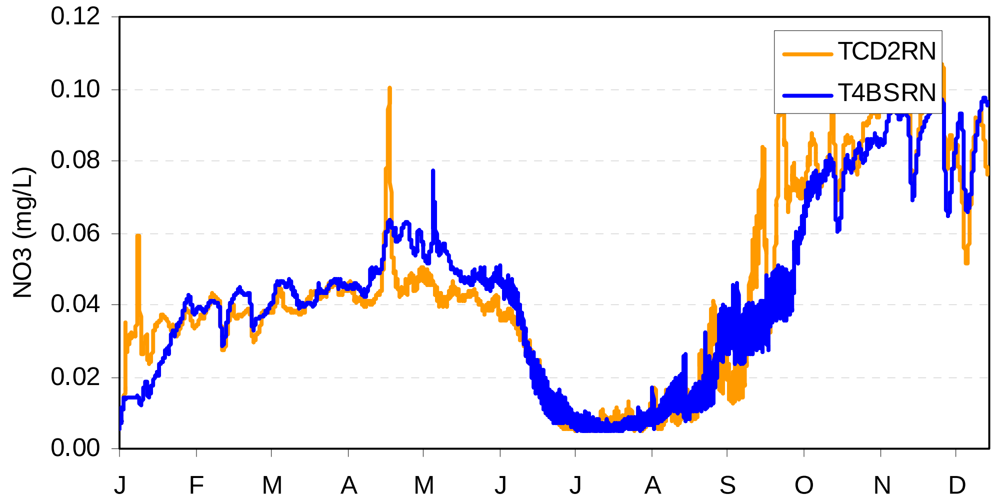

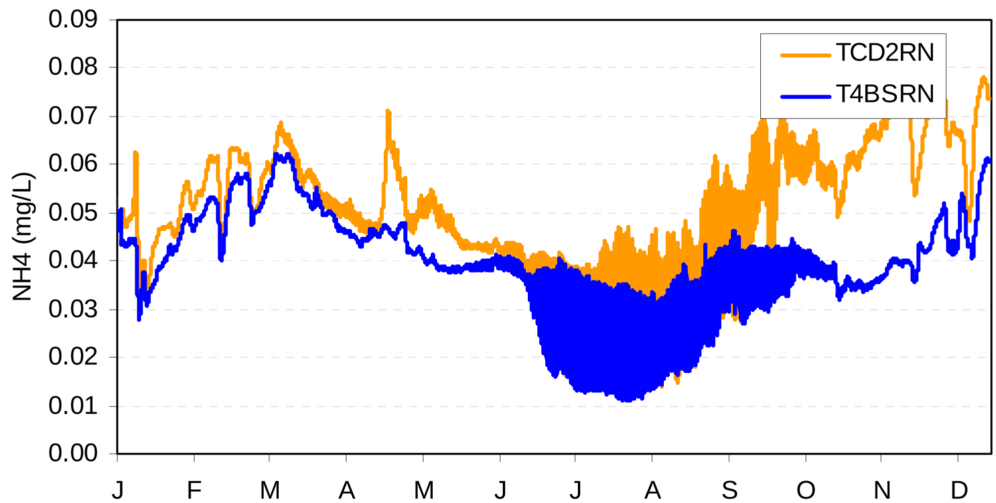

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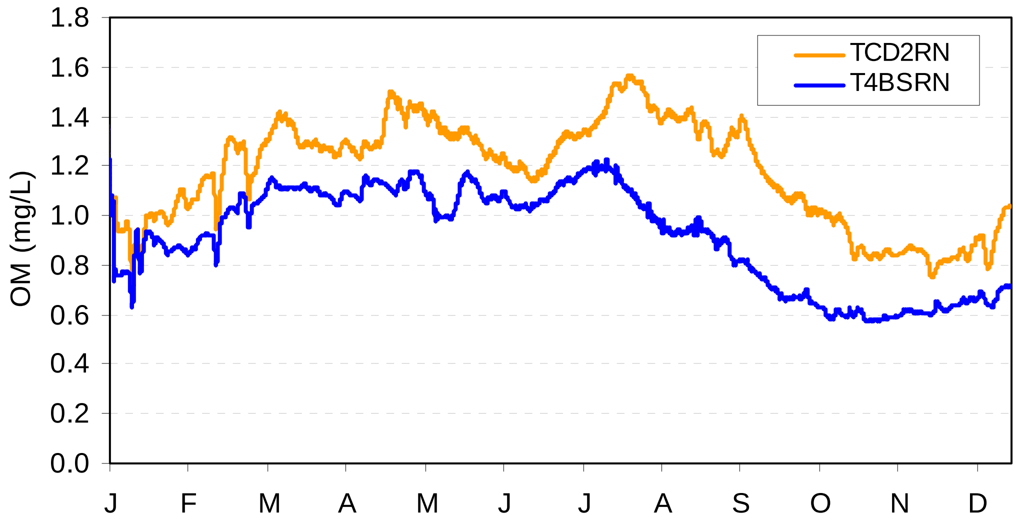

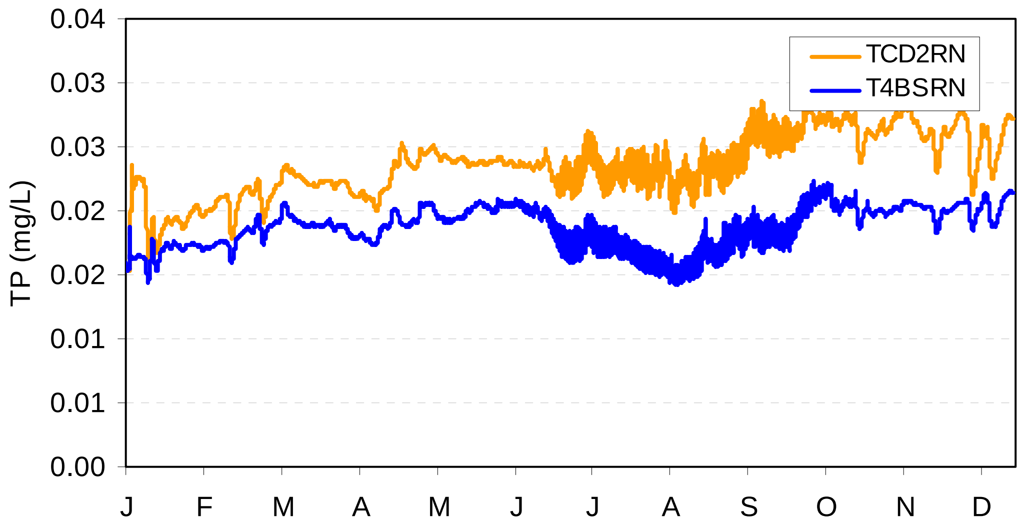

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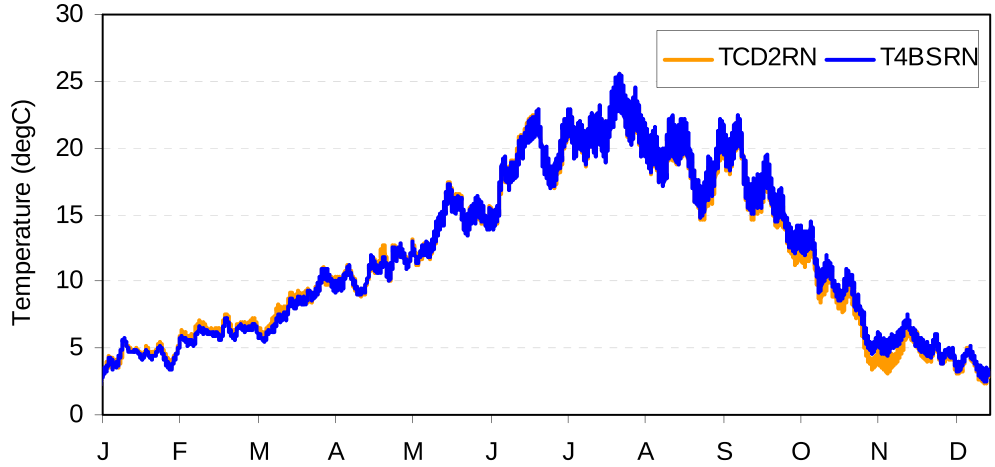

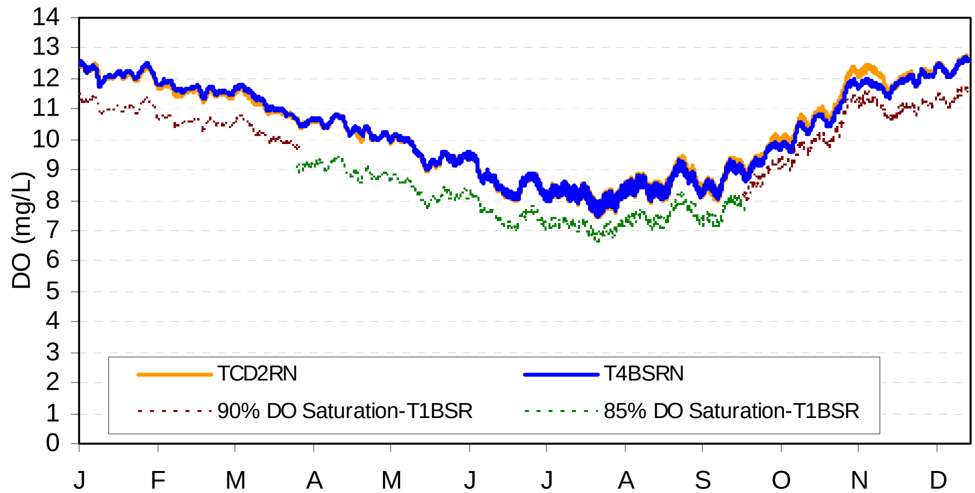

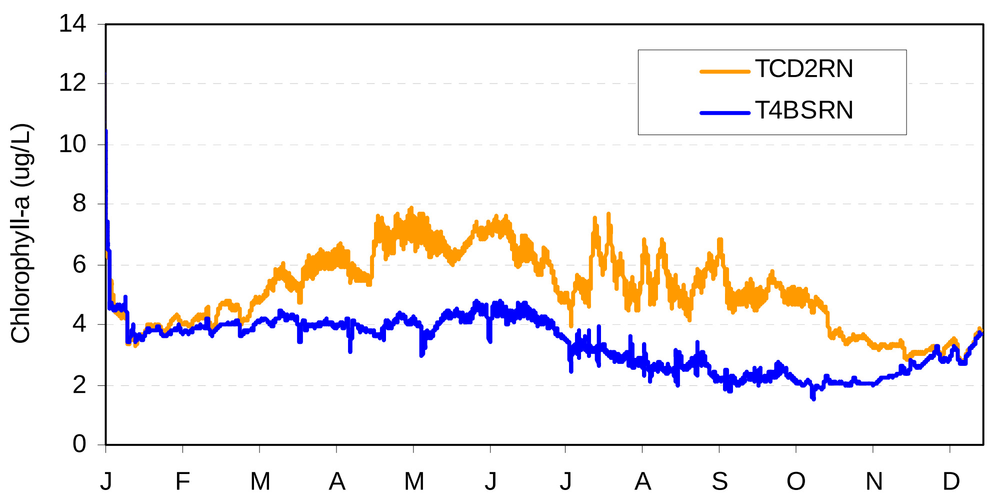

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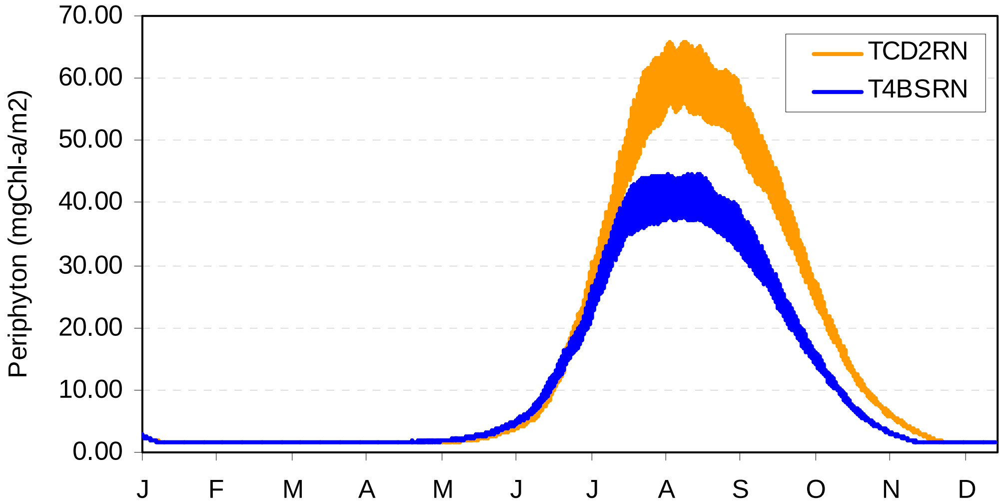

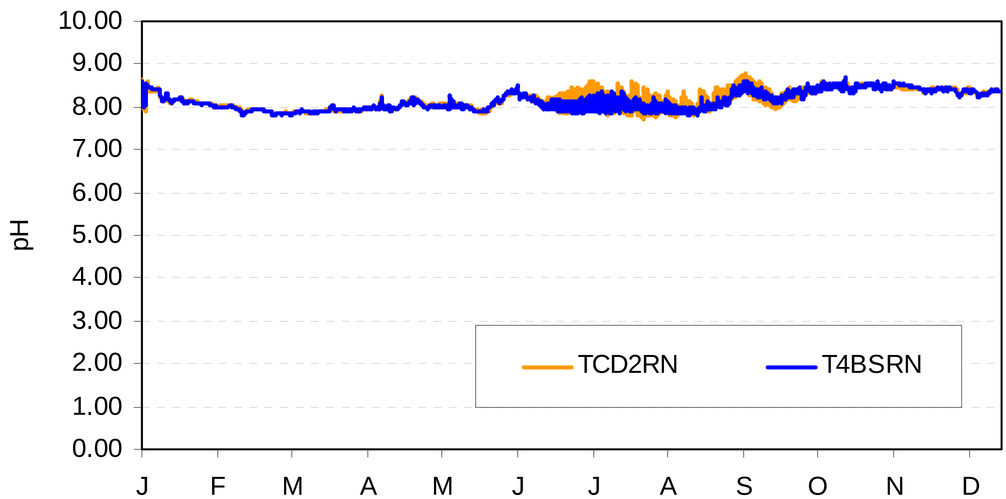

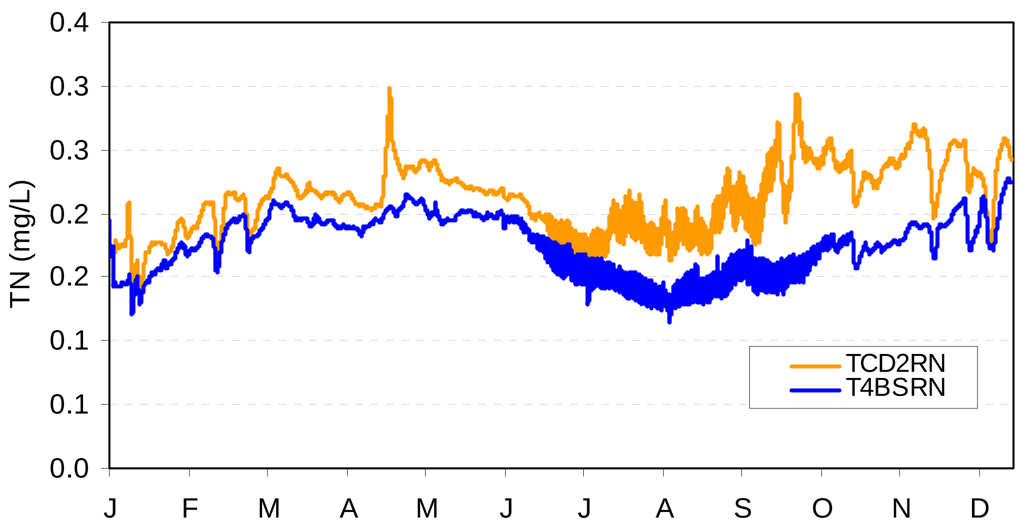

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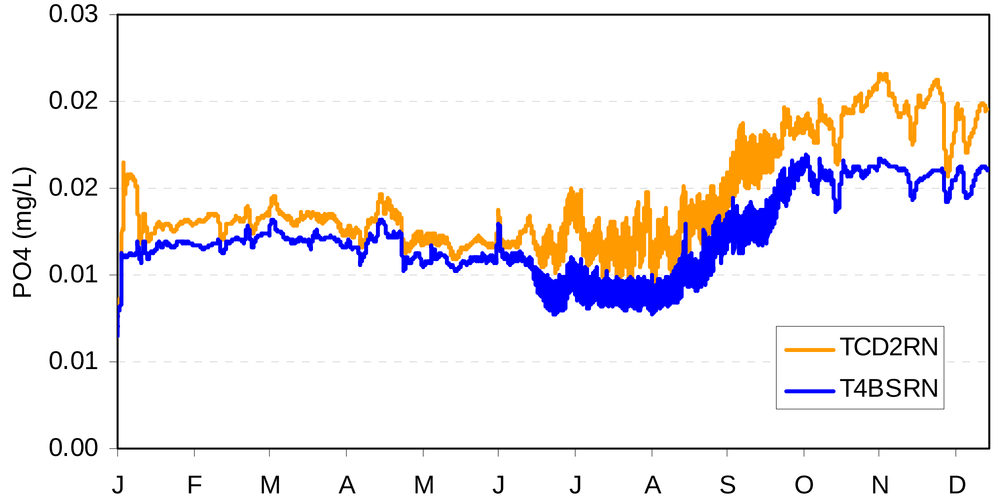

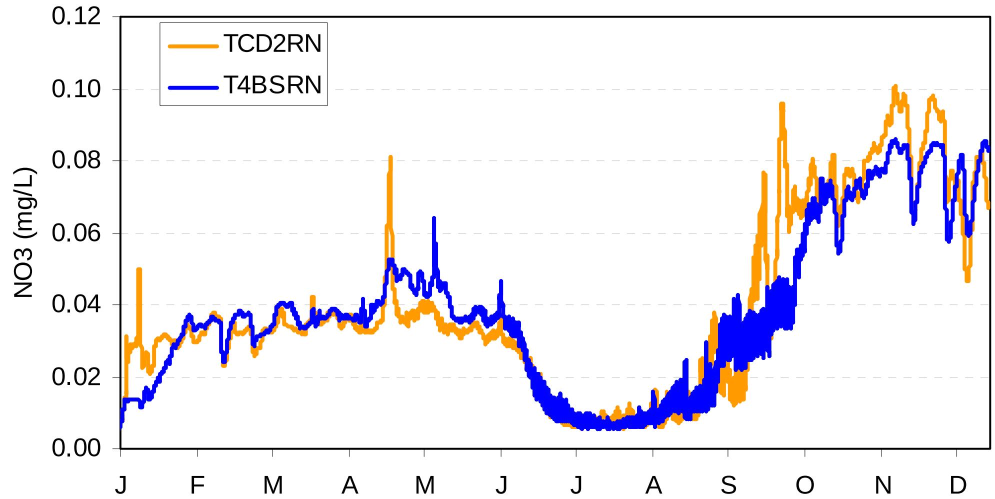

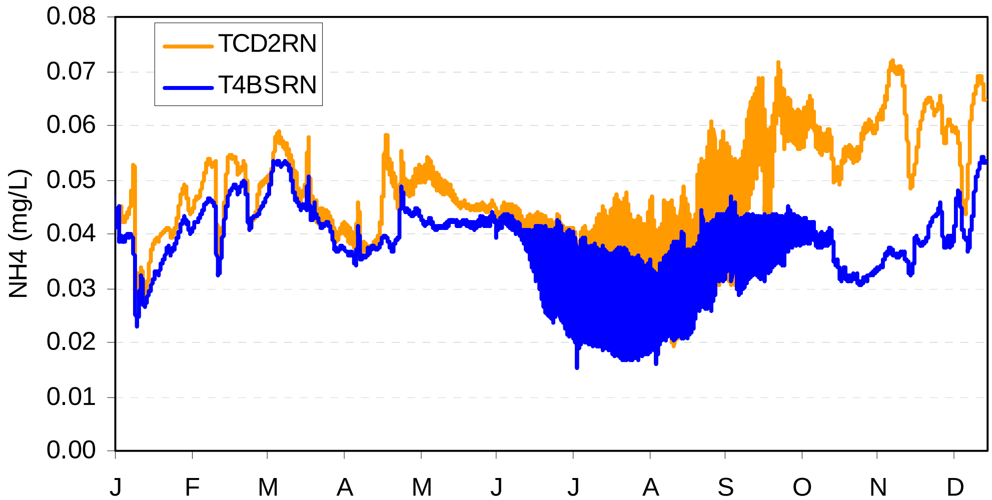

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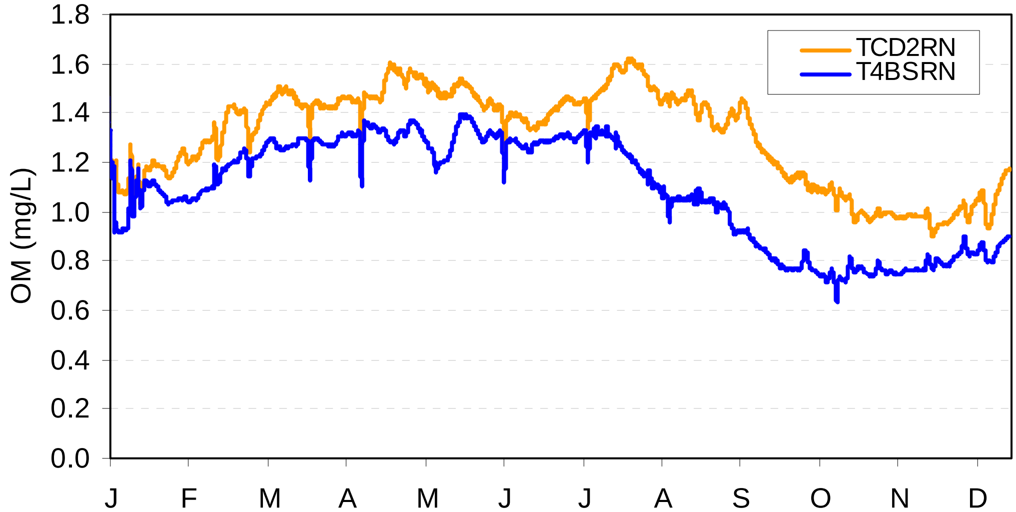

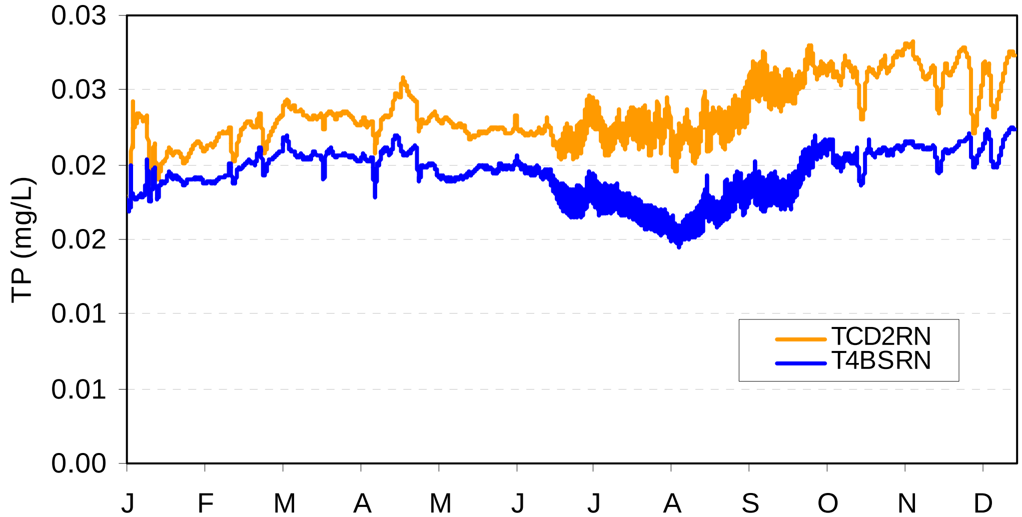

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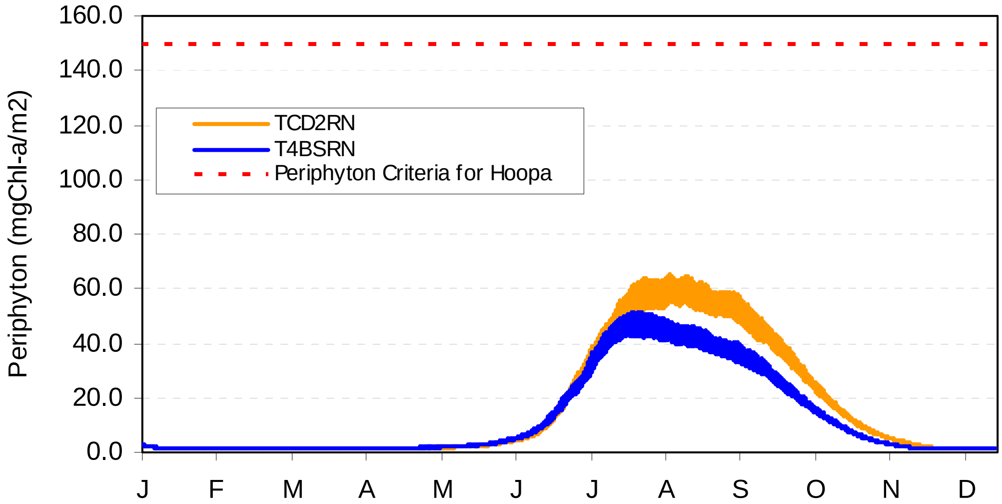

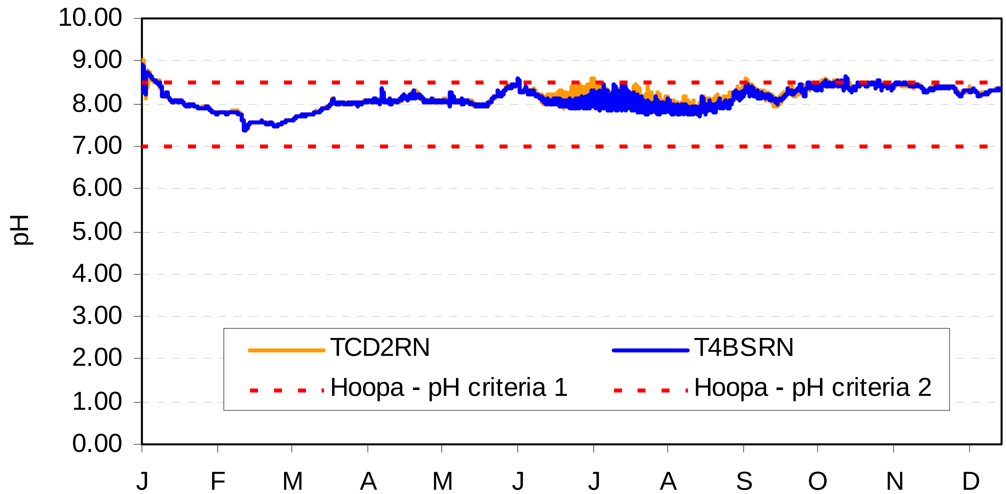

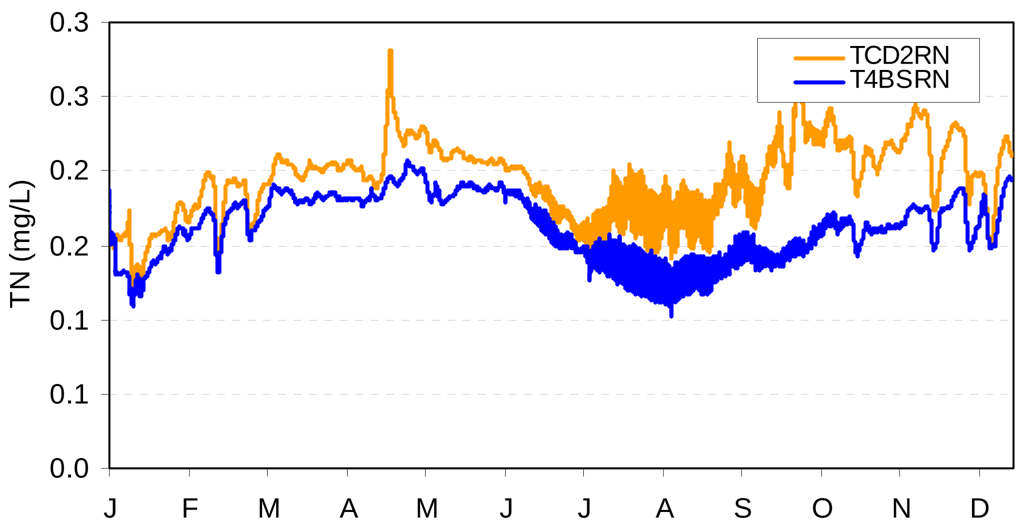

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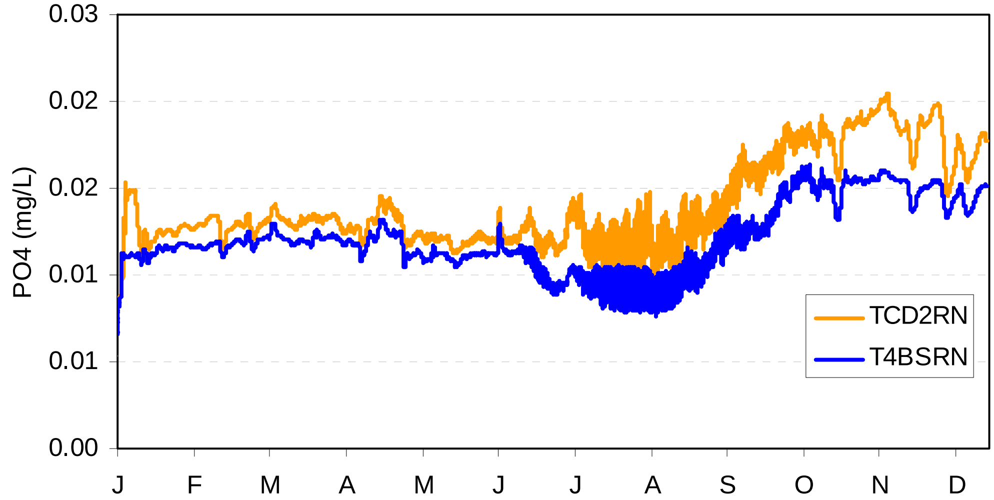

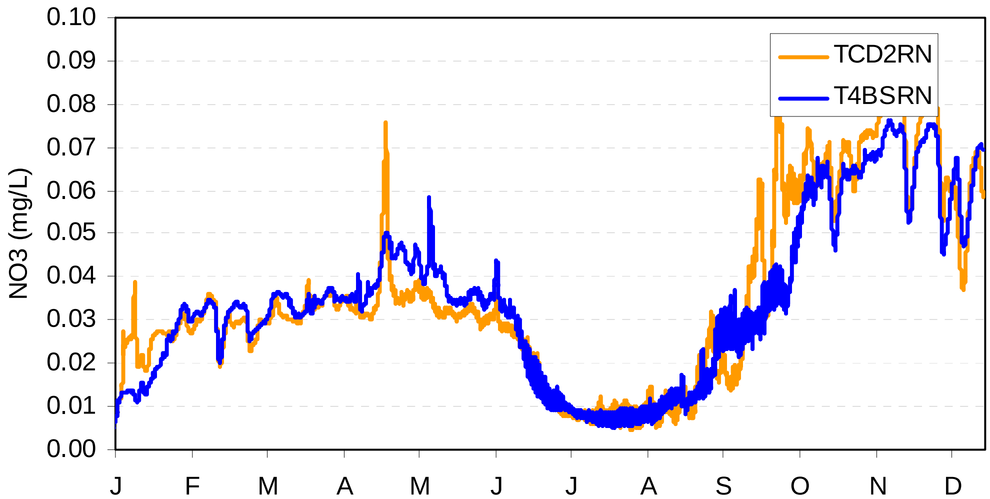

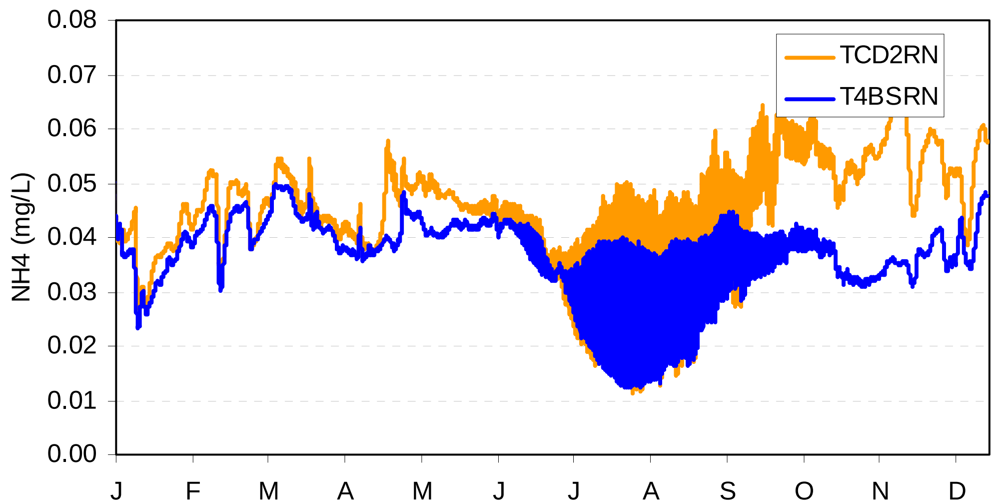

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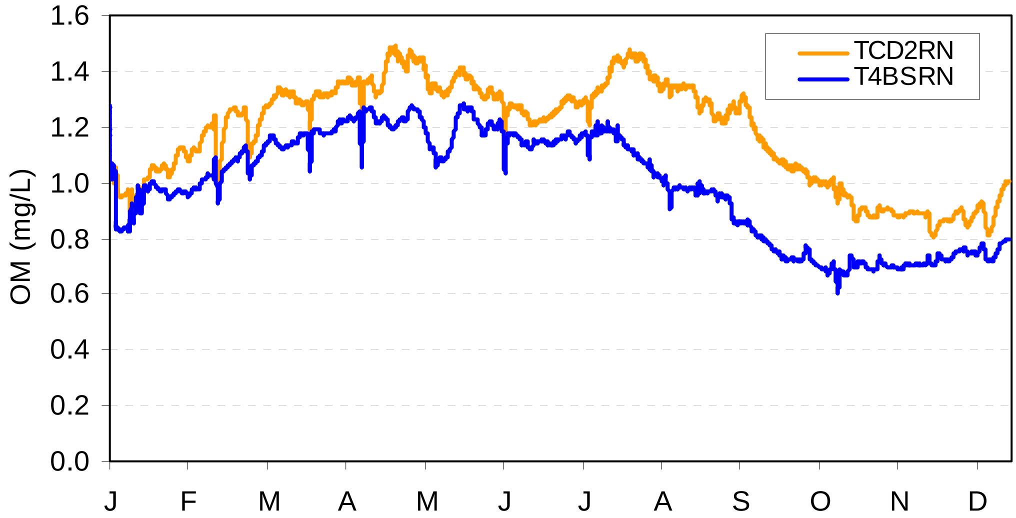

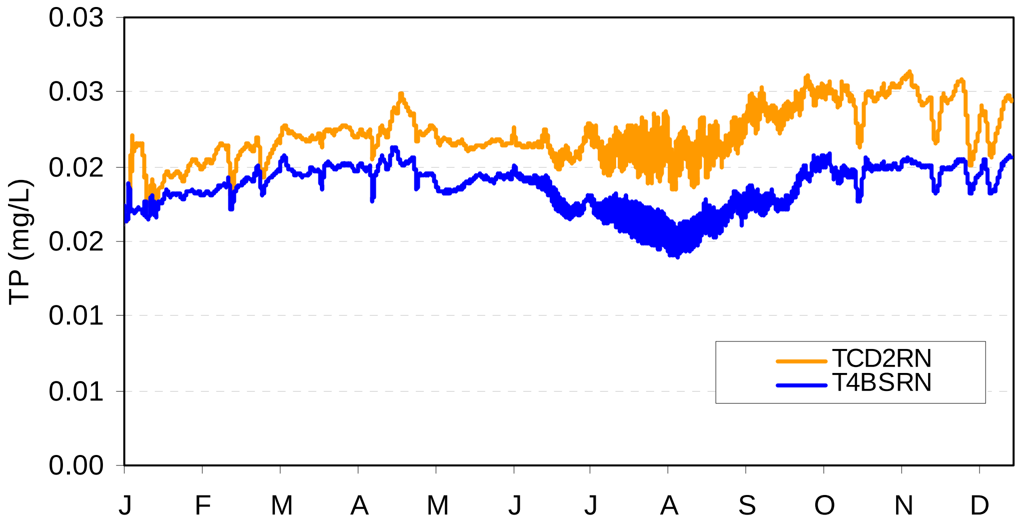

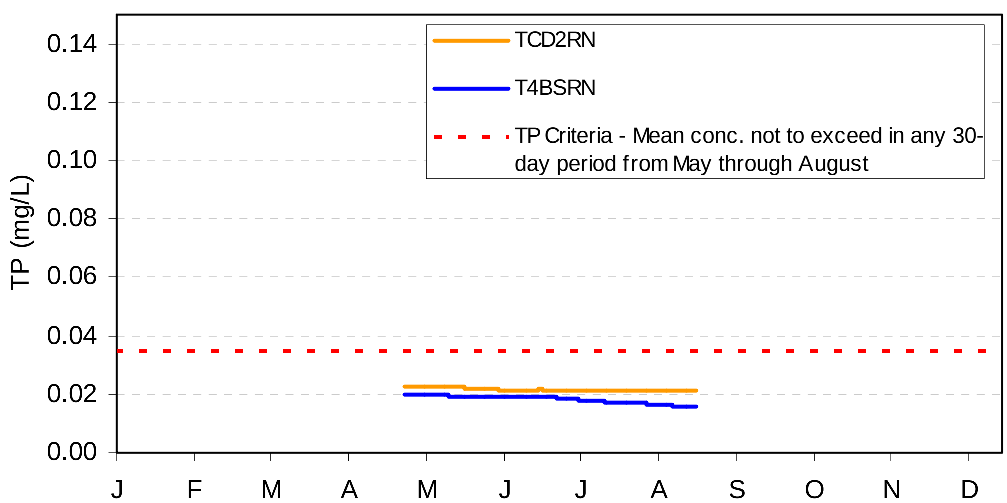

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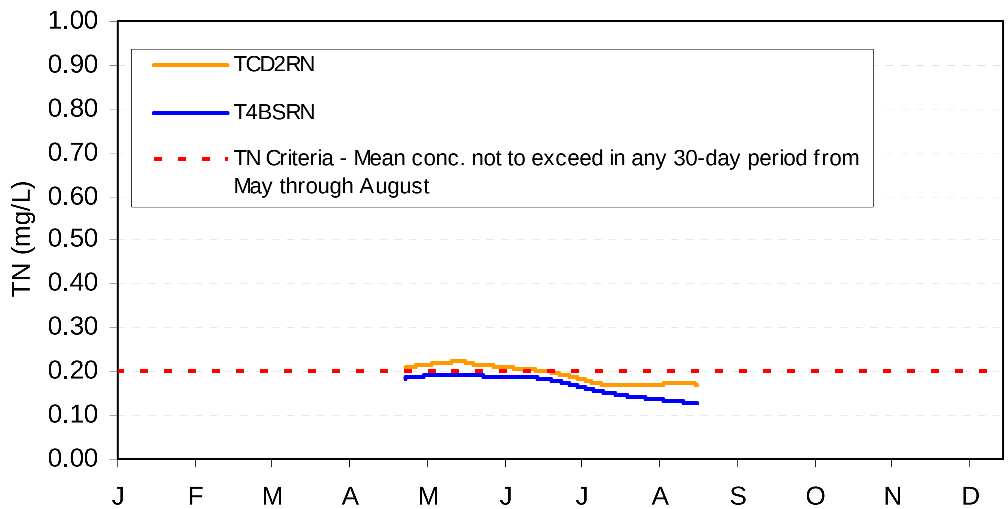

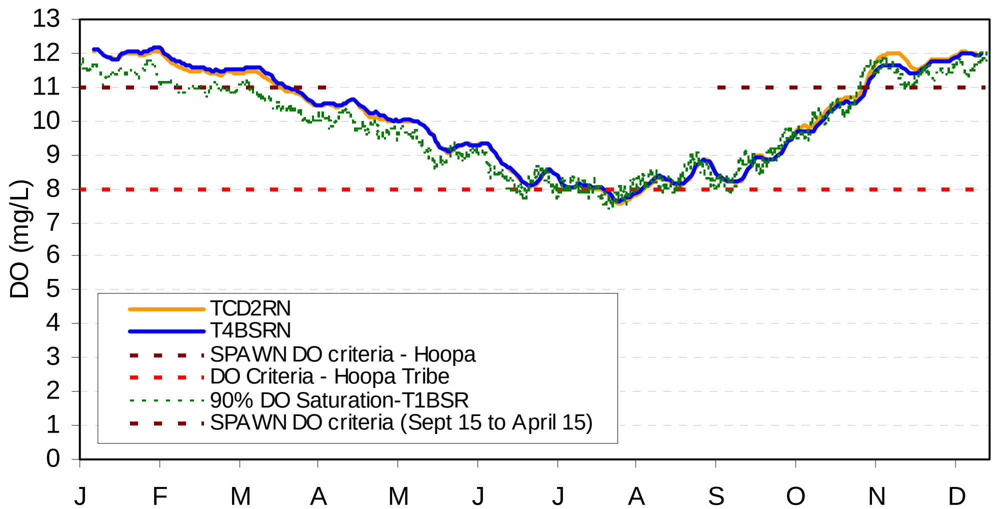

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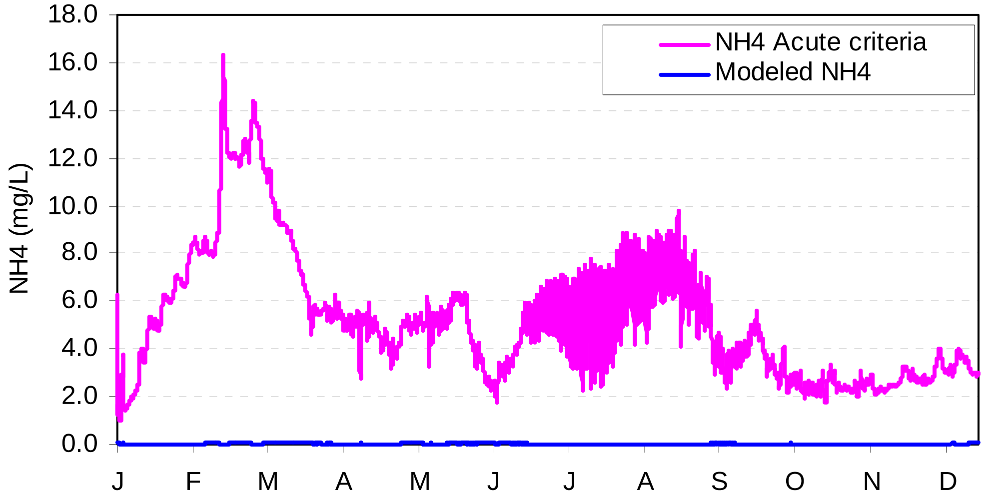

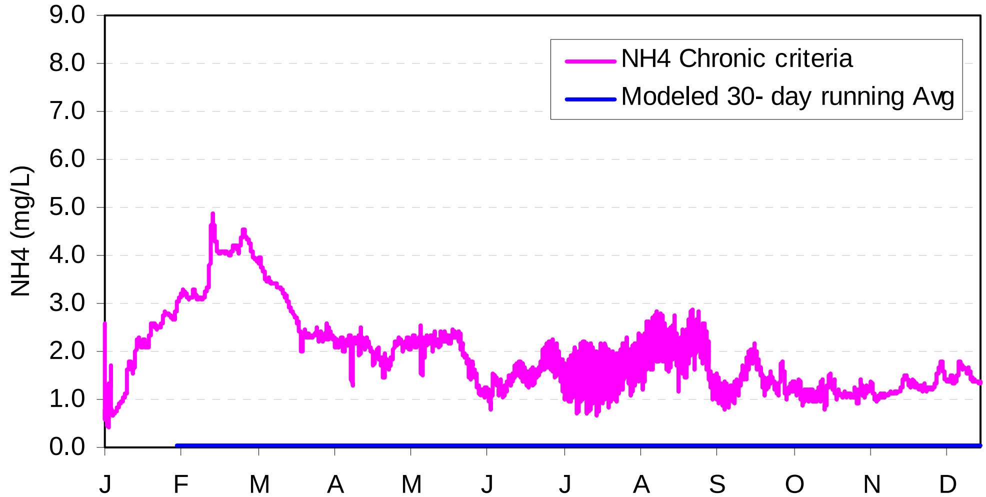

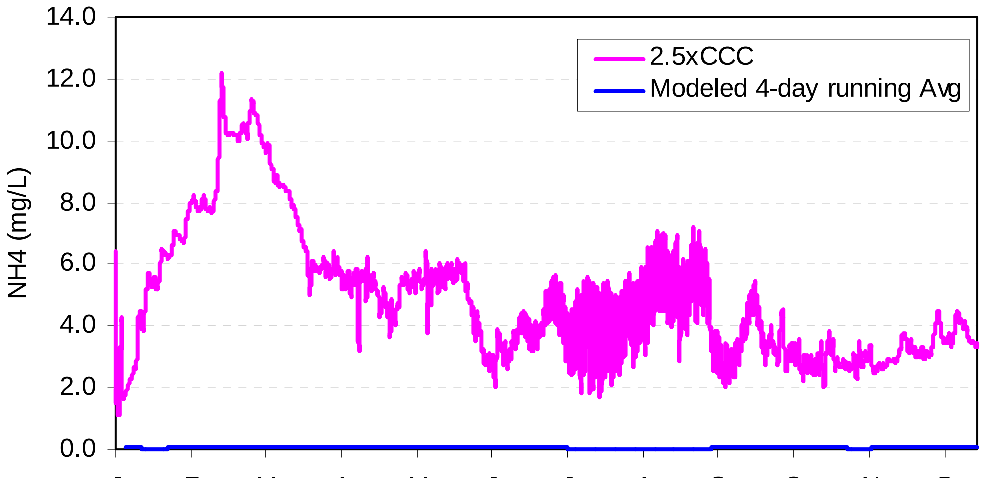

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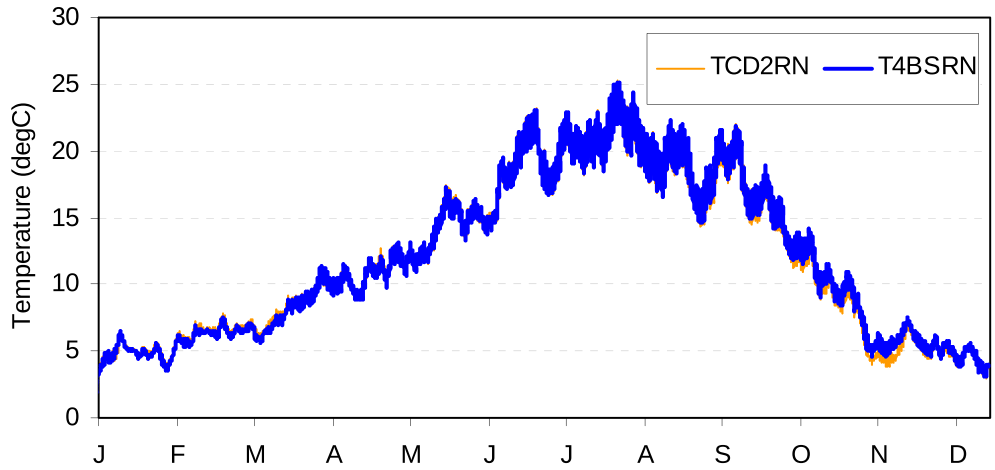

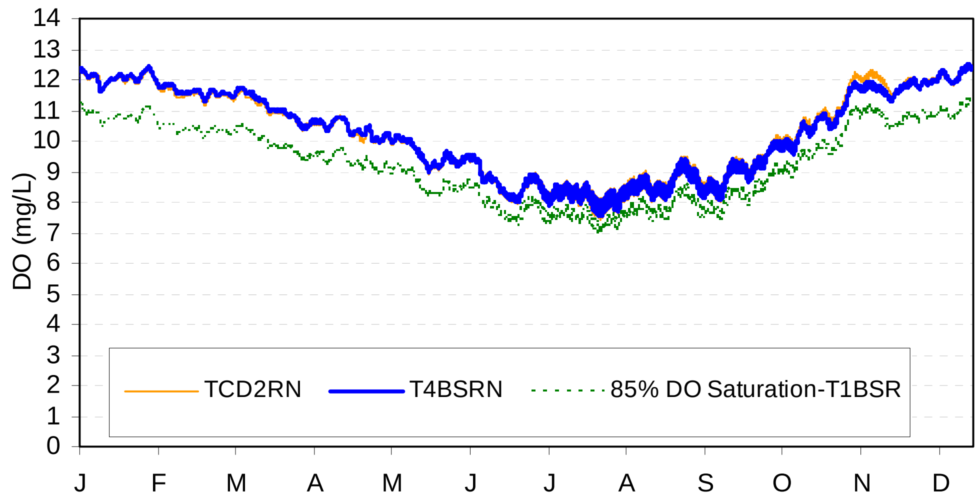

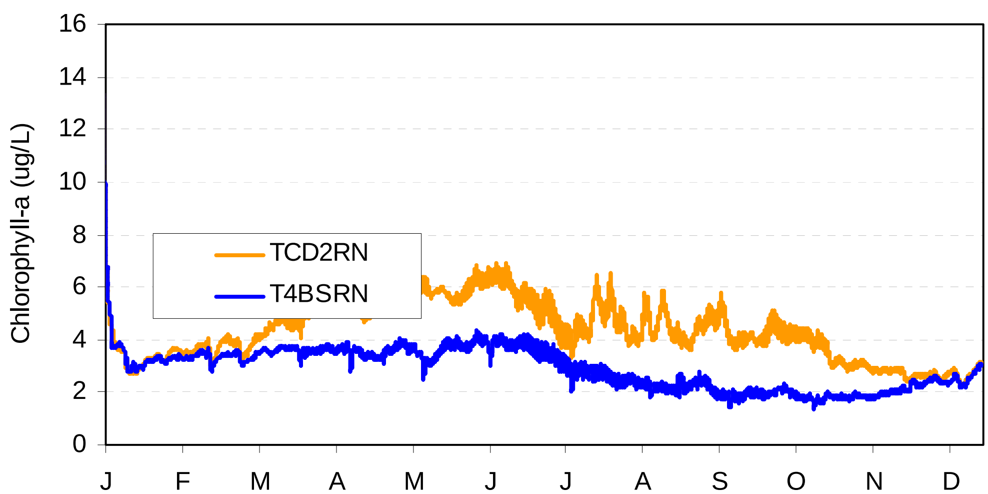

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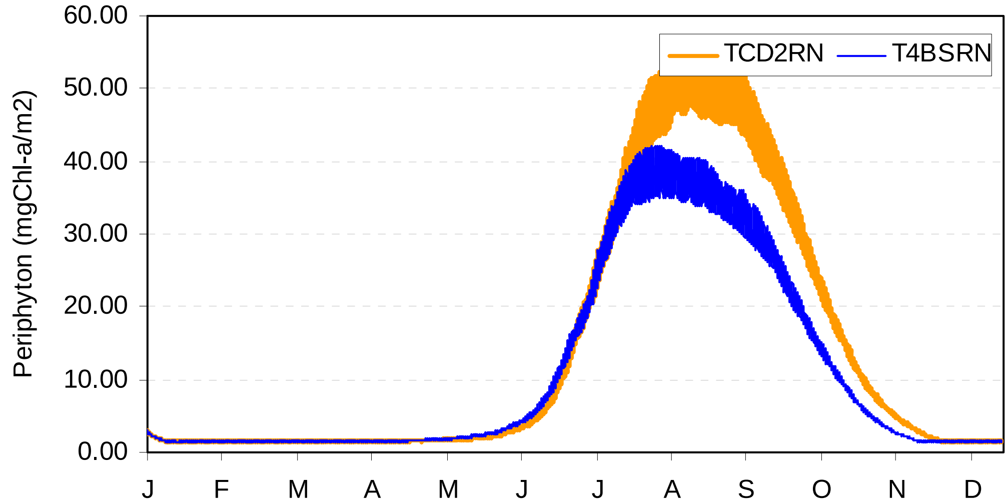

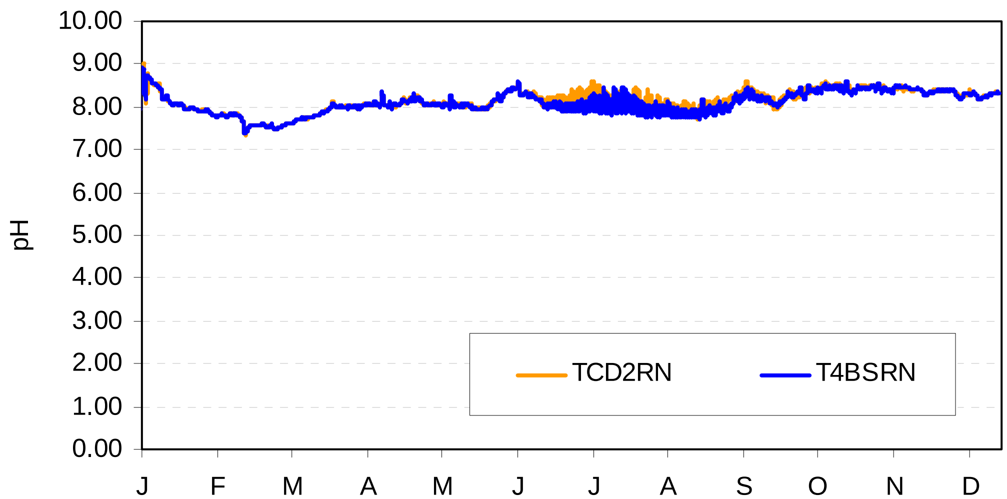

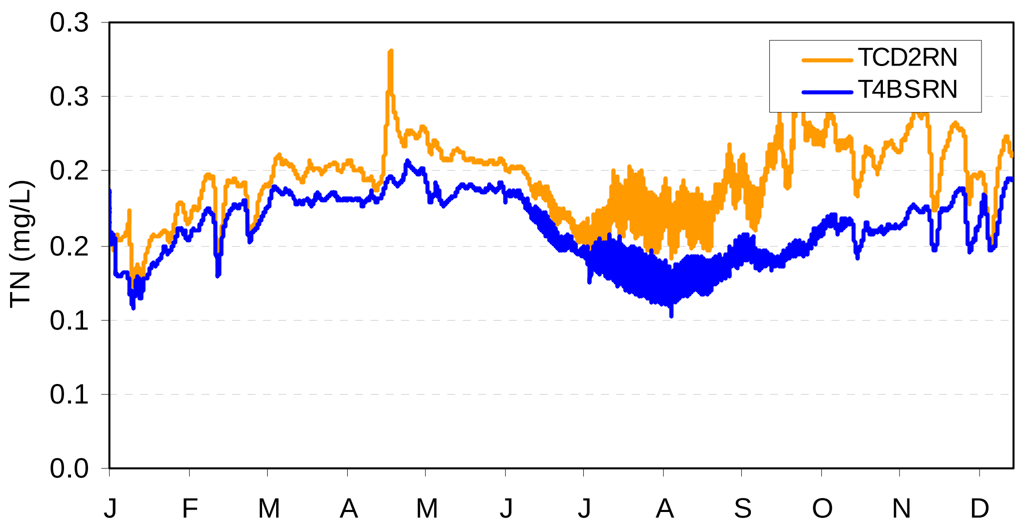

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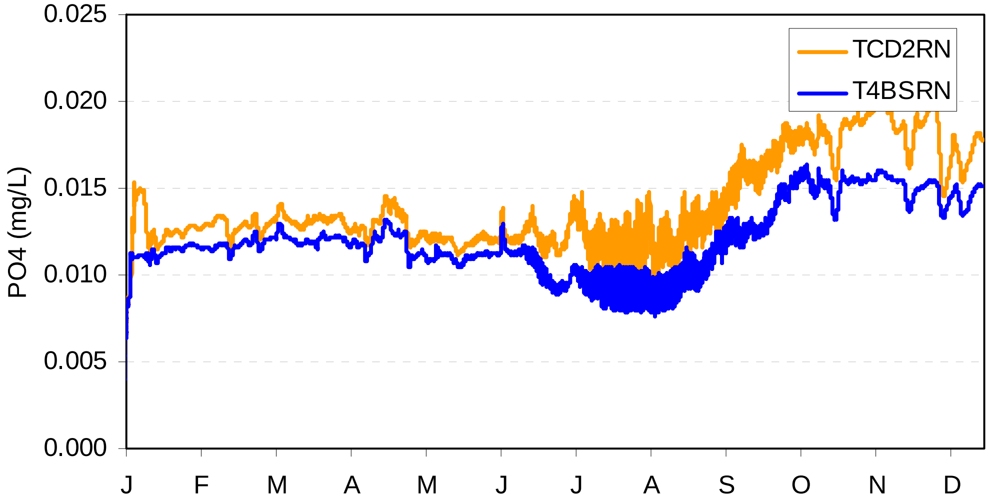

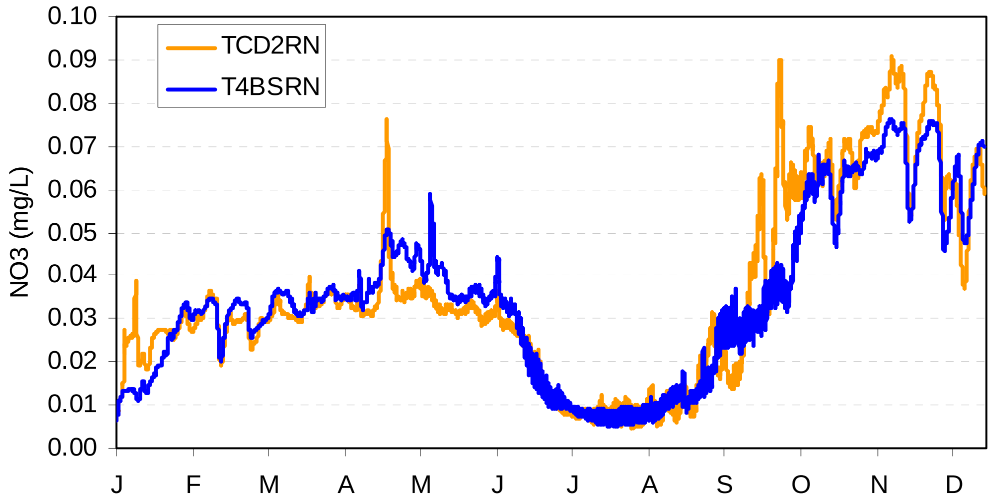

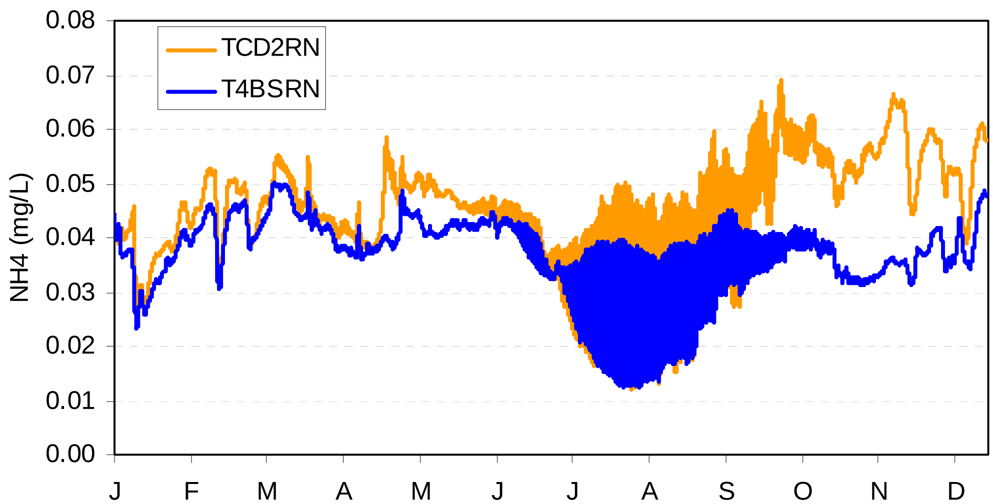

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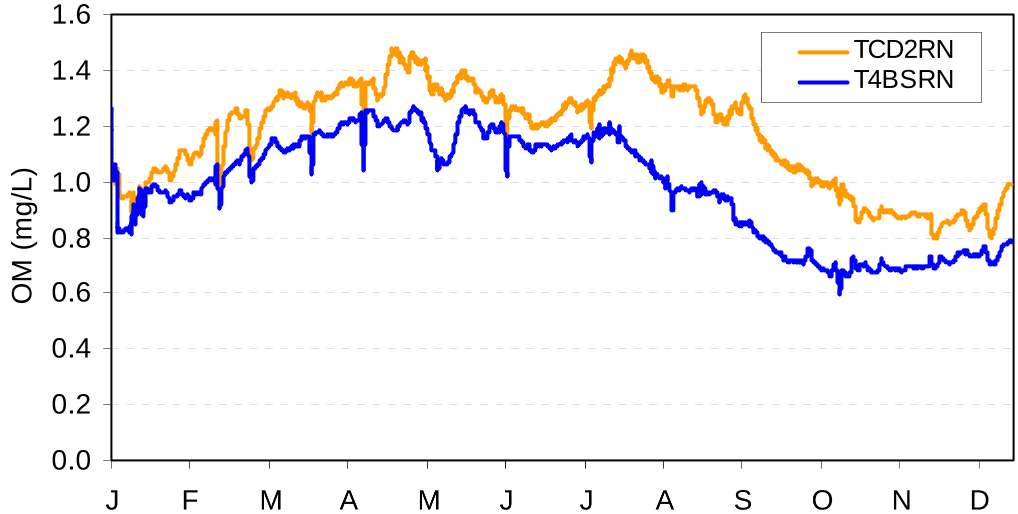

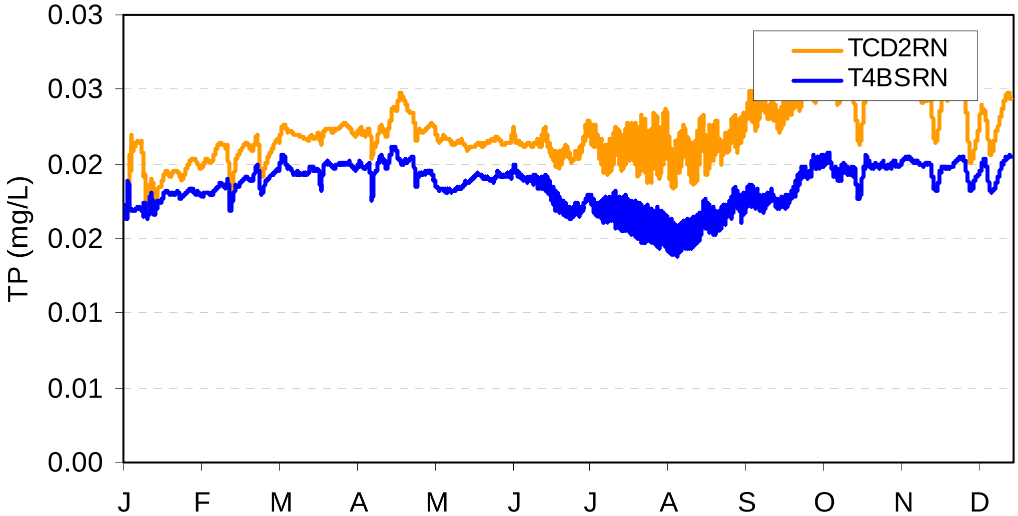

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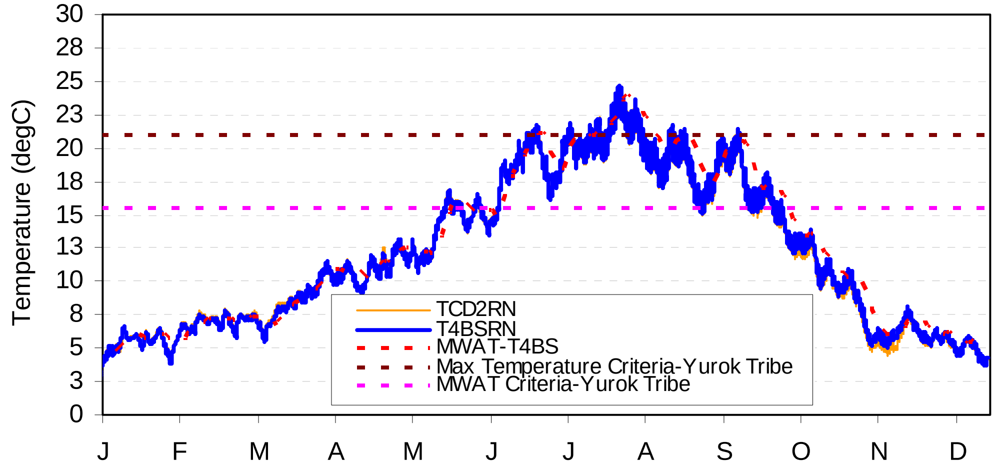

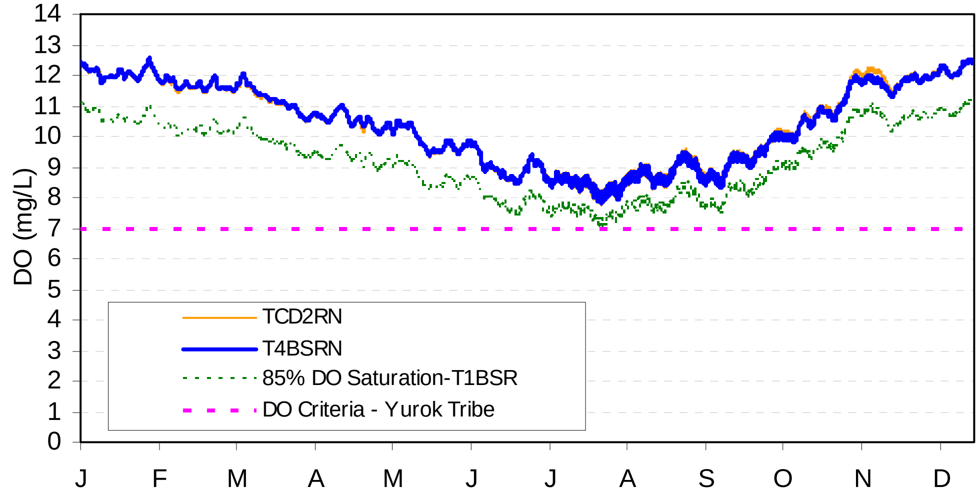

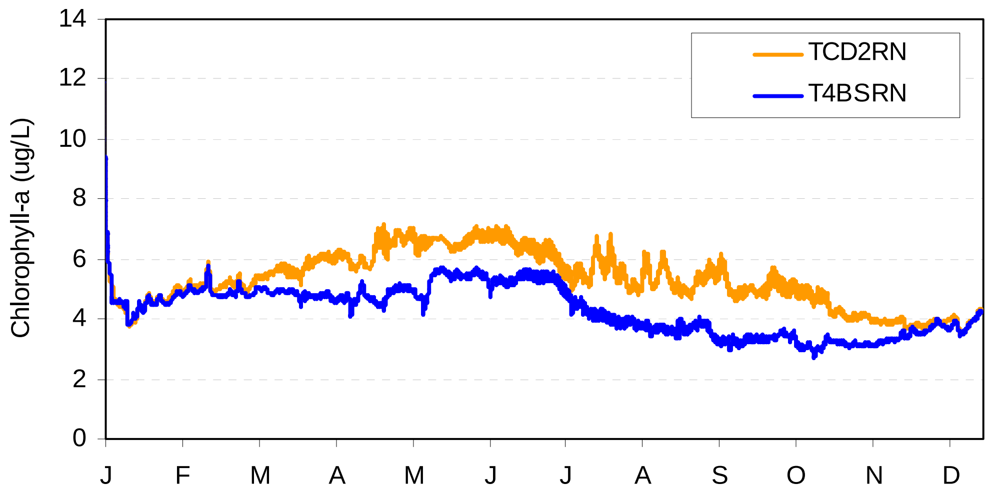

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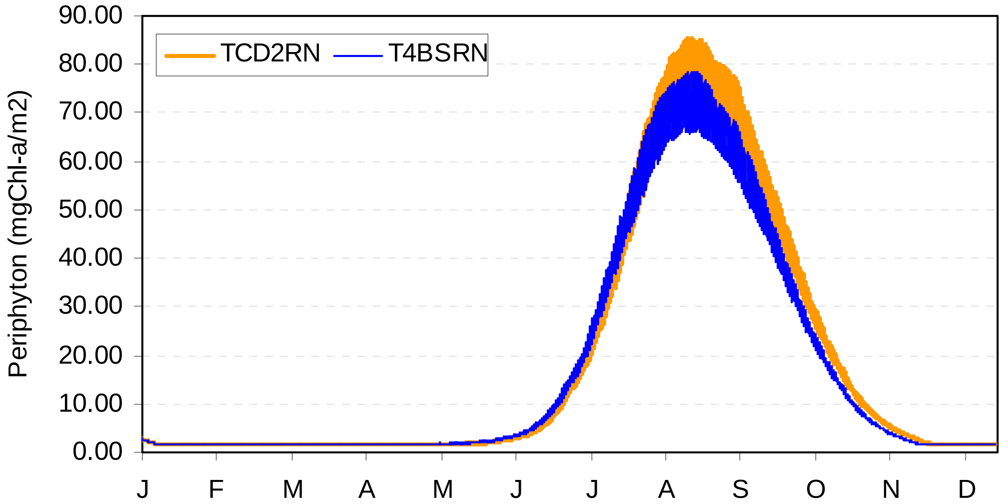

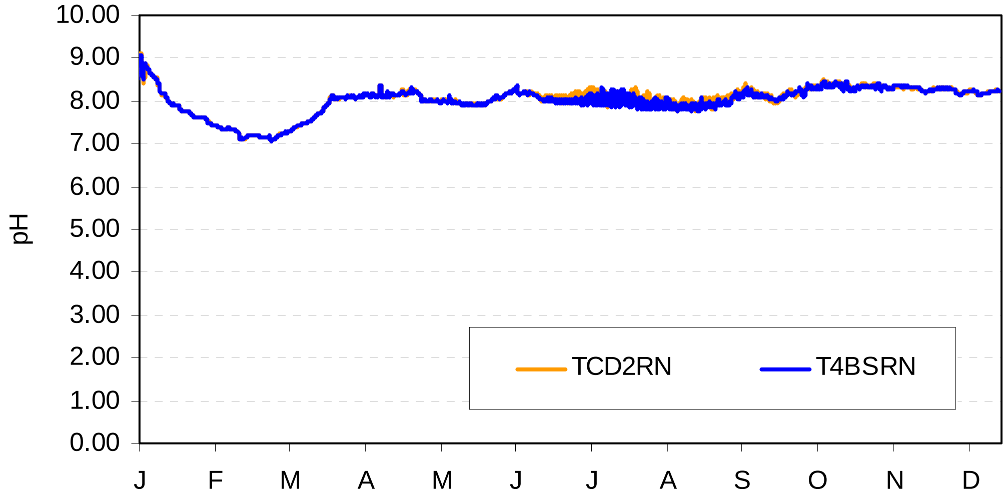

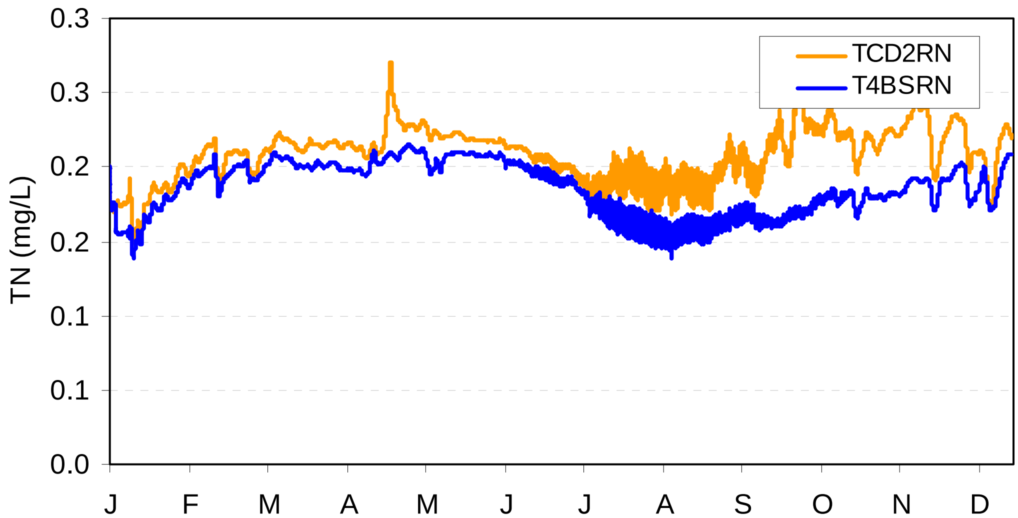

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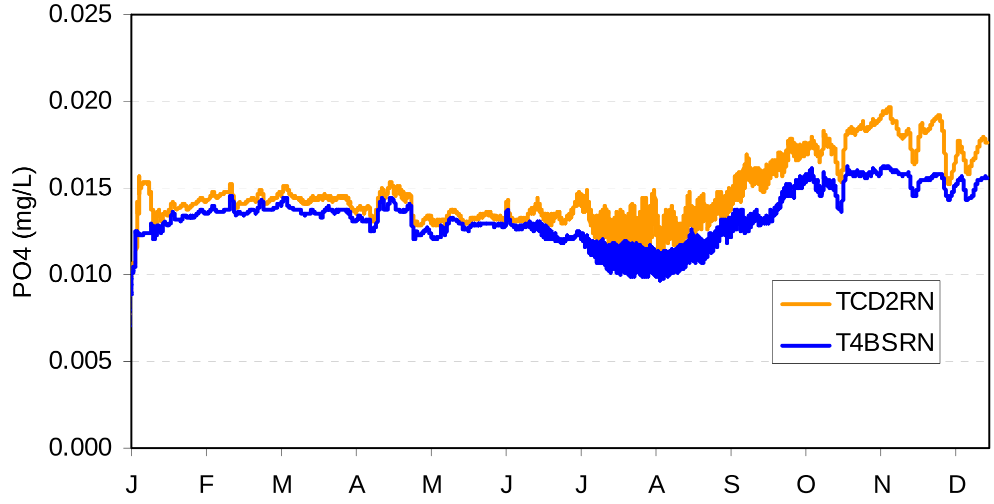

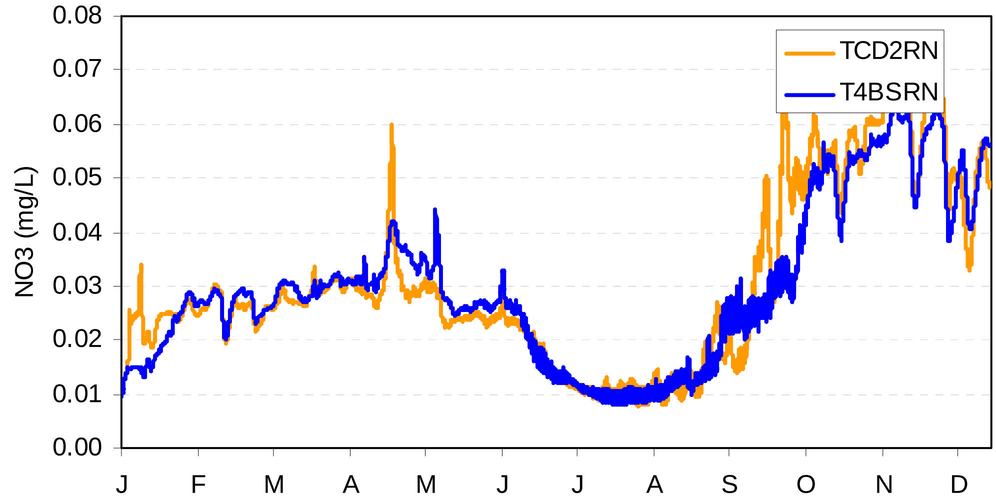

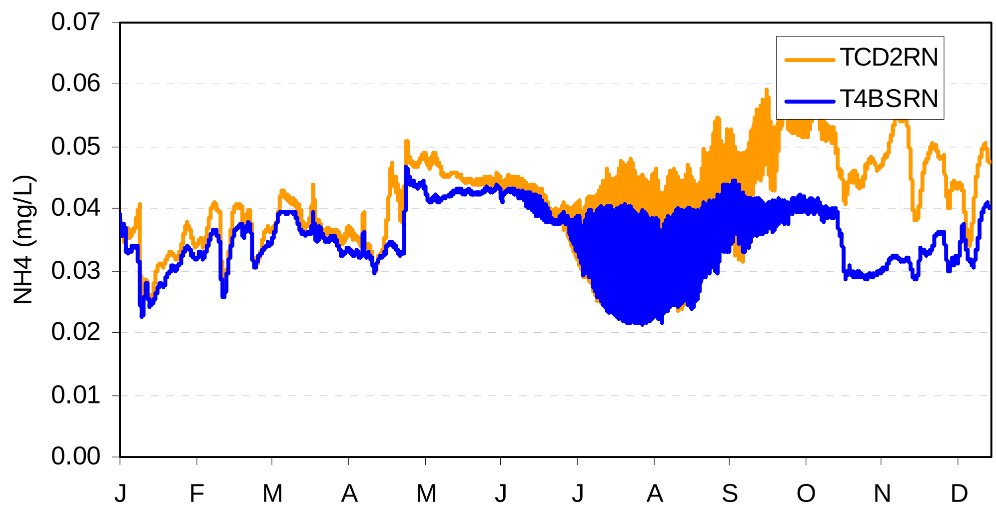

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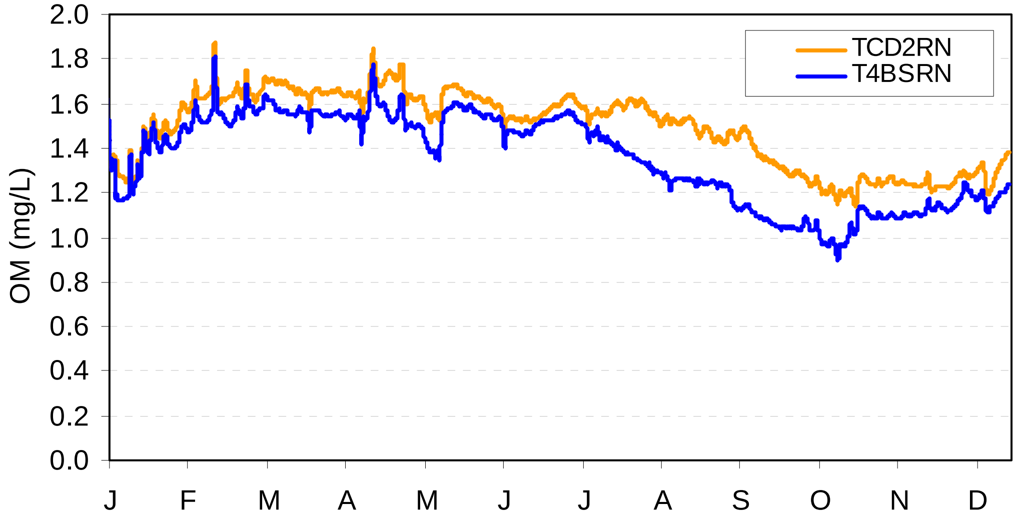

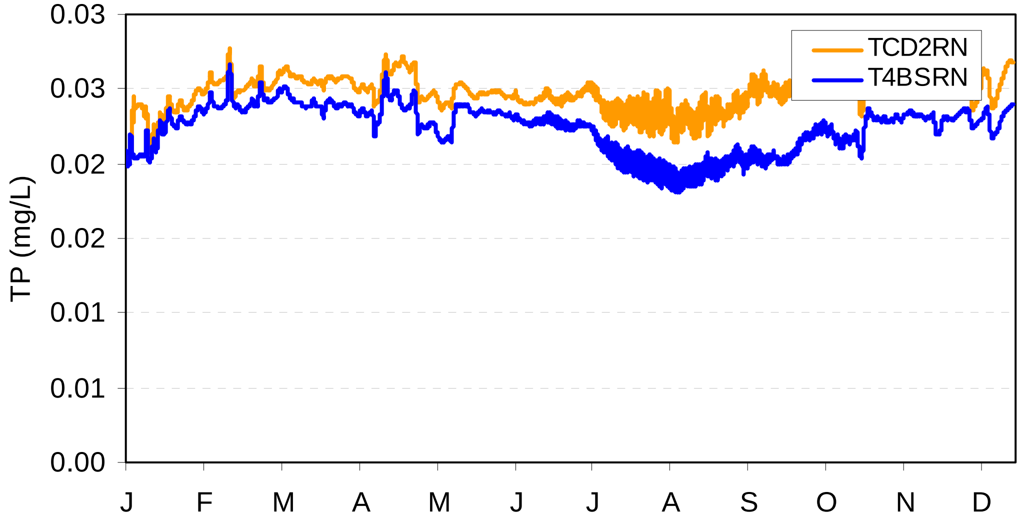

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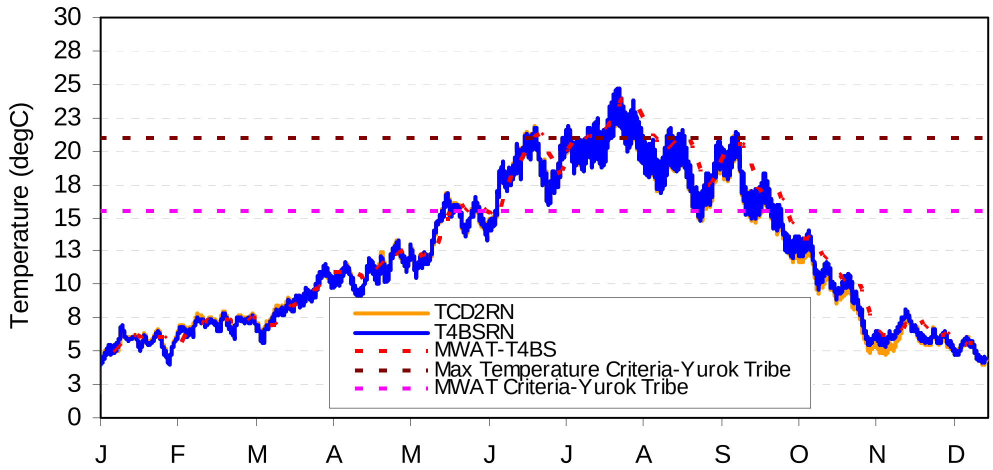
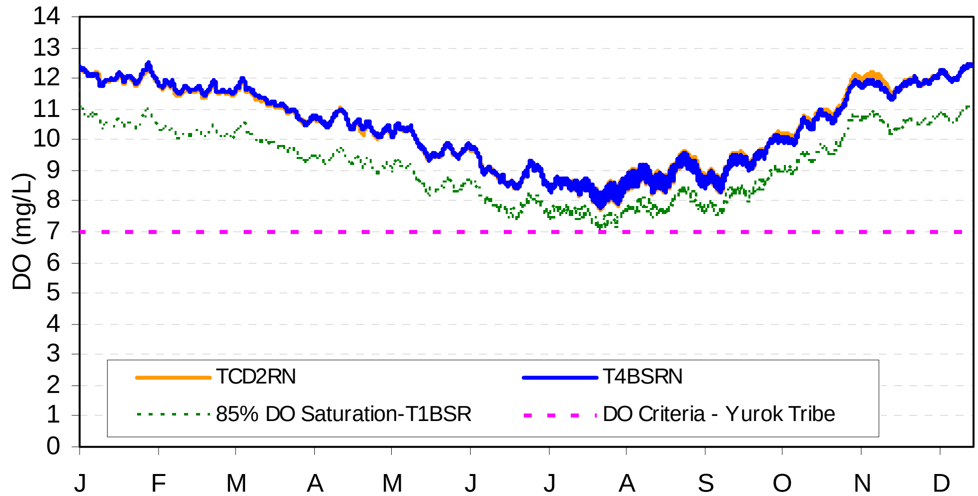
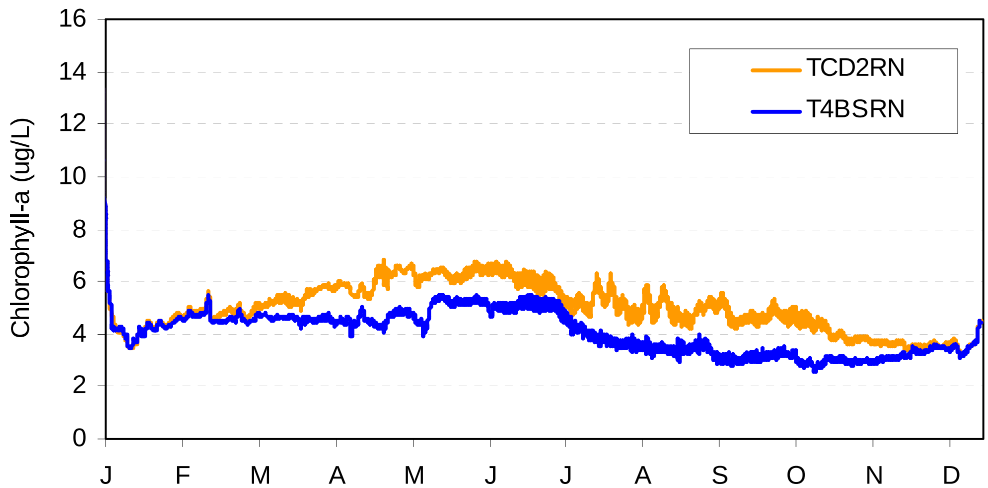
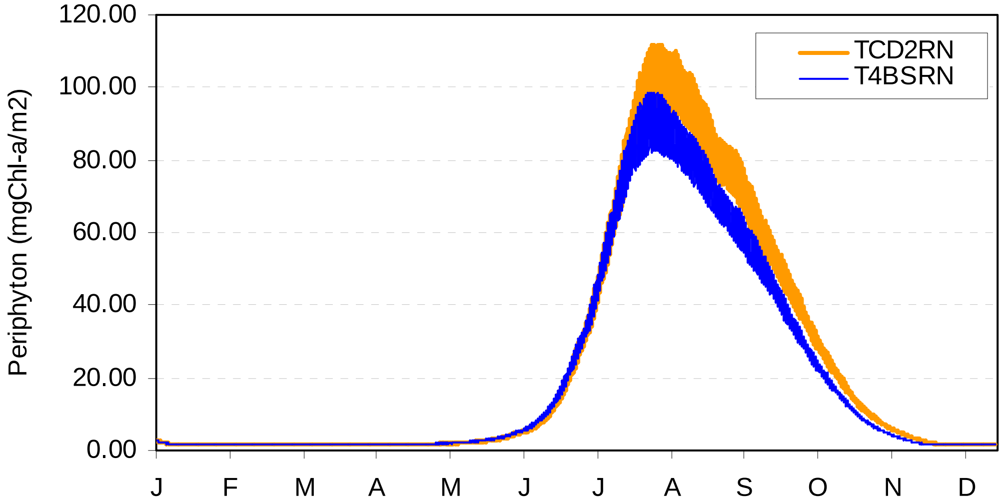
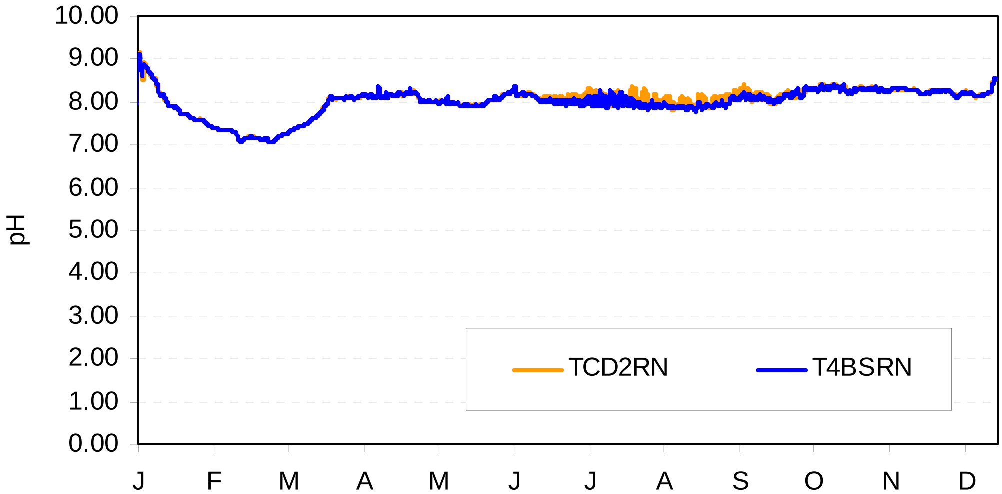


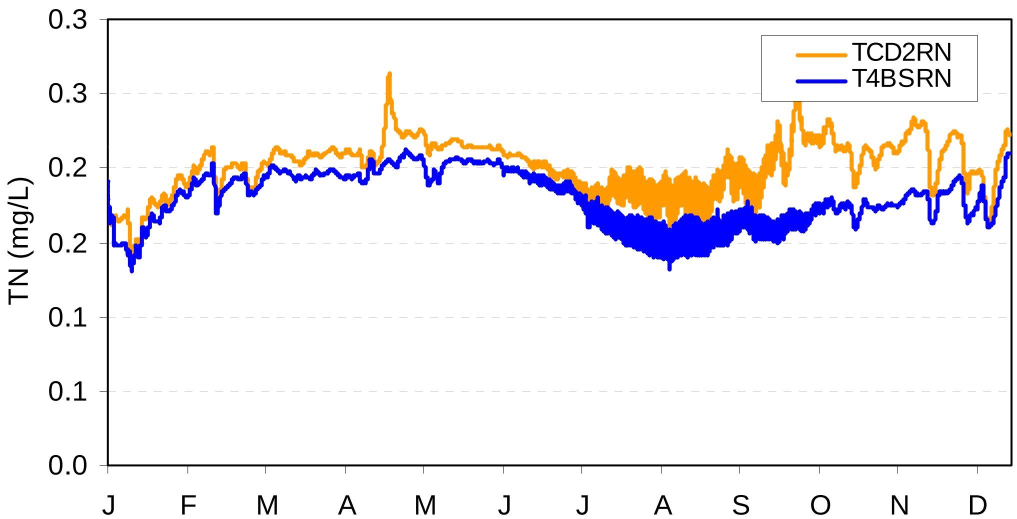




CT4BSRN_YOUNGSBAR







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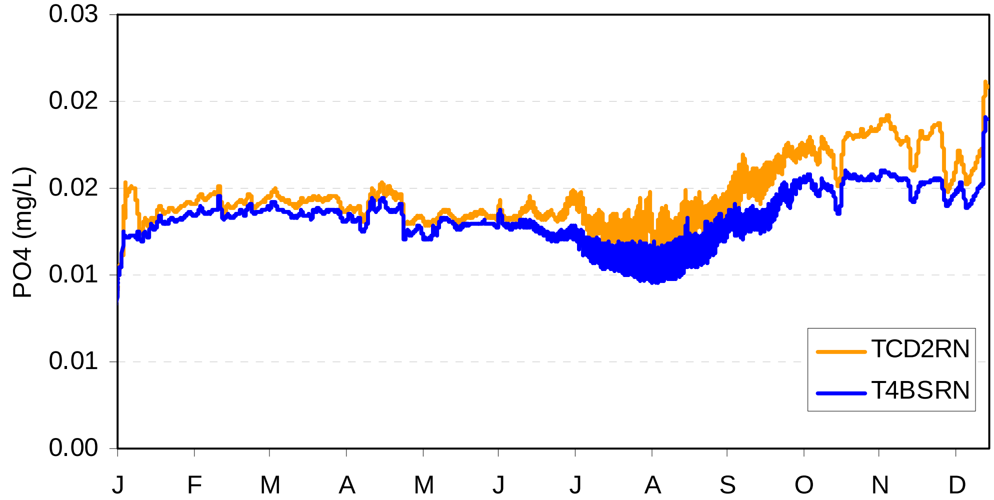

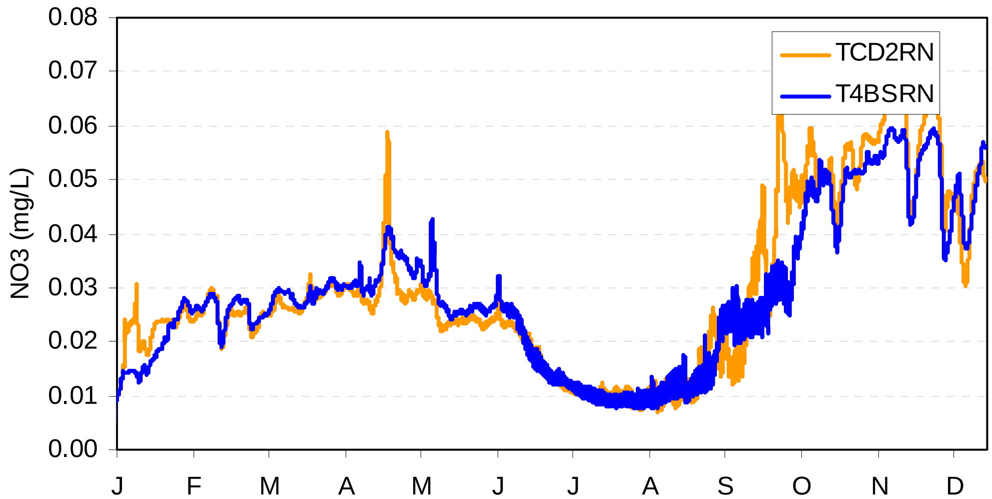

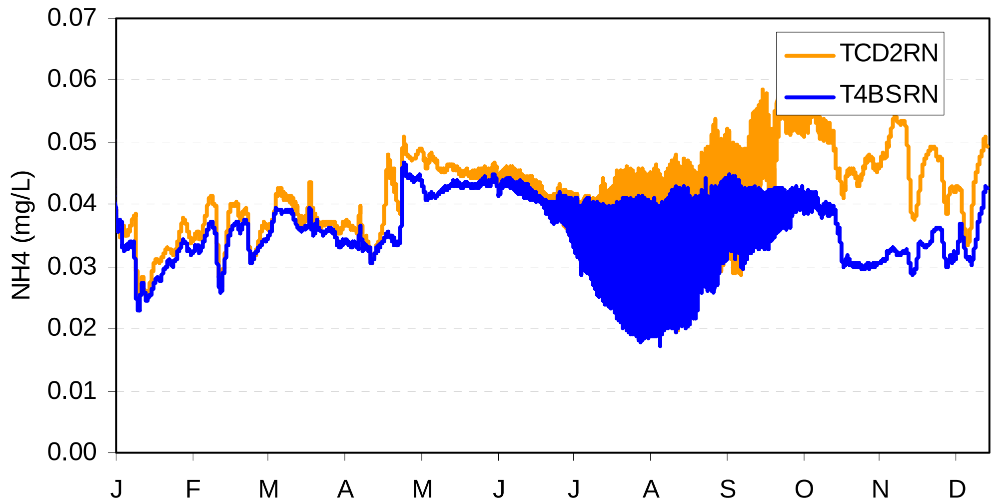

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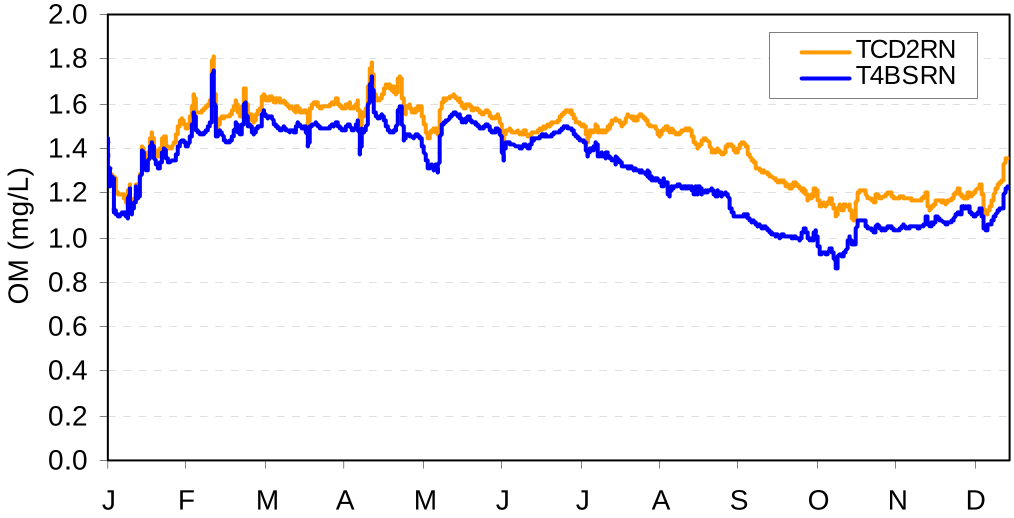
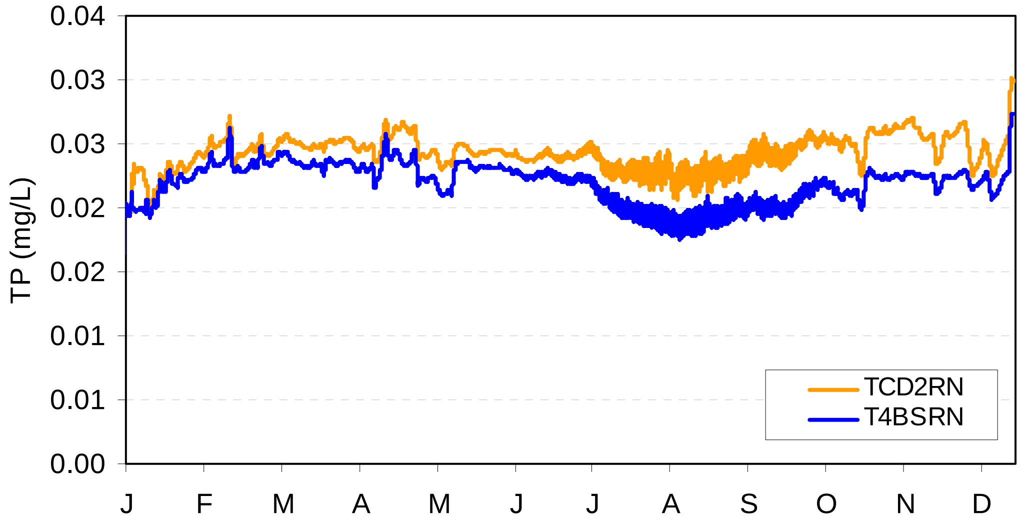
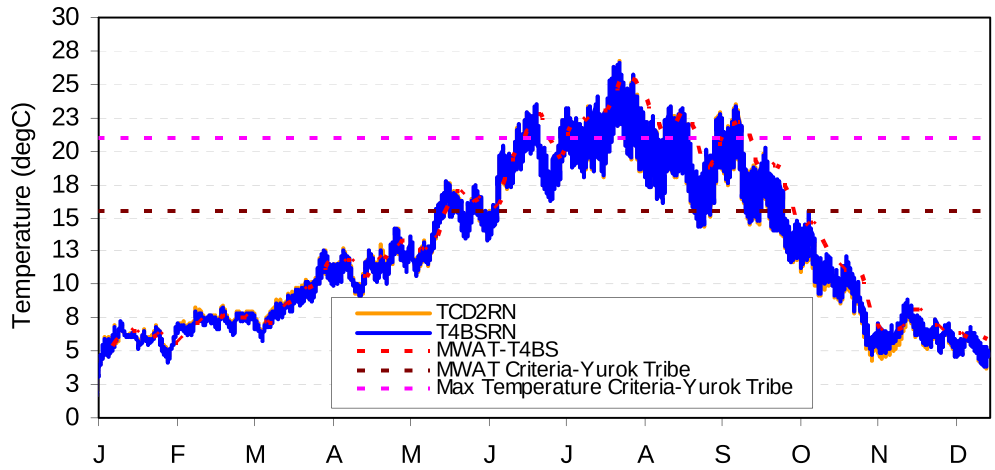
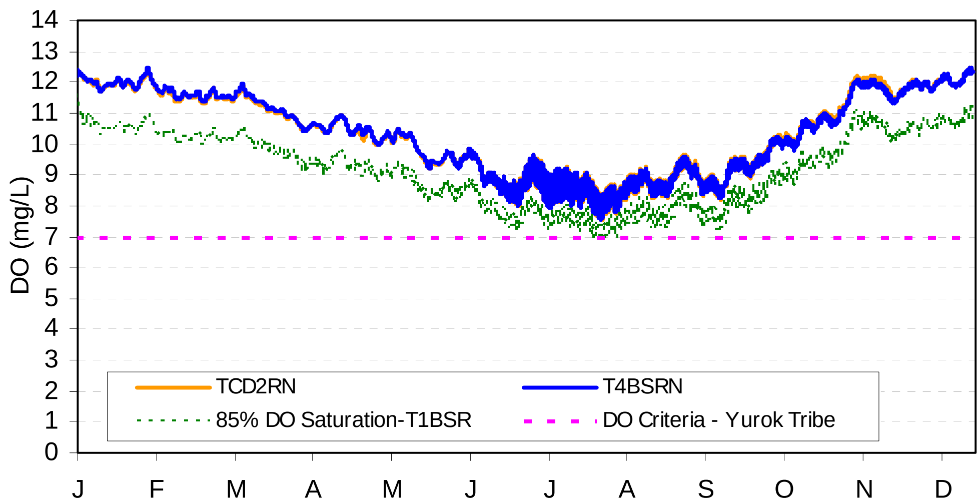
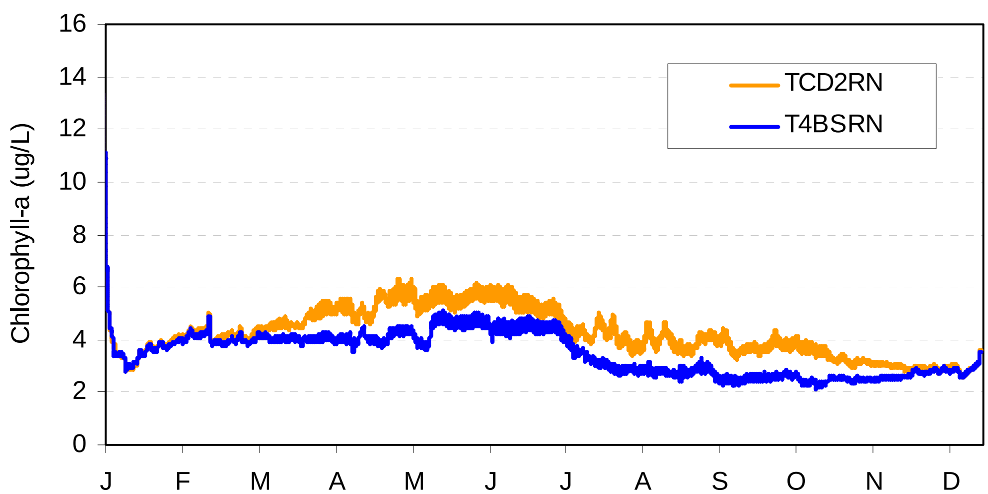




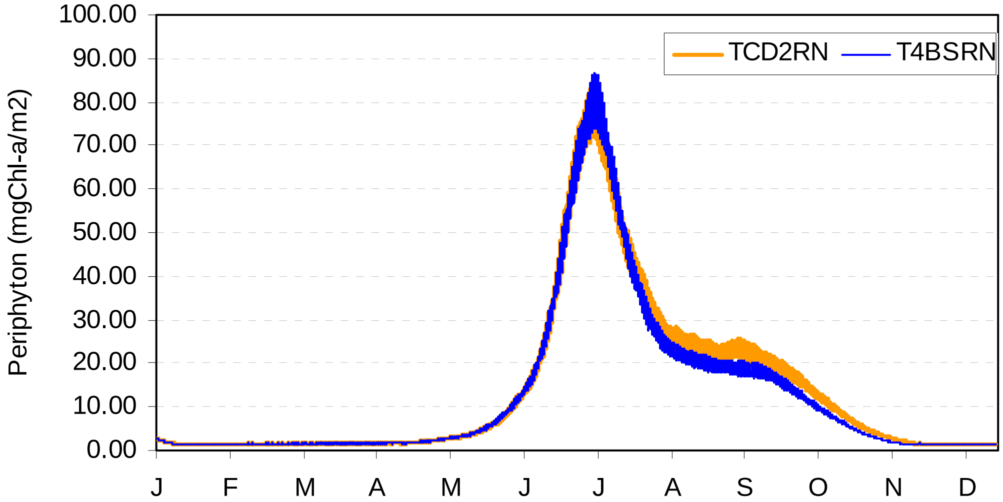
CT4BSRN_TURWAR

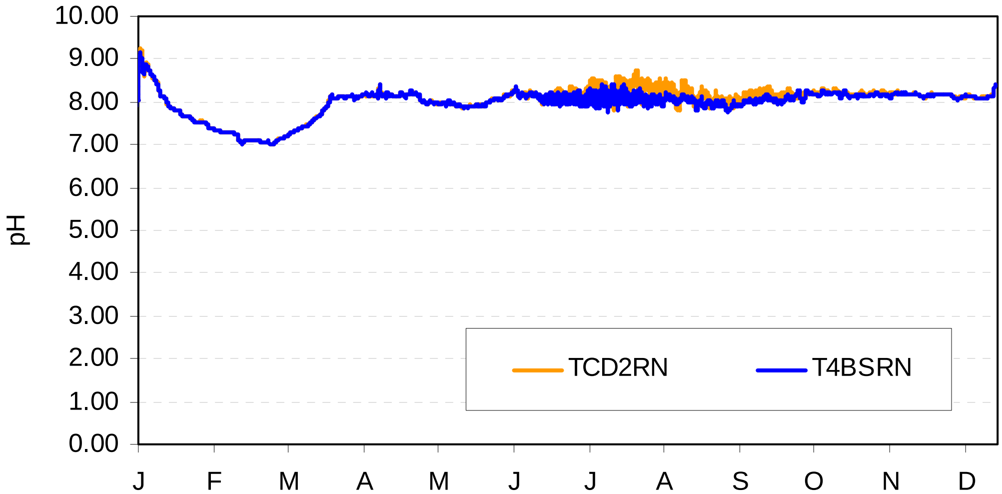


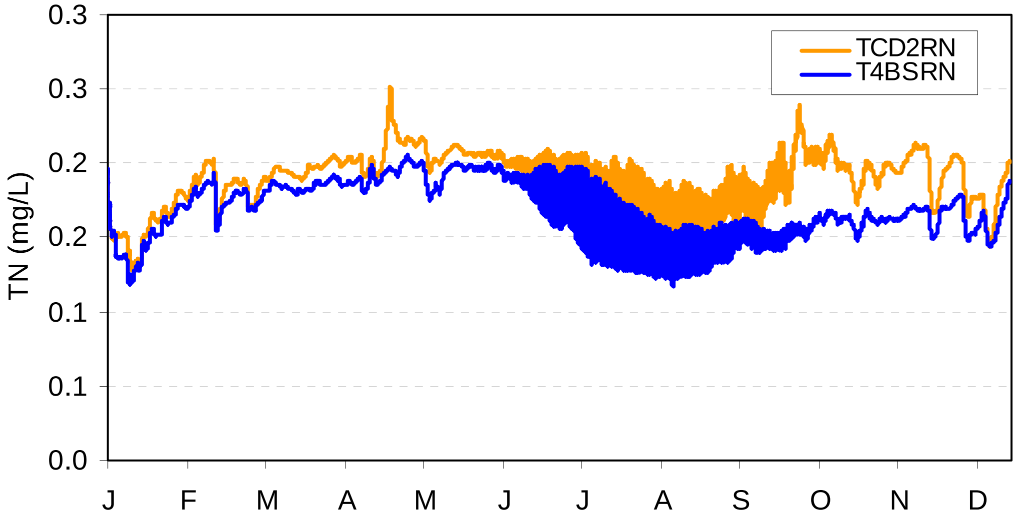




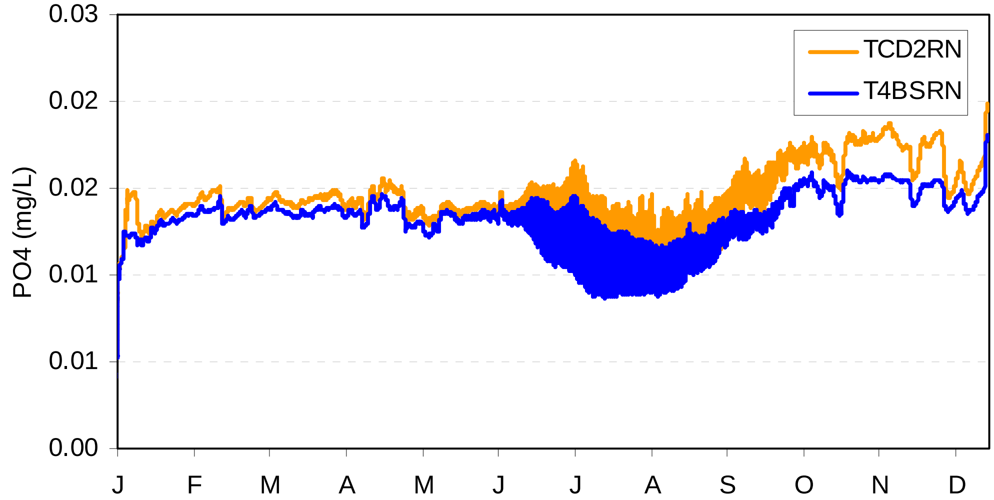
CT4BSRN_TURWAR

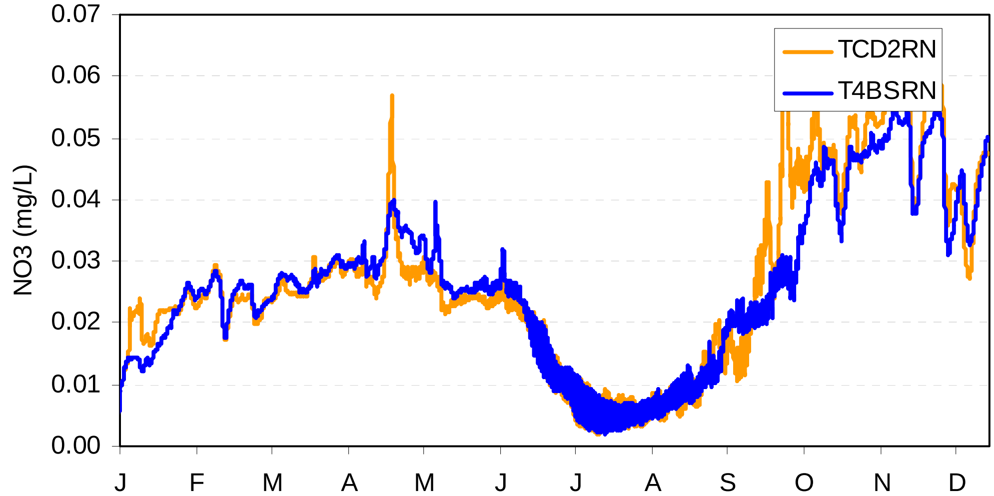


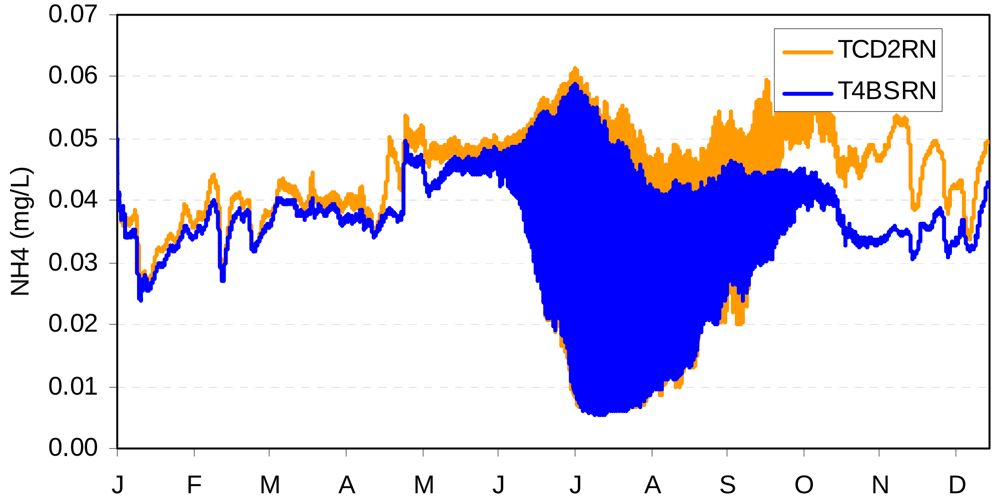




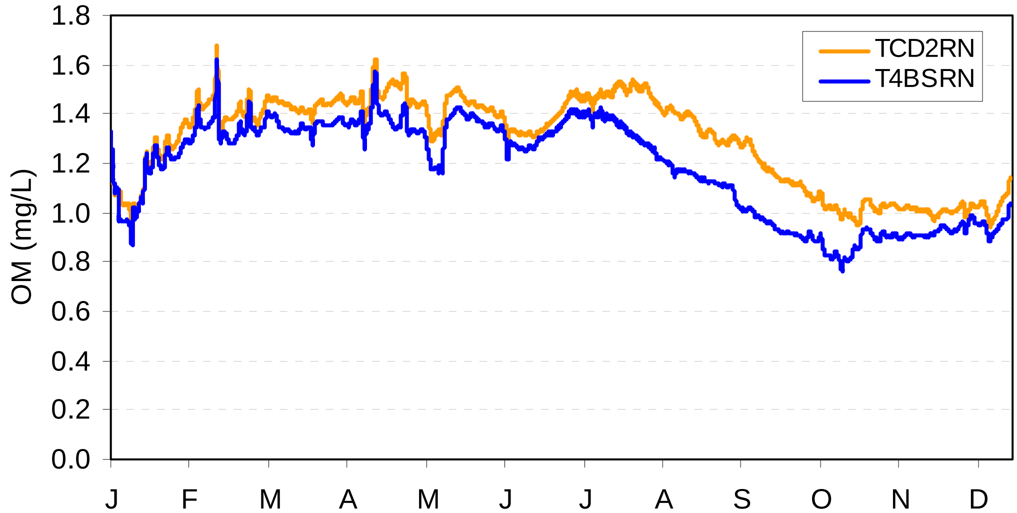
CT4BSRN_TURWAR

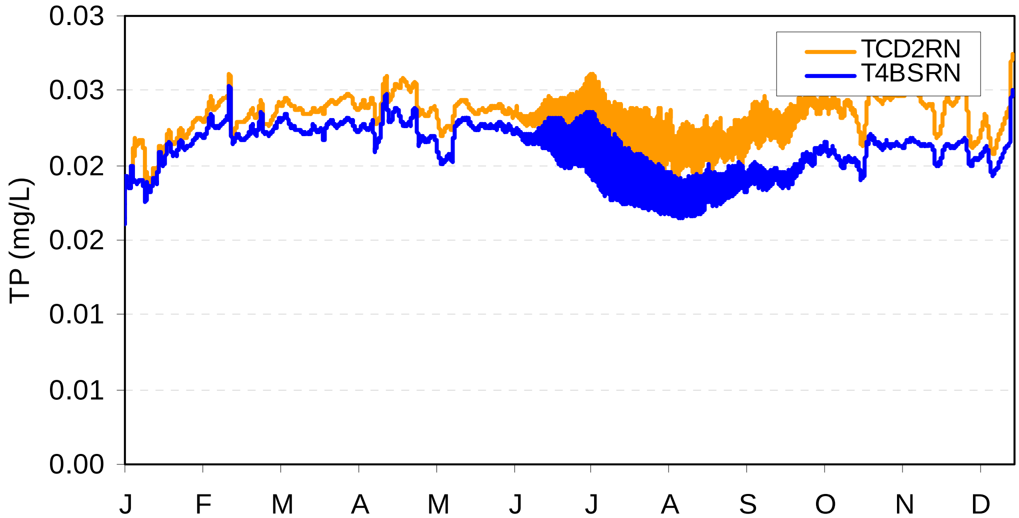




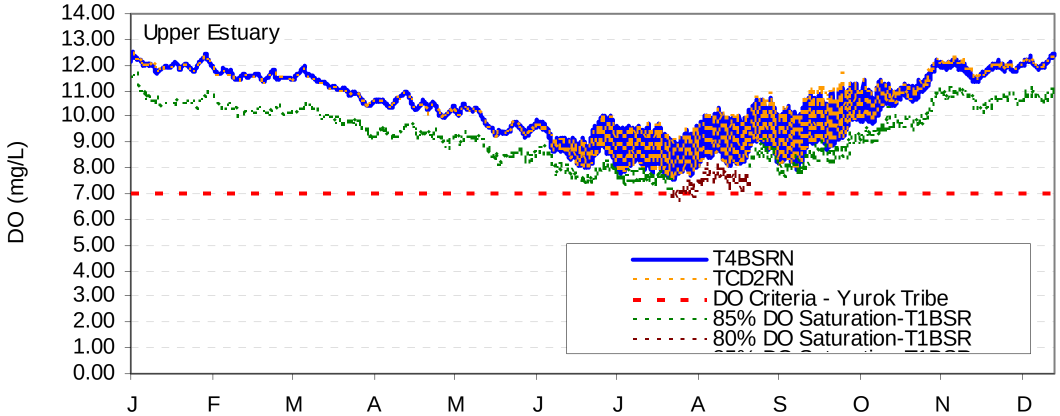


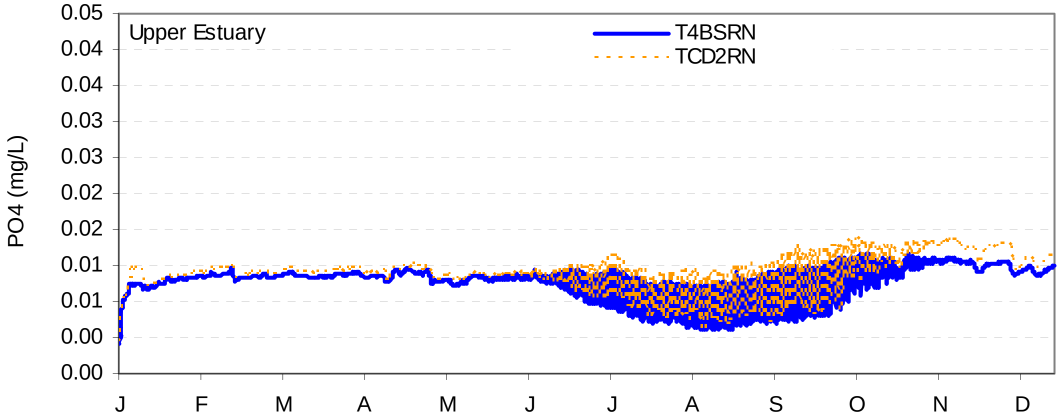
CT4BSRN_TURWAR

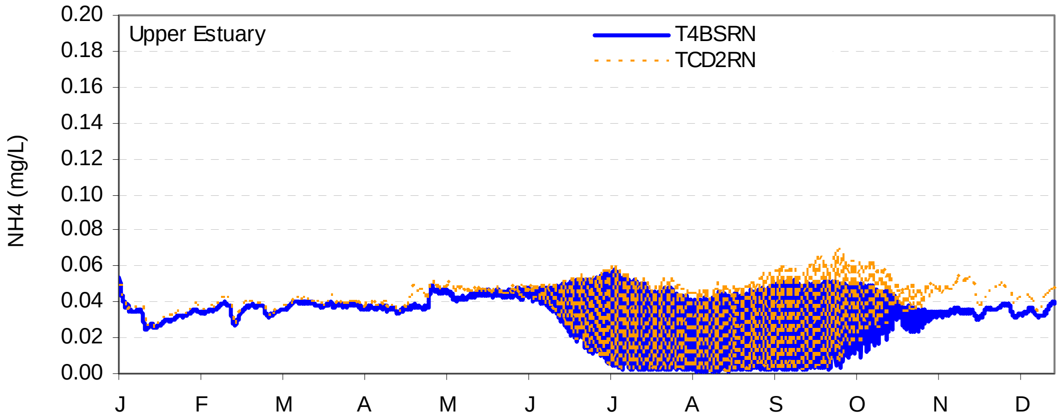


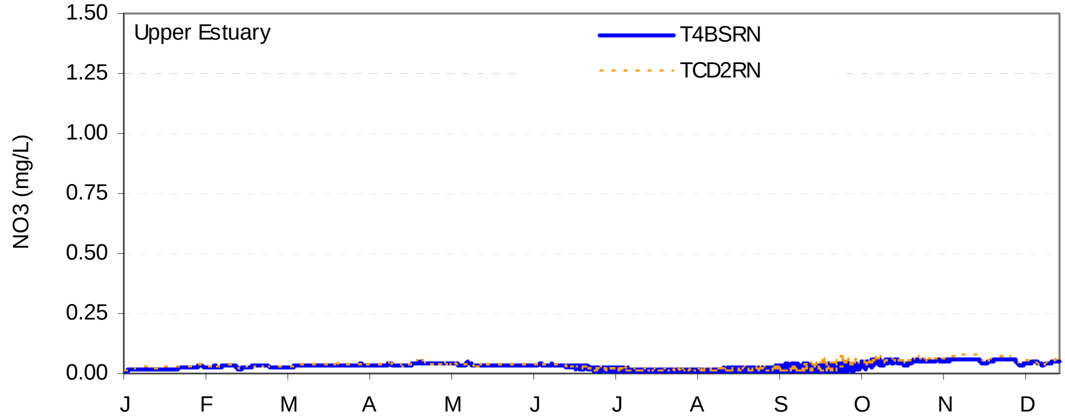


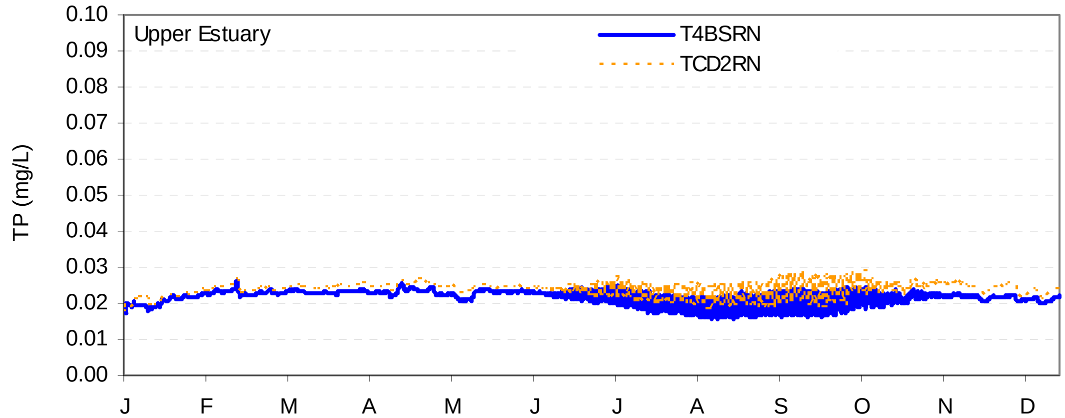
Upper Estuary

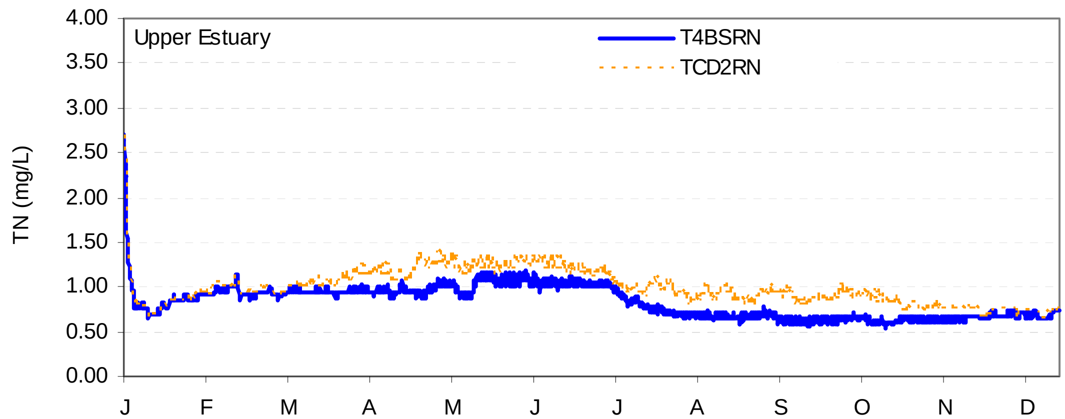


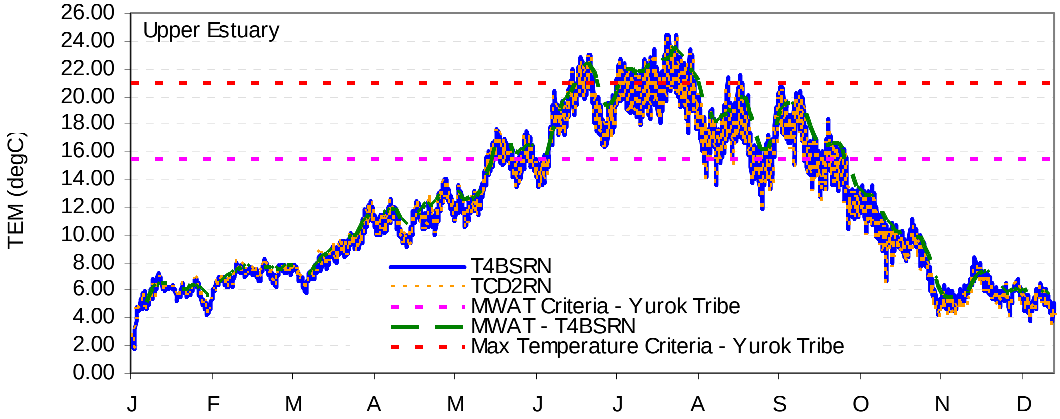


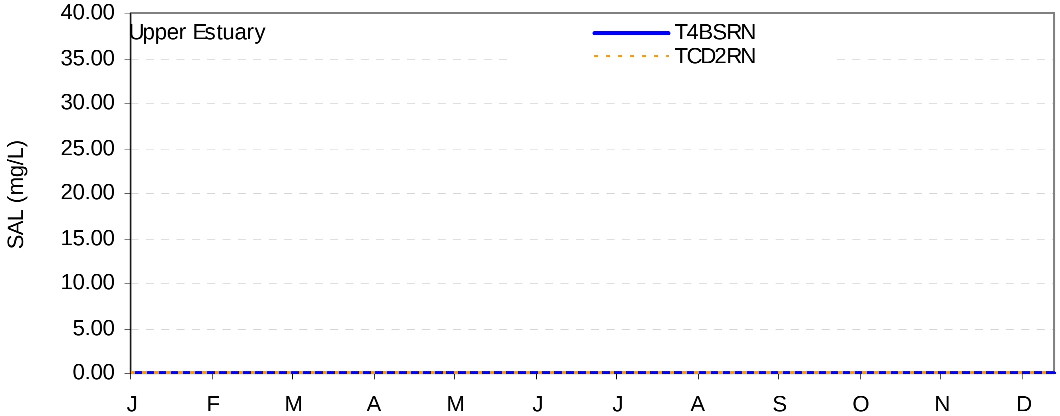


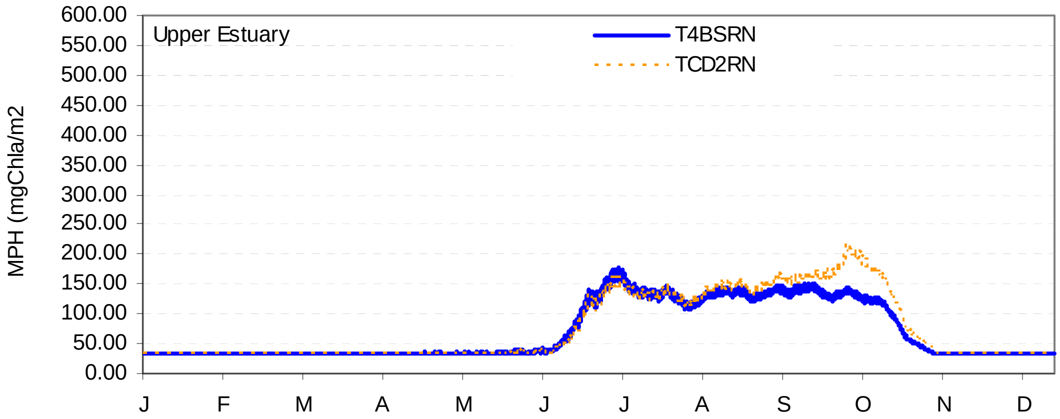

Upper Estuary
T4BSRN
TCD2RN
NO3 (mg/L)
1.50
1.25
1.00
0.75
0.50
0.25
0.00
J
F
M
A
M
J
J
A
S
O
N
D


Upper Estuary
T4BSRN
TCD2RN
TP (mg/L)
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
J
F
M
A
M
J
J
A
S
O
N
D

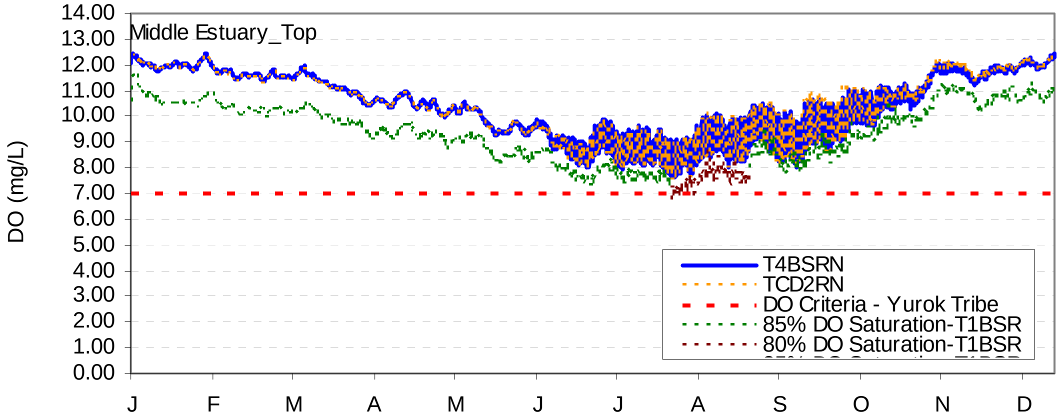

Upper Estuary
T4BSRN
TCD2RN
TN (mg/L)
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
J
F
M
A
M
J
J
A
S
O
N
D

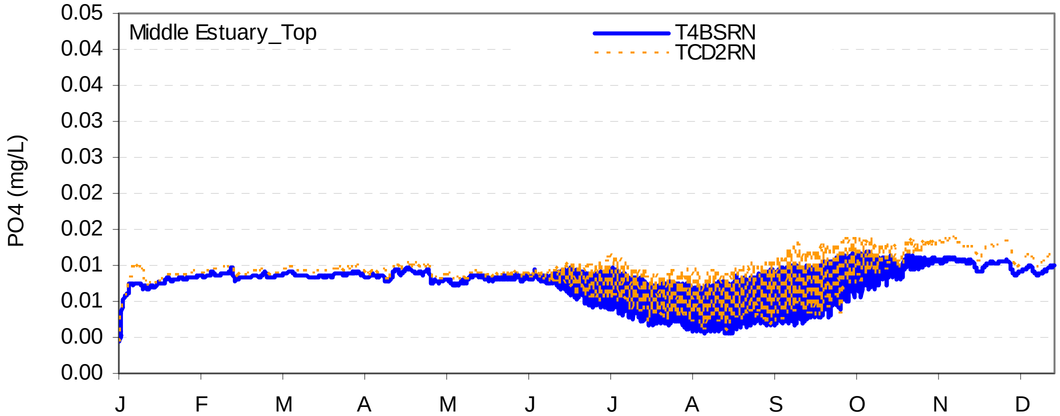

Upper Estuary
TEM (degC)
26.00
24.00
22.00
20.00
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
T4BSRN
TCD2RN
MWAT Criteria - Yurok Tribe
MWAT - T4BSRN
Max Temperature Criteria - Yurok Tribe
J F M A M J J A S O N D

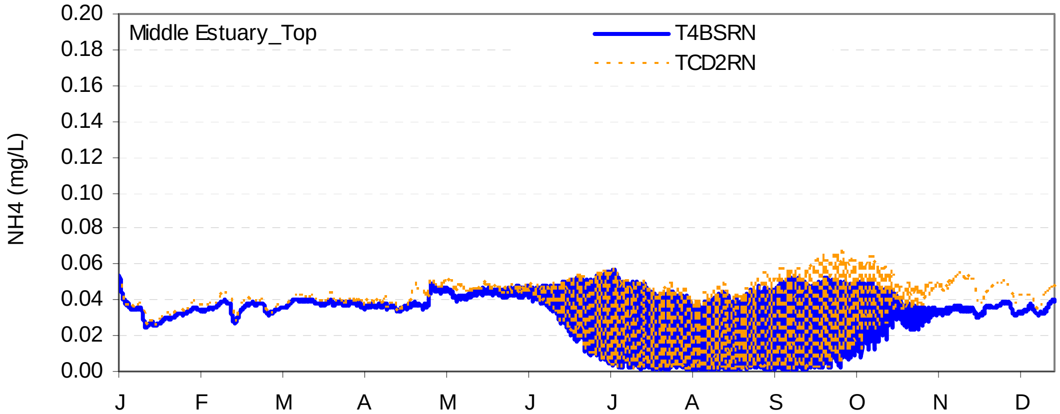

Upper Estuary
SAL (mg/L)
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
T4BSRN
TCD2RN
J F M A M J J A S O N D

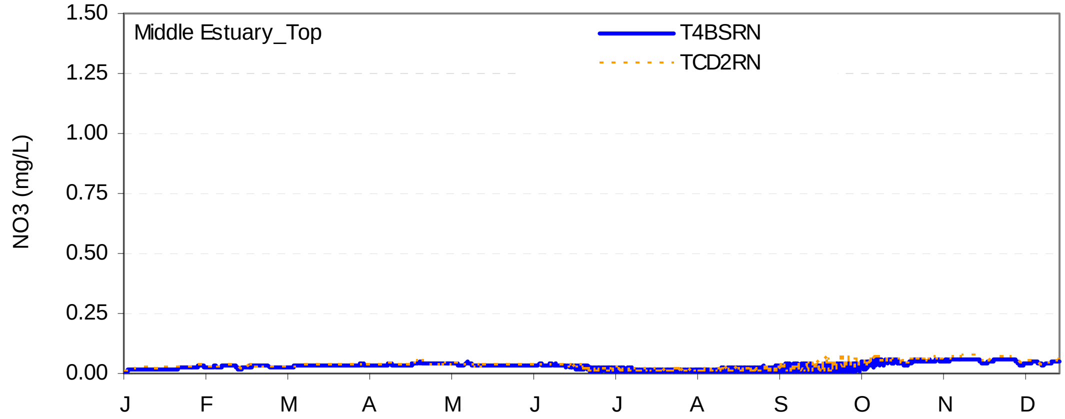

Upper Estuary
MPH (mgChla/m2
600.00
550.00
500.00
450.00
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
T4BSRN
TCD2RN
J F M A M J J A S O N D

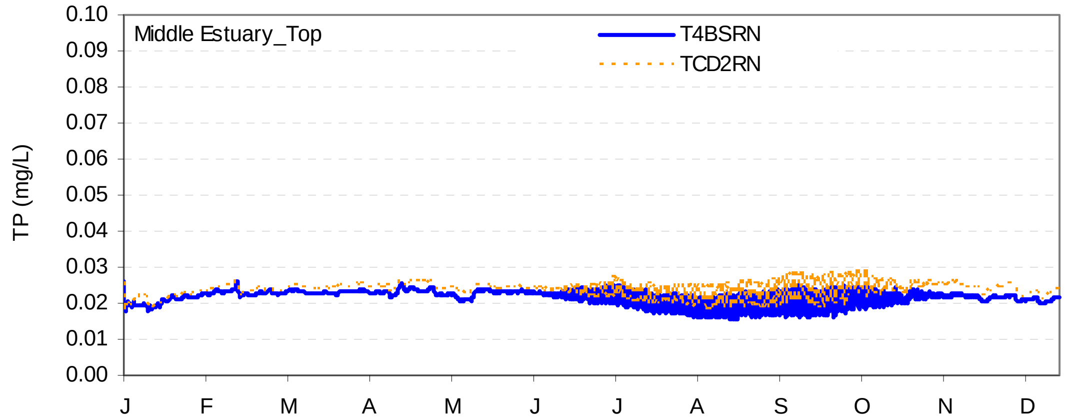
Middle Estuary - Top

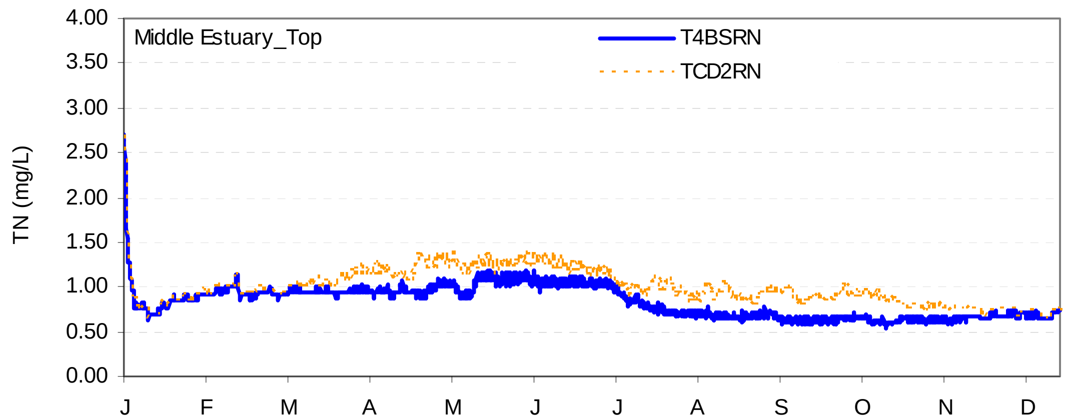


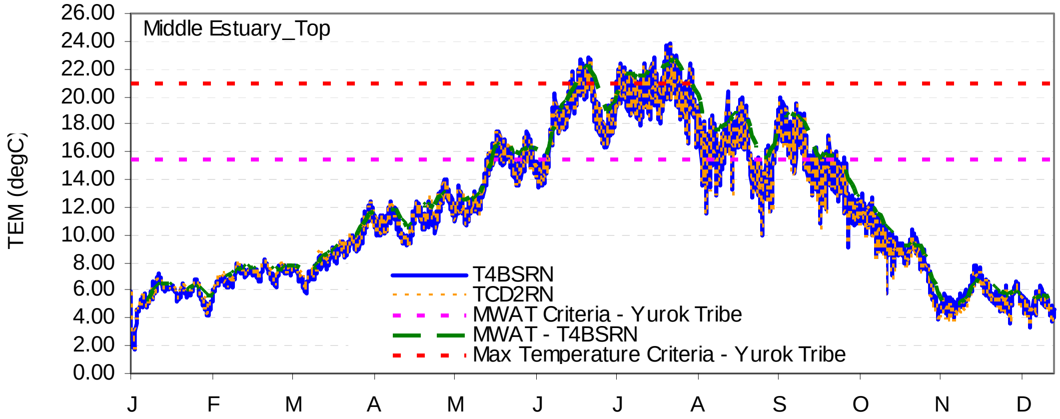


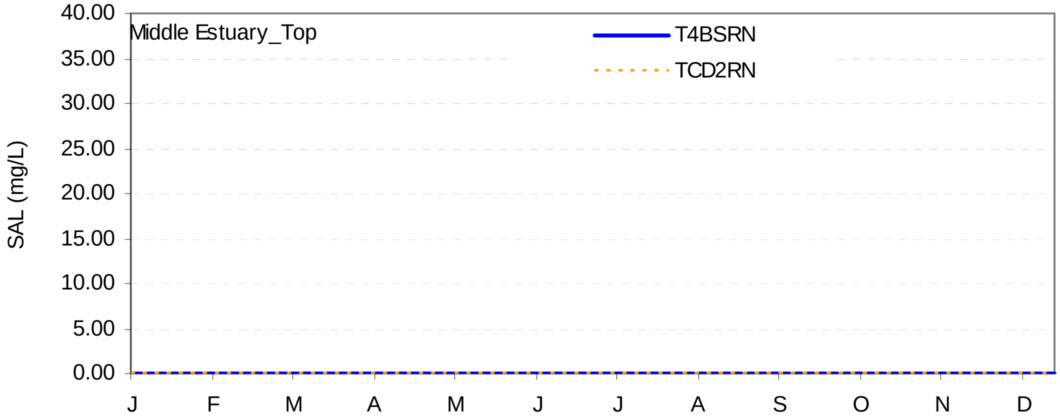


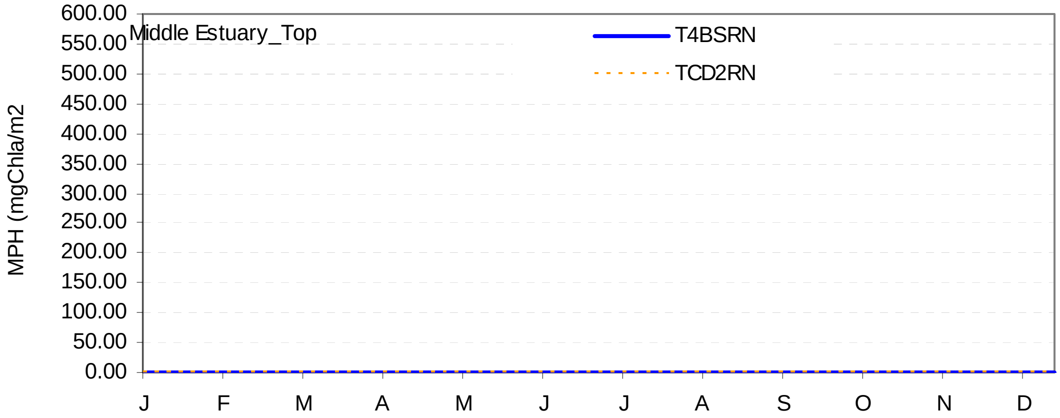

Middle Estuary_Top
T4BSRN
TCD2RN
NO3 (mg/L)
1.50
1.25
1.00
0.75
0.50
0.25
0.00
J F M A M J J A S O N D


Middle Estuary_Top
T4BSRN
TCD2RN
TP (mg/L)
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
J F M A M J J A S O N D

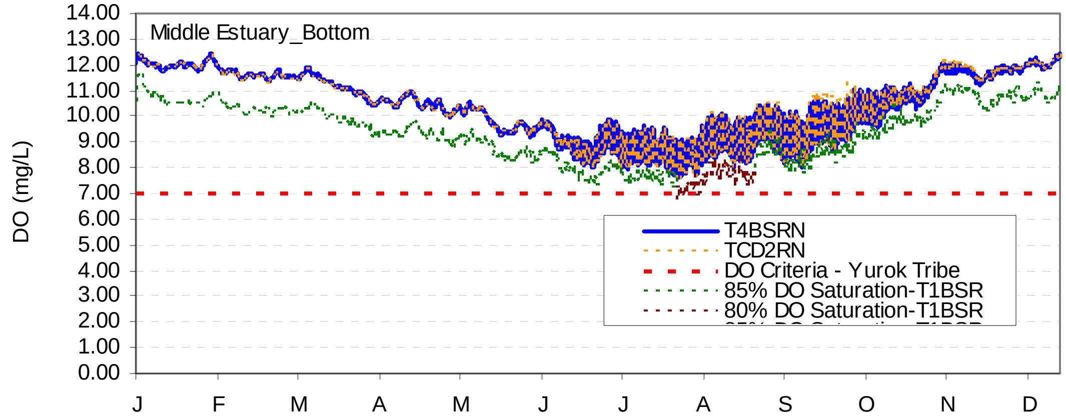

Middle Estuary_Top
T4BSRN
TCD2RN
TN (mg/L)
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
J F M A M J J A S O N D

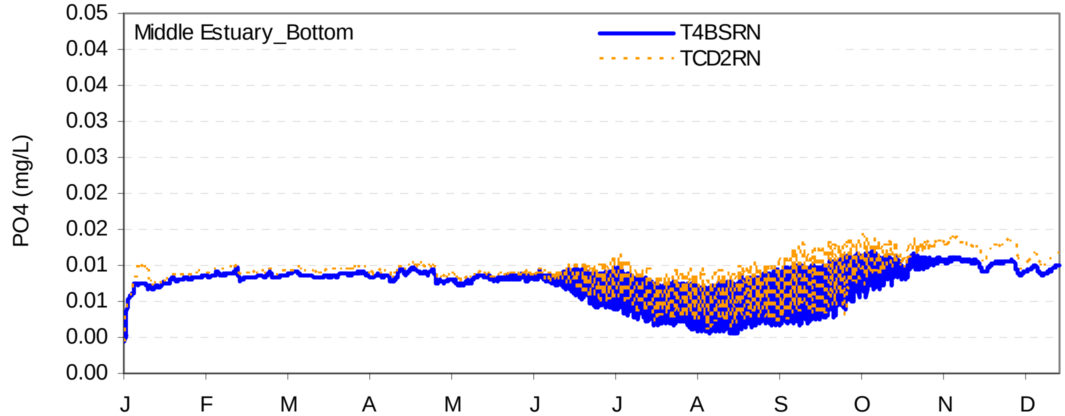

Middle Estuary_Top
TEM (degC)
26.00
24.00
22.00
20.00
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
T4BSRN
TCD2RN
MWAT Criteria - Yurok Tribe
MWAT - T4BSRN
Max Temperature Criteria - Yurok Tribe
J F M A M J J A S O N D

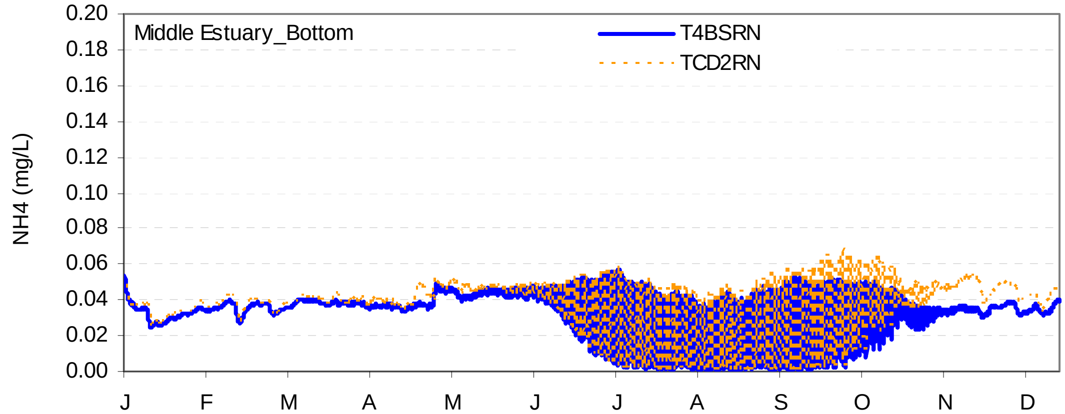

Middle Estuary_Top
SAL (mg/L)
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
T4BSRN
TCD2RN
J F M A M J J A S O N D

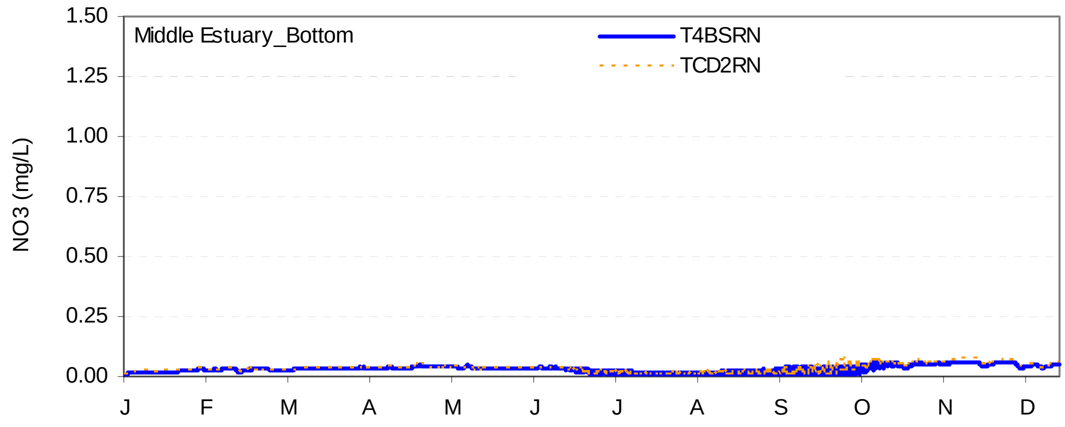

Middle Estuary_Top
MPH (mgChla/m2
600.00
550.00
500.00
450.00
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
T4BSRN
TCD2RN
J F M A M J J A S O N D

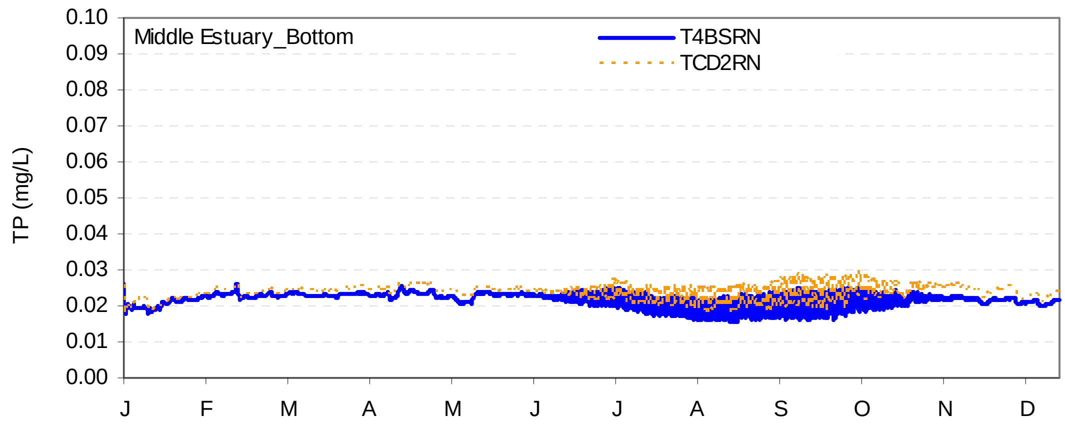
Middle Estuary - Bottom

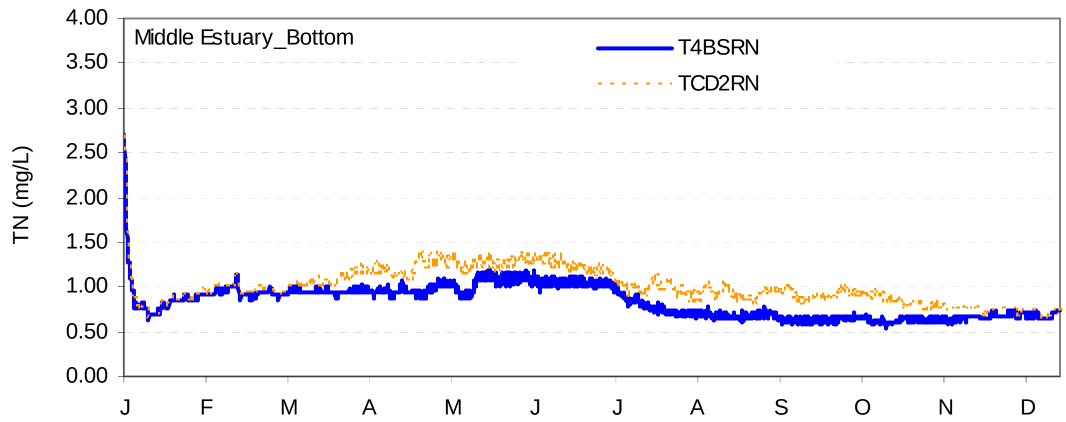


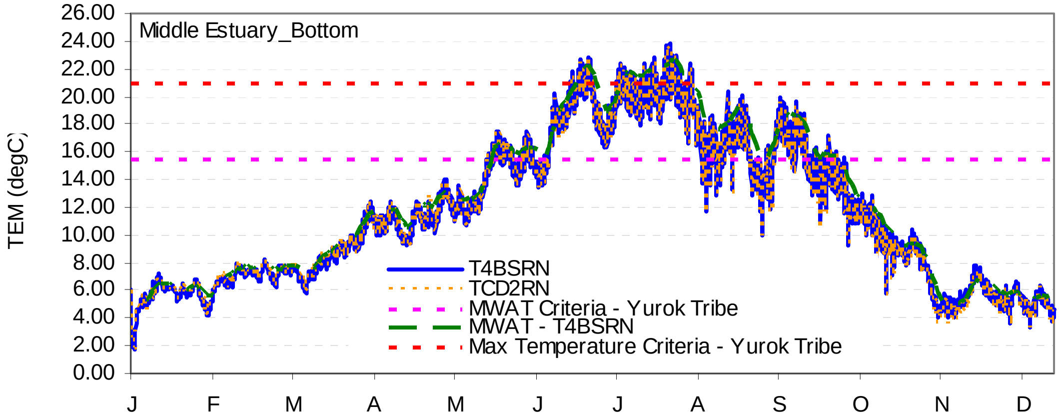


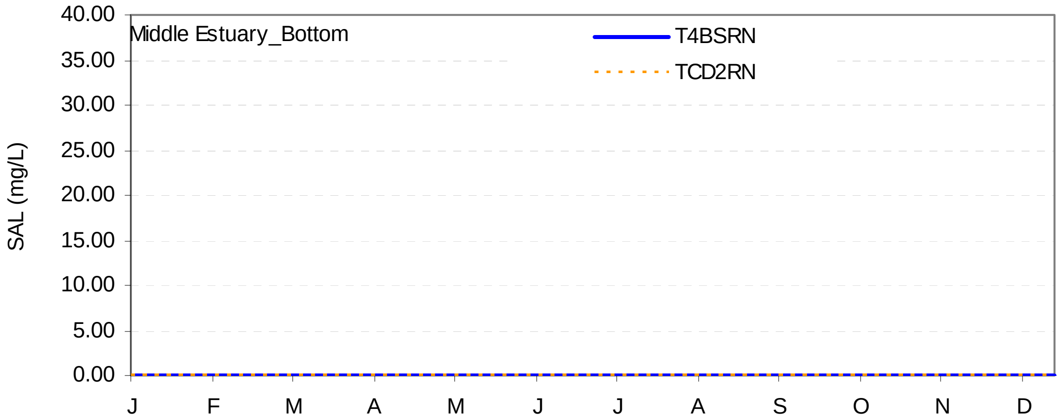


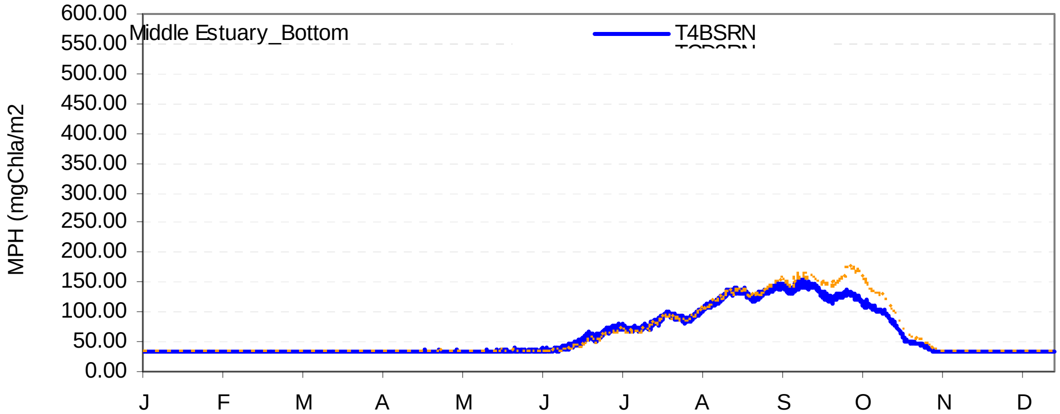

Middle Estuary_Bottom
T4BSRN
TCD2RN
NO3 (mg/L)
1.50
1.25
1.00
0.75
0.50
0.25
0.00
J
F
M
A
M
J
J
A
S
O
N
D


Middle Estuary_Bottom
T4BSRN
TCD2RN
TP (mg/L)
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
J
F
M
A
M
J
J
A
S
O
N
D

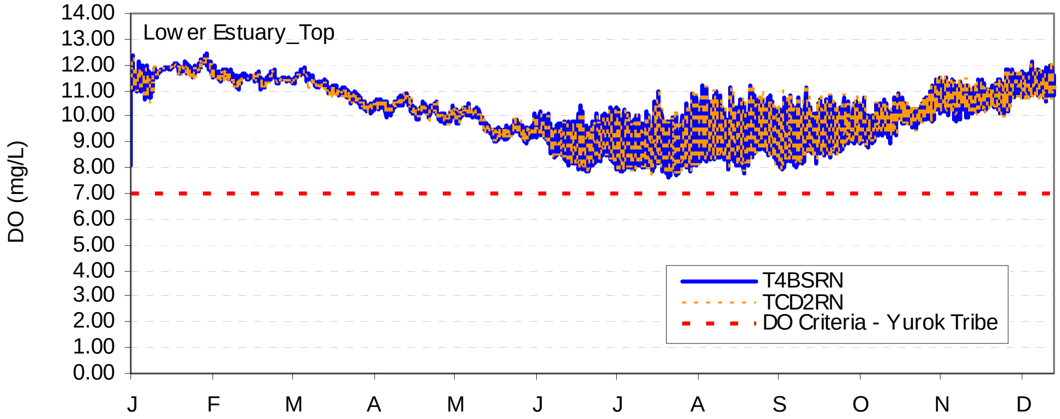

Middle Estuary_Bottom
T4BSRN
TCD2RN
TN (mg/L)
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
J
F
M
A
M
J
J
A
S
O
N
D

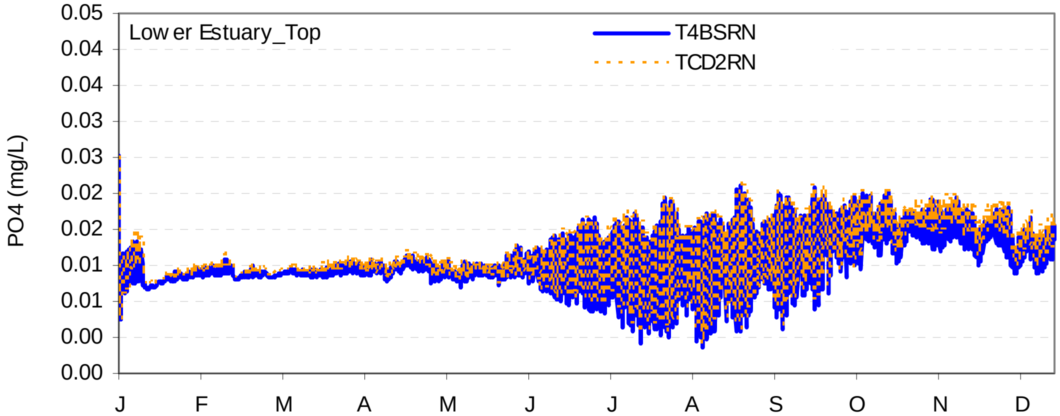

Middle Estuary_Bottom
TEM (degC)
26.00
24.00
22.00
20.00
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
T4BSRN
TCD2RN
MWAT Criteria - Yurok Tribe
MWAT - T4BSRN
Max Temperature Criteria - Yurok Tribe
J F M A M J J A S O N D

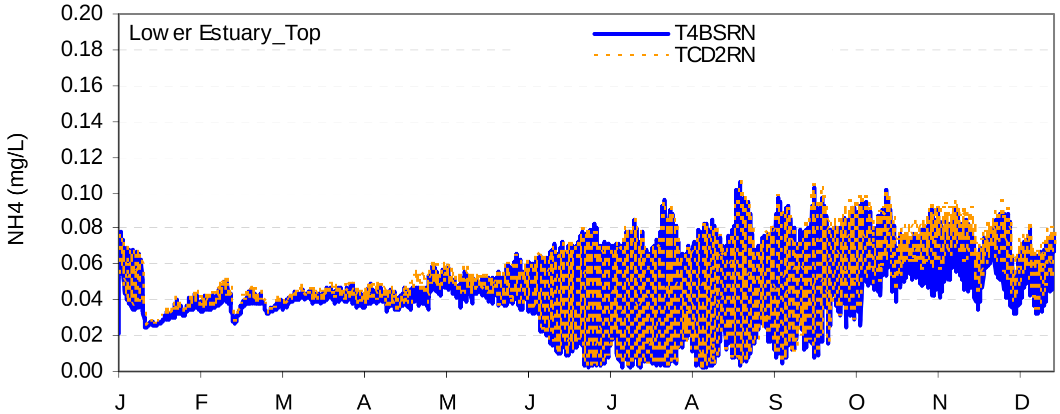

Middle Estuary_Bottom
SAL (mg/L)
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
T4BSRN
TCD2RN
J F M A M J J A S O N D

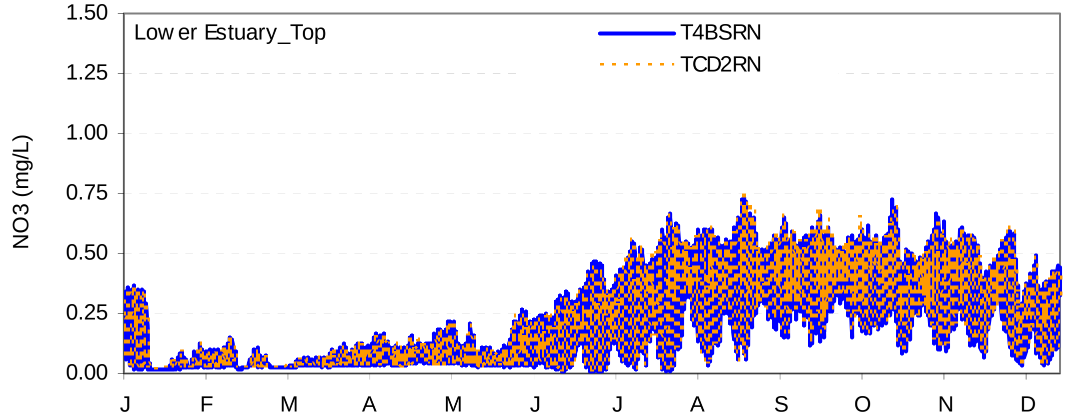

Middle Estuary_Bottom
MPH (mgChla/m2
600.00
550.00
500.00
450.00
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
T4BSRN
J F M A M J J A S O N D

Lower Estuary - Top

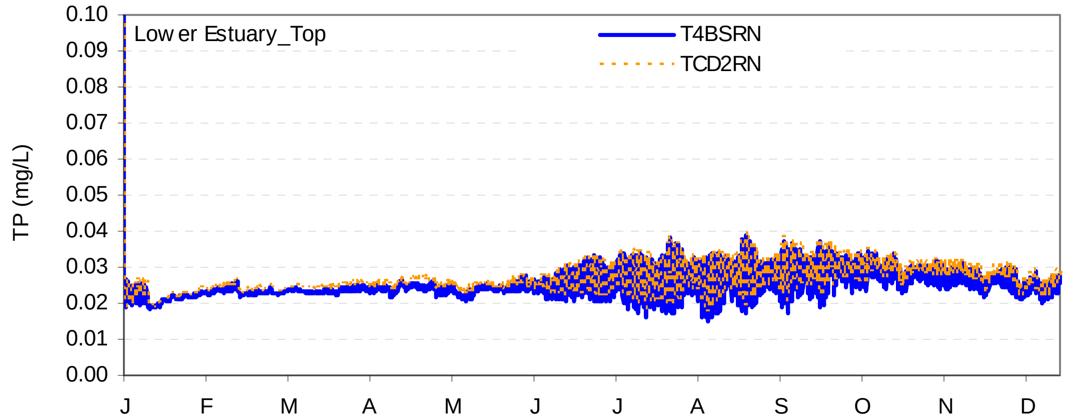




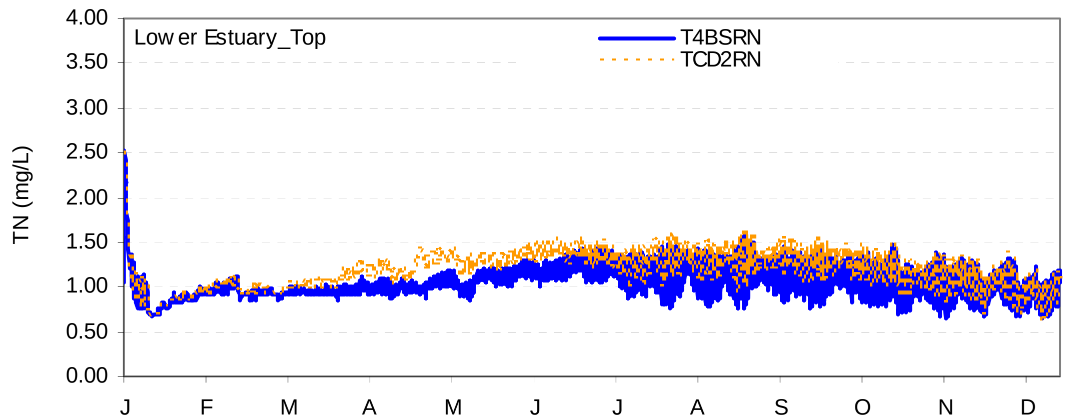




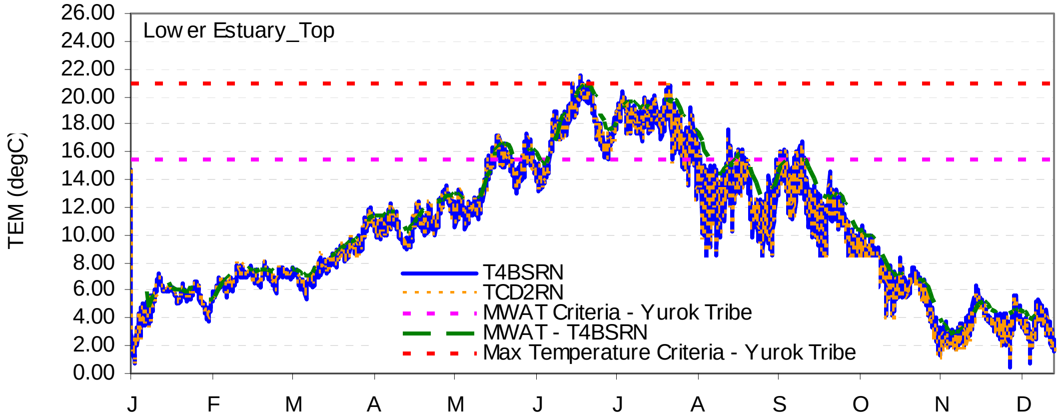
Low er Estuary_Top
T4BSRN
TCD2RN
NO3 (mg/L)
1.50
1.25
1.00
0.75
0.50
0.25
0.00
J
F
M
A
M
J
J
A
S
O
N
D

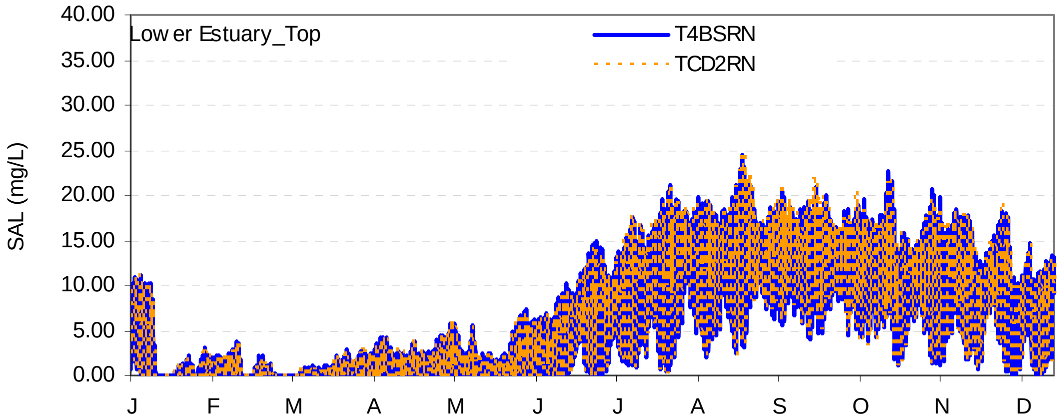


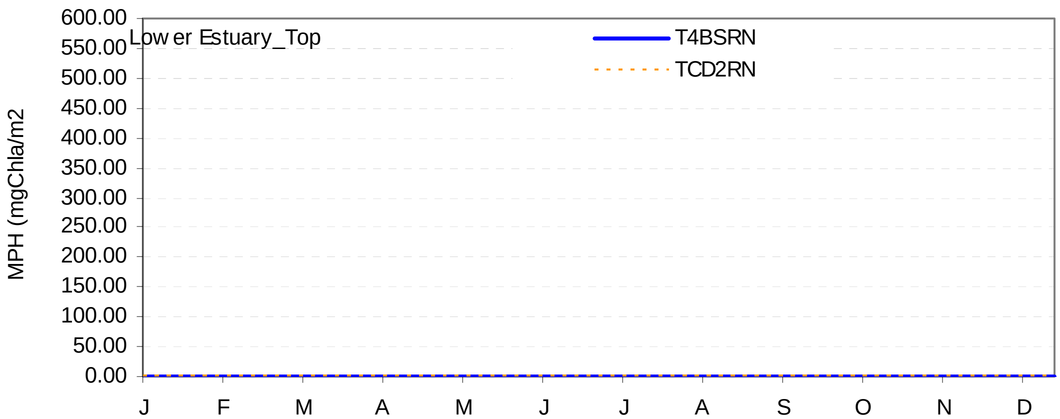
Low er Estuary_Top
T4BSRN
TCD2RN
TP (mg/L)
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
J
F
M
A
M
J
J
A
S
O
N
D



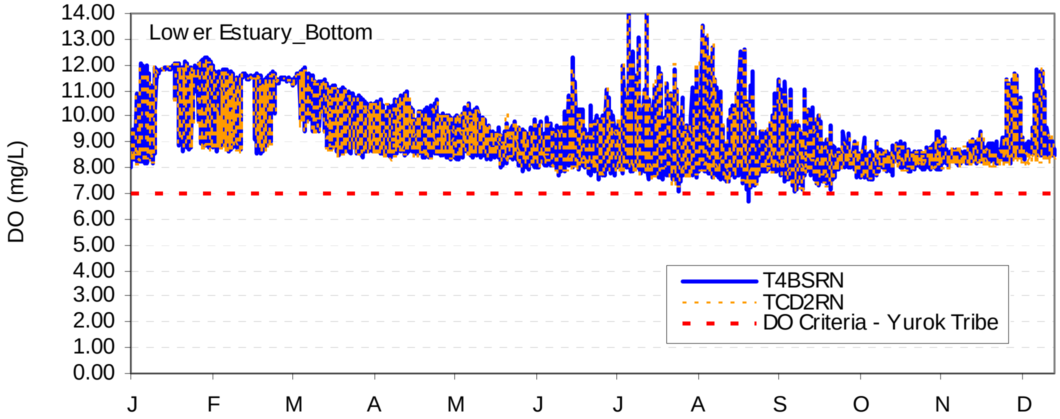
Low er Estuary_Top
T4BSRN
TCD2RN
TN (mg/L)
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
J
F
M
A
M
J
J
A
S
O
N
D

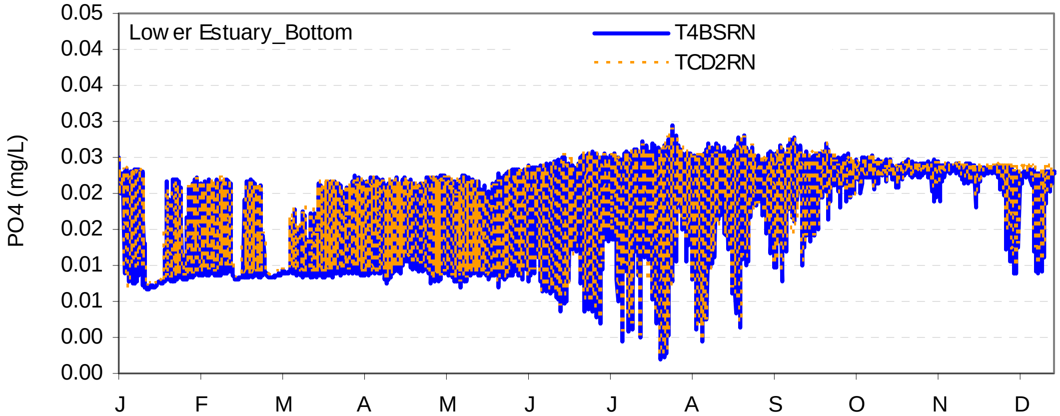

Low er Estuary_Top
TEM (degC)
26.00
24.00
22.00
20.00
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
J F M A M J J A S O N D
T4BSRN
TCD2RN
MWAT Criteria - Yurok Tribe
MWAT - T4BSRN
Max Temperature Criteria - Yurok Tribe

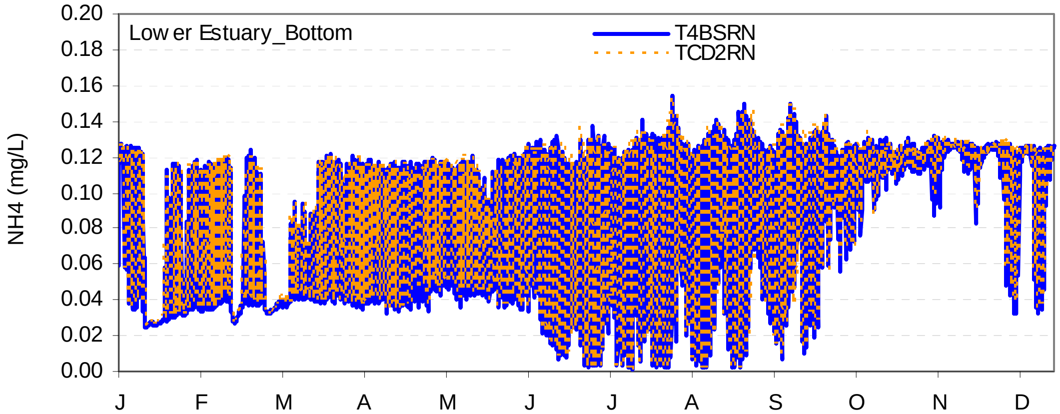

Low er Estuary_Top
SAL (mg/L)
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
J F M A M J J A S O N D
T4BSRN
TCD2RN

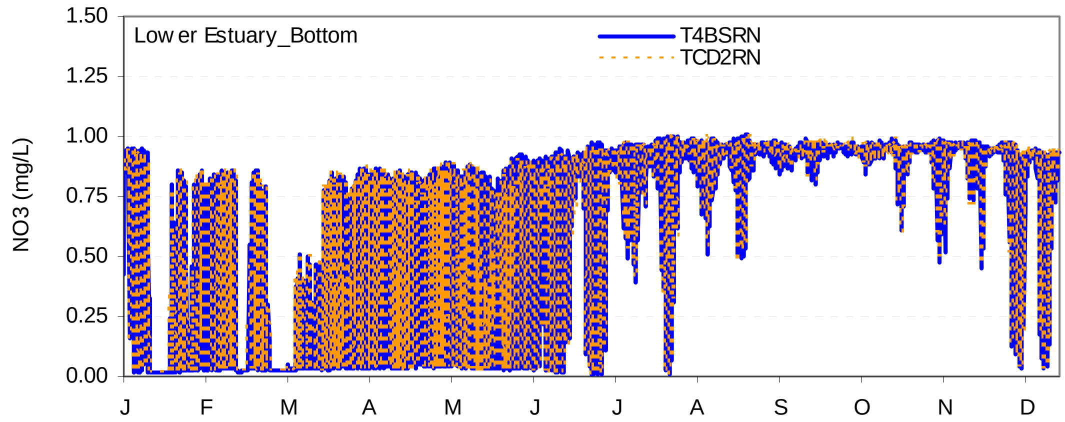

Low er Estuary_Top
MPH (mgChla/m2
600.00
550.00
500.00
450.00
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
J F M A M J J A S O N D
T4BSRN
TCD2RN

Lower Estuary - Bottom

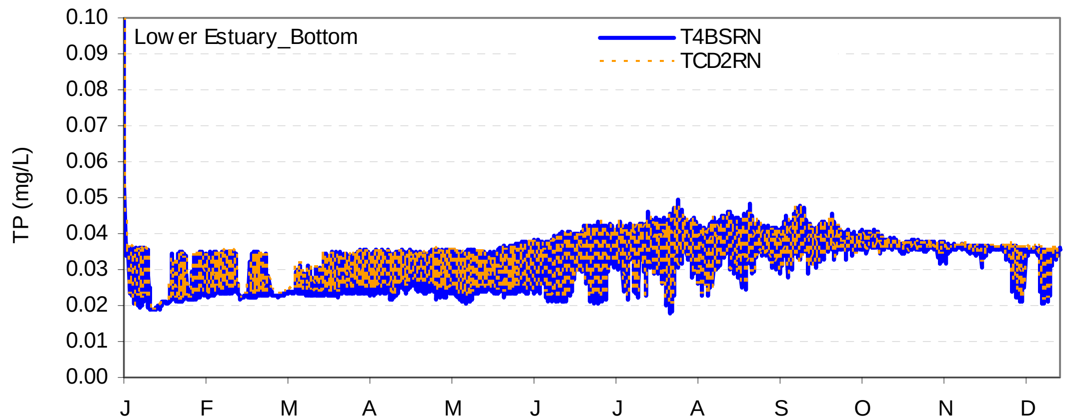




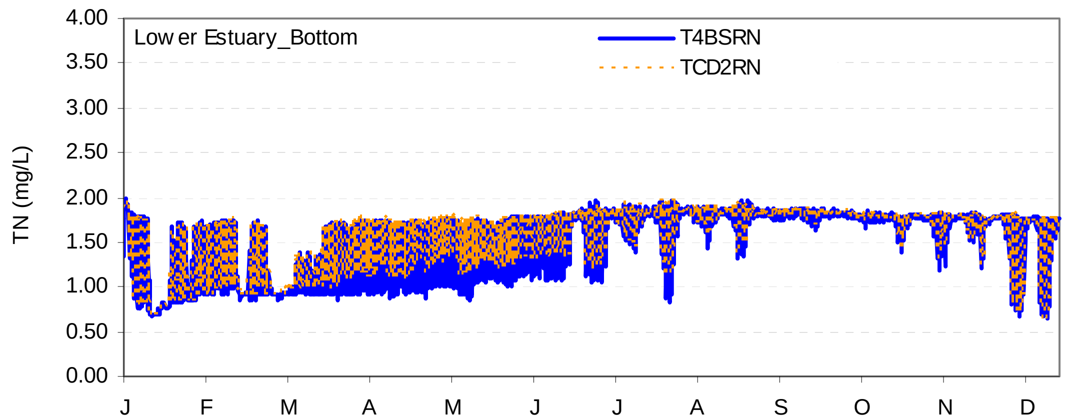




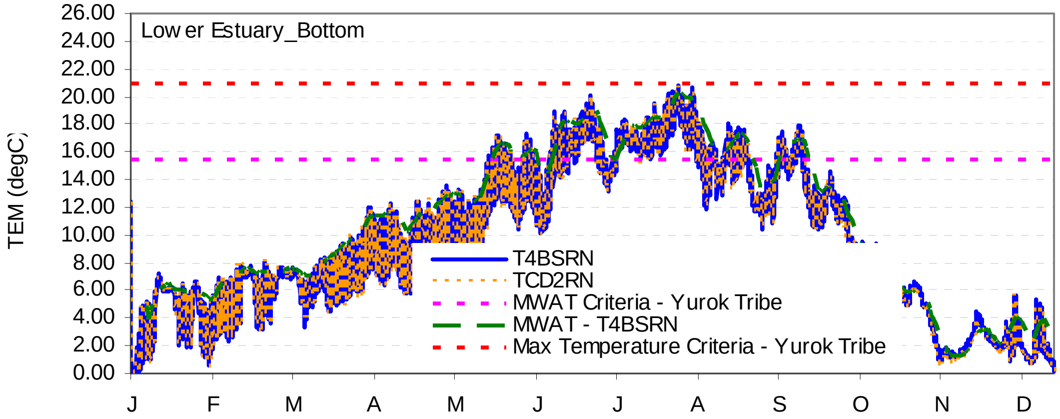
Lower Estuary_Bottom
T4BSRN
TCD2RN
NO3 (mg/L)
1.50
1.25
1.00
0.75
0.50
0.25
0.00
J F M A M J J A S O N D

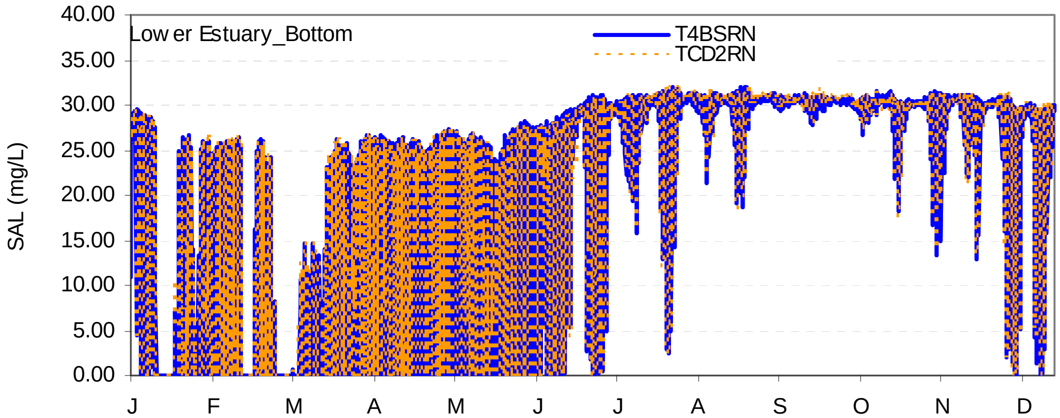


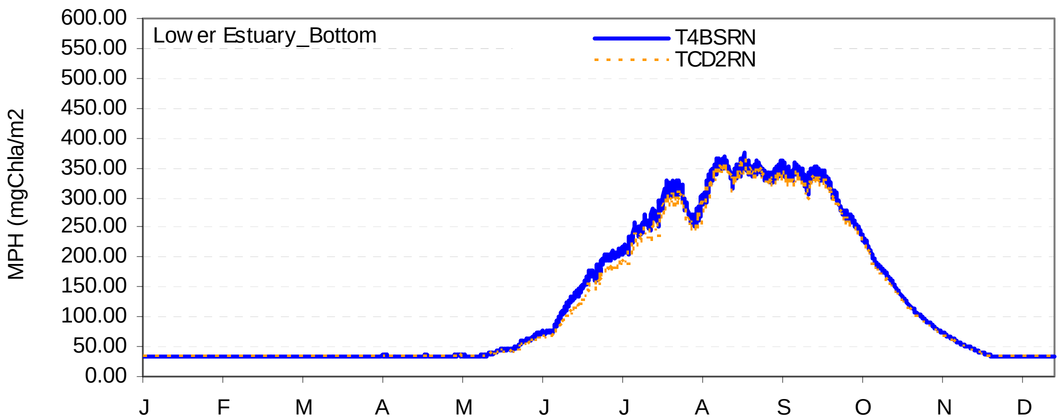
Lower Estuary_Bottom
T4BSRN
TCD2RN
TP (mg/L)
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
J F M A M J J A S O N D



Lower Estuary_Bottom
T4BSRN
TCD2RN
TN (mg/L)
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
J F M A M J J A S O N D


TEM (degC)
Lower Estuary_Bottom
T4BSRN
TCD2RN
MWAT Criteria - Yurok Tribe
MWAT - T4BSRN
Max Temperature Criteria - Yurok Tribe
26.00
24.00
22.00
20.00
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
J F M A M J J A S O N D


SAL (mg/L)
Lower Estuary_Bottom
T4BSRN
TCD2RN
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
J F M A M J J A S O N D


MPH (mgChla/m2
Lower Estuary_Bottom
T4BSRN
TCD2RN
600.00
550.00
500.00
450.00
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
J F M A M J J A S O N D

APPENDIX 8

Response to Peer Review Comments on Draft Klamath River TMDLs

North Coast
Regional Water Quality Control Board
June 2009

1.1 Introduction

In accordance with Section 57004 of the California Heath and Safety Code, the North Coast Regional Water Quality Control Board (Regional Water Board) is required to receive external scientific peer review of the scientific basis of any proposed amendment to the *Water Quality Control Plan for the North Coast Region* (Basin Plan). For the Klamath River TMDL, the proposed Basin Plan amendment (BPA) will incorporate the Action Plan for the Klamath River Temperature Dissolved Oxygen, Nutrient, and MicrocystinTotal Maximum Daily Loads (TMDL), supported by the TMDL Staff Report. Therefore, the Peer Review Draft Staff Report for the Klamath River TMDLs was reviewed by four peer reviewers. The reviewer's comments and Regional Water Board staff responses are presented below.

1.2 Response to Peer Review Comments

Comments of: Christopher A. Myrick, Ph.D.
Colorado State University
Department of Fish, Wildlife, and Conservation Biology

Comment M1:

Nutrient allocations and chlorophyll-a, Microcystis aeruginosa, and microcystin numeric targets to Copco 1 and 2 and Iron Gate Reservoirs developed to control bluegreen algae blooms, associated toxins, and protect recreation and cultural beneficial uses.

The methods used to develop the proposed TMDL for nutrient allocations appear to be based on sound scientific practices and principles. Unlike some of the earlier work in the Klamath system that focused solely on the Klamath River mainstem, the information used to develop the TMDLs also incorporated contributions from tributary streams. It was also good to see the acknowledgement that the upper Klamath River region has a high natural nutrient load that historically caused significant blooms of phytoplankton and other forms of algae.

One concern with the nutrients/organic matter standards (Table 5.1) proposed for the Iron Gate Hatchery is that it may not be realistic to expect the hatchery to be able to achieve a zero net increase of nutrient and organic matter loads between the hatchery intake(s) in the reservoir and the hatchery discharge. By their very nature fish hatcheries will produce organic matter (excess feed, fish wastes, etc.) and while the use of settling ponds and careful control of feeding rates can reduce the amount of organic matter produced, they do not wholly eliminate it.

The use of the established World Health Organization standards for microcystin drew upon a body of existing public health research and by selecting the low heath effect level (<4 µg/L) shows due concern for minimizing the impacts on beneficial uses of the river. The correlations between the microcystin and the *M. aeruginosa* cell density research cited in the development of the *Microcystis* standard (e.g., Figure 2.5) seem appropriate.

Response M1:

The project team wanted to make use of the large amount of monitoring data and scientific literature that was available regarding the Klamath Basin when developing the nutrient allocations and associated targets because in a naturally eutrophic system the margin for error for increases above background is very small. Phytoplankton blooms in Upper Klamath Lake, both natural background and the more extreme existing conditions, have an impact on downstream water quality. However, the bulk of the organic algal biomass reaching the location on the Klamath River now occupied by Copco 1 and 2 and Iron Gate Reservoirs is not actively growing or reproducing. It is when the Klamath River waters are slowed by the reservoirs, creating lake-like conditions, that phytoplankton growth increases to the point of creating nuisance conditions during the summer growing season.

The Iron Gate Hatchery discharge requires an NPDES permit and the discharge requirements of that permit must be consistent with the TMDL. The facility location provides limited space for treatment options for process water. PacifiCorp and California Department of Fish and Game, the co-permitees, will be required to meet discharge limits specified by the revised NPDES permit issued by the Regional Water Board to Iron Gate Hatchery. NPDES permits and TMDLs can incorporate compliance schedules that can take into account special circumstances that may require additional time to get the appropriate treatment technologies into place. A compliance schedule adopted as part of the permit would consider the time needed for the permittees to make any infrastructure improvements to the hatchery and to implement management measures that meet TMDL allocations. As described in the Implementation Plan, the hatchery may be able to achieve any remaining required load reductions through offset mitigation that would be coordinated through the Klamath tracking and accounting program being developed as part of the Klamath implementation plan. The final point is that the technical TMDL must assign allocations to all sources to the levels needed to meet water quality standards, without consideration of feasibility. During the implementation phase of the TMDL alternative strategies for achieving load reductions can be evaluated.

The initial Klamath TMDL targets for chlorophyll-a, *Microcystis*, and microcystin were derived from "*Technical Approach To Develop Nutrient Numeric Endpoints for California*" (Tetra Tech 2006) and other technical literature. Using monitoring data collected in Iron Gate and Copco Reservoirs, the project team was able to make a site-specific confirmation of the initial target values.

Comment M2:

Temperature and dissolved oxygen allocations to Copco and Iron Gate Reservoirs developed to support salmonid beneficial uses.
Iron Gate and Copco 1 and 2 reservoirs currently experience summer conditions that are stressful, at best, for the resident salmonids. Based on the information in the supporting documents and the draft TMDL, there are times when salmonids will experience lethal combinations of high temperatures and low dissolved oxygen levels. The approach taken in the proposed TMDL of a compliance lens (see Figure 5.9) is an interesting one, and in

theory would provide the fish with narrow band of water with tolerable temperatures (< 19°C) and dissolved oxygen levels (> 85% saturation). Research on resident and anadromous salmonids in California suggests that they can maintain their body condition when exposed to temperatures in this range, and provided that the "compliance lens" affords them sufficient access to food resources, it should provide a useful refuge against a temperature-oxygen "squeeze". One question about this approach is whether such a lens will form given the thermal and hydraulic conditions in the reservoir, and, if it does form, whether it will persist in the face of stochastic events such as strong winds.

An additional comment on the temperature and dissolved oxygen allocations is that their intention is to support the COLD fish (i.e., salmonids), yet there are other native species (see reports by Moyle [2002] and the National Research Council [2004] {#3913} for a comprehensive list of the species present) in the system that deserve protection, especially in light of studies (e.g. Castleberry and Cech 1993 that demonstrate that the other native fishes are affected by elevated temperatures and low dissolved oxygen levels. These fish might benefit from the standards, but it would be useful to conduct a more comprehensive evaluation of how the standards would affect them.

Response M2:

The TMDL Monitoring Plan (Chapter 7) recommends sampling to determine the integrity of the compliance lens. The minimum required thickness of the compliance lens is equal to depth of the river under a pre-disturbance regime. PacifiCorp's 2009 Reservoir Management Plan evaluates the potential for aerating the entire water column for both fishery support and to inhibit nutrient export from bottom sediments.

The Regional Water Board has evaluated the life-cycle requirements of other aquatic life present in the reservoirs and has determined that the existing proposed compliance lens allocation specifications for temperature and dissolved oxygen are adequate to protect the most sensitive resident species, as well as anadromous species should fish passage for the dams be provided.

Comment M3:

Analysis of tributary effects of tributary stream flow rates on stream temperatures in the tributaries and mainstem of the Klamath River.

With the realization that conditions in the Klamath mainstem immediately below Iron Gate Reservoir can reach marginal levels (particularly in terms of temperature) during the hottest summer months, the inclusion of the tributary contributions as a function of their stream flow rates is very useful. The tributaries have historically been an important component of the system, both a spawning and rearing habitat for some of the anadromous salmonids, the provision of thermal refugia, and as sources of cooler, cleaner water, and ignoring those, as some previous studies have done, would have been fundamentally unsound (National Research Council 2007). As was the case with the nutrient standards, it was gratifying to see a modeling effort on the Klamath system that included the contributions of the tributaries to the thermal status of the system. The reviewer does not have enough of a background in hydraulic modeling to comment upon the technical nature of the modeling approach.

Response M3:

Thank you for your comment.

Comment M4:

Assessing the linkage between water quality and fish disease.
Fish diseases, in particular *Ceratomyxa shasta* and Columnaris have been repeatedly cited as major fish health concerns in the Klamath basin, particularly given the high summer water temperatures and generally stressful conditions that can predispose fish for infection. The report summarizes the most recent information available on the relationship between disease and temperature, and also mentions the potential effects of the increased organic matter and nutrient load on the secondary host (polychaete worms). The proposed temperature standards for the Iron Gate Reservoir tailrace and the Iron Gate Hatchery (18.8°C) should provide some protection against severe disease outbreaks, although the temperature does fall within the range categorized as having a high disease risk for juvenile rearing and adult migration. Nevertheless, given the natural conditions in the Klamath system above Iron Gate, it is unlikely that a much lower temperature could be achieved.

Response M4:

The relationship between the prevalence of fish disease and water quality conditions continues to be a very active area of research on the Klamath River with the results being reported at the annual Klamath River Fish Health Conference in Fortuna, California. Temperature is definitely an important component of the fish disease cycle but other water quality conditions contribute as well.

The temperature targets for the Iron Gate tail race and hatchery are not standards, but are interpretations of the conditions that meet the standard, which in this case are natural temperatures. Therefore, the Iron Gate tail race and hatchery targets were developed based on natural conditions, as opposed to conditions that fully support the beneficial use.

When implemented, the TMDL Monitoring Plan will provide information that enables continued development of a fish disease model that will contribute to an improved understanding of the effect of degraded water quality conditions on fish disease in the Klamath River.

Comment M5:

Overall, the proposed total maximum daily loads for temperature, dissolved oxygen, organic matter, and nutrients have been developed using information from a wide variety of scientific sources, and using established scientific principles. While the reviewer does have some minor concerns about the implementation of the standards, and in particular about whether the “compliance lens” will function in reality as well as it does as a conceptual model, there is nothing in the draft TMDL document to warrant a comprehensive revision. The reviewer does hope, however, that once the TMDLs are adopted and implemented, the North Coast Regional Water Quality Control Board will

continue to evaluate new data as it is collected and adjust the total maximum daily loads as necessary. The Klamath River system is a dynamic one, and the ongoing anthropogenic and climatic changes may lead to additional changes in the basin's hydrology and ecology that will require modification of the TMDLs in the future.
Response M5: The Regional Water Board will ensure that monitoring measures are included that will allow for evaluation of compliance lens effectiveness. The Regional Water Board is also dedicated to the concept of adaptive management, which requires continued data collection, data review and assessment, and updating TMDL implementation measures.

Comments of: Dr. Gregory W. Characklis
University of North Carolina at Chapel Hill
Department of Environmental Sciences and Engineering

Comment C1:

After reviewing these documents, my overall opinion is that the plan makes use of contemporary mechanistic water quality models that are based on sound scientific principles, and that the (largely) deterministic results appear to be reasonable given the data and information available. That said, my primary concern is that even state-of-the-art water quality models parameterized with extensive datasets are not terribly accurate, and are often unable to predict contaminant concentrations or loadings with what most would consider to be a reasonable level of accuracy. This shortcoming is certainly apparent throughout the peer-reviewed literature (e.g., Dorner et al. 2006; Reckhow 2003; Stow et al. 2003) and was a central theme in the National Research Council's 2001 report, "Assessing the TMDL Approach to Water Quality Management," which recommends explicit treatment and discussion of uncertainty as a part of the TMDL process. Consequently, reliance on deterministic modeling results without giving due attention to the (often substantial) levels of uncertainty attendant with these estimates can provide an incomplete picture to those seeking to interpret these analyses for decision making purposes. While I understand that there will never be enough data to fully characterize a complex natural system such as the Klamath, and that decisions of this kind must often be made without the benefit of complete information, characterizations of the nature and importance of gaps in data and understanding should be more explicit. Therefore, my primary suggestion would be that a more concerted effort be directed toward the evaluation and communication of the uncertainty inherent in these models. General comments related to this issue are provided below. Also included are sections that address the specific questions posed in the request for review.

Within the review documents, many of the determinations regarding the degree of allowable contaminant loading and the sources of that loading are made on the basis of comparisons between model estimates of "natural" background levels (made mostly without data) and model estimates of current conditions (some of which are made with the benefit of a calibration step involving current data). As such, it seems appropriate that a greater level of effort be taken to more clearly describe the degree of uncertainty attendant with both of these estimates. This will provide a better understanding of the probability that a given set of mitigating actions will have the intended result.

Concerns over the lack of attention to the uncertainty issue are heightened by several additional issues, mostly related to the issues of model calibration and subsequent "corroboration" (a term which I interpret as being intended to substitute for the more commonly used term "validation"). First, while effort was expended in calibrating the model for all 9 river segments using one year's (2000) worth of data, attempts to "corroborate", and thereby evaluate model performance independently, seem to have only been undertaken in a couple of upstream segments (i.e. those residing almost exclusively in Oregon)1. None of the California segments appeared to undergo any type of validation/corroboration analysis (with the exception of the estuary, segment 9). Predictions based on water quality models, even the most advanced models parameterized with extensive data sets, are often highly divergent from observations, and without any evaluation of model performance, it difficult to place a high level of confidence in these modeled results. This would seem to be relevant given that one of the central themes in the analysis involves comparing model results from "current" conditions with the results of models designed to estimate "natural" background conditions. Furthermore, it appears that in some cases relatively small deviations between modeled estimates of current and natural conditions serve as the basis for a decision on the location and magnitude of a loading reduction. While the choice as to whether or not these models are accurate enough to reasonably support decisions on actions is a matter for policymakers to decide, I think that some quantification and presentation of the uncertainty associated with these estimates would greatly facilitate more informed decisions.

I am aware and sympathetic to the argument that academics think there is "never enough data", but still believe that there may be opportunities to better convey the level of uncertainty in modeled estimates. Along those lines, it appears that the corroboration/validation efforts were limited by both data availability and the cost associated with doing additional modeling (explanation given Chapter 3, pg. 7). I do not know the relative roles that each played in the decision to forego the validation step, and of course if there are no data available to undertake additional modeling, that is one issue (although one that might be revisited). However, if data availability is not limiting, I would offer some suggestions.

If sufficient data on current conditions exists to reasonably validate the model for the lower (i.e. California) segments of the Klamath basin , a more rigorous quantitative approach to evaluating the confidence intervals associated with estimates of current conditions would allow for a more informed comparison of current and natural conditions. In addition, while historical data on "natural" conditions are not likely to be available, some attempt at a sensitivity analysis, including an identification of the most sensitive model inputs and an evaluation of the impacts that varying these inputs has on model estimates of water quality, would provide some sense of model limitations (as currently presented, at least in Figures 2.15 and 2.16, it appears that there is very little uncertainty in modeled natural conditions). In the event that data on current conditions in the lower segments (6-9) is lacking, such a sensitivity analysis could be undertaken here as well. Some justification for the ranges of input values selected would also be informative.

I might also suggest that if increased efforts are made to collect water quality data in the system, either as a part of this or subsequent efforts, some careful planning involving consideration of a joint modeling and monitoring approach might be useful. Current advancements in the science of merging observations and modeling results in water quality can significantly reduce the costs of rigorously characterizing conditions in a river system (LoBuglio et al. 2007; Money et al. 2009) and might be worth investigating at some point.
The existing data seems to suggest that human activities are contributing to water quality

impairment in the Klamath Basin. Nonetheless, the degree to which this impairment is occurring and the level to which current conditions deviate from natural conditions is very difficult to determine using modeling as a primary analytical tool. I understand that this may be all that is currently available, but believe that a more explicit treatment of the uncertainty associated with modeling results will provide decision makers with a more informed basis for making policy choices. Let me reiterate that I find the models to be consistent with sound scientific principles, and the most up-to-date thinking on water quality models, the simple fact is that even state-of the-art water quality models are not terribly accurate. And, while one could always take issue with individual assumptions or particular input values, I am not sure that one set of choices would necessarily be better than others. I do believe, however, that the lack of explicit attention to the uncertainty issue could leave the impression that these models are more accurate than they actually are. Consequently, a more concerted effort to evaluate and communicate the uncertainty inherent in these models would seem appropriate.
Response C1: Regional Water Board staff appreciate the reviewer's comments regarding uncertainty in the TMDL models, and recognize the value of uncertainty analysis. The Klamath TMDL development team (Regional Water Board, ODEQ, US EPA Regions 9 and 10, and TetraTech) considered how best to assess and quantify model uncertainty. Due to the size and complexity of the Klamath River, limited resources, and schedules, it was determined that quantitative uncertainty analyses and formal, quantitative sensitivity analysis were not feasible. However, the TMDL development team strove to minimize uncertainty in other ways. Development and application of the Klamath River TMDL model has focused on key best practices identified in EPA's March 2009 "Guidance on the Development, Evaluation, and Application of Environmental Models," including peer review of models; QA project planning, including data quality assessment; and model corroboration (qualitative and/or quantitative evaluation of a model's accuracy and predictive capabilities). The Regional Water Board, ODEQ, US EPA Regions 9 and 10, and TetraTech have collaborated very closely over a five year period during the Klamath River TMDL modeling process at both technical and policy levels. In addition to the key practices noted above, model sensitivity and uncertainty analysis have been considered though to a lesser extent. Appendix 5 of the Klamath TMDL Staff Report, "Model Configuration and Results - Klamath River Model for TMDL Development" (Tetra Tech 2008a) details model assumptions, limitations, and uncertainty. A formal, quantitative sensitivity analysis was infeasible due to the computational complexity of the Klamath River TMDL model. However, the sensitivity of important water quality conditions to various parameters and external forcing functions was indirectly analyzed through the iterative model calibration process. Model calibration and corroboration (aka "validation") involved repeated adjustment of model parameters and boundary conditions (which were based on available data) in order to achieve the best match between predictions and observations. This process inherently considered the

sensitivity of model processes to influencing factors. Through this process and the more than forty subsequent allocation runs, it was clear that the model results are primarily driven by the magnitude and timing of boundary condition contributions (i.e., incoming loads from upstream and lateral boundaries). Model parameter sensitivity is much less influential. Therefore, the major focus of Klamath River TMDL model refinements was on acquiring and incorporating the most accurate and comprehensive data describing boundary conditions to reduce uncertainty.

Model corroboration was conducted for the Oregon segments of the Klamath River (Model Segments 1 through 5) for 2002. 2002 was selected for model corroboration because considerably more data were available for the upper portion of the river in 2002 than for other years. While cost was a factor, the model was not run downstream (Segments 6 through 9) for 2002 primarily due to limited boundary data for the downstream segments. In general, boundary condition data are limited in terms of representing the full range of temporal, spatial, and parameter variability. Thus, it is very likely that evaluation of additional calibration/corroboration would be more tied to data limitations/ uncertainty than model performance.

Model assumptions, limitations, and sources of uncertainty were identified in the TMDL and modeling reports, however a quantitative uncertainty analysis was deemed inappropriate. Uncertainty analyses such as interval number, fuzzy parameter, Monte Carlo, and Bayesian are not applicable to the Klamath River TMDL model due to the model's computational complexity and the development/application timeframe. Running the Klamath River TMDL model requires more than 4 days of continuous simulation using a 2.66 Ghz duo-core computer and results in generation of over 5 GB of results. It's simply not practical to run hundreds, thousands, or tens of thousands of scenarios to support an uncertainty analysis. In addition to computational limitations, a quantitative uncertainty analysis usually requires knowledge of the statistical distribution of data and parameters. This is not possible for the Klamath River TMDL model due to spatial and temporal data limitations. Data are generally only available during a snapshot in time at a particular location. Quantitative uncertainty analysis would provide a very limited assessment of the situation. Data limitations are largely the reason that a quantitative error analysis was also not performed on the water quality simulation. Rather, time series plots of model results versus observed data were evaluated. They provide more insight into the nature of the system and are more useful than a statistical comparison. Trends in the observed data and cause-effect relationships between various parameters can be replicated with a model, although precise values at each and every point in time may not be. In addition to computational and data limitations, uncertainty associated with the underlying model theory and its mathematical representation cannot be quantified either.

In addition to the application of the TMDL model, other lines of evidence were applied to assist in confirming allocations and targets, such as the California Nutrient Numeric Endpoints analysis (see Appendices 2 and 3), tributary temperature modeling (see Section 3.3.3.2), and statistical analysis of empirical data (see for example Section 2.3.2.2) . In addition, the Regional Water Board, ODEQ, and EPA Regions 9 and 10 have developed a Memorandum of Agreement (MOA) that establishes a framework for joint implementation of the Klamath River TMDLs. Among other things, the MOA includes agreements to:

- Work to develop and implement a joint adaptive management program, including joint time frames for reviewing progress and considering adjustments to TMDLs;
- Work with the Klamath Basin Water Quality Monitoring Coordination Group and other appropriate entities to develop and implement basinwide monitoring programs designed to track progress, fill in data gaps, and provide a feedback loop for management actions on both sides of the common state border; and
- Work to develop and implement a basinwide water quality accounting and tracking program that would establish a framework to track water quality improvements, facilitate planning and coordinated TMDL implementation, and enable appropriate water quality offsets or trades.

Regional Water Board staff's intent is for these implementation actions to minimize uncertainties and to inform decisions related to any adjustments / modifications to the TMDL that may need to be made.

Based on all of these considerations, Regional Water Board staff believe that the Klamath River TMDL models are performing well and are suitable tools for establishing Klamath River TMDL allocations and targets.

Comment C2:

1) **Nutrient Allocations and chlorophyll-a, *Microsystis aeruginosa*, and microsystin numeric targets for Copco 1 and 2 and Iron Gate Reservoirs developed to control bluegreen algae blooms, associated toxins, and protect recreation and cultural beneficial uses.**

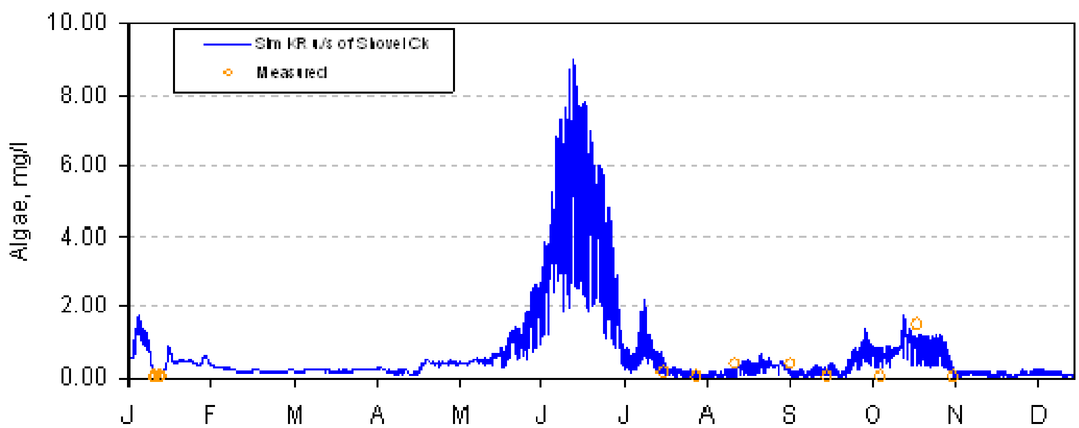
The use of chlorophyll-a as an indicator of algal growth, including Microsystis *aeruginosa*, and the accompanying microsystin seems supportable given the data presented in Figures 2.1-2.6. Similarly, the choices of target values for these three parameters seem reasonable. I am less sure of the nutrient allocations and whether the targets suggested can be fully supported by the evidence presented. There is very little effort directed toward characterizing the degree to which nutrient inputs contribute to increased algal growth. Model runs to determine algal and chlorophyll-a concentrations were undertaken for river segments upstream of the reservoirs, in particular segment 5, but in this case the models tended to substantially overpredict both, by several multiples in most cases (Figures H-17, H-24, H-31 and H-39). While the instream models are different from that (CE-QUAL) used to model the reservoirs, it does not provide a high degree of confidence that the nutrient input targets are an accurate indicator of the outcome in terms of reducing chlorophyll-a, *Microsystis aeruginosa*, and microsystin to desired levels.

Further downstream in Copco and Iron Gate reservoirs, observations of chlorophyll-a concentrations are used to calibrate the CE-QUAL model across a range of depths on several dates (Figures I-6 and J-6). Unfortunately, there is no validation exercise, and the scale on the horizontal axis of the calibration figures is in mg/l (the standard for chlorophyll-a is measured in ug/l) making it difficult to determine the relative degree of accuracy inherent in the calibration exercises. As a result, the linkage between nutrient inputs and the biological endpoints of primary interest (i.e. chlorophyll-a, *Microsystis aeruginosa*, and microsystin) is unclear, and I would have liked to have seen a more explicit rendering of the uncertainties associated with these predictions.

Response C2:

Nutrient contributions to increased algal growth are represented in the Klamath River TMDL model using modern water quality modeling technology. Both phytoplankton and periphyton are represented in the system. The prevalence of one category of algae versus the other depends on the characteristics of the segment. Nutrient impacts on phytoplankton are significant only in the reservoirs, where water retention time is long enough to enable algae to grow. In the fast-flowing riverine segments, such as segment 5, phytoplankton growth is insignificant. Thus, the algae biomass in the riverine reaches is not related to the nutrient concentration. The simulated phytoplankton biomass is similar to the observed data in segment 5 and other segments.

In a number of situations it appears that the model over-predicts chlorophyll-a levels. Predictions for the Klamath River at Shovel Creek (as shown below) exhibit high concentrations in the middle of the year. This occurs largely due to upstream conditions being carried downstream, and do not reflect in-river growth. In many of these situations, chlorophyll-a data are not available for comparison.



Although the Copco and Iron Gate model segments were not corroborated for an independent time period, calibration results for the reservoirs demonstrate that the model predicts trends in the observed data with respect to algae growth. It's acknowledged that the scales in Figures I-6 and J-6 don't provide tremendous resolution, however, even at the resolution presented the model clearly predicts increased chlorophyll-a levels during the summer and early fall. Corresponding data in the plots (at the surface) also show this trend.

As described in Section 3.3.4, in order to develop a final nutrient reduction allocation for PacifiCorp to control the blue-green algae in Copco and Iron Gate Reservoirs, iterative scenario runs (T4BSRN-C) were conducted using the Klamath River TMDL model for segments 6 and 7, to obtain desired nutrient concentrations under which the numeric target of 10 ug/L of chlorophyll-a at the surface of the two reservoirs is met.

Supporting lines of evidence were also used to develop the nutrient concentration targets for Copco and Iron Gate Reservoirs. The California Nutrient Numeric Endpoints framework and associated steady-state BATHTUB nutrient response model was applied to 2002 and 2005 using intensive monitoring data in Copco and Iron Gate Reservoirs (Tetra Tech, 2008, *Nutrient Numeric Endpoint Analysis for the Klamath River, CA* [Appendix 2 of Staff Report]). The BATHTUB analysis provides a reasonable fit to growing season mean chlorophyll a concentrations observed in the two reservoirs. BATHTUB was also used to determine the nutrient reductions needed to achieve the target of a summer average concentration of 10 µg/L chlorophyll *a.* The BATHTUB analysis suggested that a total reduction in phosphorus load of around 90 percent and a total reduction in total nitrogen load of around 65-70 percent would be needed to achieve the algal concentration target for year 2000, consistent with the reduction needs predicted by the TMDL model. The NNE analysis also looked at cyanobacterial dominance in Iron Gate and Copco Reservoirs using the Blue Green Index. This indicated that current phosphorus concentrations should lead to 50 - 60 percent or more of the algal biomass as cyanobacteria, consistent with observations of cyanobacterial blooms. Under the proposed nutrient targets, the fraction of biomass as cyanobacteria is predicted to decline to 20-25 percent of algal biomass.

Comment C3:

With regard to the allocation of "zero nutrient loading from the reservoir bottom sediments", I have a few questions. Is this intended to mean zero additional, *human induced*, nutrient loading from the bottom sediments, or zero nutrient loading of any kind? If the latter, this seems a bit strange, as I would guess that even in the river's natural state, or a condition in which the reservoir exists without human-induced nutrient loadings, that there are sure to be some natural nutrient additions to the system. Some of these are bound to be in a particulate form and make their way to the sediments where they would contribute some (non-zero) nutrient load on the water column. In either event, the concept of a "zero" allocation target is a difficult one to conceive of in any natural context, and even if it were possible, the evidence presented does not provide a high level of confidence that the biological endpoints will be reached.

Response C3:

The rationale for the "zero nutrient loading from the reservoir bottom sediments" is related to the change in form and timing of nutrient release into to the water column as a result of contact between the anaerobic hypolimnion water column and reservoir sediments. The reservoir, as an anthropogenic structure, has created conditions during summer stratification that result in the release of dissolved inorganic nutrients into the water column which are then transported downstream contributing to biostimulatory conditions below Iron Gate Reservoir, Under conditions present with a free flowing river, a similar release would not occur. The allocation amount was not set solely to address targets within the reservoir. Rather the allocation reflects the estimated contribution of TP and TN released to the water column during the summer stratification period. Section 4.2.2.2 has been revised to better describe the quantification of nutrients released from the reservoir bottom sediments.

Comment C4:

(2) Temperature and dissolved oxygen allocations to Copco and Iron Gate Reservoirs developed to support salmonid beneficial uses.
Dissolved oxygen levels and temperature are clearly linked, and the data and analyses on fish behavior makes a good case that raising D.O. and lowering temperature in the system will enhance fish survival and reproduction. The temperature model seems to calibrate reasonably well for the Copco and Iron Gate reservoirs (Figures I-1 and J-1), but some validation step would have been comforting. That said, I am not sure I understand how the targets for temperature will be met, as the thought that the difference in reservoir inflow and outflow in Copco and Iron Gate can be limited to (on average) 0.1 C and 0.3 C, respectively, seems very unlikely given the temperature data presented in Figures 4.7 and 4.8. The residence time in the reservoirs, and hence the longer exposure to sunlight and, particularly in summer, higher air temperatures would seem to make achieving this goal difficult, even with the understanding that dam releases often involve cooler water from the middle of the water column.

Response C4:

One of the primary tasks associated with the development of TMDLs is the interpretation of water quality conditions, both current and compliant, as they relate to water quality standards. Given that the water quality temperature objectives for temperature require natural temperatures, Regional Water Board staff endeavored to define the natural temperature increase that would be expected in a natural, free-flowing state, and thus define a temperature increase that is compliant with the water quality objectives for temperature. The 0.1 ^{o}C and 0.3 ^{o}C difference in reservoir inflow and outflow in Copco and Iron Gate reservoirs, respectively, represent the temperature increases expected in a free-flowing, natural state.

Comment C5:

The concept of the "compliance lens", while being new to me, is an interesting one and in theory could be quite useful, however, I am skeptical regarding the ability to design a thermal load allocation strategy that will reliably result in such a lens. While it is tempting to view reservoirs as entirely quiescent bodies of water, almost all have circulation patterns driven by wind, inflows, etc. The thought that such a large and complex natural system could be fine tuned to the degree necessary to consistently create a lens with the desired D.O. and temperature conditions strikes me as being very optimistic. Nonetheless, given the information presented in the report, if such a lens could be established, it would appear to offer a "home" to sensitive fish populations, provided they are capable of finding and making use of such regions, and assuming that no other factors (e.g., food availability) impact their ability to remain in them (I know very little about fish behavior/biology, so I am not qualified to offer many useful comments on these issues).

Response C5:

The compliance lens allocation was designed to meet the minimum conditions for beneficial use support. The allocation is required due to conditions caused by the presence of the dams, however specification of how the allocation is met is ultimately the responsibility of PacifiCorp.

Comment C6:

Lastly, I am curious as to why climate change is not explored as a possible reason for increased reservoir and stream temperatures. Surely there is data available on air temperatures in the basin, and it would be relatively easy to look for trends in increasing mean, high and low values over time. If air temperatures have been increasing, particularly increased low temperatures at night (which seem to be where the biggest impacts are observed), this would appear to be an obvious contributor to increased water temperatures in the Klamath. These are certainly "human-induced" increases to thermal load, but local actions to combat these contributions would not likely be effective. As a result, some discussion of this issue, and an analysis of the size of climate change related contributions, if any, to those from other sources (return flows, altered channel dimensions, etc.) would seem to be important when developing mitigation strategies.

Response C6:

Regional Water Board staff have added a discussion of the increase in air and water temperatures in Section 1.6.4, Climate. The added text discusses Bartholow's (2005) findings that average Klamath Basin air temperatures have increased by 0.5 ^{o}C per decade.

Comment C7:

(3) Analysis of the effects of tributary stream flow rates on stream temperatures in the tributaries and Mainstem of the Klamath River.
I hope I have not missed something in this area (and I believe I have exercised due diligence), however if I have not, it appears to me that there is insufficient data and/or evidence to support even general assessments of changes in the thermal conditions of the Klamath tributaries, or to evaluate actions that might mitigate any potential impairment. I understand that professional judgment will play a role in decisions on whether and how to regulate these systems, and that these decisions must often be made without the benefit of sufficient data to conclusively demonstrate that the proposed actions will work as intended. Nevertheless, in this case, the relative dearth of information makes it difficult for me to understand how there is a basis for any considered decisions.

Response C7:

Regional Water Board staff have added a discussion to section 3.3.3.2 of the considerable modeling efforts, and data they rely on, previously completed and that this analysis draws from. A synopsis of the data used as the basis of the previous modeling work, and calibration results are presented here, and included in the text:

"The Heat Source model was previously implemented in the Scott River as part of the Scott River TMDL development process. The original model development, described in detail in the *Staff Report for the Action Plan for the Scott River Sediment and Temperature Total Maximum Daily Loads* (Regional Water Board 2005), was based on:

- comprehensive mapping of the Scott River channel and nearby vegetation using high-resolution aerial imagery,
- substrate and width-to-depth data from habitat typing surveys,
- measured water temperatures at all 11 tributaries with surface connection to the Scott River,
- measured air temperatures at 6 sites distributed along the longitudinal axis of the Scott River,
- measured relative humidity data at 5 sites distributed along the longitudinal axis of the Scott River,
- measured wind speeds at 3 sites distributed along the longitudinal axis of the Scott River,
- periodic flow measurements at 10 sites distributed along the longitudinal axis of the Scott River and the continuous flow record at the "Scott River near Fort Jones" USGS gauge, and
- a thermal infrared survey covering the entire modeled reach (Watershed Sciences, 2004).

The model was calibrated for the August 27 - September 10, 2003, time period using temperature data from 21 sites distributed along the longitudinal axis of the Scott River, and validated using temperature data at 18 sites during the July 28 - August 1, 2003, time period (three sites were not deployed until after August 1, 2003, and were unavailable for validation).
The mean absolute error for the validation period at the 18 sites ranged from 0.5 to 2.4 ^{o}C (0.9 to 4.3 ^{o}F), and averaged 1.1 ^{o}C (2.0 ^{o}F). Average bias of the daily average error for the validation period at 18 sites ranged from –1.9 to 2.1 ^{o}C (3.4 to 3.8 ^{o}F), and averaged -0.2 ^{o}C (-0.36 $_{o}$F). The average bias of the Scott River daily average temperature near the mouth (river mile 0.5) was 0.2 ^{o}C (0.36 ^{o}F).

The Shasta River water quality model is an application of the Tennessee Valley Authority's River Modeling System (version 4), and was originally developed by Abbott (2002). The model was later refined by Deas and Geisler (2004) to take advantage of better refined hydrography data and a relatively large quantity of flow and water temperature data. The model was calibrated and validated using data from 8 flow gauges and 11 water temperature data loggers distributed along the 65.3 km (40.6 mi) simulated length of Shasta River between Dwinnell Dam and the Klamath River (Deas and Geisler 2004)."

Shasta River model validation statistics were added and presented in Table 3.2.

Comment C8: The question of whether or not a thermal impairment exists in these tributaries, and as a result, in the mainstem of the Klamath itself, revolves primarily around a comparison of natural and current conditions. It appears that both sets of conditions are evaluated almost entirely on the basis of modeling results. I could find no evidence that models of temperature in these tributaries had been calibrated with actual observations, much less validated. The only data related to this question appeared to be in Figures 2.11 and 2.13, which show some data on mainstem temperatures at the points where the tributaries enter the mainstem, but do not provide enough information to make any determination of their potential impact. The model results are contingent on accurate information related to flow rates, channel morphology, runoff inputs, effective shade and a host of other factors for which very little current data appears to exist (information on what would constitute "natural" conditions is, of course, even more scarce). Previous modeling efforts are alluded to and seem to serve as a basis for the modeling exercises in this effort (Chap. 3, pg. 11), so maybe there was some data associated with them. If so, it would be nice to include some discussion of this. Even if a comprehensive set of accurate model inputs were available, however, I think it would be difficult to use these models to try to distinguish the relatively subtle changes in stream temperature that would form the basis for a decision on whether or not the tributary were impaired (or whether the tributary contributed to the impairment of the mainstem of the river).
Response C8: Please see the response to the previous comment. Also, the assumption that "relatively subtle changes in stream temperature" have occurred as a result of human activities in Klamath tributaries is overly broad. The temperature analyses conducted in support of the Scott and Shasta TMDLs demonstrate that the major changes in hydrology and vegetation that have occurred in those basins have indeed resulted in substantial changes in stream temperature.

Comment C9: Section 3.3.3.2 of the Analytical Methods section describes a series of assumptions and modeling scenarios that suggest very little data on these systems exists (and no data is presented). The Scott River in particular seems to have been modeled with very little information other than some current flow data (Table 3.2). With regard to the other tributaries, the point is made that changes in effective shade and stream channel dimensions can have an impact on stream temperature, which is no doubt true, but the evidence that changes in either of these areas have taken place in the tributaries seems largely anecdotal. There is some vague mention of changes in land use and the effects that flooding may have had on stream channel width and riparian vegetation, but no data on this is presented (section 2.5.2.2). The subsequent analysis of the impacts of different levels of effective shade demonstrates that there could be an impact, but little evidence is provided to suggest that there actually has been a change in riparian vegetation. Similarly, a discussion in section 4.2.4.1 on the potential impacts of sediment load on temperature in the tributaries cites a higher peak stream temperature the year after a flood

(on the basis of seven years of data) as evidence that sediment loads are a factor which seems very shaky. This is then followed up by a statement describing modeling results that suggest a doubling of stream width can increase temperatures 1-2 C, but there is no data presented to suggest that stream widening in any of the tributaries has occurred.

Response C9:

Regional Water Board staff agree that data quantifying the relationship of groundwater use to surface flows in Scott Valley is lacking. The effects of the substantial interaction of groundwater and surface water on Scott River temperatures were analyzed in the Scott River temperature Total Maximum Daily Load analysis (Regional Water Board 2005). That analysis demonstrated the substantial influence of groundwater accretion on Scott River temperatures, as well as the need for a better understanding of the impacts of groundwater use on surface flows. Accordingly, a groundwater study of Scott Valley has been initiated to better understand the interaction of groundwater and surface water in Scott Valley.

Our approach to handling the uncertainty associated with unimpaired flows is to provide analyses that bracket the range of uncertainty. We found that only the flows and temperatures associated with the highest flow scenario had a significant effect on Klamath River temperatures. However, the analysis conducted by Regional Water Board staff indicates the conditions depicted in the highest flow scenario are likely to overestimate natural flows and underestimate natural temperatures. Accordingly, Regional Water Board staff chose not to assign an allocation to Scott River flows. Regional Water Board staff believe this is an appropriate approach to using the data available in a process that requires us to make decisions based on the best available information.

The refernces cited in Section 2.5.2.2 document the levels of water diversion in the basin (also discussed in section 1.6.6), as well as the history of substantial mining and timber harvest throughout the basin. It was not our intent to quantify those effects in section 2.5.2.2, rather to acknowledge that they have occurred.

Regional Water Board staff have bolstered the discussion of the evidence that channel widening and loss of riparian vegetation has occurred in section 2.5.8, which discusses the effects of sediment on temperatures.

Regional Water Board staff have added to the discussion of pre- and post-flood temperature data presented in section 2.5.8. We find the data and analysis persuasive. Similarly, we find the data, analysis, and conclusions presented in the USFS' assessment of the 1997 flood to be persuasive.

Comment C10:

As with question (3) above, I also find myself wondering whether there have been trends toward increasing air temperatures in the Basin (i.e. climate change). This would be another area in which data certainly exists, and would seem important to explore when trying to identify potential sources of increased stream temperature.

I do not want to be overly harsh here, but unless there is substantially more data and analysis of this issue than has been presented in these documents, my opinion is that there is insufficient information to make any informed judgments.

Response C10:

Regional Water Board staff have added a discussion of the increase in air and water temperatures in Section 1.6.4, Climate. The added text discusses Bartholow's (2005) findings that average Klamath Basin air temperatures have increased by 0.5 ^{o}C per decade.

Comment C11:

(4) Assessing the linkage between water quality and fish disease.
I have read through these sections and the conclusions, based on my very meager knowledge in these areas, appear to be reasonable. That said, I have no background in the biology of fish or any other form of macrobiota, so I am not at all qualified to make judgments on the scientific basis for establishing linkages between water quality and fish disease. I would, however, suggest that Professor Hans Paerl at the University of North Carolina’s Institute for Marine Sciences, would be someone capable of providing a knowledgeable review in this area or, at a minimum, could point toward other individuals with related expertise.

Response C11:

Thank you for your review and recommendation. The peer review of the Klamath River TMDLS staff report included others with fishery related backgrounds. In addition, resource agencies such as California Fish and Game, United States Fish and Wildlife Service, National Marine Fisheries Service, and Tribal fisheries programs have participated in reviews of the document. Due to the uniformly positive response to these sections no further peer review will be requested.

Comments of: Desiree D. Tullos, PhD
Assistant Professor,
Oregon State University
Biological and Ecological Engineering

Comment T1:

1.0 Nutrient, chlorophyll-a, *Microcystis*, and microcystin targets for Copco I and II, and Iron Gate reservoirs

I understand that these allocations and numeric targets were designed to control blue-green algae blooms and reduce the public health risks associated with algal toxins. I have summarized comments on the protection provided by the proposed TMDL for each constituent in the table below, and include specific issues that should be addressed or clarified in revisions to this Staff Report. It is my belief that, if fully implemented, this TMDL would be protective of beneficial uses, with the exception of the *Microcystis aeruginosa* cell density, which I understand will allow for a 50% exceedance probability.

Type	Water Quality constituent	Recommended regulation	Comments on beneficial use protection
Load allocation	Nutrient loading from reservoir sediments	0 load	This will certainly protect beneficial uses, but it is unclear how this could actually be successfully implemented.
Numeric target	Suspended algae chlorophyll-a	10 μg/L	I have some lingering questions. The "sharp increase in Microcystis aeruginosa cell density above 10mg/L Chl a" (Section 2, pages 19-21) is not as clear of a threshold as document implies. Please see comments below.
Numeric target	Microcystis aeruginosa cell density	20,000 cells/mL	Based on WHO criteria for low risk exposure. Appears to be protective of human health and beneficial uses, however, is 50% probability of exceeding low effects threshold (Section 2, page 23) good enough?
Numeric target	Microcystin	4 μg/L	Based on WHO criteria for low risk exposure. Protective of human health and beneficial uses.

Response T1:

Regional Board staff believe that the reviewers interpretation that the *Microcystis aeruginosa* cell density target represents a 50% probability of the exceedance of the low effects threshold results from an artifact of the manner in which the probability plots were calculated. Since the development of the peer review draft TMDL staff report, a technical memorandum has been released (Toxigenic *Microcystis aeruginosa* bloom dynamics and cell density/chlorophyll *a* relationships with microcystin toxin in the Klamath River, 2005-2008 – Kann and Corum 2009) that more completely discusses the risk of exceeding *Microcystis aeruginosa* cell density and microcystin target levels at a chlorophyll-*a* density of 10 µg/L. This information has been incorporated into Section 2.3.2.2.

The probability plots are a good tool for illustrating the relationship between the independent variables (i.e., chlorophyll-a concentrations and *Microcystis aeruginosa* cell densities) and the dependent variable (microcystin concentration). However the plots require an averaging algorithm that limits an evaluation of the probability of exceedance at a specific threshold. It is possible to calculate the exceedance probability at a specific level for the independent variables. The exceedance probability for the microcystin thresholds for several specific values of the independent variables are presented in Table 2.7 in Section 2.3.2.2. The point specific evaluation demonstrates that when chlorophyll-a was less than 10 µg/L that the exceedance frequencies of the public health thresholds for *Microcystis aeruginosa* density or microcystin concentration were less than 10%.

Comment T2:

Section 2, page 21 and 22 (Figures 2.3 and 2.4). Why were the Chl a – Exceedance probabilities not modeled for the numeric target (10µg/L)? If I am reading Figure 2.3 correctly, it appears that the transition actually occurs under 10µg/L for 20K and 40K cells/ml MSAE. Further, for 100K cells/ml MSAE and 20 µg/L, why were these not modeled for the higher Chl a concentrations, as the lower values were?

Response T2:

The model was run for all values of Chl-a that were measured as part of the monitoring program. In the peer review draft the probability model plot for *Microcystis aeruginosa* was erroneously presented twice and the probability model plots for microcystin were not included. This error has been corrected. The probability plots also use the same category median which introduces uncertainty for any direct interpolation from the graph regarding a precise threshold boundary. The inclusion of Table 2.7 in Section 2.3.2.2, which lists threshold values for each model component resolves this issue.

Comment T3:

Also, the document references that monitoring targets are provided in Chapter 7, though this was not included in the document I received. Further, no implementation plan was provided, and thus, it is hard for me to evaluate these TMDL regulations without some sense of how they might be implemented (and monitored), especially given the

dependence of these water quality conditions on flow modification (see section below) in the river.
Response T3: Chapters 6 and 7 are not included in the scope of the technical peer review and were not complete when the peer review was conducted. These chapters are included in the public review draft. In addition, flow modification is outside the scope of the TMDL and is addressed through other regulatory processes.

Comment T4: **2.0 Load allocations for temperature and dissolved oxygen in Copco and Iron Gate Reservoirs to support salmonid beneficial uses.** I understand that these load allocations are intended to protect the beneficial uses associated with cold freshwater habitat, spawning, migration, and early development, migration for redband/rainbow trout. My understanding is that the TMDL is a load allocation for DO and temperature during the months of May to October for 85% DO at a temperature of 18.7^{o} C. I also understand that the Regional Water Quality Board staff are proposing revisions to DO objectives, however, I do want to note my concern that the current DO background conditions are based on inappropriate data for this purpose. The proposed alternatives (Section 2, page 7) should protect these beneficial uses, if adopted and implemented. I believe the targets for overlapping temperature and DO "lens" is valid and should protect beneficial uses.
Response T4: It appears that the review comment is in reference to the current DO background objectives included in Table 3.1 of the Basin Plan. If so, the Regional Board agrees with the comment that the Table 3.1 "background" values based on daytime grab samples do not represent true daily minimums. This is why the Regional Board is proposing the use of 85% saturation at estimated natural temperatures as an alternative method for estimated background DO (see Appendix 1).

Comment T5: Please clarify how core vs. non-core designations will be established.
Response T5: The USEPA (2003) defines core habitats as those that support a moderate to high density of salmonids, whereas non-core habitats are defined as moderate to low density-supporting habitats. Ultimately, the designation of these categories to a specific water body, or reach of a water body, will require a site-specific evaluation, which is beyond the scope of the TMDL analysis. Regional Water Board staff have generally interpreted the core designation to apply to lower order streams where spawning and rearing occurs, and the non-core designation to apply to higher order streams that function primarily as migration corridors with low density rearing also occurring at refugia. The USEPA guidance document (2003) includes further guidance for making these determinations.

Comment T6: Estimated natural temperatures plotted in Figure 2.12 (Section 2, page 47) are questionable due to model limitations (see comments on model below). Using such a coarse level of bathymetry (estimated from USGS topos) can introduce substantial error into the models. While I understand that detailed bathymetry may not be available, some analysis of uncertainty in temperature estimates is warranted as part of this analysis since this is such a fundamental part of the TMDL.
Response T6: Klamath River model bathymetry was derived using the best available data and was deemed sufficient for the purpose of this study. The bathymetric representation enabled the model to reproduce observed hydrodynamic characteristics reasonably well. The temperature calibration, for example, demonstrates the model's ability to represent both observed magnitudes and trends.

Comment T7: I have some concern regarding the monthly average target for the reservoir tailraces, while the TMDL document acknowledges the influence of reservoirs on daily temperatures and the biological implications of those shifts (Section 2, pages 38 and 39). Might a seven-day moving average be applied to the tailrace temperature target as well? I believe this would be more protective of the beneficial uses this TMDL is trying to address.
Response T7: Regional Water Board staff chose a monthly average temperature based on the fact that the developed estimates rely on a single season. Interannual variability of the monthly mean is less than metrics based on a 7-day time frame. Numeric targets are simply metrics to track compliance with the TMDL allocations. Ultimately, it is the allocations that provide the protection to beneficial uses. The temperature allocations to the reservoirs are set to equal natural receiving water temperatures, and achieving these allocations, whether data is computed as 7-day moving average or monthly average, would meet the water quality standards.

Comment T8: Again, implementation is a major concern for these targets. It is my understanding that implementation would require substantial reoperation of the dams and/or new inlet structures to achieve these targets. Given the nonbinding agreement to decommission the dams in 2020, it is unclear to me whether such investment would occur in the interim. Thus, it is relevant to ask whether these targets will protect beneficial uses if not implemented until a decommissioning occurs. Throughout the anticipated delays in decision making about and implementation of the decommissioning or alternatives, it is critical that these targets be implemented in the interim to protect beneficial uses.

Response T8:

Actions taken by PacifiCorp to implement the Klamath TMDL are dependent on the outcome of the on-going settlement agreement development process. The Klamath Basin Restoration Agreement (KBRA) is a negotiated settlement agreement between as many as 26 different parties designed to settle long-standing disputes in the Klamath River basin. It focuses on water allocations in the upper basin, provides for fisheries restoration and is structured around the central assumption that an agreement to remove the lower four Klamath River Dams will be reached. On November 13, 2008, an Agreement in Principle (AIP) to remove four Klamath River dams was announced after negotiations between the federal government, representatives from the state of California, the state of Oregon, and PacifiCorp. Regional Water Board staff were not a party to the KBRA or AIP negotiations. The final agreement regarding the dams may affect the TMDL implementation schedule, which relies on the FERC relicensing process and subsequent water quality certification by the State Water Board. As currently drafted, the AIP contemplates federal legislation that would allow PacifiCorps to remain on annual licenses from FERC, thereby indefinitely delaying the 401 certification and Clean Water Act compliance. The Regional Water Board directed staff to monitor settlement developments and staff has provided input to the parties on appropriate water quality measures to address TMDL compliance during the interim periods before a decision regarding dam removal is made and, if made, between that time and dam removal.

Comment T9:

3.0 Assessment of tributary streamflow rates on stream temperatures.
While projections of streamflows from the tributaries are problematic due to lack of data, particularly for the Scott River, my concerns regarding stream temperatures are more focused on cumulative effects and the ecological relevance of 5^{o}F temperature increase. Related to implementation and its outcomes on cumulative effects, the narrative objective states that temperature cannot be altered unless demonstrated not to adversely affect beneficial uses. How will adverse effects be determined? That is, how will multiple actions be evaluated that could create adverse effects cumulatively? My second concern regarding the ecological relevance of 5^{o}F temperature increase may simply be addressed with some clarification of how the 5^{o}F limit was established. Also, please clarify that this is 5^{o}F basinwide, as opposed to 5^{o}F per action. My concerns related to establishing "natural receiving water temperatures" apply here as well.

Response T9:

Regional Water Board staff rely on the USEPA's temperature guidance to evaluate adverse effects to salmonids related to temperature, as stated in Chapter 2. In regards to the 5 ^{o}F temperature increase, because temperatures are already higher than optimal for salmonids through much of the spring, summer, and fall months, staff have concluded that beneficial uses already are being adversely affected, and thus the water quality standard becomes no temperature increase, and the 5 ^{o}F increase is not invoked. The 5 ^{o}F limit was established in 1972 when the Water Quality Control Plan for the North Coast was first developed, and applies at any time or place.

Comment T10: **4.0 Linkages between water quality and fish disease** I understand that improving the overall status of fish populations is the key end point to restoring beneficial uses of the Klamath River. To this end, I do believe the analysis presented in the TMDL staff report on linkages between water quality impairment and impacts on fish disease is based upon sound scientific knowledge, methods, and practices. The conceptual models and well-supported text provide a solid and commendable overview of current science.
Response T10: Thank you.

Comment T11: **5.0 Additional concerns** As indicated in the discussion above, I have some additional concerns regarding the development and implementation of this TMDL. I also found that the document needs substantial editing, with numerous typos throughout, syntax errors (watch missing commas and affects vs. effects), superfluous and duplicative text, and figure axes without units. In addition, a figure with the location of the Copco and Iron Gate reservoirs would be very helpful. Finally, numbering pages continuously throughout the document, as opposed to section by section, would be helpful for providing comments.
Response T11: Implementation issues regarding the Klamath River TMDL will be subject to an ongoing adaptive management process but are outside the scope of this technical review. It is the responsibility of the Regional Water Board to identify allocations that will restore supporting conditions for beneficial uses. The Regional Water Board acknowledges that there are several challenging issues related to implementation but it is beyond the purview of the Regional Water Board to dictate specifically how TMDL allocations be achieved. The Regional Water Board staff will address editing issues prior to the release of the public review draft. Location maps will be added to enhance reader understanding of geographical setting.

Comment T12: Modeling efforts to establish the "natural" conditions. As noted previously, I have concerns regarding the resolution of bathymetric inputs to the models and the calibration of the model components with limited data from different years (estuary calibrated for 2004, while Segments 1-5 for 2000 and 2002, and Segments 6-9 for year 2000). Because the model integrated results from CEQUAL- W2, RMA I and II, and EFDC were used as inputs to each other, this calibration scheme seems particularly dubious. Additionally, calibration of the model during using data from a low flow when beneficial uses are particularly susceptible to impairment would greatly strengthen the analysis [sic]. Related to this, I disagree with the statement (Section 5, page 9) that an implicit margin

of safety is appropriate "because uncertainty was greatly reduced in the analysis by applying a comprehensive, dynamic numerical model…representing conditions in great detail spatially and temporally." The model is not based on great spatial and temporal detail, and an analysis of model uncertainty is absolutely warranted.

Response T12:

As noted above, the bathymetric representation for the Klamath Model was based on the best available data, and the model is capable of reasonably reproducing the observed hydrodynamic characteristics, e.g., trends and magnitudes of temperature. With regard to calibration, the calibration period was selected considering data availability and hydrologic conditions. The model was tested under a range of hydrologic conditions, and more importantly water quality conditions, since it was calibrated for multiple years and for multiple seasons each of those years. The year 2000 was a close to average year in terms of flow while 2002 was a relatively low flow year. However, the year 2000 exhibited poor water quality conditions, and this was deemed a key consideration for TMDL development. 2004 was primarily selected due to data availability. It's important to note that the routing of flow and mass from upstream to downstream models was implemented only for models during the same year. The estuary EFDC model, for example, used observation data as its upstream boundary condition rather than model output.

An implicit MOS was used not only due to the spatial and temporal detail of the model but due to conservative assumptions that were incorporated into the modeling framework, as noted in the TMDL report.

See also Response C1.

Comment T13:

Relationship of this TMDL to the proposed decommissioning of Klamath River dams.

While I realize that this TMDL document is to be kept clearly distinct from the FERC reclicensing procedure for the Klamath Hydropower project (Section 2, page 2), it is relevant and critical to consider the relationship between the proposed TMDL and potential decommissioning. I suggest adding a discussion on how this TMDL might restrict or otherwise effect plans for removal of the 4 dams (Copco I and II, JC Boyle, and Iron Gate) on the Klamath River. Conversely, the Staff Report should establish a strategy for reconsidering the TMDL following the decommissioning. In addition, the Staff Report should consider how the TMDL targets can be met during the interim period between approval of the targets and decommissioning, which may extend well beyond the proposed plans for decommissioning in 2020. In this sense, it is hard to evaluate the TMDL's ability to protect beneficial uses without an analysis of the relationships between the proposed targets and decision making about the Klamath Hydropower project.

Response T13:

See Responses T8 and T11. Also, based on the TMDL modeling analysis, the TMDL allocations and targets would be achieved should the dams be decommissioned. Regional Water Board staff do not believe the TMDL would be reconsidered following a potential decommissioning, though the TMDL implementation MOA between the Regional Water Board, ODEQ, and USEPA Regions 9 and 10 does incorporate joint adaptive management and TMDL reconsideration.

Comment T14:

Implementation and monitoring of this TMDL.
It is difficult to provide an informed review of and meaningful feedback on this staff report without the accompanying monitoring and implementation plans. It is not appropriate for reviewers to project how the targets will be implemented, and yet, it is impossible to truly understand the impacts of the targets without some sense of how they will be applied. For example, are the secondary targets (e.g. "0 miles of excess sediment impact") even feasible? If these targets are unrealistic, what is the outcome of not meeting them? Similarly, it is clear that flow modifications to the river play a large role in the water quality of the river. Related to implementation, if the dams are reducing peak flow from 20-25% in May, and increasing minimum summer flows (Section 1, page 22), then some flow modifications are needed, which influence a number of water quality impairments addressed within
this TMDL, including:

- Flushing flows to prevent periphyton as substrate for C. Shasta (page 31)
- Summer low flows for dessication of polycheates (page 32)
- Exposure of juveniles to C. Shasta (page 42)
- Flushing sediment (page 70)

The relationships between flow, temperature, DO, salmon, and C. Shasta could be further developed in this TMDL. While I understand that altered flow that affects habitat conditions is not directly addressed in this TMDL (Section 2, page 2), it is impossible to consider whether this TMDL is achievable given the extensive modifications, particularly Lewiston and Trinity flow diversions and Copco and Iron Gate regulation of flow, in the Klamath River system.

Response T14:

Targets are expressions of the conditions that meet water quality objectives and are not independently enforceable. We believe the secondary targets are achievable over time, but recognize that the time-frame for achieving many of the targets is long. Yet, we are required to develop the targets as a quantification of conditions when water quality objectives are achieved.

Comment T15:

In summary, taken as a whole, the scientific portion of the proposed rule is based upon sound scientific knowledge, methods, and practices. However, my concerns, described above, limit my confidence in the ability of the TMDL to protect the beneficial uses of

the Klamath River. Please feel free to contact me with any questions or requests for additional information.
Response T15: Thank you for your thorough review.

Comments of: **Dr. G. Mathias Kondolf**
University of California, Berkeley
Department of Landscape Architecture & Environmental Planning

Comment K1: **General Comment** Overall the document reads well, and clearly explains processes by which water quality degradation occurs. I found the explanation of *Ceratomyxa Shasta* to be very clear, and resolved some questions I had harbored about this problem in the past. Below, I limit my comments to areas in which I have background.
Response K1: Thank you.

Comment K2: **Staff Report, Chapter 1** p.19 Drainage density is influenced largely by infiltration capacity: highly permeable substrates will support lower drainage densities, even in areas of high precipitation. The slopes of Mt Shasta receive very high precipitation, but have low drainage density by virtue of the permeability of the volcanic rocks underlying them. Water yield is still high, but it takes groundwater pathways to springs nearby. By contrast, semiarid badlands have notoriously high drainage densities but low water yield by virtue of the dry climate and low precipitation. Thus, we would not necessarily expect the pattern of drainage density to mirror the pattern of water yield.
Response K2: The text has been changed to reflect the importance of infiltration capacity in determining drainage density and to remove language linking drainage density to water yield.

Comment K3: **Staff Report, Chapter 1** p.22 Text states that Fig 1.10 shows that pattern of water use has shifted timing of peak spring flows, etc – presumably this is a typo and should refer to Fig 1.11. The basis of Figure 1.11 should be better explained. How much of this figure is based on the Bureau's natural flow study? Were the mean monthly flows in Scott and Shasta Rivers integrated later or as part of the Bureau study? Note that the Bureau study did not get rave reviews from the NRC panel (NRC 2007).
Response K3: A citation has been added to clarify that the Scott and Shasta river flows were published by the USGS. The USBR's natural flow study represents that best available natural flow estimates at the time of document preparation, and are suitable for the purposes of illustrating general comparisons.

Comment K4:

Staff Report Chapter 2

General: How would the proposed revisions to the DO objectives change the frequency and duration that the river fails to meet the objectives? It is not obvious how many DO data have been collected and what patterns emerge from them. Even under pre-disturbance conditions, we would not expect the Klamath River to have the same water quality of a mountain trout stream, so a different standard is reasonable, but what exactly is the basis for the proposed standards?

Response K4:

In the TMDL problem statement the available quality assured dissolved oxygen data for the Klamath River is evaluated relative to both the existing DO objectives and the proposed DO objective (i.e., 85% saturation at natural temperatures). Table 2.10 and Figure 2.24 provide the percent of measurements that fall below the DO objective for Klamath River reaches below Iron Gate Dam (8.0 mg/L). The analysis included nine stations where data sondes had been deployed May to October for 2004 – 2006. The quality assured data resulted in several thousand validated samples for each station. The same analysis was conducted for percent saturation. The range of violations for percent saturation (Table 2.11 and Figure 2.25) ranged from a minimum of 0% of measurements below 85% DO saturation at several stations in 2006 to 35% of measurements below 85% DO saturation at the station located above Scott River. The TMDL model analysis of dissolved oxygen conditions under natural conditions baseline alerted Regional Water Board staff to the need for a revised site-specific DO objective for the Klamath River. The natural conditions baseline modeling scenario indicated that it was not possible to meet the life-cycle and existing DO objectives in the Klamath River under natural conditions. These model runs confirm your observation that the Klamath River is not a typical cold mountain trout stream.

Appendix 1 of the Klamath TMDL Staff Report details the selection of the proposed site-specific DO objective for the Klamath River in California.

Comment K5:

Staff Report Chapter 2

p.34 *Degraded channel habitat*. Reading this section I noted that channel simplification can lead to less hyporheic exchange, but I see you brought this up later. Another consideration that should not be ignored in a conceptual model of how processes have changed on the Klamath River:

Prior to construction of the railroad in the early 20th century, during floods, the Klamath River between Klamath Falls and Keno overflowed into Lower Klamath Lake (LKL), where by virtue of its long residence time, floodwaters would have deposited suspended sediment and nutrients. Loss of this former connectivity to the lake – in effect loss of a floodplain and wetland storage function - probably produced a significant increase in flood peaks and reduction in removal of nitrogen and other nutrients. Much of the water that overflowed into LKL probably evaporated from the shallow lake surface, but some is known to have returned back to the river when, on the recession limb of the flood, river stage dropped below the elevation of the water surface of LKL. The characteristics of this return flow were not documented, but it's likely to have been warmer than the original flood waters. The hydrologic implications of this seasonal overflow into LKL (and its loss following construction of the railroad) were not adequately analyzed in the Bureau's Natural Flow Study (NRC 2007).

Response K5:

The Regional Water Board agrees that hydrologic changes to Lower Klamath Lake have likely resulted in both temperature and nutrient dynamic changes that need to be accounted for in any future updates of the conceptual model. For the current purpose of the development of initial allocations to the Klamath River mainstem from the Lost River basin the existing TMDL model adequately accounts for loading from the Lost River basin via the Klamath Straits Drain and Lost River Diversion Canal.
In regards to the temperature of returning LKL flood waters, the temperature was most certainly different from the temperature of the original flood waters, but was likely to be close to that of UKL, based on their proximity and similarity. Thus, the temperature of the returning waters was not likely to have greatly altered the temperature of the Klamath River.

Comment K6:

Staff Report Chapter 2
p.34-35 Clarify the *effects of increased fine sediment delivery to the channel* and resultant bed fining and pool filling, versus sediment starvation and bed coarsening. On p.34, the former is cited as increasing periphyton growth, while on p.35 the latter is cited as producing the same effect (because the substrate is less mobile). Perhaps they both can produce the same result of more periphyton growth, but the mechanisms need to be explained more clearly to resolve the apparent discrepancy.

Response K6:

The text has been revised to more clearly delineate the effects related to: 1) reduced desiccation due to less variation in flow regime; 2) more stable growth substrate due to channel coarsening; and 3) the reduced rate of scour / dislodgment of periphyton due to reduced rate of impingement from reduced gravel transport downstream. The discussion of the deposition of fine organic matter (senesced phytoplankton exported from upstream reservoirs) has been moved to the discussion related to impoundment effects on fish disease related processes.

Comment K7:

Staff Report Chapter 2
p.34 *Altered flow conditions*. Note that Copco and Iron Gate together impound only about 5% of the mean annual runoff. This is a very small *impounded runoff ratio* by California standards (Kondolf and Batalla 2005). (Compare to 80% for the Sacramento and 120% for the San Joaquin overall, higher for some specific drainages: 460% for Putah Creek, 240% for Stanislaus.) Storage by Upper Klamath Lake may be more

significant, probably affecting low flows the most. It's not clear that the frequency or magnitude of scouring flows is less now than in the late 19th century, because Copco and Iron Gate would have little storage effect, and counteracting reservoir storage effects was the significant loss of flood overflow into LKL. Moreover, to have increased deposition of sediment in the river bed you need not only to reduce scouring flows, but you need a sediment source below the dam, because the dams are trapping at least the coarser fraction of the sediment load.

Response K7:

Regional Water Board staff have revised the text to clarify that scouring flows are also dependent on sediment dynamics, and have removed the text discussing increased rates of deposition.

Comment K8:

Staff Report Chapter 2
p.35 *Dams halt downstream transport of gravel…* The hypothesized effect is probably correct in that directly below Iron Gate substrate has significantly coarsened, as shown by surficial grain size measurements (CH2MHill 2003). It is possible to scour periphyton from stable cobble beds by transporting sand over them, but sand is trapped by Iron Gate Reservoir so the reach immediately below the dam would be starved of sand. Note that this effect would persist downstream only until tributary contributions of sediment became significant. Below Iron Gate, Bogus Creek delivers enough gravel to the mainstem (some of which is exotic gravel placed in the channel to improve spawning habitat in the tributary) to produce mobile gravel bars starting just below the US Geological Survey gauge, about 100m downstream of the tributary confluence.

Response K8:

Regional Water Board staff agree that this process only occurs in a limited reach below Iron gate dam, but nonetheless it occurs and we believe it should be accounted for in our conceptual model, particularly because it relates to the acute incidence of disease in that reach.

Comment K9:

Staff Report Chapter 2
p.36-37 *Thermal processes related to sediment load.* It seems the document is arguing that several separate processes occur. It might be useful to clearly distinguish them, as the reader is likely to conflate them now.

The first paragraph refers to "…pool filling, increased width, decreased depth, and/or reduction of intergravel flow."

The second paragraph notes that sediment can fill pools and narrow channels, so that the river flows over an aggraded surface in what will be a wider channel. Simply by virtue of the increased width (and thus reduced average depth) we can expect more exposure to solar radiation and greater heating.

The second paragraph notes that aggradation can result in loss of riparian vegetation, but the mechanism is not stated. Is it because the aggraded channel exerts more erosive force on banks and undercuts them, causing riparian trees to fall into the channel? (In this case we should probably give some credit to the increased complexity that might result from the large wood in the channel.) Is it because the aggraded channel raises the water table in the adjacent banks and waterlogs riparian trees adapted to better-drained conditions in summer months? Whatever the mechanim(s), explain this better, and if this point is drawn from Lisle's work, cite accordingly.

The third paragraph expands on why a wider, shallower channel will gain more heat in the daytime (and lose more at night). The Poole and Berman (2001) citation is incomplete in the References Cited as only the authors and title are included in the citation, not the journal or report series. Presumably this report documents some of Poole's work in eastern Oregon, where bed complexity is a primary driver of hyporheic flow and moderation of diurnal temperature fluctuations (Poole et al. 2006). This is another mechanism, and should be clearly distinguished from the channel becoming wider and shallower, as it pertains to the form of the longitudinal profile, rather than the cross section.

Channel simplification that reduces the undulations in the bed, can reduce the exchange of surface and groundwater. Two recent studies have documented that more complex channels with significant bed undulations (e.g., pool-riffle alternations) have more hyporheic exchange and moderated diurnal temperature fluctuations. Alicia Arragoni's masters thesis research on the Umatilla (with Poole) documents the moderating effects on diurnal temperature fluctuations of complex bed topography. I believe her research has appeared in Water Resources Research by now, though I have only a draft version on my computer (Aragoni et al, submitted), which I attach. Mark Tompkins' PhD research (2007) documented hyporheic exchange in complex reaches reduced diurnal fluctuations by 2^{o}C or more on Deer Creek in Tehama County.

Response K9:

Regional Water Board staff have re-written this section for clarity and have addressed the issues identified by the reviewer. The Poole citation has been completed and refers to a journal article that presents an overview of human influences on stream heating process.

Comment K10:

Staff Report Chapter 2

The second paragraph on p.37 alludes to reduced permeability, which would result from deposition and infiltration into the bed of finer sediments (silts, clays), but this point is not developed. There are examples in the literature of side channels whose groundwater exchange has been blocked by a surficial layer of silt, such as along the Rhone River in France, where an overlying silt layer was removed explicitly to restore hyporheic exchange (Henry et al. 2002). This has probably occurred in some places in California and Oregon, but I cannot think of an example now. If there is any evidence for such effects on the Klamath or its side channels, this would be useful to present in the TMDL. Also in Australia, 'sand slugs' have reduced hyporehic exchange in many streams (Boulton et al. 2002).

Response K10:

Regional Water Board staff believe that conduction is the appropriate heat exchange mechanism, based on our understanding of the science and review of the literature. We have added language clarifying the way that conductive heat exchange processes act on hyporheic water to influence temperatures.

Comment K11:

Staff Report Chapter 2
p. 37 *Thermal processes related to flow* It may be worth noting that this simple model of more water flowing faster down the channel lies at the heart of most temperature models, but does not account for channel complexity and resulting thermal refugia. In some cases, thermal refuges like 'cool pools' function better at lower flows because they remain more hydrologically isolated from the warming main

Response K11:

Regional water Board staff have added language that clarifies that advective heat exchange works in concert with other heat exchange processes to determine the overall temperature of a stream.

Comment K12:

Staff Report Chapter 2
p.45 *Temperature* It is known that salmonids near the southern end of their range in warmer waters of California have adapted to higher temperatures

Response K12:

Regional Water board staff have added text acknowledging the existence of data that indicates that some populations of southern California steelhead may have higher temperature tolerances. However, we believe that the temperature tolerances suggested by USEPA are appropriate for assessment of temperature conditions in the Klamath, based on studies from the north coast of California (Welsh et al, 2001; Hines and Ambrose, undated).

Comment K13:

Staff Report Chapter 2
p.70, *second paragraph, streambed armoring*. Armoring of the streambed on the Klamath River is the result of trapping of sediment by the upstream dams, not alteration of the flow regime by dams. As noted earlier, Copco and Iron Gate together impound only around 5% of the mean annual runoff and have not reduced peak flows very much, but they do effectively trap all bedload sediment. Moreover, other things being equal, one would expect the greatest armoring below dams that do *not* reduce high flows (like Copco and Iron Gate) because these reaches still have the energy to transport sediment but have lost their coarse sediment load to upstream reservoirs (Kondolf 1997). Dam

Response K13:

Regional Water Board staff have refined the language in the text to remove the emphasis on the role of altered flow regime in the discussion of streambed armoring. Despite the limited range of the river bed that is impacted, the excess accumulation of periphyton in the affected reach appears to play an important role in high levels of parasite infestation.

Comment K14:

Staff Report Chapter 2
p.70, *third paragraph, tributary deltas*. Formation of deltas at tributary confluences is probably attributable to pulses of sediment from the tributaries, rather than reduced competence and transport capacity of the mainstem due to dam

Response K14:

Regional Water Board staff have removed the text attributing effects of the altered flow regime to the sediment deltas at tributaries.

Comment K15:

Staff Report Chapter 2
p. 70, *debate between second and third paragraphs*. Note that these two paragraphs imply contradictory conceptual models, though they are not spelled out. Paragraph 2 implies that transport competence and capacity have been increased by the dams (more scour of gravels) while Paragraph 3 implies that they have been reduced (less ability to mobilize sediments delivered from tributaries).

Response K15:

The changes described in the two previous responses address this comment and resolve the contradiction.

Comment K16:

Staff Report, Chapter 3
p. 13-14, *Scott River flow and temperature*. I found the discussion of interactions among surface flow, groundwater, and water extractions in the Scott Valley to be informative, not knowing much about this topic in advance. I may have missed something in my reading, but it is not clear to me what data constrain the model assumptions here. What temperature data exist, for what locations, etc? Perhaps the document would be more credible if specifics regarding available data and interpolations/estimates needed were spelled out in lieu of terms such as “moderate amount” such as in the passage, “These estimates are based on a moderate amount of verifiable information, couple with reasonable assumptions about the hydrology of the Scott Valley.” The next sentence refers to “uncertainty”; to what extent can it be quantified?

Response K16:

Regional Water Board staff have revised the description of the Scott River flows and temperature analysis, including a discussion of the considerable amount of data used in the development of the Scott River temperature model.

Comment K17:

Staff Report, Chapter 3
p.15 *Trinity River temperature*. I'm surprised there are not better temperature data for the Trinity, given the degree to which it's been studied. Again, perhaps a clearer statement of what is constrained by data, what kinds of interpolations/estimates were required, and what uncertainties would result, could improve the document.

Response K17:

Regional Water Board staff have added more text in the discussion of Trinity River to describe our reasoning related to the assignment of the Trinity River temperature boundary condition.

Comment K18:

Staff Report, Chapter 4
Figures 4.1-4.3 seem very effective ways to communicate the conceptual model of nutrients inputs. Can the figures (or supporting text) be modified to indicate which numbers are based on actual field measurement programs and which values are interpolated/estimated? Some indication of the uncertainty in these values?

Response K18:

The vector diagrams illustrating pollutant sources for total nitrogen, total phosphorous, organic matter are all based on TMDL computer model simulations. No quantitative uncertainty analysis has been conducted on the TMDL model simulations. However the TMDL model was calibrated and validated during model development. The Regional Water Board is confident that the model estimates provide an adequate basis for assigning initial allocations that will drive TMDL compliance measures. The Klamath River TMDL is an adaptive management process that will be supported by a basin-wide monitoring program. The source assessment and allocations will be reevaluated as part of the adaptive management process.

Comment K19:

Staff Report, Chapter 4
p. 33 *thermal refuges at cold-water tributary mouths*. The effect of increased tributary sediment loads filling in cold water refugia appears to be an important effect. Any citation to support the last sentence of paragraph 2?

Response K19:

Two citations supporting this point have been added to the document.

Comment K20: **Appendix 4 Fisheries** This section appears to be a good summary of available data on status of fish in the basin overall. Figures 2-4 are interesting but somewhat difficult to read. Perhaps they would be more readable if the lines showing reaches where fish persist were to be different shades or thicknesses of blue or green, while reaches where fish were extirpated were shades of red or orange.
Response K20: Comment noted. The changes suggested by the reviewer may result in maps that are easier to read. However, we believe the maps present accurate information, and due to technical reasons we are not altering the map depiction.

Comment K21: **Appendix 5-D Determination of Tributary Flow** The approach presented is reasonable as a first cut, but the explanation seems to leave many questions hanging. First, the net increase in flow from one gauge to the next is attributed to the intervening tributaries, and the water yield is assumed to be a constant per unit area, i.e. tributary responsible for 40% of the increased drainage area is assumed to produce 40% of the increased flow. Lacking any information beyond drainage area, this is reasonable, but precipitation is highly variable spatially, so it would seem that an isohyetal map should be consulted to assess the degree to which this simplification might result in significant over- or under-estimates in allocation of flow to individual tributaries. Second, the USGS method involves monthly averages, whereas the TMDL model used 7-day average values. How exactly was this done? For each water year, were days 1-7, 8-14, 15-21, etc averaged? (i.e., Oct 1-7, Oct 8-15, etc) How different were the results for high-flow months vs baseflow months? (I would expect some significant differences.) And finally, who is the mysterious “Mr. M, Flug”?
Response K21: Comment noted. We agree that the excerpted text doesn’t provide the detail that would answer the questions posed by the reviewer. However, the text is excerpted from a Pacificorp report and we can’t comment on those details of the analysis, as we were not privy to them. Finally, we believe that the mysterious M. Flug is Marshall Flug of the USGS.

APPENDIX 8. REFERENCES

Abbott, A. G. P. 2002. *The Effect of Riparian Vegetation on Stream Temperature in the Shasta River*. Master's Paper. University of California, Davis. Department of Civil and Environmental Engineering.

Bartholow, J. 2005. Recent Water Temperature Trends in the Lower Klamath River, California. North American Journal of Fisheries Management. 25: 152-162.

Boulton, A. J., S. Depauw, and P. Marmonier. 2002. Hyporheic dynamics in a degraded rural stream carrying a “sand slug.” Verh International Verein Limnology 28:120-124.

Castleberry, D. T., and J. J. Cech, Jr. 1993. Critical thermal maxima and oxygen minima of five fishes from the upper Klamath basin. California Fish and Game 78(4):145 - 152.

CH2MHill. 2003. Klamath River hydroelectric relicensing project: Analysis of project effects on sediment transport and river geomorphology, FERC Project 2082.

Deas, M. and L. Geisler. 2004. Memorandum: Shasta River flow and temperature modeling implementation, testing, and calibration. Watercourse Engineering, Inc and University of California Davis. September 13, 2004. 22pp.

Dorner, S., W. Anderson, R. Slawson, N. Kowen, and P. Huck. 2006. Hydrologic Modeling of Pathogen Fate and Transport. *Environmental Science and Technology*. 40 pp. 4746-4753.

Henry, C. P., C. Amoros, and N. Roset. 2002. Restoration ecology of riverine wetlands: a 5 year post-operation survey on the Rhône River, France. Ecological Engineering 18:543-554.

Kondolf, G.M. 1997. Hungry water: Effects of dams and gravel mining on river channels. *Environmental Management* 21(4):533-551.

Kondolf, G.M., and R.J. Batalla. 2005. Hydrological effects of dams and water diversions on rivers of Mediterranean-climate regions: Examples from California. In C. Garcia and R.J. Batalla (eds.) *Catchment dynamics and river processes: Mediterranean and other climate regions*. Elsevier, London. pp.197-211.

LoBuglio, J. N., G. W. Characklis, and M. L Serre. 2007. Cost-effective water quality assessment through the integration of monitoring data and modeling results. *Water Resources Research.* 43:1-16.

Money, E., G. Carter and M.L. Serre. 2009. Using River Distances in the Space/Time Estimation of Dissolved Oxygen along Two Impaired River Networks in New Jersey. *Water Research*.

Moyle, P.B. 2002. Inland Fishes of California, 2nd Ed. Berkeley and Los Angeles, CA. University of California Press.

North Coast Regional Water Quality Control Board (Regional Water Board) 2005. Staff Report for the Action Plan for the Scott River Watershed Sediment and Temperature Total Maximum Daily Loads

National Research Council. 2001. Assessing the TMDL Approach to Water Quality Management, National Academy Press, Washington, D.C.

National Research Council of the National Academies (NRC). 2004. Endangered and Threatened Fishes in the Klamath River Basin. Washington, D.C. National Academies Press.

National Research Council (NRC). 2007. *Hydrology, Ecology, and Fishes of the Klamath River Basin*. Available at: <http://dels.nas.edu/dels/viewreport.cgi?id=4794>.

Poole, G. C., J. A. Stanford, S. W. Running, and C. A. Frissell. 2006. Multi-scale geomorphic drivers of ground-water flow path dynamics: subsurface hydrologic dynamics and hyporheic habitat diversity. *Journal of the North American Benthological Society.*

Reckhow, K.H. 2003. On the Need for Uncertainty Assessment in TMDL Modeling and Implementation. *J. of Water Resource Planning and Management.* 129:245-247.

Stow, C. A., Roessler, C., Borsuk, M.E., Bowen, J.D. and K.H. Reckhow. 2003. Comparison of Estuarine Water Quality Models for Total Maximum Daily Load Development in the Neuse Estuary. *J. of Water Resource Planning and Management*. 129:307-314.

Tetra Tech. 2006. Technical approach to Develop Nutrient Numeric Endpoints for California. Prepared for U.S. Environmental Protection Agency (Contract No. 68-C-02-108-TO-111), and CA State Water Resources Control Board – Planning and Standards Implementation Unit. Lafayette, CA. 120 pp.

Tompkins, M. 2006. Floodplain and river corridor complexity : implications for river restoration and planning for floodplain management. PhD dissertation, University of California, Berkeley. Available at: <http://www.lib.berkeley.edu/WRCA/restoration/theses.html>.

U.S. Environmental Protection Agency (USEPA). 2003. EPA Region 10 Guidance for Pacific Northwest State and Tribal Water Quality Standards. Region 10, Seattle, WA. EPA 910-B-03-002. 49pp. Accessed on: May 31, 2009. Available at: <http://www.epa.gov/r10earth/temperature.htm>.

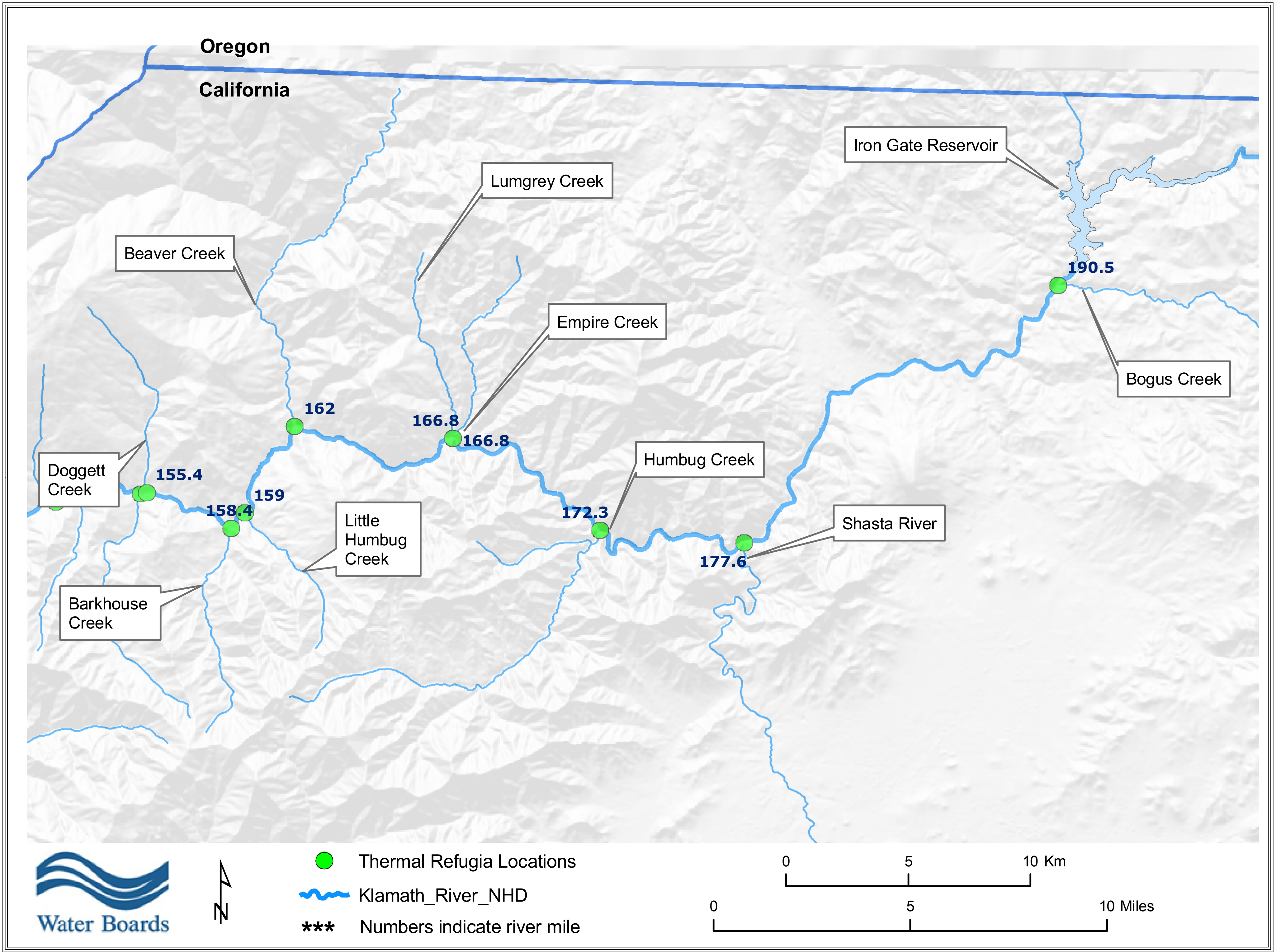
Watershed Sciences. 2004. Aerial surveys using thermal infrared and color videography: Scott River and Shasta River sub-basins. Final Report. Corvallis, Oregon. February 26, 2004. 59 pp.

Williams, J.G. 2006. Central Valley salmon: a perspective on Chinook and steelhead in the Central Valley of California. *San Francisco Estuary and Watershed Science*. Vol 6, issue 3. Available at: <http://repositories.cdlib.org/jmie/sfews/vol4/iss3/>.

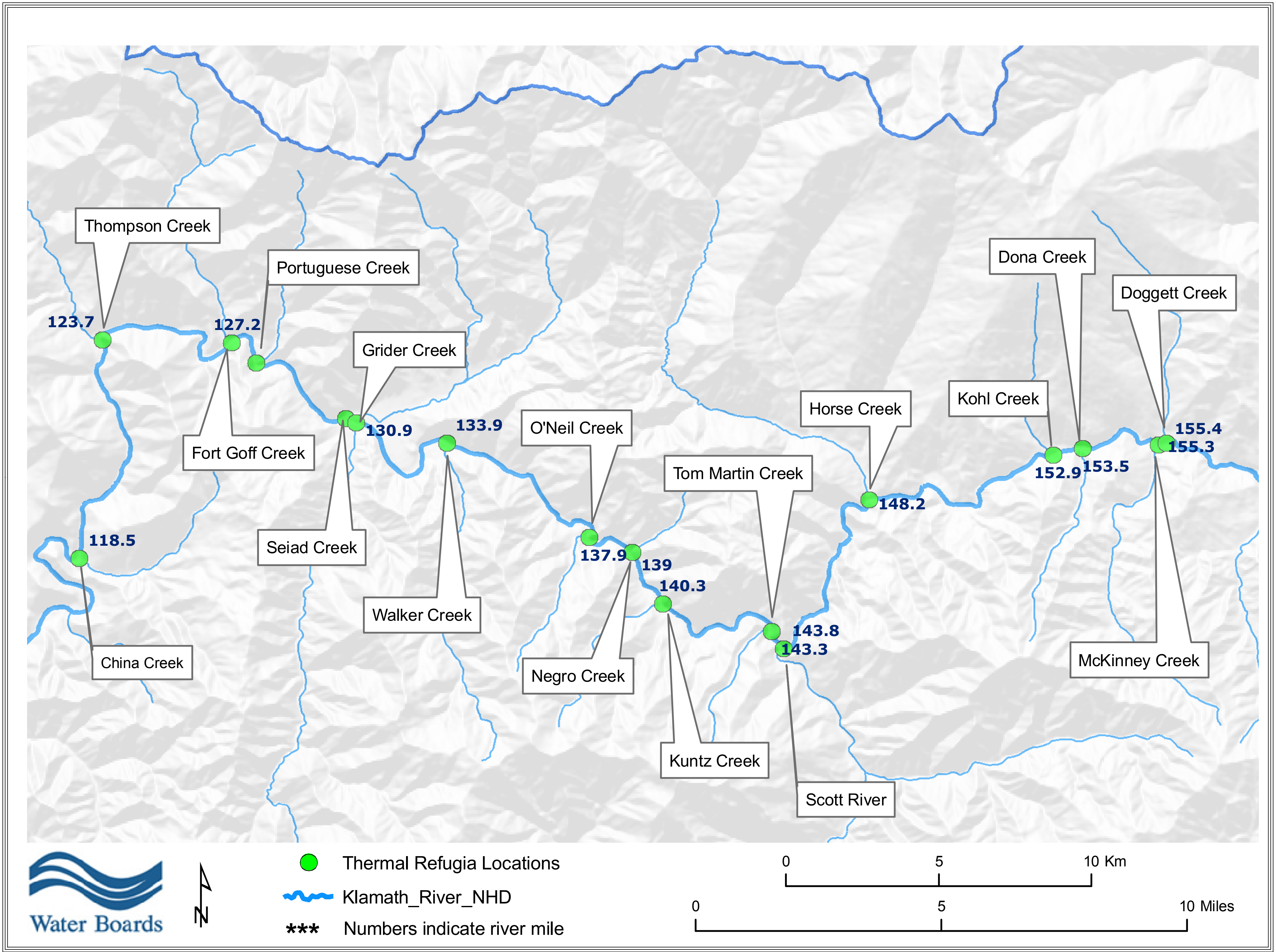
APPENDIX 9

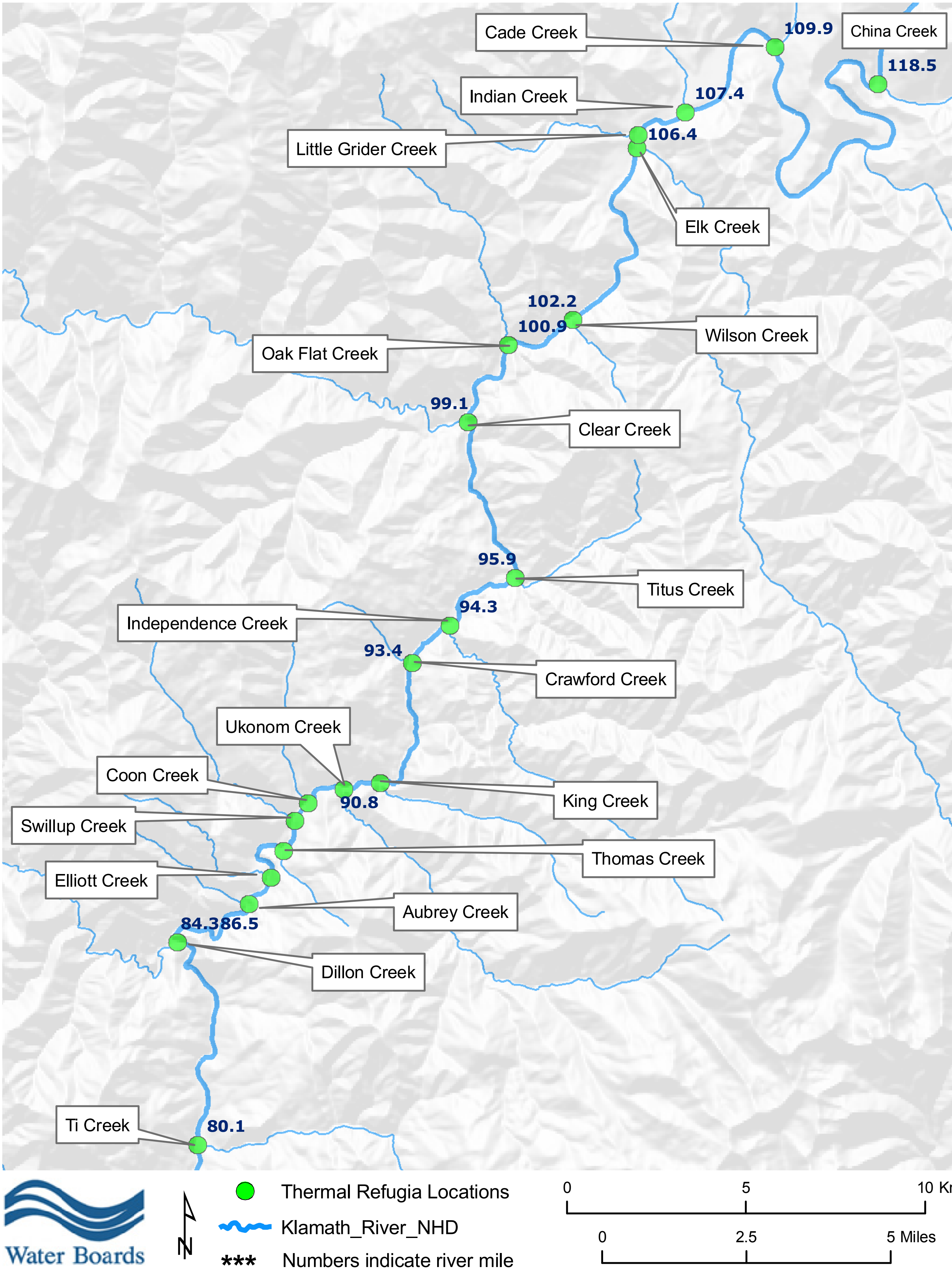
Maps of the Klamath River Basin in California Showing the Locations of Known Thermal Refugia

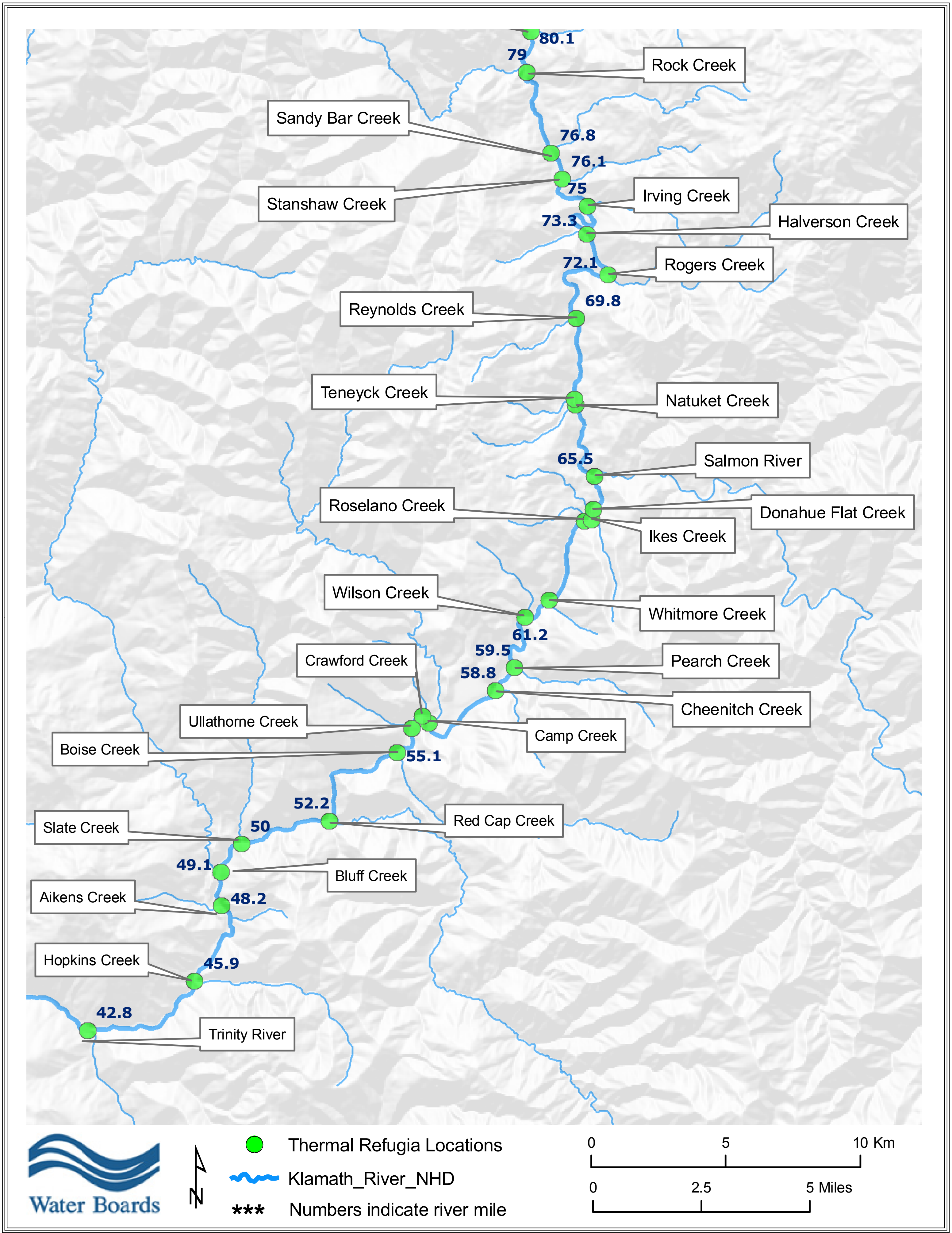
North Coast
Regional Water Quality Control Board
June 2009



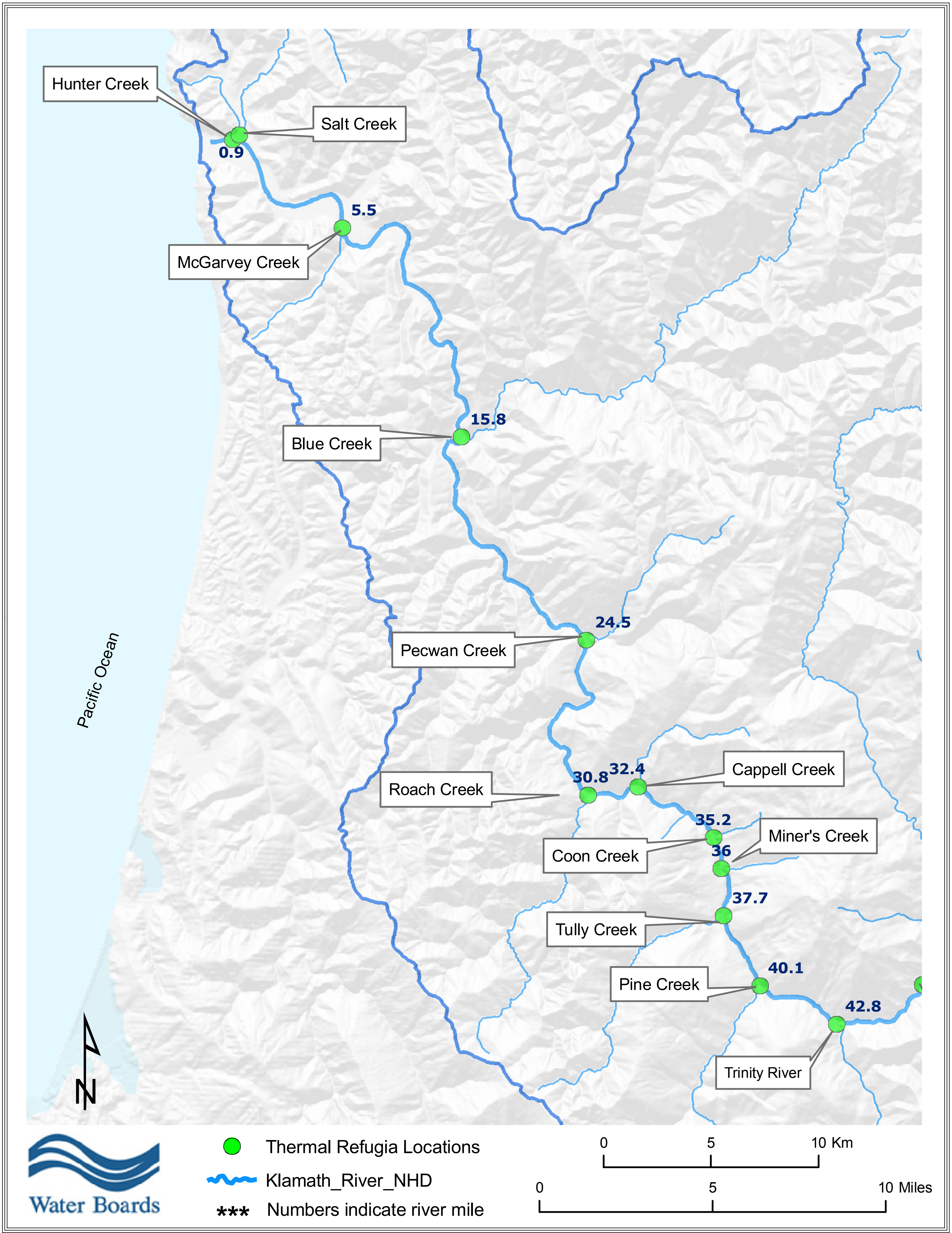
Oregon
California
Iron Gate Reservoir
Lumgrey Creek
Beaver Creek
Empire Creek
190.5
Bogus Creek
162
166.8
166.8
Doggett Creek
155.4
159
158.4
Humbug Creek
172.3
Little Humbug Creek
Shasta River
177.6
Barkhouse Creek
Water Boards
N
Thermal Refugia Locations
Klamath_River_NHD
*** Numbers indicate river mile
0 5 10 Km
0 5 10 Miles


Thompson Creek
Portuguese Creek
Grider Creek
Fort Goff Creek
Seiad Creek
Walker Creek
China Creek
O'Neil Creek
Negro Creek
Tom Martin Creek
Kuntz Creek
Scott River
Horse Creek
Kohl Creek
Dona Creek
Doggett Creek
McKinney Creek
123.7
127.2
130.9
133.9
118.5
137.9
139
140.3
143.8
143.3
148.2
152.9
153.5
155.4
155.3
Water Boards
N
Thermal Refugia Locations
Klamath_River_NHD
*** Numbers indicate river mile
0
5
10 Km
0
5
10 Miles


Cade Creek
109.9
China Creek
118.5
Indian Creek
107.4
Little Grider Creek
106.4
Elk Creek
102.2
100.9
Wilson Creek
Oak Flat Creek
99.1
Clear Creek
95.9
Titus Creek
94.3
Independence Creek
93.4
Crawford Creek
Ukonom Creek
Coon Creek
90.8
King Creek
Swillup Creek
Thomas Creek
Elliott Creek
Aubrey Creek
84.386.5
Dillon Creek
Ti Creek
80.1
Water Boards
N
Thermal Refugia Locations
Klamath_River_NHD
*** Numbers indicate river mile
0
5
10 Km
0
2.5
5 Miles



80.1
79
Rock Creek
Sandy Bar Creek
76.8
76.1
Stanshaw Creek
75
Irving Creek
Halverson Creek
73.3
72.1
Rogers Creek
Reynolds Creek
69.8
Teneyck Creek
Natuket Creek
65.5
Salmon River
Roselano Creek
Donahue Flat Creek
Ikes Creek
Wilson Creek
Whitmore Creek
61.2
Crawford Creek
59.5
Pearch Creek
58.8
Cheenitch Creek
Ullathorne Creek
Camp Creek
Boise Creek
55.1
52.2
Red Cap Creek
Slate Creek
50
49.1
Bluff Creek
Aikens Creek
48.2
Hopkins Creek
45.9
42.8
Trinity River
Water Boards
N
Thermal Refugia Locations
Klamath_River_NHD
*** Numbers indicate river mile
0
5
10 Km
0
2.5
5 Miles



Hunter Creek
Salt Creek
0.9
5.5
McGarvey Creek
15.8
Blue Creek
24.5
Pecwan Creek
Pacific Ocean
30.8
32.4
Cappell Creek
Roach Creek
35.2
Miner's Creek
Coon Creek
36
37.7
Tully Creek
40.1
Pine Creek
42.8
Trinity River
N
Water Boards
Thermal Refugia Locations
Klamath_River_NHD
*** Numbers indicate river mile
0
5
10 Km
0
5
10 Miles

Appendix 10

PUBLIC COMMENTS & RESPONSES

on the
STAFF REPORT,
APPENDICES TO THE STAFF REPORT,
and BASIN PLAN LANGUAGE

for the
KLAMATH RIVER TOTAL MAXIMUM DAILY LOADS (TMDLs) ADDRESSING TEMPERATURE, DISSOLVED OXYGEN, NUTRIENT, and MICROCYSTIN IMPAIRMENTS
IN CALIFORNIA,
the
PROPOSED SITE SPECIFIC DISSOLVED OXYGEN OBJECTIVES FOR THE KLAMATH RIVER IN CALIFORNIA,
and the
KLAMATH RIVER and LOST RIVER
IMPLEMENTATION PLANS

March 2010

Prepared by Staff
of the
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JUNE 2009 PUBLIC REVIEW DRAFT COMMENTS AND RESPONSES

DECEMBER 2009 PUBLIC REVIEW DRAFT COMMENTS AND RESPONSES

RESPONSE TO PUBLIC COMMENTS

1. Introduction

Two drafts of the Staff Report for the Klamath River Total Maximum Daily Loads (Staff Report) and the Basin Plan Language (Action Plan) were released for pubic review and comment. The first public review draft (June 2009 Public Review Draft) was release for a 50-day review and comment period and the second public review draft (December 2009 Public Review Draft) was released for a 47-day comment period. Regional Water Board staff received and responded to 321 comment letters on the June and December 2009 Public Review Draft documents as well as numerous oral comments received at public workshops and meetings. This Appendix contains those comments and Regional Water Board staff responses.

This Response to Public Comments document is divided into two sections: comments/responses on the June 2009 Public Review Draft, and comments/responses on the December 2009 Public Review Draft. Prior to providing an overview of these two sections, a summary of the primary issues raised in comments and Regional Water Board staff's overview responses are presented below.

2. Regional Water Board Summary of Comments and Responses

While comments on the draft Staff Report and Basin Plan Amendment language covered a wide range of issues, there were a number of key themes. This summary presents Regional Water Board staff response to these key themes.

Impairment Condition and Vision for Water Quality Restoration
The Klamath River, while nutrient-rich and seasonally warm, has also supported varied and abundant aquatic ecosystems, including an array of fishes, associated fisheries, and communities and cultures. The Klamath River is generally considered to have been the third most abundant producer of salmon on the West Coast of the United States, after the Columbia and Sacramento Rivers. The abundance of fishes and the health of fisheries of the Klamath River are generally acknowledged to be in serious jeopardy. Water quality of the river is also compromised, with even more nutrient enrichment, warmer water temperatures, and sediment load in the river and its watershed than the river can absorb and still support not only healthy aquatic ecosystems, but a variety of other uses dependent on the river, including fisheries, cultural, and recreational uses. A variety of human uses, both within and outside of the watershed, have contributed to the declines in water quality and associated beneficial uses.

The mission of the Regional Water Board is to preserve, enhance, and restore the quality of California's water resources, and ensure their proper allocation and efficient use for the benefit of present and future generations. The Regional Water Board sees significant opportunities for improvement and restoration of water quality and associated beneficial uses in the Klamath River and its watershed. Realizing these opportunities will require change and adjustment on the part of many in the watershed. At the same time, the Regional Water Board believes that good water quality and healthy communities are not incompatible. The Regional Water Board does not have an interest in sacrificing rural communities for water quality, but rather sees many opportunities for improving water quality and restoring beneficial uses, while at the same time supporting the full range of activities, communities and cultures of the watershed. In fact, good water quality may be essential in the long term for communities to remain healthy.

The Klamath River TMDL and Implementation Plan seek to describe the Regional Water Board's understanding of the current state of impairment of the Klamath River, water quality conditions that would form a part of the foundation of enhancement and restoration of this significant water resource, and the actions that would be needed to achieve such water quality improvements.

<u>TMDL Model Issues</u>
The Regional Water Board, Oregon Department of Environmental Quality (ODEQ), and US Environmental Protection Agency (US EPA) Regions 9 and 10, under contract with Tetra Tech, Inc. collectively the TMDL development team, amended and applied flow and water quality models of the Klamath River (from Link Dam in Oregon to the Pacific Ocean in California) to support development of Total Maximum Daily Loads (TMDLs) for the Klamath River. The TMDL model has been the source of many comments, both positive and negative.

The Klamath River TMDL model is a mathematical model that simulates water quality conditions of the mainstem Klamath River, based on representations of the physical, chemical, and biological conditions of the river system. Representation of water quality conditions can be challenging in many waterbodies. The size and attributes of the Klamath River make it especially challenging to model. Given this, the TMDL development team worked closely on all aspects of development and application of the TMDL model. Further, the TMDL development team sought peer review of the TMDL model by multiple peer reviewers at a number of steps during the TMDL development process, and addressed all comments by the peer reviewers. Given: 1) the time and 2) the resources spent on the TMDL model, 3) the collective expertise of the team, 4) the extensive peer review of the model and follow-up revisions to the model, the TMDL model development team believes that the Klamath TMDL models are scientifically sound, based on the best available information, and are appropriate tools for TMDL development. Further, the team finds the uncertainty associated with the Klamath TMDL models to be minimal, relative to the magnitude of the source load reductions needed to meet water quality standards in both Oregon and California. Any additional analysis will bring diminishing returns for determining implementation actions for the basin.

As new information becomes available, the TMDL models can and should be updated. If updates to the model demonstrate that TMDL allocations and targets should be adjusted, Regional Water Board staff will propose changes to the TMDL. As defined in the Reassessment and Monitoring Program chapter of the staff report and in the Action Plan, Regional Water Board staff are committed to an adaptive management process.

<u>Klamath Hydroelectric Project</u>
PacifiCorp contends that the Draft TMDL does not discuss how the relevant factors were considered in developing the DO and nutrient load allocation "plan." PacifiCorp repeatedly complains that it is inequitable to require "huge reductions in nutrients" not related to the actual loadings from the source. PacifiCorp then submits that temperature and numeric load allocations for the Klamath Hydroelectric Project (KHP) are unachievable and, as such, are inconsistent with

federal regulations and therefore the Regional Water Board should conduct a Use Attainability Analysis before undertaking the TMDL.

The first argument is incorrect for two reasons. First, there is no "load allocation plan"; rather, load allocations must be viewed in context with the implementation plan. Second, relevant factors were considered in drafting the implementation plan. The implementation program takes into account the difficulty of enforcing objectives and, in particular, considers the options reasonably available to dischargers to comply with the objectives. For example, the document acknowledges that the allocation at the stateline will require an unprecedented level of cooperation between the states and federal government to achieve pollutant loading reductions necessary to meet water quality objectives and support beneficial uses in both states. That topic alone indicates relevant factors under consideration which led to the formation of a Management Agreement with Oregon and EPA to help coordinate implementation, and early implementation specified on the Lost River tributary. In addition, the Regional Board has structured a pollutant trading and tracking program to encourage the implementation of centralized treatment options. This approach reflects consideration of engineering, costs, political and social factors, magnitude of impact, degree of success, and feasibility.

Regarding KHP implementation, PacifiCorp is required to submit a proposed TMDL implementation plan following TMDL adoption. Pursuant to the conditions of the Klamath Hydrological Settlement Agreement (KHSA), PacifiCorp has committed to implementing certain interim water quality measures in order to make reasonable progress toward TMDL compliance while further studies are conducted regarding the possibility of dam removal. The Regional Water Board is hopeful and committed to working within that process to produce water quality improvements in the interim time period while KHP infrastructure is studied. If the KHSA process does not move forward, PacifiCorp will need a license renewal from the Federal Energy Regulatory Commission (FERC). Both possible regulatory tracks involve decisions made in larger contexts and by agencies other than the Regional Water Board. While the Regional Water Board will decide whether a proposed implementation plan submitted by PacifiCorp is satisfactory for TMDL compliance, Regional Board approval must occur in the context of these other processes. For more information on the jurisdiction and two possible regulatory pathways for the KHP, please see comment K39.

PacifiCorp's main arguments that load allocations are improper because they are not related to the actual loadings from the source and are not achievable fail for several reasons. The KHP alters the temperature regime in the Klamath River and creates low dissolved oxygen and high temperature conditions within the reservoirs and at the tailraces. It alters the nutrient dynamics of the river by creating physical conditions that promote nuisance blooms of suspended algae, including toxin-forming blue-green algae species. The TMDL demonstrates that the load allocations are necessary to meet water quality objectives and ensure the protection of beneficial uses in the reservoirs. By altering the assimilative capacity of nutrients in the system, the reservoirs are the source, and the impairment that the allocations address would not exist in the absence of that source. Although it is often implied, Regional Water Board staff have clarified in the TMDL that the load allocations could be met by alternative management measures or offsets. Regardless PacifiCorp is responsible for the water quality conditions in its reservoirs.

PacifiCorps' comments also over emphasize the issue of "achievability," perhaps confusing a load allocation with a technology-based effluent limitation (TBEL). TBELs prescribe national standards that apply to a specific industrial category after an in-depth assessment of available pollution control technologies and practices. A model technology is selected as the basis for the required level of control. While that specific technology is not mandated, USEPA must demonstrate that the control is "achievable." The Clean Water Act also contains water quality-based requirements (WQBELs), which are developed when TBELs are not adequate to meet water quality standards in the receiving water. TBELs and WQBELs are applied to point source discharges through NPDES permits.

Because load allocations apply to nonpoint source pollution, neither TBELs nor WQBELs are necessarily relevant; however, the discussion is informative. If a load allocation were to be applied in a permit, it would be considered a WQBEL, not a TBEL, because it is based on meeting the water quality standards of the receiving water. There is no specific legal requirement to show that a load allocation is "achievable" given the current state of technology or control practices like a TBEL.

Whether or not a load allocation is achievable is not a legal standard; however, various factors can and should be considered. But again, load allocations must be viewed in context with the implementation plan. Recognizing the Regional Water Board's lack of implementing jurisdiction over the KHP, the implementation plan adds enough flexibility, through the allowance of offsets and time schedules, for implementing agencies to develop more specific conditions of approval that adequately meets the load allocations. The TMDL load allocations are sufficiently stringent to help guide decision-making to determine KHP compliance with water quality standards, but flexible enough to allow opportunities to explore various options for achieving compliance, including time schedules to accommodate various contingencies. The TMDL implementation plan does not unduly bind any implementing agency on the range of options for KHP Clean Water Act compliance.

Achievability and attainability and are two different concepts. PacfiCorps also argues that standards are not "attainable." It would be inappropriate at this time for the Regional Water Board to conduct an analysis to determine whether the existence of the KHP precludes the attainment of a potential beneficial uses, and whether it is feasible to restore the water body to its original condition. The decision by the State on whether to conduct a UAA is up to the discretion of the State and the Regional Water Board staff cannot recommend pursuing this option. The TMDL Implementation Plan is flexible enough to allow the Secretarial Determination to move forward and that process will help inform this question, which could perhaps be revisited in 2012 after the Secretary makes findings. Detailed responses to all of these issues are more are located in response to comments K39, K40, K53 and K54.

<u>Future Agricultural Waiver</u>
The June 2009 draft Klamath implementation plan proposed the development of WDRs and/or a waiver of WDRs for both irrigated agricultural and grazing in the Klamath River basin, including all tributaries, by 2012 and 2013 respectively. It also included interim measures that would be made enforceable through a Klamath Basin TMDL conditional waiver, similar to the waivers adopted alongside the Shasta River and Scott River TMDLs. Throughout both comment periods,

the Regional Water Board received comments in support of increased regulation and monitoring of agricultural land use activities in the Klamath basin. During the first public comment period, the Regional Water Board received comments from the regulated community requesting a more robust stakeholder process and questioning the appropriateness of interim requirements in basins where TMDL implementation plans already exist. The interim requirements were subsequently removed, and instead of separate WDRs/waiver for grazing and irrigated agriculture, the December 2009 draft implementation plan proposed the development of a single conditional waiver to address both land uses by December 2012. Then, during the comment period for the December 2009 draft, the Regional Water Board received comments from tribal governments and environmental interests requesting that the interim requirements be reinstated. Staff decided to not include interim requirements in the final draft TMDL for the following reasons:

1. It is inefficient to administer and enforce a separate interim waiver as when a conditional waiver of Waste Discharge Requirements is proposed for development upon adoption of the TMDL.

2. Developing an interim waiver and then the final waiver will be more confusing for responsible parties if requirements were to change.

3. There is a potential for overlapping regulatory requirements in the Klamath basin considering the existing TMDLs in the Scott and Shasta basins.

4. Removing the interim waiver and specific requirements shortens the time for the agricultural conditional waiver program to be developed.

The proposal to develop a conditional waiver for agriculture by December 2012 remains in the final draft, and an inclusive stakeholder process is scheduled to begin upon adoption of the Klamath TMDL. Regional Water Board staff believe this is a reasonable approach to regulation that addresses both the need for stakeholder input and the requirements of existing TMDL implementation plans.

Thermal Refugia

The December 2009 draft proposed a comprehensive Thermal Refugia Protection Policy that recommends enhanced protection of identified thermal refugia in the Klamath basin. The Regional Water Board received many comments expressing support for this proposed policy stressing the importance of properly functioning refugia to the survival of cold water fish. The particular policy provision that garnered the most comments was the proposal to restrict suction dredging activities from discharging waste to designated instream buffers surrounding the refugia locations during a specified time period. Several commenters disputed the scientific justification for the proposed restrictions and some claimed the restrictions would constitute a taking of private property as defined in the Mineral Estate Grant of 1866. Regarding the scientific justification, commenters cited studies showing that suction dredging does not have certain long-term impacts to water quality and other fish habitat features. In response, Regional Water Board expanded the discussion of the literature review in the staff report to more fully document the environmental impacts of suction dredging discharges. While staff agree with commenters that long-term impacts are often insignificant, the restrictions are still needed to protect the function of thermal refugia in the short-term because of their seasonal nature. Regarding the private property issue, staff do not agree that the proposed restrictions would amount to a taking of private property. First, the Klamath TMDL implementation plan proposes restrictions on suction dredge discharges only in certain sensitive locations and during certain times. Also, it does not restrict all mining; rather, it only applies to the type of mining that discharges waste. Finally, the proposed policy would only affect a minority of mining claims in the Klamath basin, and even within those claims, it would only affect a certain area. Thus miners would not be deprived of the ability to mine their claims, even with a suction dredge.

<u>Forestry</u>
The most common forestry-related comment requested Calfire's forest practice rules (FPRs) be employed as the means of implementing shade allocations on non-federal lands. This comment was addressed by revising the document to rely on the FPRs, with additional measures required to protect stream temperatures when Regional Water Board staff find the FPRs inadequate. The Board of Forestry's adoption of the significantly increased riparian retention standards contained in the Anadromous Salmonid Protection rule package was a significant event that allowed for the incorporation of the FPRs into the implementation plan. Another common comment requested clarification of the spatial extent of the Klamath TMDL, and what canopy retention standards would apply in areas outside of the range of anadromy. These comments were accompanied with statements that the standard FPRs were adequate to address temperature concerns. This comment was addressed by revising the document to rely on the FPRs, with additional measures required to protect stream temperatures when RWB staff find the FPRs inadequate. The document was also revised to encourage foresters to present harvest plans consistent with the riparian retention standards found in the Anadromous Salmonid Protection rule package.

3. Overview of June 2009 Public Review Draft Comments

Regional Water Board staff reviewed all of the written and oral comments submitted on the June 2009 Public Review Draft. The written comments were partitioned into categories based on comment topic, and each comment category was assigned a letter of the alphabet from A-Z. The oral comments were summarized and assigned their own comment category (ZZ). Categories are ordered similarly to the organization of the staff report. The comment categories are listed in Table 1 and are presented in this document alphabetically according to their assigned letter of the alphabet.

Within each of the comment categories, the comments are numbered using an alpha-numeric system. The comments are organized by the letter assigned to that category and a number (with the first comment being 1). For example, all the comments in the category “TMDL Model Comments” will be denoted with an “A” before the comment number. The first comment is A1, the second is A2, etc. In the “Impairment Assessment” category, all the comments are denoted with a “B” before the comment number: B1, B2, etc.

Table 1: June2009 Public Review Draft Comment Categories

Comment Category	Comment Category
A- TMDL Model Comments	O- Approach and Mode of Compliance
B- Impairment Assessment	P- Watershed-wide Implementation
C- Source Analysis	Q- Future Agricultural Waiver
D- Targets and Allocations	R- Monitoring and Compliance Tracking
E- TMDL Margin of Safety	S- Economics and Environmental Analysis
F- Linkage Between Technical Analysis and Implementation	T- Stakeholder Participation
G- Load Allocation at Stateline	U- Peer Review
H- Lost River Implementation	V- Data and QA/QC
I- Accounting and Tracking	W- Site Specific Dissolved Oxygen Objective
J- Blue Green Algae	X- Flow
K- Klamath Hydroelectric Project	Y- General Comments
L- Tributaries	Z - Editorial Comments
M- Sediment-Related Comments	ZZ – Oral Comments on the June 2009 Public Review Draft
N- Thermal Refugia	

Following the text of the written comment, the author(s) of the comment is identified by last name(s) and affiliation (where appropriate). For oral comments, authors are identified by their full name and affiliation (where appropriate). A complete list of the persons submitting comments on the June 2009 Public Review Draft, and the name & affiliation (where appropriate) used to identify each authors comments is presented in Table 2.

Table 2: List of persons submitting comments on the June 2009 Public Review Draft

Commenter(s) Full Name	Association (if applicable)	Name & Affiliation Used To Identify Author(s) Comments
Greg Addington & Earl Danosky	Klamath Water Users Association & Tulelake Irrigation District	Addington and Danosky – Klamath Water Users Association & Tulelake Irrigation District
Lauren Alvarado	-	Lauren Alvarado
Marcia Armstrong	Siskiyou County Supervisor, District 5	Armstrong - Siskiyou County Supervisor, District 5
Mike Becker	-	Mike Becker
Grace Bennett	Siskiyou County Supervisor, District 4	Bennett – Siskiyou County Supervisor, District 4
Michelle Berditschevsky	Mount Shasta Bioregional Ecology Center	Michelle Berditschevsky – Mount Shasta Bioregional Ecology Center
Leo Bergeron	-	Leo Bergeron
Rich Bodnar	-	Bodnar
Crystal Bowman	Quartz Valley Indian Reservation	Bowman – Quartz Valley Indian Reservation
Gary Black	-	Black
Glenn Briggs	-	Briggs
Petey Brucker	Klamath Forest Alliance	Petey Brucker – Klamath Forest Alliance
Mike Bryan	Mike Bryan Ranch	Mike Bryan – Mike Bryan Ranch
Rick Butler	-	Rick Butler
Patricia Cantrall	Modoc County Board of Supervisors	Cantrall – Modoc County Board of Supervisors
Rosalie Carnam	-	Carnam
Paul Chapman	Campbell Timber Management	Chapman – Campbell Timber Management
Regina Chichizola	-	Regina Chichizola
Dana Colgrove	-	Dana Colgrove
Kevin Collins	Humboldt Fisherman's Marketing Association	Kevin Collins – Humboldt Fisherman's Marketing Association

Table 2 (cont.): List of persons submitting comments on the June 2009 Public Review Draft

Commenter(s) Full Name	Association (if applicable)	Name & Affiliation Used To Identify Author(s) Comments
Jim Cook	Siskiyou County Supervisor, District 1	Cook – Siskiyou County Supervisor, District 1
Rick Costales	Siskiyou County	Costales – Siskiyou County
Dr. Matthew Cover	CSU Stanislaus	Cover – CSU Stanislaus
Rex Cozzalio	-	Cozzalio
Earl Crosby	Karuk Tribe	Crosby – Karuk Tribe
Aaron David	-	Aaron David
Darrell DePaul	Modoc County Farm Bureau	DePaul – Modoc County Farm Bureau
Michele Dias	California Forestry Association	Dias – California Forestry Association
Stan Dixon	Board of Forestry and Fire Protection	Dixon – Board of Forestry and Fire Protection
Neal Ewald	Green Diamond Resource Company	Ewald – Green Diamond Resource Company
Stuart Farber	Timber Products Company	Farber – Timber Products Company
Ken Fetcho	Yurok Tribe	Fetcho – Yurok Tribe
Shannon Flarity	-	Shannon Flarity
James Foley	-	Foley
Gene Foster	Oregon Department of Environmental Quality	Foster – Oregon Department of Environmental Quality
Jeffrey Fowle	-	Fowle
David Gensaw	-	David Gensaw
Dr. Richard Gierak	-	Gierak
Charnna Gilmore	Scott River Watershed Council	Gilmore – Scott River Watershed Council
Bob Goodwin	-	Bob Goodwin
Zeke Grader	Pacific Coast Federation of Fishermen's Associations	Zeke Grader – PCFFA
Jon Grunbaum	-	Grunbaum
Tom Guarino	Council for Siskiyou County	Tom Guarino – Council for Siskiyou County
Will Harling	Mid Klamath Watershed Council	Harling – Mid Klamath Watershed Council
Janet Hashimoto	U.S. Environmental Protection Agency	Hashimoto – USEPA
Janet Hashimoto & Sam Ziegler	U.S. Environmental Protection Agency	Hashimoto and Ziegler – USEPA
David Helliwell	F. V. Corregidor	David Helliwell – F. V. Corregidor
Vivian Helliwell	Pacific Coast Federation of Fishermen's Associations /Institute for Fisheries Resources	Vivian Helliwell – PCFFA/IFR
Tim Hemstreet	PacifiCorp	Hemstreet – PacifiCorp
Holly Hensher	-	Holly Hensher
Jon Hicks	U.S. Bureau of Reclamation	Hicks – U.S. Bureau of Reclamation
Leaf Hillman	Karuk Tribe	Leaf Hillman – Karuk Tribe
Greta Hockaday	Montague Water Conservation District	Hockaday – Montague Water Conservation District
Tyrone Kelly	U.S. Forest Service, Six Rivers	Kelly – U.S. Forest Service, Six Rivers
Michael Kobseff	Siskiyou County Board of Supervisors	Kobseff – Siskiyou County Board of Supervisors
Doug Korech	-	Doug Korech
David and Jacqui Krizo	-	Krizo
William Krum	Siskiyou County Resource Conservation District	Krum – Siskiyou County Resource Conservation District
Alan Levine	Coast Action Group	Levine – Coast Action Group
Danielle Lindler	Klamath Alliance for Resources and Environment	Danielle Lindler – Klamath Alliance for Resources and Environment
London**	-	London

Table 2 (cont.): List of persons submitting comments on the June 2009 Public Review Draft

Commenter(s) Full Name	Association (if applicable)	Name & Affiliation Used To Identify Author(s) Comments
Malena Marvin	Klamath Riverkeeper	Malena Marvin
Deborah E. McConnell	California Indian Basketweavers Association	Deborah E. McConnell – California Indian Basketweavers Association
Jene McCovey	-	McCovey
Kathy McCovey	-	Kathy McCovey
Scott McGowen	California Department of Transportation	McGowen – Caltrans
Randy Moore	U.S. Forest Service, Pacific South West Region	Moore – U.S. Forest Service, Pacific South West Region
Jim Morris	Siskiyou County Farm Bureau	Morris- Siskiyou County Farm Bureau
Dr. Kari Norgaard	-	Dr. Kari Norgaard
Daniel Myers	Sierra Club, Redwood Chapter	Myers – Sierra Club, Redwood Chapter
Georgiana Myers	Klamath River Coalition	Georgiana Myers – Klamath River Coalition
Felice Pace	-	Pace
Felice Pace, Diane Beck, & Joe Gillespie	North Group-Redwood Chapter-Sierra Club & Friends of Del Norte	Pace, Beck, Gillespie – North Group-Redwood Chapter-Sierra Club & Friends of Del Norte
Jocelyn Peters	-	Jocelyn Peters
Chris Quirmbach	Timber Products Company	Quirmbach – Timber Products Company
Jack Rice & Justin Oldfield	California Farm Bureau Federation and California Cattlemen's Association	Rice and Oldfield – California Farm Bureau Federation and California Cattlemen's Association
Kristen Raymond	-	Kristen Raymond
Ben Riggan	-	Riggan
Marc Robbi	-	Marc Robbi
Terry Salvestro	Fruit Growers Supply Company	Salvestro – Fruit Growers Supply Company
John Sanguinetti	-	Sanguinetti
Eric Schmidt	-	Schmidt
John Schuyler	Klamath National Forest	Schuyler – Klamath National Forest
Damien Scott	-	Damien Scott
Barbara Short	-	Barbara Short
Daniel Simon	-	Simon
William Snyder	California Department of Forestry and Fire Protection	Snyder – California Department of Forestry and Fire Protection
David Solem	Klamath Irrigation District	Solem – Klamath Irrigation District
Glen Spain	Institute for Fisheries Resources & Pacific Coast Federation of Fishermen's Associations	Spain – Institute for Fisheries Resources & Pacific Coast Federation of Fishermen's Associations
Gary Stacey	California Department of Fish and Game	Stacey – California Department of Fish and Game
Grant Stevens	-	Grant Stevens
Nita Still	-	Nita Still
Scott Sumner	Siskiyou County Public Works	Sumner – Siskiyou County Public Works
Erica Terence	Klamath Riverkeeper	Terence – Klamath Riverkeeper
Bill Tripp	-	Bill Tripp
Various*	Klamath Riverkeeper	Klamath Riverkeeper – Various
Thomas Walz	Sierra Pacific Industries	Walz – Sierra Pacific Industries
Wright**	-	Wright

* The commenter "Various" represents all persons who sent the form letter comments developed by the Klamath Riverkeepers. Regional Water Board staff received 450 of these form letters. Comments by these authors are denoted as "Klamath Riverkeeper – Various" in the comments section of this document.
** Person did not state first name when commenting.

Responses are provided for each comment that was received. At times, when several similar comments on a topic were received, the comments were summarized and all persons who made the comment are listed. If a comment or portion of a comment has been answered elsewhere within a comment category, or answered in another comment category, the reader will be referred to the comment number where the response to their comment may be found. For example, in the "Watershed-wide Implementation" category, the response to Comment P12 states: "See the response to comment P30." This means that the response to P30 is also the response to P12. An example of where the reader is referred to a response in another comment category is found in the "Source Analysis" category where the response to comment C62 states: "Also, please see the response to comment A2." This means the reader is referred to the "TMDL Model Comments" category, response to comment A2.

Due to the large volume of written comments that Regional Water Board staff received and responded to, a list of the persons submitting written comments on the June 2009 Public Review Draft and the comment category letter and number where their comments may be found is presented in Table 3. Due to the large size of this table, it has been placed at the end of this introduction (see Introduction pages 7 to 15). Oral comments can all be found in section titled "Oral Comments on the June 2009 Public Review Draft", which is category ZZ.

4. Overview of December 2009 Public Review Draft Comments

Regional Water Board staff reviewed all of the written and oral comments submitted on the December 2009 Public Review Draft. Written comments were extracted and compiled by author. Oral comments are summarized under the heading "Oral Comments on the December 2009 Public Review Draft", and the author of each comment is identified. When several similar oral comments on a topic were received, the comments were summarized and all persons who made the comment are listed. A complete list of the persons submitting comments on the December 2009 Public Review Draft, and the name & affiliation (where appropriate) used to identify each authors comments is presented in Table 4.

Table 4: List of persons submitting comments on the December 2009 Public Review Draft.

Commenter(s) Full Name	Association (if applicable)	Last Name Used To Identify Author(s) Comments
Greg Addington & Earl Danosky	Klamath Water Users Association & Tulelake Irrigation District	Addington and Danosky
Anthony Antisno	Shasta Valley Water Users Association	Anthony Antisno – Shasta Valley Water Users Association
Marcia Armstrong	Siskiyou County Supervisor	Marcia Armstrong - Siskiyou County Supervisor
Grace Bennett	Siskiyou County Supervisor, District 4	Bennett
Crystal Bowman	Quartz Valley Indian Reservation	Bowman
Petey Brucker	Klamath Forest Alliance	Petey Brucker – Klamath Forest Alliance
Jason Cameron	U.S. Bureau of Reclamation	Cameron
Paul Chapman	Campbell Timber Management	Chapman
Susan Corum	Karuk Tribe	Susan Corum – Karuk Tribe
Rick Costales	Siskiyou County	Costales
Rex Cozzalio	-	Cozzalio
Robert Davis	-	Davis
Walter Epp	-	Epp

Table 4 (cont.): List of persons submitting comments on the December 2009 Public Review Draft.

Commenter(s) Full Name	Association (if applicable)	Last Name Used To Identify Author(s) Comments
James Foley	Upper Mid-Klamath Watershed Council	James Foley – Upper Mid-Klamath Watershed Council
Adriane Garayalde	Shasta Valley Resource Conservation District	Garayalde
Dr. Richard Gierak	-	Gierak
Tom Guarino	Siskiyou County's Counsel	Tom Guarino –Siskiyou County's Councel
Janet Hashimoto	U.S. Environmental Protection Agency	Hashimoto
Janet Hashimoto & Sam Ziegler	U.S. Environmental Protection Agency	Hashimoto and Ziegler
Tim Hemstreet	PacifiCorp	Hemstreet – PacifiCorp
Leaf Hillman	Karuk Tribe	Hillman
David Lewis	California State Grange	Lewis
Dan Macsay	Modoc County Board of Supervisors	Macsay
John Menke	-	John Menke
Robert Musgrove	Sierra Club, Shasta Group	Musgrove
Daniel Myers	Sierra Club, Redwood Chapter	Myers
Chris Quirmbach	Timber Products Company	Quirmbach
Gary Rynearson	Green Diamond Resource Company	Rynearson
Kathleen Sloan	Yurok Tribe	Sloan
Glen Spain	Institute for Fisheries Resources & Pacific Coast Federation of Fishermen's Associations	Spain – Institute for Fisheries Resources & Pacific Coast Federation of Fishermen's Associations
Erica Terence	Klamath Riverkeeper	Terence
Various*	Klamath Riverkeeper	Klamath Riverkeeper – Various
Robert Walker	Upper Mid-Klamath Watershed Council	Walker - Upper Mid-Klamath Watershed Council
Thane Woodley	Klamath Soil & Water Conservation District	Woodley

* The commenter "Various" represents all persons who sent the form letter comments developed by the Klamath Riverkeepers. Regional Water Board staff received 63 of these form letters. Comments by these authors are denoted as "Klamath Riverkeeper – Various" in the comments section of this document.

Responses are provided for each comment that was received. If a comment or portion of a comment on the December 2009 Public Review draft has already been answered in the June 2009 Public Review Draft section of this document, the reader will be referred to the comment number where the response to their comment may be found. For example, the response to comment number 13 submitted by the authors Addington and Danosky states "See the response to comment O22." This means that the response to this comment is the same as the response to comment O22 in the in the "Future Agricultural Waiver" category from the June 2009 Public Review Draft comments. Additionally, if an author's comment on the December 2009 Public Review Draft is similar to those submitted by another author on the December draft, one response will be given to both (or all) comments and the authors will be referred to the location of that response. For example, the response for comment 10 by the authors Addington and Danosky states: "See response to Hashimoto and Ziegler – 8". This means that the response to comment 8 submitted by Hashimoto and Ziegler is also the response to Addington and Danosky's comment number 10.

Table 3: List of Persons Submitting Written Comments on the June 2009 Public Review Draft and the Location of Those Comments and Responses Within This Document

Comment Category	**Addington and Danosky** Klamath Water Users Association	**Armstrong** Siskiyou County Supervisor, District 5	**Bennett** Siskiyou County Supervisor, District 4	**Bodnar**	**Bowman** Quartz Valley Indian Reservation	**Black**	**Briggs**
A-TMDL Model Comments	-	-	-	-	166, 167, 171, 172	-	-
B- Impairment Assessment	25, 26	-	41	42	-	-	-
C- Source Analysis	25, 26, 29, 42, 49-52, 98	-	-	-	43, 97	-	101
D- Targets and Allocations	-	-	-	-	54	-	-
E- TMDL Margin of Safety	-	-	-	-	-	-	-
F- Linkage Between Technical Analysis and Implementation	1	-	-	-	-	-	-
G- Load Allocation at Stateline	1-3	-	-	-	-	-	-
H- Lost River Implementation	1-8, 25, 26	-	-	-	15, 26	-	-
I- Accounting and Tracking	-	-	-	-	1-4, 6	-	-
J- Blue Green Algae	-	-	-	5	1-3	-	-
K- Klamath Hydroelectric Project	-	-	-	56	2, 12-15, 21	-	57
L- Tributaries	-	-	1, 17	-	39	45	-
M- Sediment-Related Comments	-	-	-	-	3	-	-
N- Thermal Refugia	-	12-15	16	-	3-5	-	-
O- Approach and Mode of Compliance	1, 24	17, 18, 22, 23a, 23b	2, 23b	-	-	-	-
P- Watershed-wide Implementation	-	-	6, 81	-	8, 9, 37, 63-66	-	-
Q- Future Agricultural Waiver	-	2	-	-	3	-	-
R- Monitoring and Compliance Tracking	-	-	-	-	2-12, 35	-	-
S- Economics and Environmental Analysis	1, 2, 16-19	3, 4	5, 6	-	-	-	-
T- Stakeholder Participation	14, 15	-	1	-	13	-	-
U- Peer Review	-	-	-	-	-	-	-
V- Data and QA/QC	-	-	-	-	1	-	-
W- Site Specific Dissolved Oxygen Objective	1	-	-	-	7-12	-	-
X- Flow	-	2	-	-	4	-	-
Y- General Comments	-	-	-	-	-	-	-
Z - Editorial Comments	1, 2	-	-	-	3-11, 55	-	-

Table 3 (cont.): List of Persons Submitting Written Comments on the June 2009 Public Review Draft and the Location of Those Comments and Responses Within This Document

Comment Category	**Cantrall** Modoc County Board of Supervisors	**Carnam**	**Chapman** Campbell Timber Management	**Cook** Siskiyou County Supervisor, District 1	**Costales** Siskiyou County	**Cover**	**Cozzalio**
A-TMDL Model Comments	169, 170	-	-	-	-	-	182, 183
B- Impairment Assessment	-	-	-	-	-	-	36
C- Source Analysis	27, 28, 31-35, 53-58	-	-	-	-	-	45, 46
D- Targets and Allocations	-	-	-	-	-	-	-
E- TMDL Margin of Safety	-	-	-	-	-	-	-
F- Linkage Between Technical Analysis and Implementation	2-6	-	-	-	-	-	-
G- Load Allocation at Stateline	4	-	-	-	-	-	-
H- Lost River Implementation	8-14	-	-	-	-	-	-
I- Accounting and Tracking	-	-	-	-	-	-	-
J- Blue Green Algae	-	-	-	-	-	-	-
K- Klamath Hydroelectric Project	-	-	-	-	-	-	8, 9
L- Tributaries	-	-	2, 3, 11	-	-	-	-
M- Sediment-Related Comments	-	1	-	10	-	2	-
N- Thermal Refugia	-	1	-	26	27	2	-
O- Approach and Mode of Compliance	22, 23b	-	-	-	-	-	13-15, 26, 27
P- Watershed-wide Implementation	-	7	12, 31-36	-	58, 69	-	26
Q- Future Agricultural Waiver	-	-	-	7	5, 13	-	-
R- Monitoring and Compliance Tracking	-	1	-	-	-	-	-
S- Economics and Environmental Analysis	4, 7, 9, 10	-	-	-	16	-	-
T- Stakeholder Participation	-	-	-	-	-	-	6
U- Peer Review	-	-	-	1	-	-	3
V- Data and QA/QC	10	-	-	-	-	-	3-5
W- Site Specific Dissolved Oxygen Objective	-	-	-	-	-	-	5
X- Flow	-	3	-	-	-	-	14
Y- General Comments	-	-	-	-	-	-	8
Z - Editorial Comments	-	-	-	-	-	-	-

Table 3 (cont.): List of Persons Submitting Written Comments on the June 2009 Public Review Draft and the Location of Those Comments and Responses Within This Document

Comment Category	**Crosby** Karuk Tribe	**Dixon** Board of Forestry and Fire Protection	**DePaul** Modoc County Farm Bureau	**Dias** California Forestry Association	**Ewald** Green Diamond Resource Company	**Farber** Timber Products Company	**Fetcho** Yurok Tribe
A-TMDL Model Comments	166, 167, 171, 172	-	-	-	-	-	166, 167, 171, 172
B- Impairment Assessment	-	-	-	-	-	-	-
C- Source Analysis	43, 97	-	-	-	-	-	43, 97
D- Targets and Allocations	54	-	-	-	-	-	54
E- TMDL Margin of Safety	-	-	-	-	-	-	-
F- Linkage Between Technical Analysis and Implementation	-	-	-	-	-	-	-
G- Load Allocation at Stateline	-	-	-	-	-	-	-
H- Lost River Implementation	15, 26	-	17	-	-	-	15, 26
I- Accounting and Tracking	1-4, 6	-	-	-	-	-	1-4, 6
J- Blue Green Algae	1-3	-	-	-	-	-	1-3
K- Klamath Hydroelectric Project	2, 12-15, 21	-	-	-	-	-	2, 12-15, 21
L- Tributaries	39	-	-	-	-	-	39
M- Sediment-Related Comments	3	-	-	-	-	-	3
N- Thermal Refugia	3-5	-	-	-	-	-	3-5
O- Approach and Mode of Compliance	-	-	3, 19, 22, 23b, 25	-	-	-	-
P- Watershed-wide Implementation	8, 9, 37, 63-66	40	-	38, 39	41-43	44-52	8, 9, 37, 63-66
Q- Future Agricultural Waiver	3	-	-	-	-	-	3
R- Monitoring and Compliance Tracking	2-12, 35	-	-	-	-	-	2-12, 35
S- Economics and Environmental Analysis	-	-	-	-	-	-	-
T- Stakeholder Participation	13	-	-	-	-	-	13
U- Peer Review	-	-	-	-	-	-	-
V- Data and QA/QC	1	-	-	-	-	-	1
W- Site Specific Dissolved Oxygen Objective	7-12	-	-	-	-	-	7-12
X- Flow	4	-	-	-	-	-	4
Y- General Comments	-	-	-	-	-	-	-
Z - Editorial Comments	3-11, 55	-	-	-	-	-	3-11, 55

Table 3 (cont.): List of Persons Submitting Written Comments on the June 2009 Public Review Draft and the Location of Those Comments and Responses Within This Document

Comment Category	**Foley**	**Foster** Oregon Department of Environmental Quality	**Fowle**	**Gierak**	**Gilmore** Scott River Watershed Council	**Grunbaum**	**Harling** Mid Klamath Watershed Council
A-TMDL Model Comments	-	-	-	-	-	-	-
B- Impairment Assessment	-	-	27	28-30	-	31	-
C- Source Analysis	-	-	-	-	-	-	-
D- Targets and Allocations	-	-	-	-	-	-	-
E- TMDL Margin of Safety	-	-	-	-	-	-	-
F- Linkage Between Technical Analysis and Implementation	-	-	-	-	-	-	-
G- Load Allocation at Stateline	-	5-8	-	-	-	9	-
H- Lost River Implementation	-	-	-	-	-	-	-
I- Accounting and Tracking	-	-	-	-	-	-	-
J- Blue Green Algae	-	-	-	-	-	-	-
K- Klamath Hydroelectric Project	7	-	-	3-5	-	-	58
L- Tributaries	-	-	17, 38	-	17, 18, 30	-	46
M- Sediment-Related Comments	-	-	-	14	-	-	-
N- Thermal Refugia	17a-19, 21-24	-	-	6	-	-	32
O- Approach and Mode of Compliance	-	-	23b	21	-	-	29
P- Watershed-wide Implementation	-	-	-	-	-	10	100, 101
Q- Future Agricultural Waiver	-	-	10	-	-	-	-
R- Monitoring and Compliance Tracking	-	-	-	13	-	36	42, 43
S- Economics and Environmental Analysis	-	-	11, 20	-	-	-	-
T- Stakeholder Participation	-	-	2	-	-	-	-
U- Peer Review	-	-	-	-	-	-	-
V- Data and QA/QC	-	-	-	-	-	-	-
W- Site Specific Dissolved Oxygen Objective	-	-	-	-	-	-	-
X- Flow	-	-	-	15	-	5	-
Y- General Comments	5	-	-	-	-	1	9, 10
Z - Editorial Comments	-	-	-	12	-	-	-

Table 3 (cont.): List of Persons Submitting Written Comments on the June 2009 Public Review Draft and the Location of Those Comments and Responses Within This Document

Comment Category	**Hashimoto** USEPA	**Hashimoto and Ziegler** USEPA	**Hemstreet** PacifiCorp	**Hicks** U.S. Bureau of Reclamation	**Hockaday** Montague Water Conservation District	**Kelly** U.S. Forest Service, Six Rivers	**Klamath Riverkeeper** Various*
A-TMDL Model Comments	-	-	1-10, 25-163, 168	11-24	-	-	-
B- Impairment Assessment	-	-	1-22, 37-40	23, 24, 32-34	-	43, 44	-
C- Source Analysis	-	-	1-20, 36-41, 47, 48, 68-96	21-24, 59-61	-	100	-
D- Targets and Allocations	-	29, 62	1-27, 30, 31, 33-53, 60 61	28	-	63-65	-
E- TMDL Margin of Safety	-	-	1-8	-	-	-	-
F- Linkage Between Technical Analysis and Implementation	-	7, 8	-	9	-	-	-
G- Load Allocation at Stateline	-	-	-	10	-	-	-
H- Lost River Implementation	-	18	-	27	-	-	-
I- Accounting and Tracking	-	-	5	-	-	-	-
J- Blue Green Algae	-	-	-	-	-	-	-
K- Klamath Hydroelectric Project	-	16	1, 32-55	-	-	-	6
L- Tributaries	-	-	-	-	4, 19-23, 25-28, 40	-	5
M- Sediment-Related Comments	-	4	-	5	-	15	-
N- Thermal Refugia	-	-	11	-	-	-	-
O- Approach and Mode of Compliance	-	4	-	-	-	-	5, 6
P- Watershed-wide Implementation	-	67	-	-	-	89-99	-
Q- Future Agricultural Waiver	-	-	-	-	-	-	-
R- Monitoring and Compliance Tracking	-	14, 37-39	25-34	15-18	-	-	40
S- Economics and Environmental Analysis	-	12	23, 24	-	-	-	-
T- Stakeholder Participation	-	-	8a-8c, 16	-	9, 11, 12	-	-
U- Peer Review	-	-	4-18, 20	-	-	-	-
V- Data and QA/QC	-	-	6-9, 11	-	-	-	-
W- Site Specific Dissolved Oxygen Objective	2	-	6	3, 4	-	-	-
X- Flow	-	-	-	-	-	-	-
Y- General Comments	-	-	-	-	-	-	2
Z - Editorial Comments	-	13-25	36-54	26-33	34	-	-

Table 3 (cont.): List of Persons Submitting Written Comments on the June 2009 Public Review Draft and the Location of Those Comments and Responses Within This Document

Comment Category	**Kobseff** Siskiyou County Board of Supervisors	**Krizo**	**Krum** Siskiyou County Resource Conservation District	**Levine** Coast Action Group	**London**	**McCovey**
A-TMDL Model Comments	-	-	-	-	-	-
B- Impairment Assessment	-	-	-	-	-	-
C- Source Analysis	-	62-67	-	-	-	-
D- Targets and Allocations	-	-	-	-	-	-
E- TMDL Margin of Safety	-	-	-	-	-	-
F- Linkage Between Technical Analysis and Implementation	10	-	-	-	-	-
G- Load Allocation at Stateline	-	-	-	11	-	-
H- Lost River Implementation	-	-	-	-	-	-
I- Accounting and Tracking	-	-	-	-	-	-
J- Blue Green Algae	4	-	-	-	-	-
K- Klamath Hydroelectric Project	-	-	-	-	-	-
L- Tributaries	6	-	7, 24, 26, 29-33, 41, 42, 44	34, 35	-	-
M- Sediment-Related Comments	-	-	-	-	-	-
N- Thermal Refugia	20, 25	-	-	28	7	-
O- Approach and Mode of Compliance	20	-	-	7	-	-
P- Watershed-wide Implementation	53, 68	-	-	54, 55	-	-
Q- Future Agricultural Waiver	4	-	-	-	-	-
R- Monitoring and Compliance Tracking	-	-	-	-	-	-
S- Economics and Environmental Analysis	6	-	-	13	-	-
T- Stakeholder Participation	3, 7, 10	-	4	-	-	-
U- Peer Review	19	-	-	-	-	-
V- Data and QA/QC	-	-	-	-	-	-
W- Site Specific Dissolved Oxygen Objective	-	-	-	-	-	-
X- Flow	-	-	-	6	-	7
Y- General Comments	6	-	-	3	-	-
Z - Editorial Comments	-	-	35	-	-	-

Table 3 (cont.): List of Persons Submitting Written Comments on the June 2009 Public Review Draft and the Location of Those Comments and Responses Within This Document

Comment Category	**McGowen** Caltrans	**Moore** U.S. Forest Service, Pacific South West Region	**Morris** Siskiyou County Farm Bureau	**Myers** Sierra Club, Redwood Chapter	**Pace**	**Pace, Beck, Gillespie** North Group-Redwood Chapter-Sierra Club & Friends of Del Norte	**Quirmbach** Timber Products Company
A-TMDL Model Comments	-	-	-	-	-	-	-
B- Impairment Assessment	-	-	-	-	-	-	-
C- Source Analysis	-	-	-	-	-	99	-
D- Targets and Allocations	-	-	-	-	-	-	-
E- TMDL Margin of Safety	-	-	-	-	-	-	-
F- Linkage Between Technical Analysis and Implementation	-	-	-	-	-	-	-
G- Load Allocation at Stateline	-	-	-	-	-	-	-
H- Lost River Implementation	-	-	-	-	-	-	-
I- Accounting and Tracking	-	-	-	-	-	6, 8	-
J- Blue Green Algae	-	-	-	-	-	-	-
K- Klamath Hydroelectric Project	-	-	11	-	-	-	-
L- Tributaries	-	16	30	-	-	-	-
M- Sediment-Related Comments	-	12, 13	-	-	-	-	11
N- Thermal Refugia	-	-	-	-	-	9, 10	-
O- Approach and Mode of Compliance	-	-	22, 23b	9	16	12	-
P- Watershed-wide Implementation	1-5, 88	27, 28, 77-79, 84, 85	-	-	-	29, 80, 86, 87	17-24, 59
Q- Future Agricultural Waiver	-	-	8	-	-	11	-
R- Monitoring and Compliance Tracking	-	-	-	-	-	24	-
S- Economics and Environmental Analysis	14	15	7	-	-	-	-
T- Stakeholder Participation	-	-	-	-	-	-	-
U- Peer Review	-	-	2	-	-	-	-
V- Data and QA/QC	-	-	-	-	-	-	-
W- Site Specific Dissolved Oxygen Objective	-	-	-	-	-	-	-
X- Flow	-	-	12	-	10	13	-
Y- General Comments	-	-	-	-	-	-	-
Z - Editorial Comments	-	-	-	-	-	-	-

Table 3 (cont.): List of Persons Submitting Written Comments on the June 2009 Public Review Draft and the Location of Those Comments and Responses Within This Document

Comment Category	**Rice and Oldfield** California Farm Bureau Federation and California Cattlemen's Association	**Riggan**	**Salvestro** Fruit Growers Supply Company	**Sanguinetti**	**Schmidt**	**Schuyler** Klamath National Forest	**Simon**	**Snyder** California Department of Forestry and Fire Protection
A-TMDL Model Comments	-	-	-	-	-	-	-	-
B- Impairment Assessment	-	-	-	-	-	-	-	-
C- Source Analysis	-	-	-	-	-	-	-	-
D- Targets and Allocations	-	-	-	-	-	58	-	-
E- TMDL Margin of Safety	-	-	-	-	-	-	-	-
F- Linkage Between Technical Analysis and Implementation	-	-	-	-	-	-	-	-
G- Load Allocation at Stateline	14	-	-	-	-	-	-	-
H- Lost River Implementation	-	-	-	-	-	-	-	-
I- Accounting and Tracking	-	-	-	-	8	-	-	-
J- Blue Green Algae	-	-	-	-	-	-	-	-
K- Klamath Hydroelectric Project	10	-	-	-	-	-	-	-
L- Tributaries	15, 43	-	-	14	-	12, 13	-	-
M- Sediment-Related Comments	-	-	11	-	-	9	-	-
N- Thermal Refugia	-	8	-	-	-	-	-	
O- Approach and Mode of Compliance	22, 23b, 28	-	-	-	10	-	-	-
P- Watershed-wide Implementation	60	25, 76	17-24, 59	-	-	13-16, 61, 62, 70-75, 83	-	57
Q- Future Agricultural Waiver	12	-	-	-	-	-	-	-
R- Monitoring and Compliance Tracking	-	-	-	-	-	-	-	-
S- Economics and Environmental Analysis	22	-	-	-	-	15	20, 21	-
T- Stakeholder Participation	5	-	-	-	-	-	-	-
U- Peer Review	-	-	-	-	-	-	-	-
V- Data and QA/QC	-	-	-	-	-	-	2	-
W- Site Specific Dissolved Oxygen Objective	-	-	-	-	-	-	-	-
X- Flow	11	-	-	9	-	-	-	-
Y- General Comments	-	-	-	7	-	-	-	-
Z - Editorial Comments	-	-	-	-	-	-	-	-

Table 3 (cont.): List of Persons Submitting Written Comments on the June 2009 Public Review Draft and the Location of Those Comments and Responses Within This Document

Comment Category	**Solem** Klamath Irrigation District	**Spain** Institute for Fisheries Resources & Pacific Coast Federation of Fishermen's Associations	**Stacey** California Department of Fish and Game	**Sumner** Siskiyou County Public Works	**Terence** Klamath Riverkeeper	**Walz** Sierra Pacific Industries	**Wright**
A-TMDL Model Comments	-	164, 165, 173-181	-	-	-	-	-
B- Impairment Assessment	-	-	-	-	35	-	-
C- Source Analysis	-	44	-	-	-	-	-
D- Targets and Allocations	-	55, 57, 59	-	56	-	-	-
E- TMDL Margin of Safety	-	-	-	-	-	-	-
F- Linkage Between Technical Analysis and Implementation	-	-	-	-	-	-	-
G- Load Allocation at Stateline	13	-	-	-	12	-	-
H- Lost River Implementation	-	20-24	-	-	19	-	-
I- Accounting and Tracking	-	6, 7	-	-	6	-	-
J- Blue Green Algae	-	-	-	-	-	-	-
K- Klamath Hydroelectric Project	-	-	18-20, 22-31	-	17	-	-
L- Tributaries	-	-	10	8, 9	36, 37	-	-
M- Sediment-Related Comments	-	-	-	6-8	-	-	-
N- Thermal Refugia	-	29	-	-	30	-	-
O- Approach and Mode of Compliance	-	11	8	-	-	-	-
P- Watershed-wide Implementation	-	-	-	82	-	58	-
Q- Future Agricultural Waiver	-	-	-	-	9	-	6
R- Monitoring and Compliance Tracking	-	20-23	19, 41	-	-	-	-
S- Economics and Environmental Analysis	-	-	-	-	-	-	-
T- Stakeholder Participation	-	-	-	-	-	-	-
U- Peer Review	-	-	-	-	-	-	-
V- Data and QA/QC	-	-	-	-	-	-	-
W- Site Specific Dissolved Oxygen Objective	-	-	-	-	-	-	-
X- Flow	-	-	-	-	8	-	-
Y- General Comments	-	-	4	-	-	-	-
Z - Editorial Comments	-	-	-	-	-	-	-

* The commenter "Klamath Riverkeeper – Various" represents all persons who sent the form letter comments developed by the Klamath Riverkeepers. Regional Water Board staff received 450 of these form letters.

June Comments

TMDL MODEL COMMENTS

Regional Water Board staff received comments on the Klamath River TDML Models from Link River Dam to Keno Dam from the U.S. Bureau of Reclamation (written by the U.S. Geologic Survey under contract with USBR). These comments and their responses can be found in Attachment 1 to the TMDL Model Comments in the document titled "*Klamath River TMDL Development Team Draft Response to USGS Review of Klamath River TMDL Models from Link River Dam to Keno Dam*".

A1. Comment(s):
The modeling performed to support the Draft TMDL's analyses and source allocations is flawed and cannot be relied upon to accurately represent "natural conditions" against which current impairments are assessed. Undocumented, unjustified, and questionable source code modifications were made that render the model-based aspects of the TMDL flawed and unsuitable for use to set load allocations. (cover ltr p.2) (final comments p.1)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The TMDL model was developed, tested, and applied following standard modeling practices by experienced professionals. In order to overcome limitations of off-the-shelf models for representing unique characteristics of the Klamath River, source code modifications were indeed implemented. This is typical of highly complex modeling applications. Modifications were based on environmental science and documented in the Klamath River Model for TMDL Development Report. Model source code was subjected to multiple peer reviews and made available during the public review of the TMDL Report.

A2. Comment(s):
Analyses and model performance metrics that allow model uncertainty to be quantified are absent. Without quantification and incorporation of model uncertainty, the adequacy and accuracy of the TMDL analyses are dubious, and the resulting TMDL load allocation questionable. (cover ltr p.2) (final comments p.1)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
Model uncertainty can be evaluated in quantitative and/or qualitative terms. Because this model is a dynamic model of a highly variable system, the project team determined that qualitative review of plots of predicted-versus-measured conditions was the preferable method to evaluate uncertainty for this project. All of the plots reviewed by the project team are included in the Klamath River Model for TMDL Development Report. For additional discussion regarding Klamath River TMDL model uncertainty evaluation,

refer to the response to USGS comments that are included as Attachment 1 to this document.

Recognizing that quantitative statistics can provide for comparison with other modeling efforts, the agencies (along with another commenter – USGS on behalf of the Bureau of Reclamation) have generated error statistics for the final TMDL report.

The decision on the adequacy of the model for use in TMDL development is based not only on consideration of uncertainty but also on a number of other factors, including: prospects for reducing uncertainty with additional analysis and calibration, potential impact of additional model evaluation on allocation decisions, and schedule/funding constraints.

A3. Comment(s):

The models used are based on only a single model year and additional model years are not included even though sufficient data were available to extend the models to additional years. This omission severely limits the TMDL analysis because of a complete lack of accounting for inter-annual variability. This results in uncertainty that the allocations accurately represent source contributions to water quality impairment or will achieve the desired water quality objectives. (cover ltr p.2) (final comments p.1)

Comment(s) Made By:

Hemstreet – PacifiCorp

Response:

The TMDL development team disagrees with the comment that the TMDL is severely weakened by the use of a single model year. TMDLs are frequently developed using a single, "design" year selected by the project team. The year chosen for developing the model and establishing the TMDL was selected because it included periods of critical low flow and poor water quality conditions. This is consistent with the margin of safety requirement and the goal of developing environmentally conservative allocations.

The comment does not account for the documented capability of the model to capture within-year variability in this highly managed and variable system. The model development process has been heavily focused on capturing seasonal variability to the extent practicable. The Board does not believe that adding more model years to the model development process would significantly change the model parameters, given the within-year variability in this system.

Additionally, the Klamath River exhibits highly variable water quality conditions from incoming sources, and limited data are available to accurately characterize these sources. The system also exhibits a short retention time, so signals from major inflows have a significant impact on in-stream water quality. Modeling multiple years in the absence of sufficient data would largely involve estimating/deriving/refining boundary conditions rather than adjusting parameter values.

It should also be noted that the Oregon portion of the model was calibrated using two model years. There was not sufficient data to evaluate the California portion of the model for the second year.

A4. Comment(s):

The upstream boundary conditions rely on flawed assumptions. The Draft TMDL indicates that the models' upstream boundary conditions were based on a scenario that assumes full compliance with Oregon's Upper Klamath Lake TMDL (ODEQ 2002). However, upon review, it is clear that the model's upstream boundary conditions were set at levels that are below the average loading conditions predicted when water quality conditions are fully compliant with the Upper Klamath Lake (UKL) TMDL and possibly below expected natural conditions. Given the likelihood that the UKL TMDL will never be met, it is unreasonable and inappropriate to set the Klamath TMDL model boundary conditions to those water quality parameters, much less values that are substantially below the average values predicted by ODEQ even if the UKL TMDL were to be met. (cover ltr p.2) (final comments p.1)

Comment(s) Made By:

Hemstreet – PacifiCorp

Response:

The UKL boundary condition was based on the median condition, not the average condition, as noted by the commenter. The following rationale was extracted from the new draft Oregon Klamath TMDL: http://www.deq.state.or.us/wq/TMDLs/docs/klamathbasin/uklost/KlamathLostTMDLWQMP.pdf

Page 2-41 of that document states:

"The Upper Klamath Lake boundary condition for the natural conditions baseline model was based on the existing Upper Klamath Lake TMDL (DEQ 2002, also see Section 2.6.2 for the source assessment, Section 2.8.1 for discussion of uncertainty and Chapter 1 for discussion of policy). The Upper Klamath Lake TMDL model is predicting a bi-modal distribution of summer phosphorus concentrations with 2 of the 8 years experiencing high phosphorus concentrations (> 200 ìg/L) associated with large algae blooms (Figure 2-29). For the purpose of the Klamath River TMDL, one of the moderate years was chosen because it would provide for more conservative allocations (see Section 2.8.2). Specifically, concentrations for water quality constituents were based on 1995 Upper Klamath Lake model output which represents a median year (Figure 2-29). Choosing a specific year, rather than averaging the eight years of model results, allowed for the removal of the influence of the two extreme years and their lingering impact in the following winters. The year 1995 had the sixth highest spring phosphorus concentrations and the fourth highest summer concentrations (out of eight years). Since the year 1995 was not influenced by the two extreme years, the total phosphorus concentrations are lower than the multiple year, average targets presented in the Upper Klamath Lake TMDL of 30 ìg/L (March – May) and 110 ug/L (annual) (DEQ 2002). For 1995, the average March – May total phosphorus concentration was 27 ug/L and the annual average was 23 ug/L. "

The Regional Water Board disagrees that the TMDL compliance levels are below background levels. Nevertheless, achieving any measure of reduction will take several years. Ongoing research will be evaluated during that period of time to determine if pollutant loading targets should be reassessed.

Comments regarding achievability are speculative and premature. The Regional Water Board, along with other parties (including PacifiCorp), will be convening a pollutant reduction workshop to discuss pollutant reduction strategies for the Klamath River including a wide range of innovative landscape engineering approaches. One product of the workshop will be a workplan to conduct a feasibility study to develop the optimal combination of pollutant reduction technologies to improve water quality conditions in the Klamath basin.

A5. <u>Comment(s):</u>
In the case of temperature targets assigned to the Iron Gate and Copco 2 tailraces, the California compliance scenario developed in the Draft TMDL also assumes absence of Iron Gate and Copco 1 and 2 dams, equal to temperature conditions predicted by model analysis for the year 2000 for a hypothetical "Natural Conditions Baseline" that assumed river reaches without dams (pages 2-15 and 3-9).

The Draft TMDL admits that the "determination of compliance with water quality objectives for temperature is complicated" by the fact that under current conditions the temperature of water entering California upstream of the reservoirs "carries an anthropogenic heat load from upstream sources" that are "allocated temperature loads through the State of Oregon's Klamath River TMDL", and that "these allocations are expected to be achieved gradually over time" (page 5-16). There are three fundamental flaws with the Draft TMDL's numeric temperature targets to the Iron Gate and Copco 2 tailraces.

First, the targets are based solely on hypothetical without-dam modeled conditions. Yet, the Draft TMDL does not provide any analysis or quantification of modeling uncertainty, and the Draft TMDL allocations and targets include no consideration or allowance for this uncertainty.

Second, the targets are based on a single year (2000) of modeled conditions. Yet, the Draft TMDL does not provide any analysis or quantification of natural monthly, seasonal, and annual variability in temperatures, and the Draft TMDL allocations and targets include no consideration or allowance for this natural variability as a result of differing hydrology or meteorology. In addition, current flow conditions are higher than the 2000 flows modeled because of the updated Biological Opinion flow requirements at Iron Gate dam[1]. This change in conditions is not incorporated into the TMDL model.

Third, the numeric temperature targets are based on thermal loading allocations upstream of the reservoirs that the Draft TMDL admits would be achieved “gradually over time” (page 516). Thus, the targets applied to the reservoir tailraces are not realistic and achievable unless and until allocations upstream are achieved at a certain future time. (final comments p.5, 6)

[1] U.S. Fish and Wildlife Service 2008-2018 Biological Opinion, dated April 2, 2008 and National Marine Fisheries Service Biological Opinions on Klamath Project Operations from June 1, 2002 through March 31, 2012, dated May 31, 2002.

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The temperature TMDL allocations only assume that the thermal pollution caused by the dams is addressed to the degree that water quality standards are met. Regional Water Board staff made no assumption about the future of the dams, nor are we proposing that removal of the dams be required.

In regards to uncertainty, please see the response to comment A2. In regards to the use of a single simulation year, please see the response to comment A3.

Regional Water Board staff acknowledge that the tailrace targets are not likely to be met in the near future. The tailrace numeric targets are intended to give a reasonable depiction of temperature conditions that meet water quality standards. Compliance with the load allocation is proposed to be determined based on the difference between the temperature of water entering a reservoir and the temperature as it leaves a reservoir. Thus, the load allocations attributed to the dam tailraces are independent of water temperatures at stateline.

A6. Comment(s):
The Draft TMDL assigns nutrient allocations to Copco and Iron Gate reservoirs of 74,569 pounds TP annually and 1,091,654 pounds TN annually to be achieved at a location *upstream* of Copco reservoir (emphasis added) (page 5-22). These load allocations are inappropriate, particularly given that the reservoirs are not a source of nutrients, but a net sink of nutrients. Even the Draft TMDL acknowledges that the reservoirs are a significant net sink of nutrients (see Table 4.5 on page 4-20). Because the reservoirs are a net sink of nutrients, the net nutrient loading in the Klamath River from Stateline to downstream of Iron Gate is significantly less with the reservoirs in place than it would otherwise be.

Assigning nutrient load allocations to Project facilities, which are not sources but rather net sinks of nutrients, is inappropriate. It points to the Draft TMDL’s failure to accurately and realistically portray and account for the nutrient sources and dynamics in the Klamath River system. Even the Draft TMDL’s model outputs clearly show that the reservoirs substantially reduce large nutrient pulses emanating from the Klamath River upstream (in response to bloom conditions in Upper Klamath Lake). Yet this information is not used in the TMDL to identify and account for the positive implications the reservoirs have on nutrient conditions in the system.

Using the Draft TMDL models recently obtained from Tetra Tech for review, PacifiCorp's water quality modeling consultant (Watercourse Engineering) performed model runs that clearly show that TP loads at Iron Gate dam are substantially lower under current conditions than under conditions assuming the dams are absent. This is due to the significant retention and loss of inflowing organic matter in the reservoirs that would not occur without the reservoirs.

To illustrate this point, Figure 3 shows bar charts of annual nutrient loads for the Klamath River below Iron Gate Dam for three modeled scenarios: (1) Existing Conditions (or current conditions); (2) Natural Baseline (as defined in the Draft TMDL); and Modified Natural Baseline. The Existing (S1) and Natural Baseline (T1BSR) scenarios are the same as used in Figures 5.9 to 5.11 in the Draft TMDL. The Modified Natural Baseline was developed by Watercourse Engineering (and is not in the Draft TMDL analysis) to represent the natural baseline scenario without Project dams (i.e., Keno, J.C Boyle, Copco 1, Copco 2, and Iron Gate dams are absent) if model boundary conditions assume existing conditions at Link River, rather than assuming unrealistic Upper Klamath Lake TMDL compliance conditions. When compared to Existing Conditions (or current conditions), the Modified Natural Baseline scenario allows for a direct and realistic assessment of the effects of Project reservoirs on nutrient loads. The difference between annual nutrient loads simulated for Existing Conditions (or current conditions) and the Modified Natural Baseline scenario gives the combined retention effects of J.C. Boyle, Copco, and Iron Gate reservoirs.

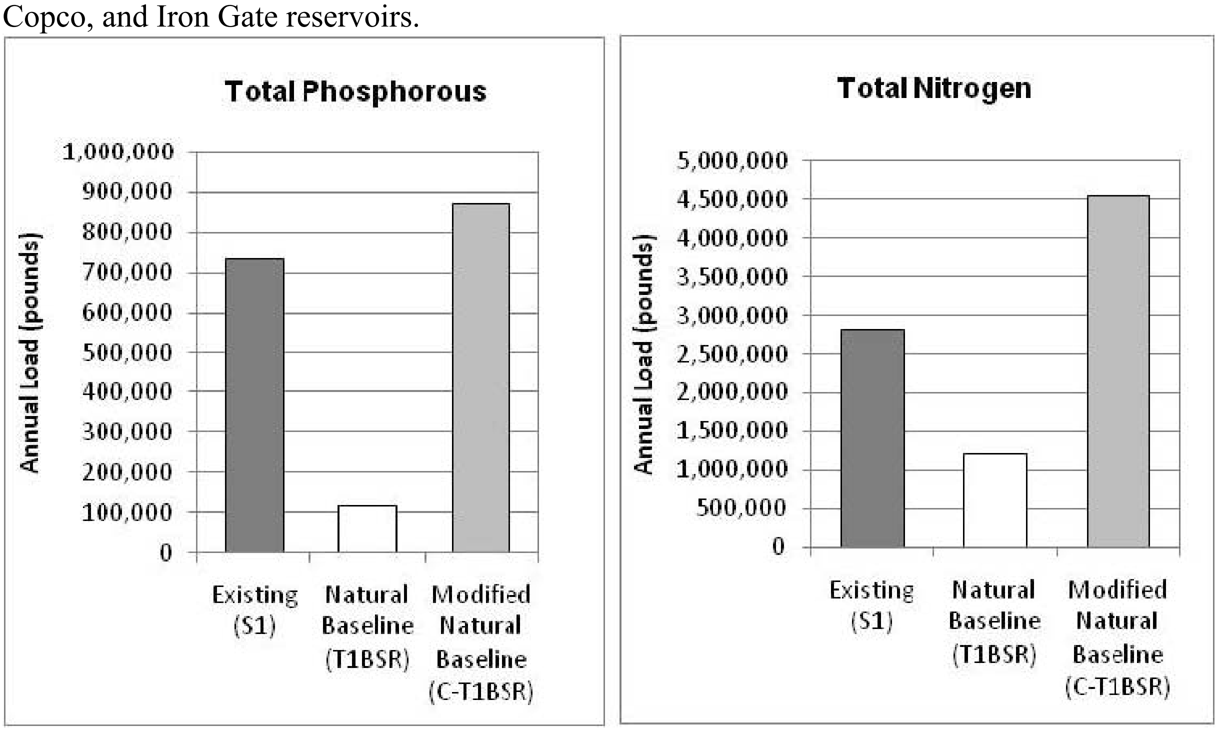

Figure 3. C omparison of current annual TP a nd TN loads below Iron Gate Dam to natural con ditions base line loads. C-T1BS R i s a m odification of T1BSR based on existing boundary conditions at Upper Klamath Lake.

Comparison of model results for Existing Conditions (or current conditions) and the Modified Natural Baseline scenarios demonstrates that the reservoirs provide significant nutrient retention. Figure 3 shows that the annual nutrient loads to the Klamath River at Iron Gate dam are less under current conditions than the no-dam natural baseline scenario by approximately 38 percent for TN and approximately 15 percent for TP.

Figure 4 shows that total nutrient loads from May to October – when the growth season occurs – also follow a similar pattern as the annual nutrient loads, i.e., there would be greater nutrient loads in the no-dam scenario. During May to October, nutrient loads to the Klamath River at Iron Gate dam are less under current conditions than the no-dam natural baseline scenario by approximately 55 percent for TN and approximately 20 percent for TP.

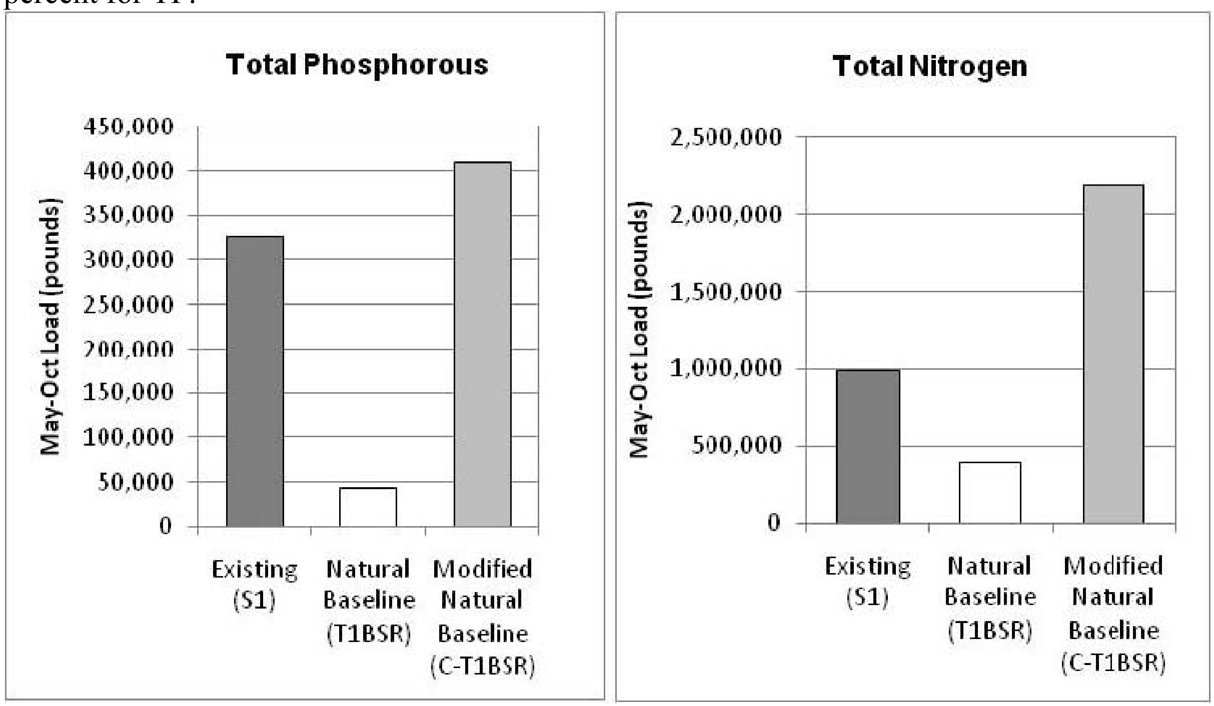

Figure 4. Comparison of current TP and TN loads below Iron Gate Dam to natural conditions baseline loads for the months of May to October. C-T1BSR is a modification of T1BSR based on existing boundary conditions at Upper Klamath Lake.

Figures 5 and 6 show the monthly distribution of nutrient loads from these model runs for the Klamath River at Iron Gate Dam. As seen from these graphs, the monthly nutrient loads under Existing Conditions (with reservoirs) are substantially lower than the Modified Natural Baseline scenario during the peak algal growth period in summer – on the order of two to three times lower. This is due to the significant retention and loss of inflowing organic matter in the reservoirs that would not occur without the reservoirs.

Figures 5 and 6 also show that peak nutrient loads coming from upstream sources are significantly lower under Existing Conditions (with reservoirs) and also shifted later into the fall than under the Modified Natural Baseline scenario. This shift into the fall also is important because, with dams in place, nutrients tend to leave the reservoirs later in the season after benthic algae standing crop in the river has started to diminish.

The significant retention of inflowing nutrients and organic matter in the reservoirs, and the shift of peak concentrations into the fall, provide important water quality benefits. Without the reservoirs, the loading of nutrients and peak summer nutrient concentrations would be greater in the Klamath River below Iron Gate dam, and would cause more growth of benthic algae downriver. More growth of benthic algae would exacerbate the pathway described in the Draft TMDL (page 2-32) in which more benthic algae downriver would increase polychaete habitat and result in more fish disease.

Without the reservoirs, the greater loading of nutrients and peak summer nutrient concentrations would also cause more growth of suspended algae (phytoplankton) in slow-moving backwater areas of the river and in the estuary. More growth of suspended algae could result in a greater incidence of blue-green algae, including potentially-toxigenic species like Microcytis, in river backwater areas and the estuary. More growth of suspended or benthic algae also could cause other detrimental effects on water quality that often accompany increased algae growth, including significant diurnal reductions in DO and increases in pH. These potential water quality impairments that could occur without the nutrient retention provided by the reservoirs could impact aquatic species and identified beneficial uses in the lower river. These potential impacts should be thoroughly analyzed and understood to ensure TMDL implementation does not result in unanticipated or unintended adverse consequences.

These reservoir benefits are not discussed in the Draft TMDL. A more comprehensive and appropriate representation of actual reservoir dynamics in the TMDL is needed to allow better assessment of potential implementation actions and key intermediate milestones en route to TMDL compliance. Detailed discussion of travel time and nutrient dynamic through various river reaches from Link Dam to the Estuary is provided in PacifiCorp (2006) based on both model results and field data. PacifiCorp (2006) was not referenced in the draft TMDL.

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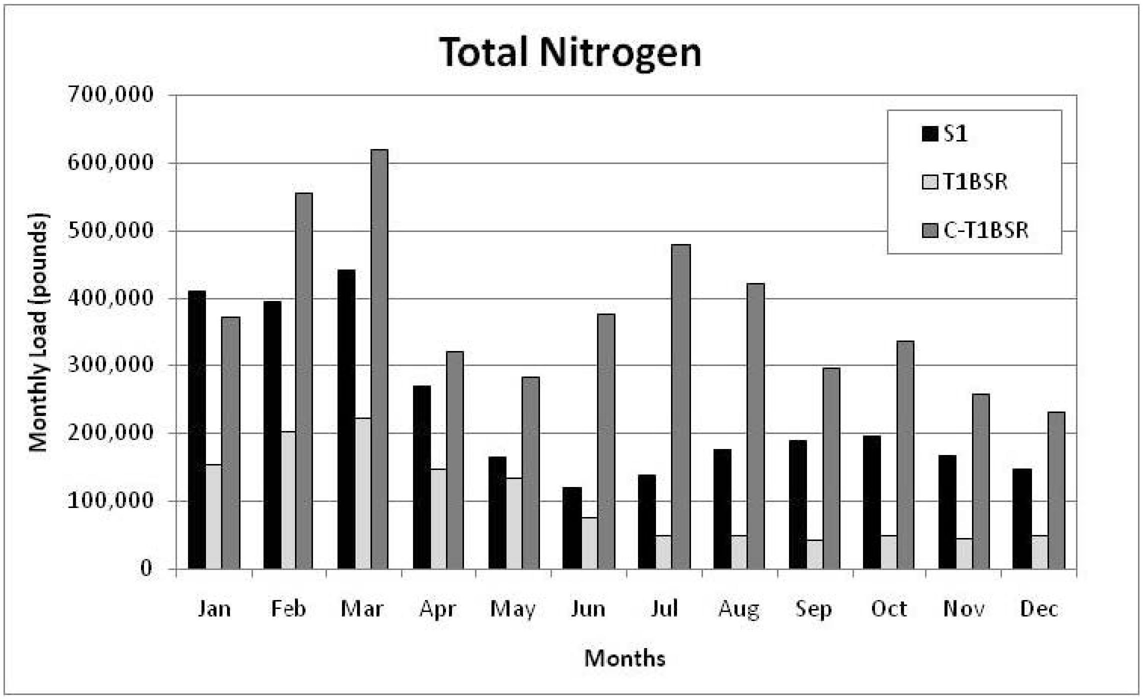


Figure 5. Comparison of monthly TN loads below Iron Gate Dam.

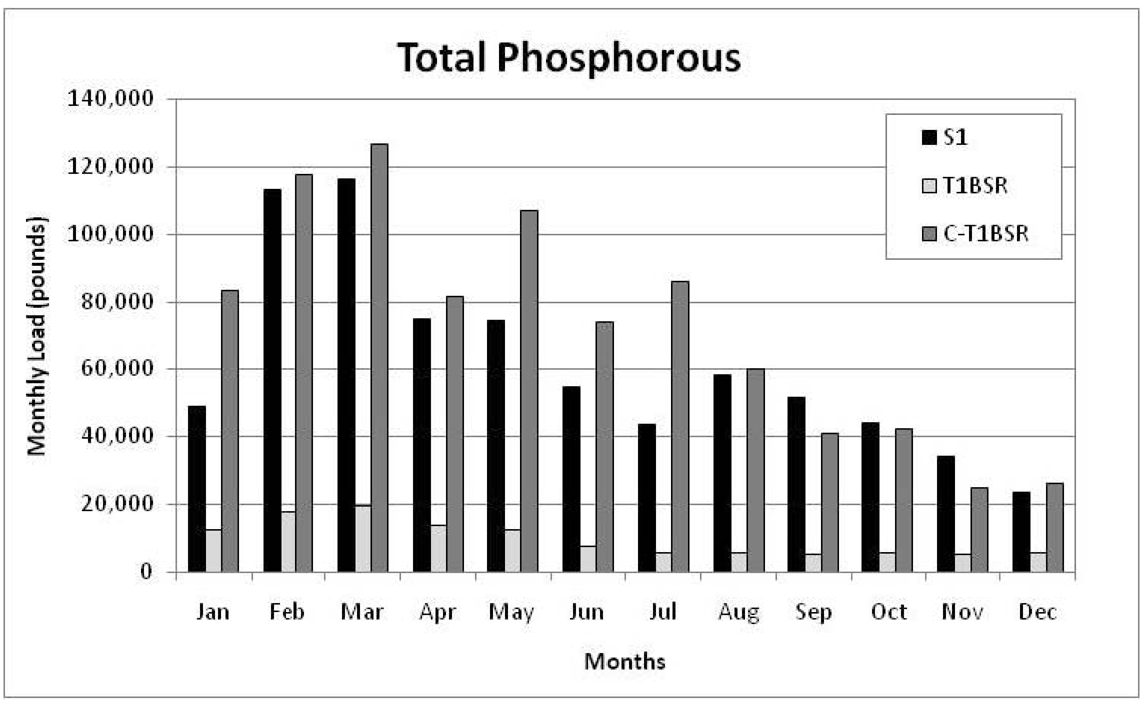


Figure 6. Comparison of monthly TP loads below Iron Gate Dam.

The Draft TMDL incorrectly describes the presence of the reservoirs as an impairment by making a misleading conclusion regarding the reservoirs as "a significant nutrient risk cofactor" (page 2-36) and by concluding that the additional nutrient allocations (as discussed above) "highlight the difficulty of having dams on a naturally productive river" (page 5-22). However, as discussed above, these conclusions are made despite the Draft

TMDL disregarding important information on the effects of net nutrient reductions in the Klamath River as a result of the presence of the reservoirs.

The Draft TMDL makes misleading or one-sided data comparisons to support statements regarding reservoir effects. For example, in a section titled "2.5.3.4. Chlorophyll-a Reservoirs", the Draft TMDL displays chlorophyll *a* data for twenty sites along the Klamath River that are a mix of reservoir and river locations (Figure 2.22 on page 2-59 and Figure 2.23 on page 2-60). A horizontal bar is included on each figure demarking the 10 µg/L chlorophyll *a* target for the reservoirs, and the Draft TMDL then suggests the reservoirs are causing impairment because "chlorophyll *a* at all of the reporting stations for the reservoirs are at or above the summer mean numeric target of 10 µg/L" (page 2-61).

The Draft TMDL misleads by not pointing out that the 10 µg/L chlorophyll *a* target is specifically related to <u>suspended</u> algae (i.e., phytoplankton) and is a target that the Draft TMDL has clearly derived to apply <u>only</u> to the reservoirs. The Draft TMDL does not explain that many of the river sites are below the 10 µg/L chlorophyll *a* line on the figures because the river is a fundamentally different lotic habitat, which by its very nature has much less phytoplankton. The comparison and analysis in these figures is as misleading or one-sided as figures that might be made that show chlorophyll *a* values for <u>attached or benthic</u> algae (i.e., periphyton). On such graphs, the 150 mg/m^2 benthic chlorophyll <u>a</u> targets would be shown as exceeded at the river sites, but essentially zero at the reservoir sites. Does that suggest that the river channel is an impairment? Of course not. Chlorophyll *a* values for <u>attached or benthic</u> algae are not a concern, and are not even measured in the reservoirs, because it is a fundamentally different lentic habitat, which by its very nature has much less attached or benthic algae. (final comments p. 29-35)

<u>Comment(s) Made By:</u>
Hemstreet – PacifiCorp

<u>Response:</u>
This lengthy comment raises several issues:

- Rationale for the nutrient reductions assigned to PacifiCorp facilities upstream of the reservoirs;
- Whether PacifiCorp should be credited for the nutrients retained by the reservoirs;
- Appropriateness of chlorophyll *a* targets assigned to the reservoirs;
- Whether a modified natural baseline should be considered in the TMDL analysis; and
- Downstream water quality conditions without the reservoirs.

This is a difficult comment to address because it is based on several incorrect assertions and assumptions.

The nutrient allocations (in the public review draft) to the PacifiCorp reservoirs in California are 38,641 pounds of TP and 1,091,654 pounds of TN. The first sentence in the PacifiCorp comment inserted the net reduction from stateline necessary to meet the reservoir allocation for TP (74,569 pounds) with the allocation.

PacifiCorp fails to acknowledge that the allocation is necessary to address ongoing water quality impairments within the reservoir caused by nuisance algal blooms. Since the condition occurs as a result of the environment created by the reservoirs the nutrient reductions have to occur upstream of the reservoirs. The Regional Water Board has evaluated other proposed nuisance algal bloom control options proposed by PacifiCorp in their Reservoir Management Plans for 2007, 2008, and 2009. However none of the in-reservoir treatment options offered reasonable assurances or levels of protection for beneficial uses. Regional Water Board staff's best professional judgment following initial review of PacifiCorp's RMPs is that beneficial use protection option is the reduction of nutrients upstream of the reservoirs. The chlorophyll *a* target is intended for the reservoir since it is a good indicator of risk to beneficial uses within the reservoir environment. The rationale for the chlorophyll *a* target is fully explained in the TMDL staff report.

In addition, the Regional Water Board also does not agree with the PacifiCorp assertion that the reservoirs should be credited as a net sink of nutrients. The neta annual loading to the lower Klamath River is lower but not significantly lower on a percentage basis (Asarian et al. 2009). The bulk of the net annual retention is during the winter and spring and is in a particulate (less bioavailable) form. During the summer critical growth period there is little if any reservoir retention of nutrients. The TMDL has used many lines of evidence to assess the water quality impacts of the reservoirs and their role in nutrient dynamics. The allocations actually represent a balancing of these factors.

PacifiCorp comments related to the chlorophyll a are addressed in several other Regional Water Board responses elsewhere including comment responses B6 and D4. PacifiCorp refers to a modified model run scenario in their comment that was conducted by their consultant that has not been submitted to the Regional Water Board nor has it been peer reviewed. The use of existing conditions as the "modified natural baseline" boundary conditions at Link River for the model scenario is misleading in the extreme and would more appropriately be termed current conditions without the dams.

The assertions regarding downstream water quality impacts without the dams are unsupported. The Regional Water Board will evaluate the modified model scenarios conducted by PacifiCorp as part of our regular TMDL reassessment activities for adaptive management consideration. However the Regional Water Board stands by the modeling analyses and allocation strategy presented in the TMDL staff report.

A7. <u>Comment(s):</u>
The Draft TMDL assigns "zero nutrient loading from reservoir bottom sediments … to account for the flux of nutrients (e.g., ammonia and orthophosphate) from reservoir bottom sediments under anoxic conditions during the critical period May through October" (page 5-22). Yet, the Draft TMDL admits that nutrient flux from reservoir sediments is very small compared to loads entering the reservoirs (page 4-19). The TMDL may not arbitrarily assign a separate load allocation to reservoir sediments. The

reservoir sediments must be considered in conjunction with the reservoirs as a whole. On this sediment-related allocation, one of the Peer Reviewers states that "the concept of a "zero" allocation target is a difficult one to conceive of in any natural context, and even if it were possible, the evidence presented does not provide a high level of confidence that the biological endpoints will be reached" (Appendix 7, page 12).

In addition, the allocation is inappropriate because the Draft TMDL makes several incorrect assumptions and conclusions in justifying and deriving this allocation. First and foremost, this allocation is inappropriate because it does not account for the fact that the reservoirs are <u>not</u> a source of nutrients, but a <u>net sink</u> of nutrients. Therefore, the net nutrient loading in the Klamath River from Stateline to downstream of Iron Gate is <u>less</u> with the reservoirs in place than would occur if they did not exist. Because the reservoirs also act as a trap for organic nutrients, a proper accounting of the net effect of the reservoirs must consider the accumulated flux of nutrients to the reservoir bed sediments. That is, the bed is also accumulating and storing nutrients. Correctly accounting for nutrient retention by the reservoirs will result in sediment loads identified in the TMDL being reduced and becoming negative, i.e., reservoirs as net sinks.

The Draft TMDL appears to justify the allocation of zero nutrient loading from reservoir bottom sediments in part on the assumption that anoxic conditions in the bottom layers of the reservoirs (hypolimnion) during summer stratification can transfer nutrients from the sediment to the water column. The Draft TMDL goes on to assume that the transfer of nutrients to the water column could stimulate algae growth or "exacerbate" DO conditions (pages 4-16 and 417). However, the processes and effects described in the Draft TMDL related to nutrient loading from reservoir bottom sediments are largely not applicable to Iron Gate and Copco reservoirs.

Nutrient loading from reservoir bottom sediments, if and when it occurs, emanates from the reservoir sediment under anoxic conditions. Therefore, internal nutrient loading in stratified reservoirs does little to exacerbate DO conditions because for internal loading to occur, anoxia already must be present. Anoxia occurs primarily because of seasonal stratification and is largely driven by the very large inflow loads of particulate organic matter that sink and accumulate in the hypolimnions of the reservoirs. Because it occurs during stratification, nutrients released from reservoir bottom sediments are generally confined to the hypolimnion and do not contribute to epilimnetic algae production.

When the reservoirs attain isothermal conditions in the fall, anoxia is gone and no nutrient release from sediments would occur. Any nutrients that were contained in the hypolimnetic volume during turnover are of minimal consequence to the algae production in the reservoirs and river downstream because the shorter days and cooler temperatures limit algal growth. Copco and Iron Gate Reservoirs have very short residence times, on the order of days, during elevated flow conditions in fall and winter, so carryover of hypolimnetic nutrients from one season to the next is likely insignificant.

Finally, the Draft TMDL's own analysis shows that the numerical estimate of potential loading from the sediments is only one percent of influent loads (as shown in Figures 4.1 to 4.3). Aside from the hypolimnetic confinement of nutrient loading from the sediments, if and when it occurs, such a small percent is unlikely to result in any additional measurable water quality impairment in the reservoirs or the river downstream. (final comments p. 35, 36)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The Regional Water Board disagrees with comment assertions related to reservoir nutrient retention and nutrient dynamics and the impacts of nutrients generated from reservoir sediments. Regional Water Board responses to these assertions have been included in responses to other comments: A6, A33, A37, A38, C3, C10, and C13. The Regional Water Board continues to support the analysis and concept of zero discharge of nutrients from reservoir sediments. However, the updated TMDL staff report has adopted a more comprehensive approach to the reservoir allocations that does not require the designation of an allocation specific to reservoir sediments.

A8. Comment(s):
There are several substantial issues associated with the modeling performed to support the Draft TMDL's analyses and recommended allocations. Undocumented, unjustified, and questionable source code modifications were made that render the technical basis of the TMDL flawed and unsuitable for use to set load allocations. Uncertainty analyses or even model performance metrics that allow model uncertainty to be quantified are absent. Without quantification and incorporation of model uncertainty, the adequacy and accuracy of the TMDL analyses remain dubious, and the resulting TMDL load allocations questionable. The models are based on only a single model year. Additional model years are not included even though sufficient data were available to extend the models. This omission severely limits the TMDL analysis because of a complete lack of accounting for inter-annual variability. The Draft TMDL indicates that the models' upstream boundary conditions were based on a scenario that assumes complete compliance with Oregon's Upper Klamath Lake TMDL (ODEQ 2002). However, upon review, it appears that model upstream boundary values were set inconsistently below expected conditions presented in the UKL TMDL, and possibly even below expected natural conditions. (final comments p.39)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
Please refer to the responses to the USGS model review for a detailed discussion of these issues. The model boundary conditions were set consistent with the approved UKL TMDL See responses to comments A2, A3, and A4.

A9. Comment(s):
Numerical models can be extremely useful tools when applied properly. The strength of many water quality models, including the models that are the basis of the Klamath River TMDL, is that they are developed from physics of hydrodynamics and well-accepted representations of biological and chemical processes. Using acceptable numerical models, standard procedure is to calibrate model parameters to fit data from the river system being simulated. Often, calibration is followed by validation of the model. After calibration, the model may be considered representative of the river system and is applied to scenarios describing different boundary conditions for evaluation of management options. For obvious reasons, standard practice dictates that calibrated values not be changed from one scenario to another. In such case, scenario outcomes would not be comparable.

But the model calibration done to support the Draft TMDL deviated significantly from standard, acceptable practice. In the Draft TMDL simulations, calibrated values are changed during so-called validation. Changes appear in parameter values from one reach to the next with no apparent reason. Furthermore, calibrated parameter values are not always used throughout the simulation of management scenarios. Parameter values change, often slightly and sometimes significantly, throughout the simulations used in the TMDL. These changes are unacceptable in development and application of numerical models, particularly for assessing and determining regulatory actions, with costs and implications as significant as those required by the Draft TMDL. (final comments p.39)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
Every effort was made to maintain consistency among calibration, corroboration, and scenario simulation parameters, where appropriate. The TMDL development strategy called for the explicit use of a varying set of scenarios to explore several sets of conditions that would be used to support the TMDL decision making process. These scenarios are described in Appendix 7 of the TMDL staff report. Model parameters were changed (and documented) in accordance with the different assumptions that were employed with different scenarios. In a few situations, minor discrepancies among parameters were identified by reviewers. These discrepancies have been corrected in the model. For additional discussion refer to response to USGS model review above.

A10. Comment(s):

Both models used as the basis for the Klamath River TMDL, the RMA models and CE-QUALW2, are well-established models that have been applied extensively worldwide. However, although the models are based on well-accepted numerical model programs, the model programs and source codes have been modified for use in the TMDL in significant ways and these modifications have not been documented nor have they been peer-reviewed. Models containing undocumented and questionable code changes raise serious concerns regarding the TMDL technical analyses and must be resolved promptly. In fairness, there appear to be some code changes that likely are valuable and useful in better representing some water quality processes. However, documentation of such changes is either absent or presented with inadequate detail.

One particular modification made to model source code is troubling. Specifically, the model codes used to develop the Draft TMDL have been modified with undocumented changes that reduce short-wave solar radiation by 20 percent in the water temperature logic. These modifications are applied to all reaches except for the hydropower project reservoirs where no reduction is applied. This undocumented, unjustified, and questionable source code modification results in "natural" baseline water temperatures that are colder by nearly 2°C in summer than would occur without the 20 percent reduction. Water temperatures modeled under "existing" conditions, with dams in place, have not been similarly manipulated, introducing bias of one scenario over another. The Regional Board staff should clarify their purpose for making this code modification and clearly document and justify all source code modifications, and promptly provide this information.

Code modifications to reduce solar radiation input values by 20 percent were made in both RMA11 and CE-QUAL-W2 models. In W2, code was added to ensure this reduction applied only to the Lake Ewauna-Keno reservoir. This arbitrary change to well-established source code is unexplained. The intention seems to have been to only affect changes to water temperatures because this code change only applied to the heat budget and was not applied to solar radiation inputs for either light extinction or photosynthetic light calculations.

Standard practice is for programmers to clearly identify changes made to model code, but the code change that reduces solar radiation is unmarked and undocumented in any way. The fact that this code is unmarked should be a "red flag" to anyone considering the credibility of this TMDL and the validity of its analyses. Until such information is provided, this matter casts significant doubt on the technical basis and validity of the Klamath River TMDL. PacifiCorp recommends removal of code that modifies the heat budget equations, followed by model reanalysis. [Refer to Response 10a.]

Another modification was made in the logic to calculate pH in river reaches based on alkalinity and total inorganic carbon. This code was added to the PacifiCorp version of the RMA11 model by Tetra Tech. After careful review the actual equation to solve for pH appears valid; however, the iterative technique used to find a solution is flawed. In the TMDL model, values for pH are iteratively tried until a solution criterion is attained.

In assessing the implications of this technique, PacifiCorp's consultants found at least one instance in which the technique stepped over the correct solution. In such cases, solution criteria are never met and the module continues searching until it returns a numerical error in the model. [Refer to Response 10b]

Another section of undocumented code results in a significant alteration of reaeration rates in short sections of the river. This logic caused serious problems in running the model. The TMDL model contains new code in the RMA-11 program that resets reaeration rates in a short section at the beginning of each river reach. The code uses a so-called "turbulence factor" to presumably try to account for the higher concentrations of DO found in sections of river reaches just below dams. This addition is unstable and made simulation impossible under certain conditions. During review of TMDL simulations, this user-specified factor was set to unity, neutralizing its effect, in all reaches. It is unclear what purpose this code was intended to serve, but when the code was provided to PacifiCorp's modeling consultant, FTURB[2] was set to 100 in the input file of some reaches. [refer to Response 10c]

Other notable changes to model source code include (discussed further in Appendix A):

- Light extinction and organic matter representation in RMA11
- Benthic algae code modification in RMA11
- Addition of a new spillway formula (with no reference to its source) in W2
- Modifications to sedimentary organic matter computations in W2
- Modification to the phytoplankton and benthic algae in Keno reservoir, wherein "healthy" and "unhealthy" algae are modeled in response to DO conditions. This code (applied to W2) is not documented and parameter values to control the outcome of this logic are not supported in the literature

PacifiCorp requests that the Regional Board provide clear documentation on all model changes, such as identified above. Further, PacifiCorp's modeling consultant (Watercourse Engineering) received multiple versions of the code over several months – several of which were not the "latest" version, which resulted in considerable review effort spent on the incorrect model code and files. Version control is a crucial element in modeling, particularly in large scale applications such as the Klamath River basin. PacifiCorp has concerns about version control with the TMDL at this time, i.e., whether the May 2008 version of the code is the "current" version and whether that version has been used in all TMDL simulations. [Refer to Response 10d]

PacifiCorp provided the Klamath water quality models developed by its consultant, Watercourse Engineering, to be used as the basis for the Klamath TMDL modeling effort in order to save the states of California and Oregon, and EPA significant time and money. The models were provided with the understanding that refinements to the models would be developed cooperatively between Tetra Tech and Watercourse Engineering in an open and transparent manner. This understanding was intended to assure that: (1) the TMDL model incorporated the latest water quality monitoring and data collection information; (2) modifications, additions, and recalibrations of the model were identified; and (3) model scenarios and assumptions necessary to enhance model calibration, identify data gaps, and provide model improvements were shared. The serious flaws with the modeling done for the Draft TMDL (as described above) could have been avoided had Regional Board staff more fully. (final comments p.39-42)

[2] The user-specified factor, FTURB, modifies the reaeration rate in the first 2 elements of the grid defining the river reach. In the water quality parameter input file of the TMDL Model, the turbulence factor, FTURB, was set to 100.0 for some reaches. Application of this factor results in a reaeration rate as much as 100 times greater than would be calculated by standard reaeration formulas included in the code.
collaborated and shared modeling information with PacifiCorp throughout the TMDL development process as intended in the License Agreement. [See Response 10e].

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
Response 10a: The 20% reduction to short-wave solar radiation that the commenter refers to was configured in the model during temperature calibration. This reduction was applied to all riverine segments in the system (i.e., RMA) and initially to Lake Ewauna/Keno. The 20% reduction for Lake Ewauna/Keno was ultimately removed, however one remnant of the adjustment still remained when the model was distributed. This remnant has been removed from the model for Lake Ewauna/Keno, however the 20% setting for the riverine segments has not been changed.

The 20% reduction was applied to riverine segments because the model was unable to accurately predict temperature between J.C. Boyle Dam and Copco Reservoir. Using the solar radiation code in the original RMA-11 model resulted in simulated temperatures that were consistently higher than observed values. It was suspected that for the riverine sections (or at least significant portions of the riverine sections), the previously used solar radiation in the RMA-11 models was too high due to biases in the equations used relating solar radiation to latitude, longitude, and elevation of the modeled area. Since RMA-11 internally calculates solar radiation for use in temperature and biological calculations, it is possible that the internal calculation of solar radiation may deviate from actual conditions. During calibration solar radiation was calculated between J.C. Boyle and Copco Reservoirs and compared with the observed solar radiation in the Copco Reservoir model. It was found that the internally calculated solar radiation was approximately 20% higher than the observed values. Therefore during the calibration process solar radiation was reduced, and predictions were significantly improved.

Modification of the internally calculated solar radiation boundary condition, which inherently has associated uncertainty (since it is not measured data), was justified to achieve consistency with observed data and thus more accurate temperature predictions. Although the over-estimation of temperature and solar radiation was not necessarily consistent along the length of the river, the 20% reduction was deemed appropriate for all riverine segments; to maintain consistency in assumptions used for the RMA model segments.

It should also be noted that although the model was calibrated to historical conditions, its primary use is for relative comparisons. Therefore, the reduction percentage was applied for all scenarios, and not solely for calibration. This approach maintains the integrity of the model and consistency for application to regulatory purposes. Although other factors were considered when calibrating temperature, the solar radiation reduction was deemed most appropriate. Other alternatives would have been to add fictitious flow and/or temperature inputs to more closely replicate in-stream temperatures, however this would have jeopardized the integrity of the model for source allocation and TMDL development.

Response10b: The iterative algorithm never caused a problem in the numerous scenario analyses conducted during TMDL development. It is certainly plausible that numerical instability could occur in special cases. This is, however, common with numerical modeling. Thus , we do not agree with the characterization in the comment.

Response 10c: The reaeration enhancement was only applied downstream of Iron Gate Dam to account for the extreme turbulence at this location, which can increase DO concentrations quickly. Water drawn from the depths of the stratified reservoir is characterized by low DO. Since this is the water that is passed downstream, DO immediately downstream of the dam would also exhibit low DO if significant reaeration did not occur. This is not the case, however, and DO is significantly higher downstream of the dam. The standard reaeration equation and parameter values in RMA-11 are not capable of simulating this significant increase in DO concentration caused by turbulence-induced reaeration. Therefore, the enhancement was instituted to simulate the extreme reaeration. The reaeration enhancement never caused a problem in the numerous scenario analyses conducted during TMDL development.

Response 10d: The Klamath River TMDL Model evolved significantly over time, particularly during scenario analysis and allocation determination. In order to provide PacifiCorp with the maximum amount of time to review the model code and results, model code was often provided soon after it was developed. Inevitably changes were made to further improve assumptions and predictions. As such, multiple versions of the code were indeed provided. The TMDL development team was available, however, to answer questions regarding the code. Model code for all scenarios has been reviewed and modified, as appropriate, to ensure consistency for application.

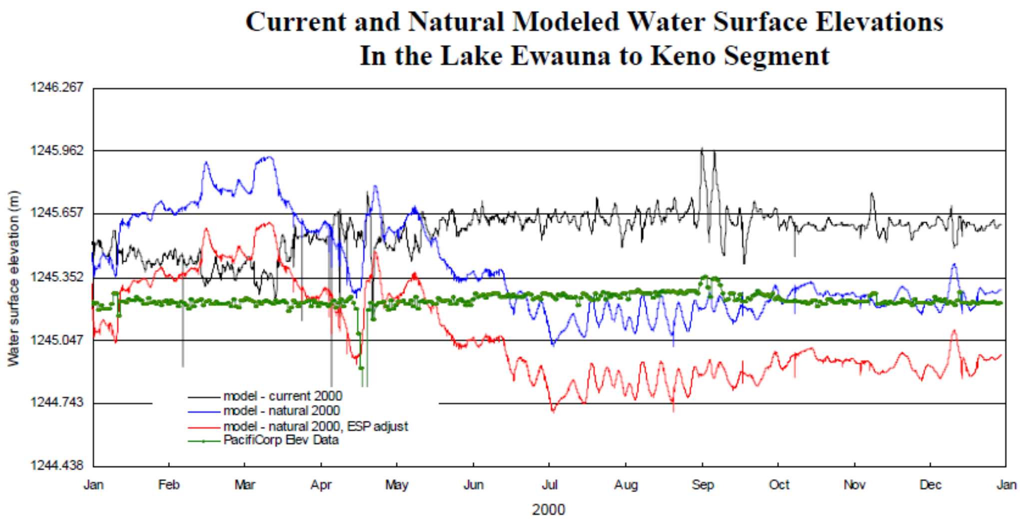
Response 10e: See the earlier response to A10. The FTURB was set to 1.0 everywhere except downstream of Iron Gate Dam (where it was set to 100.0). It was deemed necessary during calibration to increase FTURB to 100.0 at this location, in order to reproduce the significant change in DO concentrations due to turbulence. The significant turbulence-induced reaeration downstream of Irongate Dam was discussed with Dr. Michael Deas of Watercourse Engineering (personal communication).

A11. Comment(s):
Reclamation has identified significant differences in the flows used in the two different scenarios, “natural conditions” and “current conditions”. The “current conditions” modeling appeared to include all point and non-point sources of additions and diversion to flows in the Lake Ewauna to Keno segment, including eleven estimated sources labeled “storm water”. Presumably, this is to account for the unmeasured accretions in this reach to help create a water balance. In the “natural conditions” modeling the “storm water” accretions were eliminated and the flows used in the diversions to the Ady and North canals were not the same as those used in the “current conditions” scenario. These two modeling code changes made a significant difference in flows and therefore surface water elevations (see attached excel file data and graph below). We can not find any reasonable justification for assuming that the “storm water” labeled accretions would suddenly disappear under “natural conditions”. The flows utilized in both scenarios should be identical except for the removal of the small point source flows and their nutrient additions.

Comment(s) Made By:
Hicks – U.S. Bureau of Reclamation (page 1 – General Comments)

Response:
The TMDL development team does not agree that flow for existing conditions should be identical to that for natural condition. Some flows included in the existing conditions model represent contributions that would not be present under natural conditions (such as storm water flow due to urban runoff). Additionally, some of these current conditions contributions were arrived at through the water budget calibration process. The water budget for natural conditions was assumed to be quite dissimilar to that for current conditions. Thus, it was deemed inappropriate to include the identical flows for the natural conditions. This is also the case for the North Canal and ADY Canal.

A12. Comment(s):
The water surface elevations in the Lake Ewauna to Keno segment in the “current conditions” scenario do not match, or even approximate the measured elevations recorded by PacifiCorp. One possible reason the error is occurring is if the modeler is using hourly flows at the Link River gage which include peaking flows from PacifiCorp’s Eastside power plant. These hourly change in flows are easily absorbed by the twenty miles of naturally occurring storage in the reach and would not be reflected in flow variation at Keno. The large discrepancy between the modeled current conditions and the actual current conditions can be observed below. In addition, the USGS discovered a one foot error in the weir elevations used in the natural 2000 scenario. The adjusted modeled elevations are also shown in red below.



<u>Comment(s) Made By:</u>
Hicks – U.S. Bureau of Reclamation (page 1 – General Comments)

<u>Response:</u>
This was caused by a minor shift in the Keno reef datum. The shift was caused by a unit conversion from feet to meters when using a lower resolution conversion factor. The model has been updated using a higher resolution conversion factor, i.e., 1 meter = 3.281 feet, to obtain the same datum as indicated in this comment.

A13. <u>Comment(s):</u>
Statement: Chapter 3, Section 3.2.1, page 3-2, last paragraph states "Enhancements were made in the following areas: ……."
Comment: Based on the recent USGS review (USGS, 2009), it is apparent that there are significant problems with the enhancements to the CE-QUAL-W2 model made by Tetra Tech (some of which are listed in the TMDL document others of which are not) which place serious doubt about the validity of model results for both existing condition and natural condition scenarios.

<u>Comment(s) Made By:</u>
Hicks – U.S. Bureau of Reclamation (page 6 – General Comments)

<u>Response:</u>
See Response to A1.

A14. <u>Comment(s):</u>
Statement: Chapter 3, Section 3.1, page 3-5, states "In general, bathymetry is the most critical component in developing the grid for the system."
Comment: Based on the recent USGS review (USGS, 2009), the grid used in the CE-QUAL-W2 model for the Keno Reservoir reach indicates that it is approximately 12%

longer than the actual channel and layer widths do not vary smoothly with depth. The grid used should be changed to more accurately reflect Keno Reservoir reach conditions as they may affect modeled water quality conditions at stateline.

Comment(s) Made By:
Hicks – U.S. Bureau of Reclamation (page 6 – General Comments)

Response:
The grid is exactly the same as in the original PacifiCorp model. The length of the Keno Reservoir reach also agrees with another version of the map of the river. The TMDL team didn't attempt to modify the grid, because it was our understanding that the original grid was developed using all available data. Additional data that would refute the representation in the PaciCorp model were not identified by the Bureau during its review of the model in 2005. Additionally, the PacifiCorp model had been subject to a peer review, and no issues were raised regarding the physical configuration.

A15. Comment(s):
Statement: Chapter 3, Section 3.2.1.1, page 3-7, last sentence states "The Klamath TMDL development (US EPA Regions 9 and 10, ODEQ, Regional Water Board, and Tetra Tech) finds that the Klamath River TMDL models are suitable tools for establishing Klamath River TMDL allocations and targets."
Comments: Based on the recent USGS review (USGS, 2009), changes made by Tetra Tech to the CE-QUAL-W2 model suggest that problems exist with the configuration and inputs to different model scenarios, a more exhaustive evaluation of model scenarios should be completed before numeric allocations are finalized.

Comment(s) Made By:
Hicks – U.S. Bureau of Reclamation (page 7 – General Comments)

Response:
Refer to Response A1. It should be noted that a number of updates were made to the model based on comments received. These updates resulted in minor changes to numeric allocations.

A16. Comment(s):
Statement: Chapter 3, Section 3.3.2, Page 3-9 states "It should be noted that results for two model runs; one that used current conditions flows from Upper Klamath Lake and one that used estimated flows from a natural regime (USBR, 2005), were compared and not found to be substantially different."
Comment: Data should be provided to quantify the difference and demonstrate that the modeling runs were "not found to be substantially different". A table should be presented in the text showing the relative difference in temperature, dissolved oxygen, pH, and loads of organic matter, nitrogen (all species), and phosphorous (all species).

Comment(s) Made By:
Hicks – U.S. Bureau of Reclamation (page 7 – General Comments)

Response:
The statement cited was in reference to flows, not the water quality parameters noted in the comment. It was primarily necessary to use current flows from UKL in the baseline run to guarantee flow balance when the dams are put back in. One of our scenarios (T1BS from 12/10/2007) showed that changing the flows to existing from natural had little effect on water quality exceedance results. Of course, many changes have been made to the scenarios since that sensitivity analysis was performed, however we believe that the scenario rationale and uncertainty are valid and acceptable.

A17. Comment(s):
Statement: Chapter 3, Section 3.3.2, page 3-9, states "Keno reef was represented using data provided by the Bureau of Reclamation."
Comment: Reclamation did provide a stage-discharge relation derived for the Keno Reef, however, a review of the natural conditions modeling scenario indicate that an incorrect datum was used that could give a misleading representation of Keno Reservoir stage and travel times (USGS, 2009).

Comment(s) Made By:
Hicks – U.S. Bureau of Reclamation (page 7 – General Comments)

Response:
Refer to response A12.

A18. Comment(s):
Statement: Chapter 3, Section 3.3.2, Page 3-9 states "The Upper Klamath Lake boundary condition for the model was based on the existing Upper Klamath Lake TMDL (ODEQ 2002). Specifically, median concentrations for constituents and existing temperature were applied at the outlet and based on 1995 Upper Klamath Lake model output."
Comment: More detail needs to be provided to the reader. Are the median concentrations for all years of existing data? Do the concentrations change throughout the year? Or are the concentrations static for all time-steps in the model? A detailed description and a table showing the data used for the Upper Klamath Lake boundary condition would be useful for the reader.

Comment(s) Made By:
Hicks – U.S. Bureau of Reclamation (page 7 – General Comments)

Response:
Response: The UKL TMDL model predicts loading entering Link River for multiple years, where the year of the median loading, i.e., 1995, was identified to be used to represent the UKL boundary condition for the natural baseline condition. The

concentration was predicted by the UKL TMDL model with bi-weekly frequency (value changes every two weeks), so the concentrations do change with time. The data have been made available in the T1BSR model files. For additional discussion of this topic see response A4 above.

A19. Comment(s):
Statement: Chapter 3, Section 3.3.2, Page 3-9 states "Flow from Upper Klamath Lake was set at existing conditions, in order to maintain consistency with the existing conditions scenario" and "The Lost River Diversion Channel (LRDC) and Klamath Straits Drain (KSD) were represented using current conditions flow, however, their water quality and temperature were set to be the same as Upper Klamath Lake."
Comment: Using water quality and temperatures equal to Upper Klamath Lake for discharges from the Lost River Diversion Channel and Klamath Straits Drain is inappropriate. The water temperature and water quality would change significantly (water temperature increases and the water quality/chemistry is altered) as the water flows in the Klamath River between the outlet of Upper Klamath Lake and the points of discharge at the Lost River Diversion Channel and the Klamath Straits Drain.

Comment(s) Made By:
Hicks – U.S. Bureau of Reclamation (page 7 – General Comments)

Response:
Flows between these model scenarios needed to be the same for comparison purposes. Since LRDC and KSD did not typically discharge into the Klamath River under natural conditions, for the natural condition baseline, we chose to minimize their impact to water quality by setting their water quality and temperature to the UKL representation of natural conditions. You are correct that some temperature and water quality change would be expected to occur. However, basing model boundary conditions on instream model predictions is a more complex approach and would not likely change the allocations to these sources.

A20. Comment(s):
Statement: Chapter 4, Section 4.2.2.2, page 4-17, states "The Klamath River TMDL model includes a benthic flux term that simulates the release of nutrients from sediments at the bottom of the river under anoxic conditions."
Comment: Based on the recent USGS review (USGS, 2009), there appears to be an error in the coding of the CE-QUAL-W2 model for this term that needs to be fixed. If the flux term is turned on, the calculated values are not correct due to the coding error. This entire section needs reworked or removed to account for this coding error for reaches that the CE-QUAL-W2 model was used.

Comment(s) Made By:
Hicks – U.S. Bureau of Reclamation (page 9 – General Comments)

Response:
The sediment modification was not intended to be used, nor was it used, in this study. As such, it has no implications on the analysis that was performed.

A21. Comment(s):
Statement: Chapter 4, Page 4-19, Table 4.
Comment: Based on the recent USGS review (USGS, 2009), the TMDL CE-QUAL-W2 outputs for nitrate in the Keno Reservoir show a seasonal pattern the opposite of what monitoring data appear to show. This places some doubt as to the validity of TN loading numbers determined for the May-October timeframe and may affect loading numbers at stateline.

Comment(s) Made By:
Hicks – U.S. Bureau of Reclamation (page 9 – General Comments)

Response:
The USGS review neglects the fact that the modeled NO3 concentrations match the observed NO3 concentrations for the 2002 simulation. 2002 has low NO3 concentrations in the lake. The 2000 NO3 data in the database show that there is a very high NO3 concentration during the summer at the Hwy66 station. This contradicts the USGS conclusion. The model does mimic the trend shown in the data reasonably well.

A22. Comment(s):
Statement: Chapter 5, Section 5.2.3, Figure 5.7, page 5-17.
Comment: Based on the recent USGS review (USGS, 2009), provided that the CE-QUAL-W2 was used to determine natural changes through reaches with the reservoirs removed, a recent review of the model showed absolute mean errors on the order of 1 degree Celsius for the Keno Reservoir reach. The model should be improved to reduce this error and develop more accurate temperature changes for all reaches modeled with the dams removed.

Comment(s) Made By:
Hicks – U.S. Bureau of Reclamation (page 9 – General Comments)

Response:
Refer to response A2. The error statistics presented can be misleading.

A23. Comment(s):
Statement: Chapter 5, Section 5.3.1, page 5-20, Table 5.10.
Comment: Based on the recent USGS review (USGS, 2009), differences in seasonal patterns between empirical nitrogen (nitrate and ammonia) numbers from monitoring compared to seasonal patterns from the CE-QUAL-W2 model, TN concentrations should

be reevaluated to reflect more accurately conditions in upstream reaches. Also, again the term monthly mean concentrations need to be more precisely defined.

Comment(s) Made By:
Hicks – U.S. Bureau of Reclamation (page 9 – General Comments)

Response:
The ammonia and nitrate data have been reevaluated. And, the model was found to reproduce the observed patterns for the calibration and corroboration years. The seasonal pattern shown by the USGS reflects general trends over many years instead of the trend that occurred specifically for the model calibration year. The model calibration focused on a single year, and the model was configured to reproduce the observed trend for that year.

A24. Comment(s):
Statement: Chapter 5, Section 5.3.1, page 5-20, Table 5.10.
Comment: More detail needs to be provided describing how the nutrient and organic matter monthly mean concentration allocations were developed. (page 9 Specific comments)

Comment(s) Made By:
Hicks – U.S. Bureau of Reclamation

Response:
The methodology for developing TMDL allocations is described in Chapter 3 of the TMDL staff report. The Stateline monthly mean allocations are based on the TMDL model compliance run which provides output in an hourly time step. The allocation values reported in Table 5.10 are the monthly means for this compliance point. These values were the point at which the dissolved oxygen target was met for the entire critical period (May – September).

A25. Comment(s):
The Klamath River is naturally enriched with nutrients. The primary source of water to the Klamath River is discharge from historically (and naturally) eutrophic, and currently hypereutrophic Upper Klamath Lake. The average TP concentration measured at the mouth of Link River near the outlet of Upper Klamath Lake is currently 0.147 mg/L, based on data collected from 2000 through 2008 (PacifiCorp website). The UKL TMDL mean concentration is 0.041 mg/L, and the Klamath River TMDL assumed natural conditions baseline concentration is 0.022 mg/L. Sources of phosphorus between Link dam and Stateline include municipal, industrial, and agricultural activities. Groundwater, in the form of large springs, enters the river with considerable flow and nutrient load below J.C. Boyle reservoir (TP concentration in these springs is approximately 0.080 mg/L).

The Draft TMDL asserts that TP concentration at Stateline below these springs will range from 0.030 to 0.039 mg/L when loads from Oregon are in compliance with the Oregon TMDLs, and the Draft TMDL assigns allocations to Copco and Iron Gate reservoirs in the same range (page 5-20).

Thus, the Draft TMDL requires TP concentrations at Stateline (and at other downstream locations by extension) that are lower than upstream concentrations from Upper Klamath Lake under future compliant TMDL conditions and naturally-occurring groundwater base flows.

Based on the above data, it is evident that the TP allocation for Stateline, as depicted in the Draft TMDL would require all four of the following conditions in order to be achieved:

- A 40 percent reduction in external phosphorus loading to Upper Klamath Lake, as estimated in the Upper Klamath Lake TMDL (ODEQ 2002) to achieve a compliant TMDL condition;
- Elimination of all (100 percent) of phosphorus loads (municipal, industrial, agricultural) between Link River and Keno dam to ensure that the Upper Klamath Lake compliant condition is maintained below Keno dam, i.e., no additional loads between Link Dam and Keno Dam;
- At a minimum, an additional 20 to 40 percent reduction in TP concentration between Keno dam and Stateline to reduce the Upper Klamath Lake compliant condition (0.041 mg/L) plus groundwater inflow loading (at a concentration of 0.080 mg/L) below J.C. Boyle to attain the range from 0.030 to 0.039 mg/L as required in the Draft TMDL at Stateline; and
- An additional 60 percent reduction in the total phosphorus concentration of base flow groundwater to the Klamath River above Stateline from 0.080 mg/L to 0.030 mg/L as required in the Draft TMDL at Stateline.

The first bullet alone – a 40 percent reduction in external phosphorus loading to Upper Klamath Lake to achieve a compliant TMDL condition – is itself likely unattainable. Because the anthropogenic load to Upper Klamath Lake is about 40 percent of the total load, the Upper Klamath Lake TMDL (ODEQ 2002) proposed to return the external phosphorus loading of the lake to background conditions. In addressing this aspect of the Upper Klamath Lake TMDL, the National Research Council (NRC 2004) concludes that "[e]ven a 20% reduction would be ambitious and potentially infeasible", and that "even a reduction of 40% in total external phosphorus loading would probably be ineffectual without suppression of internal phosphorus loading, given that internal phosphorus loading is very large for Upper Klamath Lake".

Aside from the likely unattainability of just the first condition above, the combination of all four conditions is clearly unachievable. There are no realistic methods for the desired future Upper Klamath Lake TMDL compliant condition to be reduced further and account for groundwater inputs to attain 0.03 mg/L as required in the Draft TMDL at Stateline. As a result, the Draft TMDL fails to provide proposed TP load allocations that are achievable, practicable, or enforceable.

The Draft TMDL provides no explanation, including in the Implementation Plan discussion, of any legal or practicable means of ensuring that the TP reductions would occur at Stateline (and at other downstream locations by extension). Also, the Draft TMDL provides no quantification of the reductions that are likely to be achieved. Because the TP allocations at Stateline (and at other downstream locations by extension) are unachievable, the Draft TMDL is unachievable. That, in turn, means that the relevant water quality objectives cannot be achieved. Accordingly, the Draft TMDL is inconsistent with the Clean Water Act and EPA's implementing regulations, and the appropriate course before completing the TMDL would be to either revise the relevant water quality objectives (if the revisions would protect beneficial uses) or conduct a use attainability analysis to remove uses or subcategories of uses that cannot be attained, or to establish new, more refined and site-specific subcategories that are more reflective of this system. (final comments p.24-26)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
The Regional Water Board provides a strategy for achieving compliance with TMDL targets at Stateline, which is described in Chapter 6 of the staff report. In addition, Oregon has its own implementation process to address allocations above Stateline. The Regional Water Board has confidence that Oregon will apply their designated process to work towards achieving their own allocations which are designed to meet CA water quality objectives at Stateline. In addition the Regional Water Board has been working with PacifiCorp, ODEQ, and others to develop the Klamath Basin Water Quality Tracking and Accounting Program that will facilitate a collaborative approach to funding and implementing necessary TMDL mitigation and restoration activities. That is, the emerging framework provides the mechanism for working collaboratively across state lines to achieve both the TMDL allocations and water quality objectives.

For an explanation of the boundary conditions used in the TMDL please refer to DEQ's draft Klamath River TMDL (http://www.deq.state.or.us/wq/TMDLs/docs/klamathbasin/uklost/KlamathLostTMDLWQMP.pdf), page 2-41, for a discussion on the representation of UKL, other sources in Oregon and resulting instream concentrations. The concentrations used to represent the UKL in the allocation scenario are consistent with the upstream TMDL which is the best available prediction of restored conditions. The UKL TMDL model predicted a range of conditions. A conservative set of those condition were chosen to represent TMDL conditions for the Klamath River model. Therefore, the predicted phosphorus concentrations are a conservative estimate of TMDL conditions and are expected to be greater during some years. In Oregon, compliance with allocations is determined on a source by source basis and does not rely on meeting stand alone instream criteria but rather a change in conditions or measurements at an outfall.

A water quality model is a better predictor of reservoir phosphorus concentrations than the assumption in the comment that the springs' concentration is equal to the reservoir concentration. Dissolved inorganic phosphorus is not a conservative constituent but can be removed from the water column by periphyton and can settle if bound to solids. Therefore, comparison between the concentrations of springs and the concentration of the river to determine a 'realistic' concentration is not appropriate. The annual average upstream boundary input at the UKL outlet is 0.022 mg/l under the natural condition baseline (the commenter cites a different value from the UKL TMDL 0.041 mg/l - that is not applicable to this analysis). Using the correct upstream boundary condition, the predicted downstream TP concentrations in the TMDL scenario (0.030-0.039 mg/l) are higher, not lower, than the assumed phosphorus concentration at the upstream UKL boundary (0.022 mg/l). Therefore, the statement that "the Draft TMDL requires TP concentrations at Stateline (and at other downstream locations by extension) that are lower than upstream concentrations from Upper Klamath Lake under future compliant TMDL conditions and naturally-occurring groundwater base flows" is incorrect.

A26. Comment(s):
Page 4-1, Footnote. The calculation for conversion of organic matter to CBOD, and to CBOD ultimate is not presented in the analyses. Basic stoichiometric considerations and decay rates are not provided to convert among these parameters. As such the reader of the technical TMDL cannot interpret what Regional Board staff has used in calculating load allocations for CBOD. (p. 23) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
The OM is converted to CBODu by: CBODu=OM*(0.45 gC/gOM)*(2.67 gO2/gC).

A27. Comment(s):
Page 4-1, Paragraph 4, Bullet 1. Please show how the UKL TMDL compliance target for TP of 0.11 mg/L was converted to nutrient boundary conditions used in scenarios. (p. 23) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
The conversion was made as follows. Also note that 13.45 ug/L now replaces the target of 0.11 mg/L.

- Estimate ratio based on existing Pelican Marina 2000 data (n=16) (TN/TP, SRP/TP, NO/TN, and NH3/TN).
- The UKL TMDL model provides the Total P, Algal P, and Non Algal P in ppb (bi-weekly output).

- Use the above ratios and UKL TMDL model Total P to estimate TN, SRP, NO3, and NH4.
- Estimate OP as OP = Non Algal P – SRP. Note that the maximum value of the difference between the algalP-SRP and the minimum positive OP concentration was used. This was used because the conversion ratio is based on an annual average, which can cause deviation/scatter of data resulting in negative concentrations. The minimum positive OP value was first estimated (estimated to be 0.239 ug/L). This minimum positive value of 0.239 was used to cap the OP concentration if it resulted in a negative value.
- Next estimate the OM as OM = OP * 180.
- LPOM = 0.1 * OM and LDOM = 0.9*OM.
- The resulting average TP (SRP+[LPOM+LDOM]*0.0055) is now 13.45 ug/L.
- Additionally, the algae was previously estimated using the predicted chl-a from the UKL TMDL model, but it is now estimated using the predicted Algal P from the UKL TMDL model. The algae (mg/L) was estimated from the Algal P as Algal P*180/1000.

A28. <u>Comment(s):</u>
Page 4-5, Paragraph 2, Line 1 (and Figure 4.1). Only loads from 2000 are taken into consideration, while loads almost certainly change from year to year. The lack of assessment of inter-annual variability in the draft TMDL provides no measure of, for example, interpreting reservoir benthic loading impacts because there is no information on year-to-year variability and an understanding of the range of potential conditions. Based on data in Figure 4.1, total phosphorus benthic loads in 2000 are a little over 1 percent of the load at Stateline. The range in benthic loads is probably small – reservoir stage is fairly constant year-to-year, the reservoir stratifies each year, and the reservoir experiences anoxia in the hypolimnion every year (albeit with some variability). However, the natural inter-annual range in total phosphorus at Stateline is probably considerably larger than the entire benthic load, not to mention the uncertainty in data and model runs etc. The TMDL simply lacks the technical rigor in the categories of inter-annual variability, sensitivity analysis of numerical tools, and overall uncertainty analysis to formulate robust load allocations and provide a strong basis for implementation actions. (p. 25) (PacifiCorp – Appendix A and B.doc)

<u>Comment(s) Made By:</u>
Hemstreet - PacifiCorp

<u>Response:</u>
Refer to Responses for A2 and A3.

A29. <u>Comment(s):</u>
Page 4-16, Table 4.3. Table states period is from May 2004-May 2005, while text refers to May 2005-May 2006. Likewise, annual values in table do not correspond to annual values in text, and it would be helpful to present all data in days or years, or both. Please

clarify that these are “compromise” values (Appendix 2, section 3.2) used in analysis. How any of these values for residence time were determined is not described here or in Appendix 2. Residence time information is readily available from the CE-QUAL-W2 models of the reservoirs in model output. (p. 30) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
The text will be revised to ensure that the dates are consistent. Unsure what the commenter means by “compromise” values. The analysis did not involve a dynamic model so representative values were selected for the analysis.

A30. Comment(s):
Page 4-13, Figure 4.6. There is no supporting data or detailed documentation in the Draft TMDL document for the derivation of "natural conditions" baseline presented in these graphs. What are the flows and concentrations that make up these loads? It is especially confusing that the total phosphorus load is presumed to have increased nearly six-fold when the difference between "current" conditions (based on actual data) and "natural" conditions (based on groundwater and tributary streams) is only about two-fold. For example, the current average total phosphorus concentration in the Klamath River in the vicinity of the Project is about 0.18 mg/L. Assuming 0.18 mg/L is six-fold greater than "natural" conditions would require a "natural" concentration of 0.02 mg/L (assuming same flows). A total phosphorus concentration of 0.02 mg/L is unrealistic for this river, even substantially lower than the current total phosphorus concentration in "natural" groundwater (at the J.C. Boyle bypass reach). It is important to enumerate the load reduction for TP, TN, and CBOD (OM) required by Oregon to attain natural baseline conditions at Stateline. Over 300K pounds of the 700K pounds of phosphorus is from Stateline and above. Over 1.4 million pounds of the 3 million pounds of nitrogen is from Stateline and above. Almost 6 million pounds of the 14 million pounds of CBOD is from Stateline and above. A range of years would provide considerable insight to the potential variability and ranges of loads. Also, should simulation from 2000 be applied for a TMDL that will be completed a decade later? Have UKL TMDL implementation actions improved water quality in the six years since adoption of that TMDL? At a minimum an assessment of available data should be carried out to assess current conditions at UKL and determine if indeed improvements have been observed. Such information would be useful to include in the Klamath River TMDL because if loads have been reduced (or increased, or stayed the same…or simply experienced a range of conditions) at Link Dam this would directly affect load allocation determination. (p. 27-28) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
For an assessment of Upper Klamath Lake please see Oregon's draft TMDL, page 2-26.

http://www.deq.state.or.us/wq/TMDLs/docs/klamathbasin/uklost/KlamathLostTMDLWQMP.pdf

It is correct that the TMDL is predicting Klamath River concentrations of phosphorus less than the concentration in the springs. Please see response A25 for explanation of this phenomenon.

A31. Comment(s):
Page 4-13, Paragraph 2, Lines 3-4. The draft TMDL states that the analysis isolated the effects of each reservoir. However, review of the data indicates that this was only completed in a simplistic fashion. The conclusion is: the difference calculations actually do not isolate the reservoirs, but actually assess the impact of the reservoir and any upstream reservoirs. Thus, the results for Copco reservoir (Figure 4.7) include operations and effect of J.C. Boyle reservoir, and the results for Iron Gate Reservoir include operations and effects of Copco reservoir and J.C. Boyle reservoir. The results presented in the TMDL are incorrect and misleading. (p. 28) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
By comparing temperatures upstream of the reservoirs to temperatures downstream, the temperature impact associated with each reservoir is isolated. Regional Water Board staff acknowledge that the upstream temperature influences are implicitly incorporated in to the upstream temperatures.

A32. Comment(s):
Page 4-6 to 4-8, Table 4.2. As noted above, the data presented in the Table 4.2 (and Figures 4.14.3) suggests accuracy to single pounds, which suggest greater accuracy in the analysis than can possibly exist. The table does not represent the net reservoir benthic load from the sediments. Benthic load shown here is only that portion that emanates from the reservoir sediment under anoxic conditions. However, the reservoir also acts as a trap for organic sediments. Thus to assess the net effect of the reservoir both the accumulated flux of phosphorus to the bed (phosphorus in organic matter, sorbed to particulate matter) and from the bed should be presented. That is, the bed is also accumulating and storing phosphorus (and other nutrients) as well and should be included in the calculation. Correctly accounting for this will result in the already small loads identified in the TMDL being further reduced and becoming negative, i.e., reservoirs as net sinks. Using values listed in Table 4.2 and assuming "Stateline to Iron Gate" inputs are loaded at Jenny Creek in Iron Gate reservoir, natural loss (no reservoirs) is greater than current loss (with reservoir) in location of Iron Gate reservoir. The loss (or load unaccounted for) in this

reach for the natural condition baseline is approximately 48,000 lbs, while loss under existing conditions is approximately 31,000 lbs, calculated using values rounded to thousands of pounds as:

Natural loss = Copco out + Jenny Cr in + "sediment flux" - Iron
Gate out = 105+60+0-117 = 48 (thousand lbs)
Current loss = Copco out + Jenny Cr in + "sediment flux" - Iron
Gate out =702+60+4-735 = 31 (thousand lbs)

It seems counter intuitive that under natural conditions the loss is 50 percent greater when no reservoir is present to trap material. A comparison of CBOD at Stateline under current and natural baseline conditions is approximately 55 percent and approximately 35 percent of the Trinity River CBOD load, respectfully. This is difficult to believe given that the Trinity River borders on mesotrophic to oligotrophic status and the Klamath River at Stateline is clearly eutrophic. This probably stems from using the reporting limit or method detection limit for CBOD when non-detects are encountered in the data. Clear documentation of how censored data were used in the construction of Table 4.2 is necessary in the TMDL documentation to effectively interpret these figures and table. (p. 26) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
The presents the TMDL model estimates of reservoir retention for nutrients and organic matter. The allocations referred to by PacifiCorp are required because of controllable water quality conditions within the reservoir not because of their net effect on nutrient mass balance. The Regional Water Board staff are not suggesting accuracy to the single digits – rather we are reporting the model output as calculated.

A33. Comment(s):
Internal nutrient loading in stratified reservoirs does little to exacerbate dissolved oxygen conditions because for internal loading to occur, anoxia must be present. Anoxia occurs primarily because of seasonal stratification and is largely driven by organic matter loading and sediment oxygen demand. Resulting loading from the sediments is generally limited to the hypolimnion. When the reservoir attains an isothermal condition in the fall, dissolved oxygen conditions are typically no longer of concern. Likewise any available nutrients that were contributed from the hypolimnetic volume during turnover are of minimal consequence because the shorter days and cooler temperatures limit algal growth. Copco and Iron Gate Reservoirs have very short residence times in the winter due to the relatively small storage, large inflows, and isothermal condition, so carryover of hypolimnetic nutrients from one season to the next is most likely insignificant. (p. 30) (PacifiCorp – Appendix A and B.doc) (This comment has also been included in the Source Analysis – C10)

<u>Comment(s) Made By:</u>
Hemstreet - PacifiCorp

<u>Response:</u>
The remarks presented here are generally true. Stratification does limit the transport of nutrients derived from anoxic bottom sediments to surface waters – but does not eliminate their transport. Whether or not this is significant must be based on an analysis of the processes, not on a value judgment that the internal loading "does little" to impact oxygen conditions. Two important considerations must be added to the view presented in the comment. First, both molecular and turbulent diffusion occur across the thermocline, resulting in gradual mixing of hypolimnetic nutrients into surface waters even under stratified conditions. Second, it has long been recognized that many cyanophytes (blue-green algae) possess gas vacuoles that enable the organisms to regulate their position in the water column. As summarized by Wetzel (1975), "…blue-green algae are able to regulate buoyancy and undergo limited vertical migration to poise themselves within vertical gradients of physical chemical gradients favorable to growth… The population maximum, coupling population growth with movement downward, apparently often occurs as epilimnetic nutrient concentrations are depleted in summer. Movement to lower strata of low light and temperatures and increased nutrient availability occurs." Thus, cyanophytes under bloom conditions may actively "pump" nutrients from the thermocline, derived from bottom sediments, into surface waters.

The comment ignores the capability of cyanophytes to migrate within the water column to retrieve nutrients from the hypolimnion during the evening and return to the surface during the day. This phenomenon has been documented in Copco Reservoir by Pia Moisander. Samples taken at station CRSC02 in August 2008 clearly show a *Microcystis aeruginosa* population shifting their population to lower depths in the night early morning hours, with the 6 AM population peak coinciding with the maximum vertical extent of elevated ammonia concentrations derived from the hypolimnion (Figure C10.1). As described in Moisander (2009):

"Both Microcystis and Aphanizomenon are able to use vertical migration for nutrient acquisition (Rabouille et al., 2005; Chu et al., 2007), a strategy that could be very useful in Iron Gate and Copco Reservoirs which have a permanent anoxic bottom layer maintaining high NH4 + and DIP in the summertime (Kann and Asarian, 2007). Riverine inputs from the upper watershed serve as another abundant source of DIN, potentially supporting Microcystis blooms."

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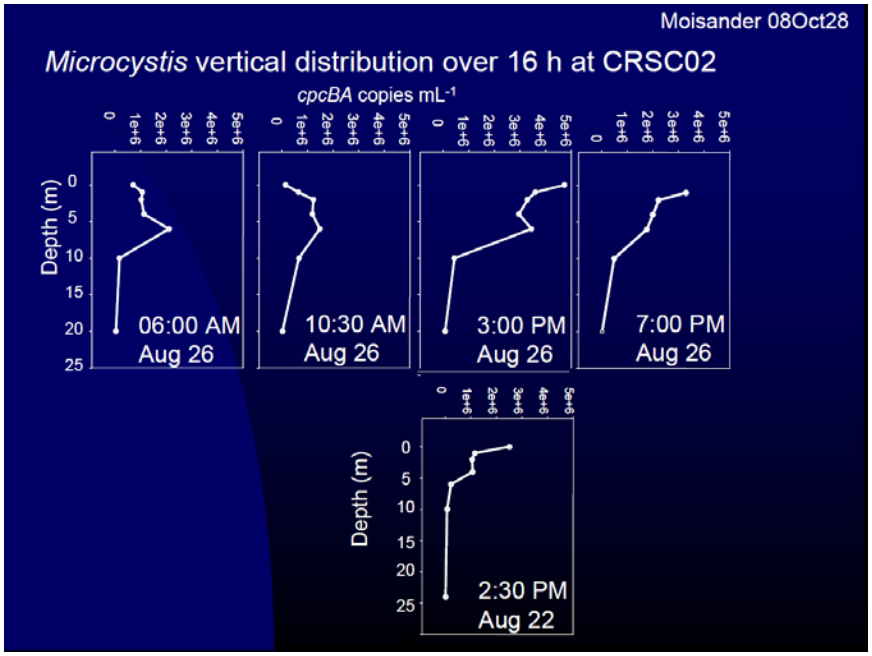

Figure A33.1 Vertical migration of *Microcystis* over a 16 hour period in Copco Reservoir on August 26, 2006. From: Diversity and nutrient limitation of *Microcystis*in Klamath River reservoirs, a slide presentation by Pia H. Moisander, University of California Santa Cruz, Ocean Sciences Department.

Regarding "When the reservoir attains an isothermal condition in the fall, dissolved oxygen conditions are typically no longer of concern.", DO at deepest depths is near-zero even after temperature stratification breaks down. For example, at Copco Reservoir on 9/21/2005, there was only a 5 degree C difference between surface and bottom temperature difference, but DO at 25m depth was near-zero). Similarly in 10/4/2005, there was only a 2 degree C difference in surface and bottom temperatures, but DO at 25m was near-zero)(see Appendix A1 of Asarian and Kann 2009). Conditions at Copco were Similar in 2006 and 2007. The same phenomenon also occurs in Iron Gate, but later (November).

Actually, dissolved oxygen concentrations can be a concern in late September and October, when fall chinook spawn. In 2008, September D.O. concentrations below Iron Gate Dam were lower than in any other month June-September, with mean D.O. concentrations less than 7 mg/L (see Figures C10.2 from Karuk Tribe 2008).

It is probably true that releases of low D.O. water from Iron Gate are more driven by stratification than by internal loading, but does not eliminate internal loading as a potential contributing factor.

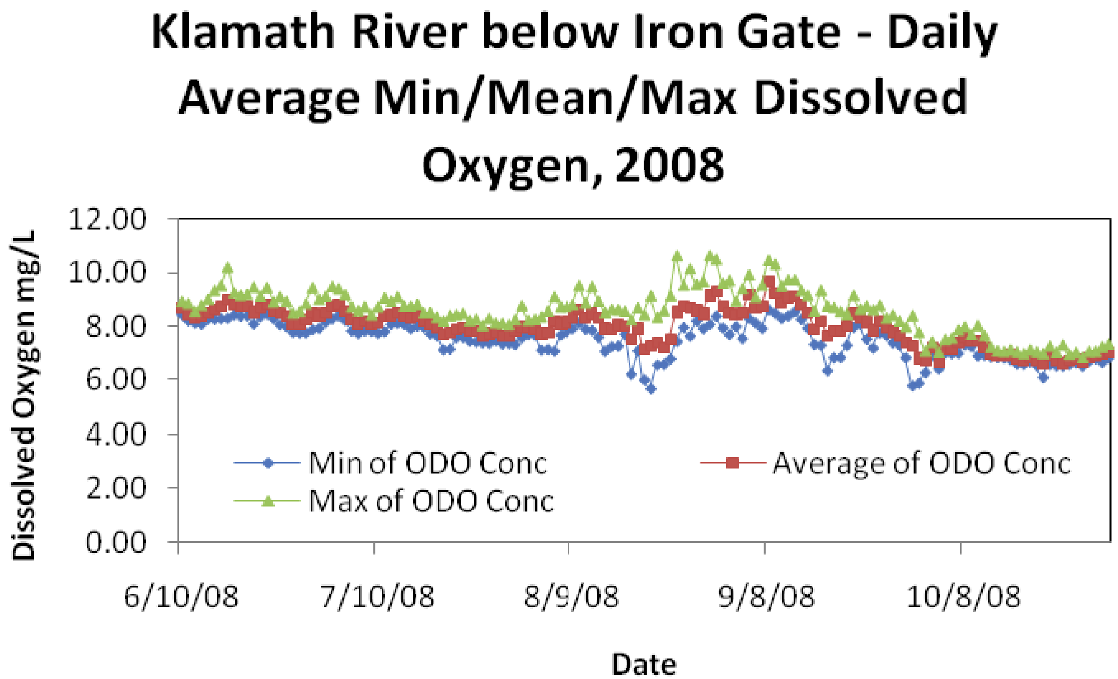

Figure A33.2 Daily Average, Minimum and Maximum DO Conditions below Iron Gate Dam for June – October 2008

<u>References cited in A33 Response:</u>

Asarian, E., J. Kann, and W.W. Walker. 2009. Multi-Year Nutrient Budget Dynamics for Iron Gate and Copco Reservoirs, California (Review Draft). Prepared for the Karuk Tribe of California, Dept. of Natural Resources. Riverbend Sciences and Kier Associates, Eureka, CA.

Karuk Tribe. 2008. Water Quality Assessment Report 2008. Karuk Tribe Department of Natural Resources, Orleans, CA. 75 p. Available online at: http://www.klamathwaterquality.com/documents/2009/2008_WQReport_Karuk.pdf

Moisander, P.H., et al. 2009. Nutrient limitation of Microcystis aeruginosa in northern California Klamath River reservoirs. Harmful Algae (2009), accessed at: http://dx.doi:10.1016/j.hal.2009.04.005

Wetzel, R.G. 1975. *Limnology*. W.B. Saunders Co., Philadelphia.

A34. <u>Comment(s):</u>
The listed bullet points are largely not applicable to Iron Gate and Copco reservoirs, and the implications of internal loading on these reservoirs should be explained in the context of their physical and chemical characteristics. Basic processes information can be found in any basic limnology textbook and readily presented in light of conditions at Copco and Iron Gate reservoirs. Specifically, anoxia occurs primarily because of seasonal

stratification and is largely driven by organic matter loading and sediment oxygen demand. Resulting loading from the sediments is generally limited to the hypolimnion. When the reservoir attains an isothermal condition in the fall, dissolved oxygen conditions are typically no longer of concern. Likewise any available nutrients that were contributed from the hypolimnetic volume during turnover are of minimal consequence because the shorter days and cooler temperatures limit algal growth. Copco and Iron Gate Reservoirs have very short residence times, on the order of days, during elevated flow conditions in winter due to the relatively small storage, large inflows, and isothermal condition, so carryover of hypolimnetic nutrients from one season to the next is most likely insignificant. This is an important distinction of the Klamath River reservoirs: lakes with longer residence times allow nutrients from the hypolimnion to mix throughout the entire water column during the fall and the onset of stratification in the subsequent spring captures some of these nutrients in the epilimnion making them available for primary production. Through time this cycle can shift a reservoir from a lower trophic state to a higher trophic state (i.e., eutrophication). Loading from the sediments is just over one percent of influent loads (as shown in Figures 4.1 to 4.3) and does not contribute widely to the reservoir water quality impairment (nor does it affect the river downstream to an appreciable degree because the contributions are small and any increases will occur later in the year during the waning periods of the annual algae growth season).

Before addressing each of the five bullet points, it should be noted that all of the process may happen somewhere in a lake or reservoir or river, but the important question is whether they are driving water quality conditions in these reservoirs.

Bullet 1 – Wind driven currents are important in water quality and mixing considerations in lake environments. However, sediment disturbance by wind is a process that is more of a factor in shallow lakes. Copco and Iron Gate reservoirs are impoundments located in steep canyon areas and thus are deep with sloping sides. Because they are maintained at stable levels for hydropower purposes, macrophytes tend to ring these reservoirs dissipating wind energy and minimizing resuspension of sediment. This process (along with degassing and bioturbation) is probably small in the reservoirs.

Bullet 2 – This bullet point describes the basic process of sediment release under anoxic conditions.

Bullet 3 – High pH at the sediment surface may affect sediment flux, but under anoxic conditions pH is typically low under reduced conditions in the reservoir bottom waters. Both Copco and Iron Gate bottom waters during summer have pH values typically below 7.5 and sometimes well below 6.0. This may occur in shallow margins areas of the reservoir, but is probably not a dominant process.

Bullet 4 – This bullet point erroneously suggests that shallow lakes experience seasonal stratification. Shallow lakes (e.g. Upper Klamath Lake) do not experience seasonal stratification because wind mixing imparts sufficient energy into the system to overcome density differences. The result is that shallow lakes often have weak, intermittent stratification, but not persistent stratification. Important to this discussion is that even short duration, weak stratification can produce anoxia and sediment nutrient release, which under subsequent mixing conditions can be introduced into the

photic zone and support primary production. However, the main stem reservoirs are deep and experience strong seasonal stratification that precludes this condition from representing a dominant process.
Bullet 5 – Reservoirs can produce large standing crops of BGA that are nitrogen fixers. However, nitrogen fixation does require energy and there has been no analysis to date if this process is occurring. The mere presence of heterocysts is not conclusive of actual nitrogen fixation. In addition, both reservoirs experience the persistent presence of considerable standing crop of both non-nitrogen fixing BGA (e.g., *Microcystis*) and nitrogen fixing BGA (e.g., *Aphanizenmenon*) which suggests that this is not a dominant process in the Project reservoirs.

In sum, these are valid points for UKL, but in the context of Chapter 4 discussions, they appear to be aimed at PacifiCorp reservoirs, where they are not readily applicable in describing dominant water quality processes. From an internal loading perspective, the critical process of fall turnover to reintroduction nutrients to the near-surface waters from deeper waters is not even mentioned in the draft TMDL. As noted above, the short residence time of the reservoirs in winter indicates that these nutrients would be exported downstream and not have notable carryover effects on water quality in subsequent years. This comment reflects an overall concern with the TMDL – that Regional Board staff may not fully grasp the complex interrelationships at work in the Klamath River and reservoir reaches and are oversimplifying critical components in the TMDL analysis, leading to inappropriate load allocations. (p. 31-32) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp – Page 4-17, Paragraph, Bullet points.

Response:
This comment largely repeats Comment A.33, with the addition of further material relative to the bullet points presented on p. 4-17. Please refer first to the response to Comment A.33.

The TMDL document does not contend that internal recycling of nutrients is the major factor "driving water quality conditions in these reservoirs." Instead, the TMDL document clearly acknowledges that the majority of the nutrient load is derived from upstream. However, additional incremental contributions do occur from internal loading. Regulations require that the TMDL attempt to account for all sources, stating that the TMDL should include "Last for any nonpoint sources of pollution and natural background sources, tributaries, or adjacent segments" (40 CFR §130.2(i)).

The comment mischaracterizes the five bullet points on p. 4-17. The document does not contend that all five processes are active and significant at all times in Copco and Iron Gate. Rather, it says that, under stratified conditions with an anoxic hypolimnion, a "reservoir is subject to one or more of the following processes that can lead to the transfer of nutrients from the reservoir bottom sediments back into the water column; processes collectively referred to as internal nutrient loading."

Regarding the individual bullets:

- Bullet 1 is acknowledged but characterized as "probably small in the reservoirs." This is likely true. Nonetheless, wind driven currents do contribute to the regeneration of nutrients and so are appropriate to consider as one of various potential mechanisms for contributing to internal nutrient loading.
- Bullet 2 is acknowledged without comment.
- Bullet 3 refers to high pH at the sediment surface, which can enhance phosphorus release. The comment says that in Copco and Iron Gate "bottom waters during summer have pH values typically below 7.5." This in no way negates the bullet point. Indeed, a pH of 7.5 is above neutral conditions. Jacoby et al.'s (1982) study of Long Lake, WA demonstrates that equilibrium total dissolved P tends to increase rapidly above a pH of 6, while at a pH of 7.5 the total dissolved P concentration in midlake sediments was about twice that observed at a pH of 6.
- Bullet 4 is said to "erroneously suggest [s] that shallow lakes experience seasonal stratification." In fact, this bullet describes the phenomenon of algal vertical (active or passive) migration that enables algae to transport nutrients from the thermocline to surface waters (see response to Comment A.34). This phenomenon is not dependent on the lake being shallow. Indeed, it is more likely to be of importance in deeper, stratified lakes. The text should be corrected to say "In *stratified* lakes…" rather than "In *shallow* lakes…" With this correction, the phenomenon clearly does apply to Copco and Iron Gate.
- Bullet 5 comments acknowledge the likelihood of nitrogen fixation by cyanophytes in the reservoirs but "suggests that this is not a dominant process in the Project reservoirs." The point of the bullet is that the process does occur, and does contribute to internal nutrient loading. There is no attempt to imply that it constitutes a major part of the total nutrient mass budget, only that it is a source and thus should be considered as a part of the total loading under the TMDL regulations.

Regarding Regional Board staff's understanding of complex issues on the Klamath River and reservoirs, we would note the positive reviews of the TMDL staff report submitted by the independent scientific peer review panel and the broad support in general from the larger scientific community involved in the Klamath River.

References Used in A.34:

Jacoby, J.M., D.D. Lynch, E.B. Welch, and M.A. Perkins. 1982. Internal phosphorus loading in a shallow, eutrophic lake. *Water Res.*, 16:911-919.

A35. Comment(s):

This analysis of benthic flux does not use a standard "control volume" approach. The analysis only estimates flux from the sediments into the water column and there is no discussion of nutrient flux to the sediments through settling and retention in the reservoirs. This has little meaning when evaluating the net effect of reservoirs on nutrient flux. Also, because comprehensive sediment diagenesis is not included in the models, benthic flux as represented in the model accounts for uncertainty from a number of different processes. Net reservoir benthic flux may be negative, i.e., a net loss of nutrients. (p. 32) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp – Page 4-17, Paragraph 4.

Response:
The comment reflects a misunderstanding of the analysis, which is designed to show only the sensitivity of the calibrated model to the benthic efflux assumptions. This is done appropriately by comparing the phosphorus concentrations at the outlet from Iron Gate for runs with and without the benthic efflux term. There is no need for a "control volume" approach because the intent is not to develop a mass balance.

We agree that net benthic flux can well be negative due to settling losses. Indeed, both model runs shown here retain the settling and loss components; thus, the run with the benthic efflux removed represents a situation with net negative benthic flux.

We further acknowledge that there is uncertainty in the representation of benthic flux in the model. It is, however, unlikely that this uncertainty would be resolved by incorporating "comprehensive sediment diagenesis" in the model, as sufficient data are not available to parameterize such a model – which would, in essence, exhibit the same level of uncertainty, only represented in a more complex form. To the extent that there is uncertainty, TMDL regulations require that allocations be reduced to account for the uncertainty through a Margin of Safety.

A36. Comment(s):
Review of draft TMDL Appendix 6, Appendix K illustrates that DO plots for model calibration can readily be used to define the "critical growth period." Specifically, the diurnal range of DO is minimal (well under 1 mg/L) until approximately mid-May. Subsequently the diurnal range begins to expand notably at sites throughout the Klamath River, wherein the diurnal range may extend from less than 2 mg/L to over 4 mg/L through August. As solar altitude and day length decrease more rapidly by mid-August, all traces show a reduction in diurnal DO, indicating the seasonal reduction in standing crop. By the end of September there is little or no diurnal range in DO. Important in assessing this information is that after approximately early-to mid-August the decline in standing crop may still produce notable diurnal variation in dissolved oxygen and pH, but that additional nutrient loading will most likely have minimal impact because standing crop is being constrained by light limitation (day length). Thus by early- to mid-September, by a conservative estimate, increased nutrient loading as shown in Figure 4.9 will have a negligible biostimulatory effect on standing crop. Figure 4.9 clearly indicates that much of the load will occur well outside of the biostimulatory period– on the order of half the load occurs after October 1. Further, these very modest increases in concentration prior to that date (typically less than 0.005 mg/L) are probably having little effect on a system that is typically nitrogen limited from June –September. In sum, the

statement in paragraph 2 stating this "increase in bio-available phosphorus occurs during the growth period (see subsequent comment), contributing to biostimulatory conditions downstream of the reservoirs" is misleading because much of the load occurs after the growth season and is probably an overstatement of impacts. Further, any impacts of this small increase identified in Figure 4.9 on biostimulatory conditions downstream are not quantified and would probably have little or no effect due to the naturally elevated levels of phosphorus in the Klamath River system. (p. 32) (PacifiCorp – Appendix A and B.doc) (This comment has also been included in the Source Analysis – C12)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The Regional Water Board staff disagrees with this comment which is misleading on a number of levels. Photosynthesis will decline as light availability decreases and temperatures drop. However, the statement that "By the end of September there is little or no diurnal range in DO" is simply untrue. Examination of the figures in Appendix K to Appendix 6 shows that significant diurnal DO fluctuations on the order of 1 mg/L occur into early October and the size of these fluctuations is validated by observed data in mid September at numerous locations. Positive pH fluctuations also persist into October, indicating active photosynthesis. Although growth rates have generally declined by mid September, it is not safe to conclude that increased nutrient loading "will have a negligible biostimulatory effect on standing crop." That assertion can only be made relative to the pre-existing nutrient status of periphyton biomass prior to the onset of fall.

The comment then goes on to discuss Figure 4.9, claiming that this figure "clearly indicates that much of the load will occur well outside of the biostimulatory period." This makes little sense, as Figure 4.9 does not present loads, but only concentration differences due to the assumptions about phosphorus benthic flux. The TMDL report clearly acknowledges that the load contribution due to benthic flux is small relative to the total phosphorus load transported in the river: "While these bottom sediment nutrient flux loads are relatively small compared to the current total loadings entering the reservoirs, they do represent a controllable increase in nutrient loading that would not occur in the absence of anoxic conditions created by the presence of the reservoirs." Further, the increase in concentration shown in Figure 4.9 becomes noticeable by about the first of August, and clearly co-occurs with peak growth conditions in the river. Whether or not "the majority of these loads occur during the summer months" depends on how the summer months are defined. As can be determined from Table 4.2, 73 percent of the benthic phosphorus flux from Copco and Iron Gate occurs during the May to October period. The fraction would of course be less if October was omitted from the "summer" designation.

A37. Comment(s):
Role of Copco and Iron Gate Reservoirs in Klamath River Nutrient Dynamics. To reiterate earlier comments, the TMDL definition of the critical growth period from May

through October masks critical intra-seasonal dynamics in the Klamath River. Reservoirs do affect both timing and form of source load. Discussions have focused on annual or six month loading assessments presented in the draft TMDL and have missed critical within season dynamics. The fundamental flaw in this analysis is the omission of carefully examining TMDL model outputs which clearly show that the reservoirs dramatically reduce large nutrient pulses emanating from Oregon (in response to bloom conditions in UKL). As described in detail in section III.D of the cover document preceding this appendix, PacifiCorp's water quality modeling consultant (Watercourse Engineering) performed model runs (using the Draft TMDL models recently obtained from Tetra Tech for review) that clearly show that TP and TN loads at Iron Gate dam are substantially lower under current conditions than under conditions assuming the dams are absent. This is due to the significant retention and loss of inflowing organic matter in the reservoirs that would not occur without the reservoirs.
As described in detail in section III.D of the cover document preceding this appendix, the peak nutrient loads coming from upstream sources are also shifted later into the fall than would occur without the reservoirs. This shift into the fall is important because, with dams in place, nutrients tend to leave the reservoirs later in the season after benthic algae standing crop in the river has started to diminish. The simulation models used in the Draft TMDL have the ability to effectively characterize the impacts of the reservoirs on the dynamics of nutrient loads, but have not been used in the Draft TMDL to more fully account for these important processes. Detailed discussion of nutrient dynamics in the project area presented in detail in PacifiCorp (2006) provides additional information based on both model results and field data, none of which was referenced in the draft TMDL. (p. 33) (PacifiCorp – Appendix A and B.doc) (This comment has also been included in the Source Analysis – C13)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
The cited model runs conducted by Watercourse Engineering have not been provided for peer review, and the Regional Board is unable to comment on their accuracy. Simulated retention and delay of nutrient pulses depends not just on the model parameters but also on the assumptions regarding nutrient speciation in the boundary conditions. For example, nutrients in particulate organic form will be much more likely to settle and be retained than nutrients in dissolved form. The existing model runs for 2000 clearly show that nutrient retention rates in the reservoirs are low on an annual basis (less than 10 percent except for nitrogen in Iron Gate – see Appendix 3). Further, the modeled estimate of nitrogen retention in Iron Gate in 2000 (about 18 percent) does not appear to be representative of typical nitrogen retention rates in this reservoir. Asarian et al. (2009) recently completed a detailed empirical analysis of the reservoir nutrient budgets over a 2 ½ years period of intensive monitoring of the reservoirs (May 2005 – December 2007). For total phosphorus, this report estimates an annual retention rate of 11 percent in Copco and 7 percent in Iron Gate – with negative retention rates over the May – September period. For total nitrogen, this report estimates an annual retention rate of 7 percent in Copco and 5 percent in Iron Gate, with somewhat higher retention rates over the May –

September period, likely due to denitrification losses. There is variability in retention from month to month. However, examination of Figures 23 – 26 in Asarian et al. (2009) and copied below shows that reservoirs have at most a minimal effect on the timing of the delivery of loads to the lower river.

<u>References Used in Response A37:</u>

Asarian, E., J. Kann, and W.W. Walker. 2009. Multi-Year Nutrient Budget Dynamics for Iron Gate and Copco Reservoirs, California (Review Draft). Prepared for the Karuk Tribe of California, Dept. of Natural Resources. Riverbend Sciences and Kier Associates, Eureka, CA.

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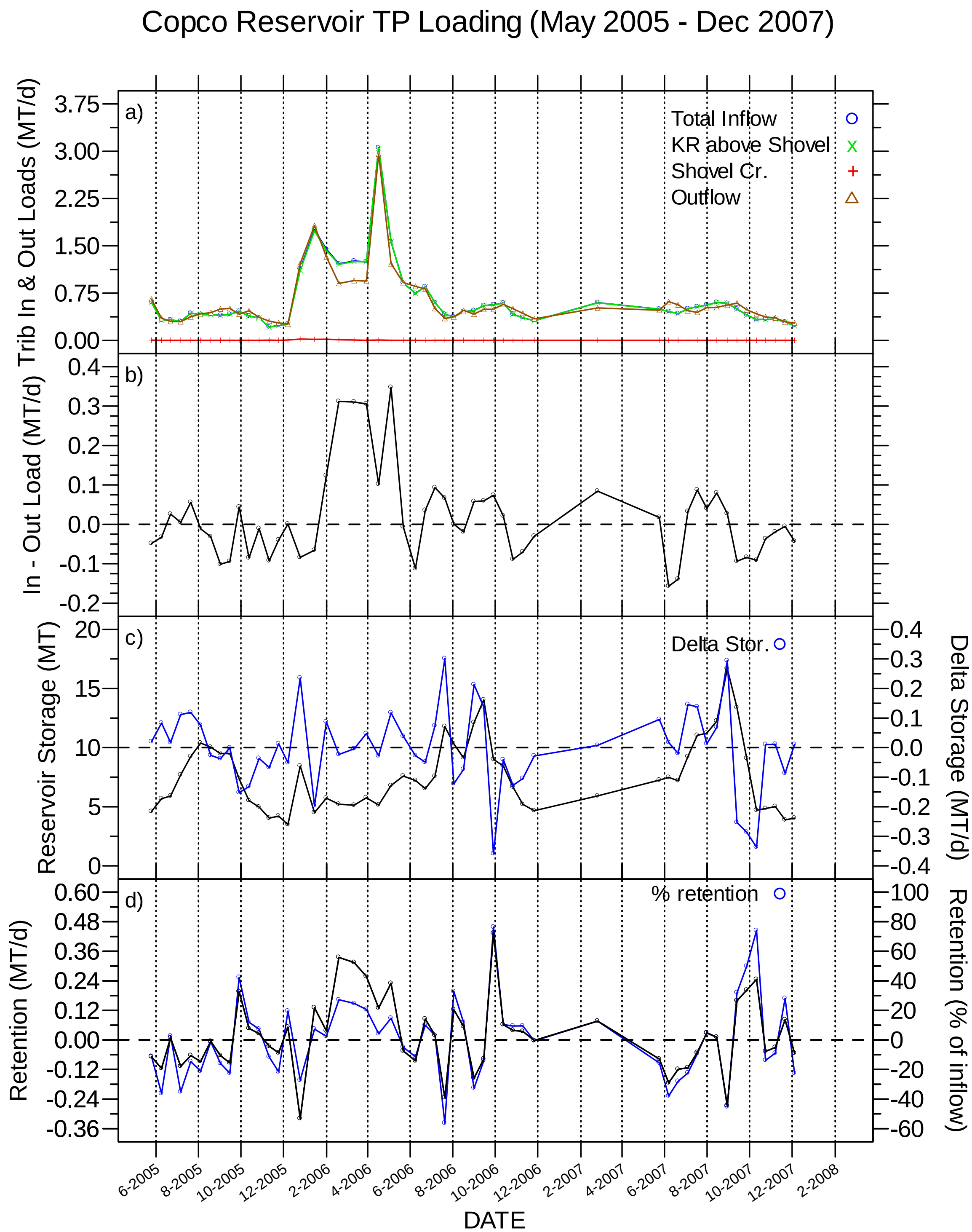

Figure 1. Tim e series of Copco Re servoir total phosphorus loading, May 2005 – Dec 2007. Ea ch point represents data from an entire sam pling interval (~biweekly) and is placed at the m idpoint of the two adjacent sampling dates. Horizon tal dashed lines are placed at zero fo r ΔStorage and retention.

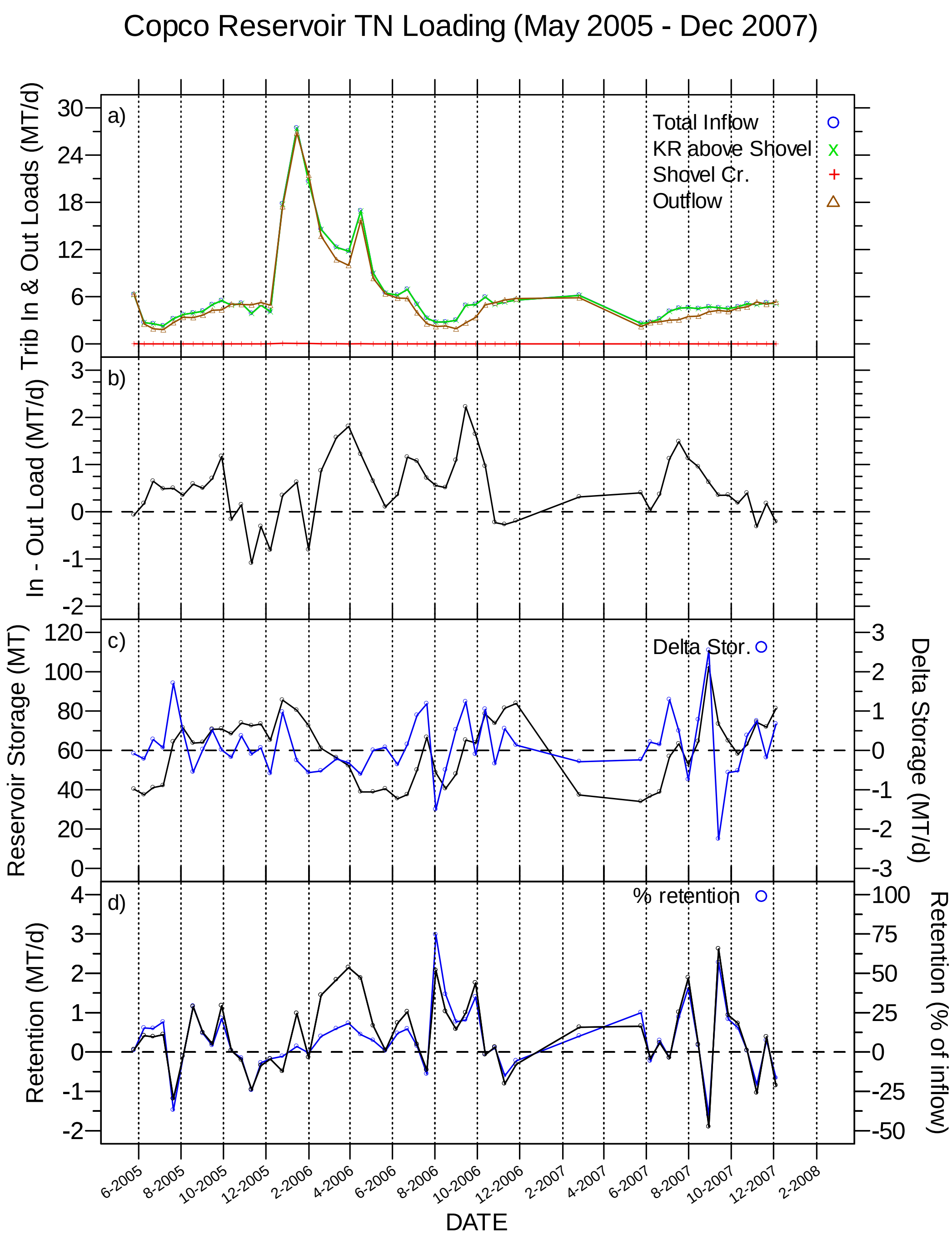

Figure 2. Time series of Copco Reservoir total nitrogen loading, May 2005 – Dec 2007. Each point represents data from an entire sampling interval (~biweekly) and is placed at the midpoint of the two adjacent sampling dates. Horizontal dashed lines are placed at zero for ΔStorage and retention.

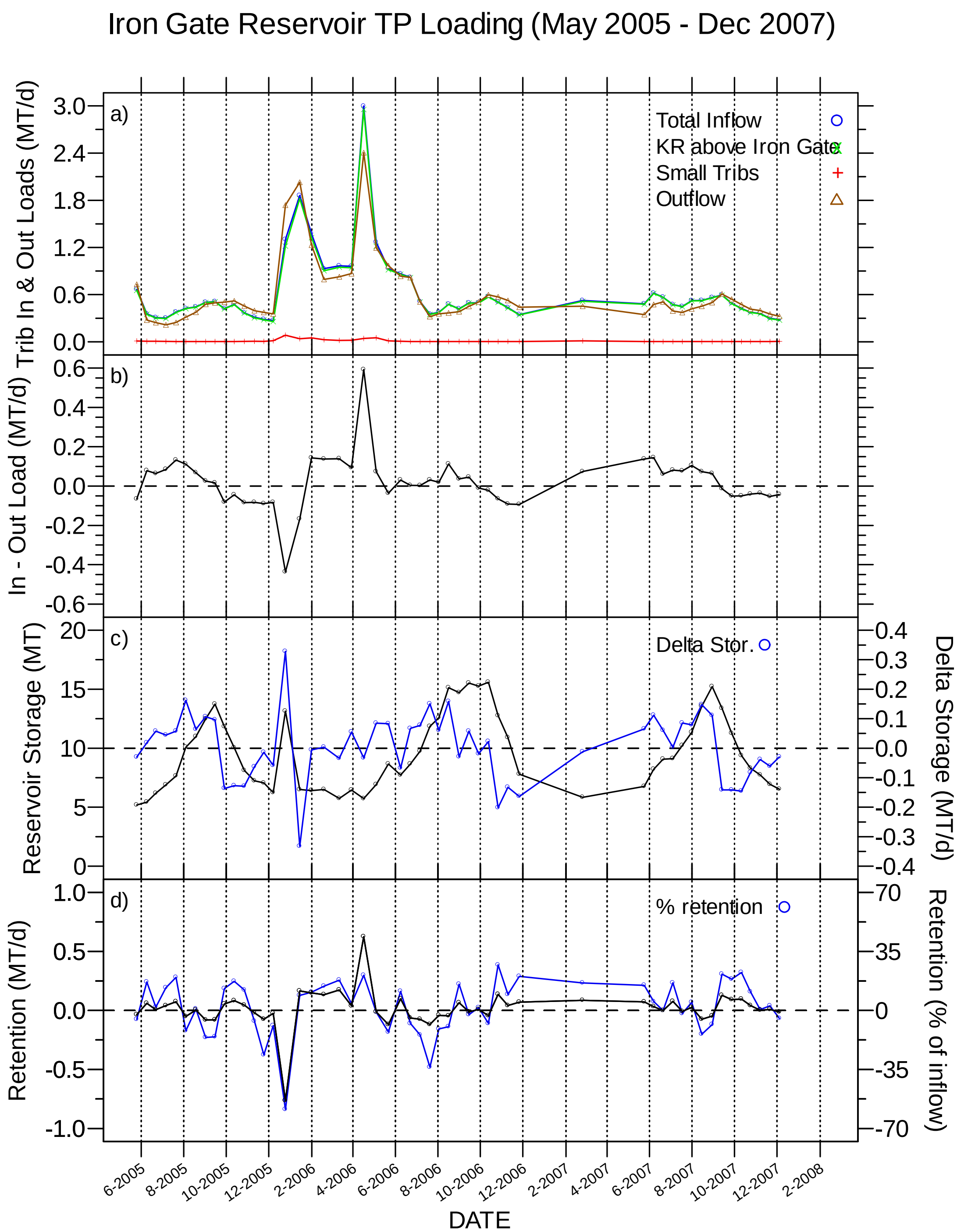

Figure 3. Time series of Iron Gate Reservoir total phosphorus loading, May 2005 – Dec 2007. Each point represents data from an entire sampling interval (~biweekly) and is placed at the midpoint of the two adjacent sampling dates. Horizontal dashed lines are placed at zero for ΔStorage and retention.

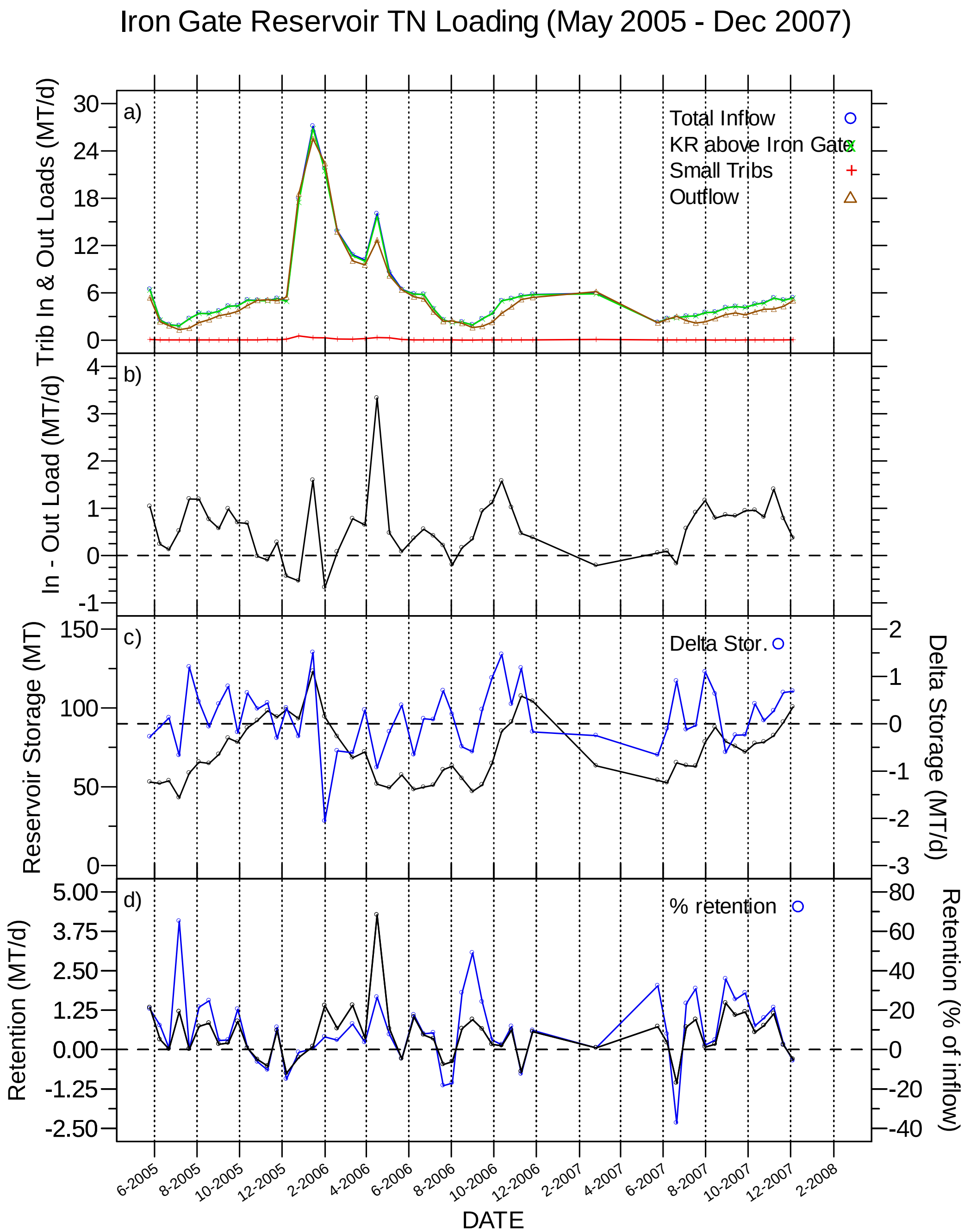

Figure 4. Time series of Iron Gate Reservoir total nitrogen loading, May 2005 – Dec 2007. Each point represents data from an entire sampling interval (~biweekly) and is placed at the midpoint of the two adjacent sampling dates. Horizontal dashed lines are placed at zero for ΔStorage and retention.

A38. Comment(s):
Why would the TMDL model retention "not account for nitrogen exported downstream within living biomass?" All nitrogen forms (including algal biomass) are included in model output and the calculation is straightforward. Clearly, reservoirs can retain significant amounts of nutrients, all methods cited, and overall the table on page 4-20 represents clear positive retention, yet this information is not used in the TMDL to identify any positive implications the reservoir may have on nutrient conditions in the system. Finally, the terminology identified herein should be defined: a certain portion of nutrients entering the reservoir are lost through sedimentation and denitrification, while others are retained, but may be exported in a future time period. Please clarify terminology and consider quantifying loss versus retention to allow more complete consideration in TMDL analysis. (see also comment Page 4-19, paragraph 3: Role of Copco and Iron Gate Reservoirs in Klamath River Nutrient Dynamics). (p. 33-34) (PacifiCorp – Appendix A and B.doc) (This comment has also been included in the Source Analysis – C14**)**

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
The cited text is in error and has been corrected. The section has also been amended to include the most recent nutrient budget analysis from Asarian et al. 2009. The positive retention characteristics of the reservoirs are clearly described and characterized within the TMDL staff report. Other aspects of this comment are addressed below.

Table 4.20 is cited as showing "clear positive retention". In fact, the retention rates shown in this table are generally small, and in some cases negative. As noted in the response to Comment A.37, the revised multi-year analysis of Asarian et al. (2009) shows for total phosphorus an annual retention rate of 11 percent in Copco and 7 percent in Iron Gate, and, for total nitrogen, an annual retention rate of 7 percent in Copco and 5 percent in Iron Gate.

The statement that reservoir retention "is not used in the TMDL" is incorrect, as the TMDL runs (with dams in) include retention, and indeed may over-estimate nitrogen retention in Iron Gate.

As to the terminology, it is best to work in terms of *net* retention, which is the difference between influent and effluent loads. The net retention includes both permanent losses to the atmosphere and deep burial along with temporary storage and exchanges with the active sediment and gains from the atmosphere due to nitrogen fixation. However, only the net effect of these processes can be resolved and validated from observed water column concentration data. In the end it is the net retention – the difference in loads and the resulting differences in concentration – that controls eutrophication response in the reservoirs and export of nutrients downstream.

A39. Comment(s):
Given the above discussion, it appears that the information in this table (Page 4-20. Table 4.5) is incomplete – failing to capture considerable reductions during critical periods of the year. Presenting annual and semiannual (or longer) averaging periods and failing to account properly for travel time serves to significantly reduce beneficial impacts the reservoirs have on water quality. The simple model simulation exercise of placing the TMDL existing conditions (with dams) boundary conditions into the TMDL natural conditions baseline (no dams) indicates that the reservoirs have a profound impact on water quality all the way to the estuary in late-spring well into summer – the most critical period of primary production in the river. These findings indicate that reductions above Stateline need to occur early in the process and are paramount to any successful implementation actions in California. (p. 34) (PacifiCorp – Appendix A and B.doc) (This comment has also been included in the Source Analysis – C15)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
The Regional Water Board staff has compared the model output from Table 4.5 and it appears that the TMDL model may over-estimate the temporary retention of TN during the summer. This may be attributable to a difference between years. However because the Assarian et al. (2009) estimates are based on an analysis of monitoring data, the estimates in Table 4-5 will be updated using the results included from their report. It is also important to note that the results from Assarian et al. (2009) do not show significant delay of nutrient load peaks. The Regional Water Board staff agrees that reductions above Stateline need to occur to achieve the TMDL; however, independent applicability means that the reductions within CA should not be dependent on first achieving reductions in Oregon.

A40. Comment(s):
The Draft TMDL cites Kann and Asarian (2009); however, Kann and Asarian (2009) is only a Powerpoint presentation of preliminary information that specifically states "do not cite". In addition, the information presented in the Draft TMDL includes information that is not included in the Powerpoint presentation. The report by Kann and Asarian (2009) is not available. The Draft TMDL should delete reference to this information unless and until a report has been made available for public review. There have been substantial flaws with previous nutrient loading analyses by these authors (i.e., Kann and Asarian 2005, Asarian and Kann 2006, Kann and Asarian 2007) as described in PacifiCorp (2006), PacifiCorp (2008b), and Butcher (2008). (p. 34) (PacifiCorp – Appendix A and B.doc) (This comment has also been included in the Source Analysis – C16)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
This comment is no longer relevant, as Asarian et al. (2009) have produced a full report and provided it for review. It is incorrect to characterize the previous efforts and of Kann and Asarian as having "substantial flaws"; however, there were some valid concerns regarding methodology. Dr. Butcher reviewed the new report from Asarian et al. and concluded that the new report resolves the significant methodological questions regarding the earlier work, and revises and confirms the magnitude of previous estimates of retention rates.

References Used in Response A40:

Asarian, E., J. Kann, and W.W. Walker. 2009. Multi-Year Nutrient Budget Dynamics for Iron Gate and Copco Reservoirs, California (Review Draft). Prepared for the Karuk Tribe of California, Dept. of Natural Resources. Riverbend Sciences and Kier Associates, Eureka, CA.

A41. Comment(s):
The section addresses nutrients, but bullet 1 discusses oxygen allocations and implications for fisheries. This point is out of place or needs additional information to make it relevant to this section. Further, the draft TMDL is vague about where and when oxygen depletion occurs and which fishery (COLD or WARM) is affected.

Bullet 2 – Two useful points are presented herein. First, that excessive nutrient loads from upstream are responsible for biostimulatory conditions. Second, that a reservoir environment is a biostimulatory condition. The draft TMDL states that the reservoir condition creates impairment, without considering the ability of the reservoirs to reduce upstream nutrient loads that would create additional impairment downstream of the reservoirs if not retained. Benthic chlorophyll *a* targets will probably not be met in river reaches, indicating that even under extreme nutrient reductions (as presumed under the natural conditions baseline) challenges will remain. Thus, stating that the reservoirs cause the impairment is arbitrary.

Bullet 3 – The nutrient retention and export information in Table 4.5 is insufficient and misleading. Reservoirs provide substantial benefits and retention and loss plays a dominant role in regulating the amount and timing of nutrient loads downstream. The implications of markedly increased nutrient loads under the dam removal condition (natural baseline) on river reaches and the estuary needs to be more comprehensively and accurately assessed to determine implications of dam removal prior to achievement of TMDL goals.

Further, a more comprehensive and appropriate representation of actual reservoir dynamics in the TMDL would allow better assessment of potential implementation actions and key intermediate milestones en route to compliance. (p. 34-35) (PacifiCorp – Appendix A and B.doc) (This comment has also been included in the Source Analysis – C17)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
The comment does not raise any substantive issues regarding bullet 1. This bullet is of course included here because nutrient loads cause excessive algal growth which in turn is one of the causes of oxygen depletion.

The comment appears to agree with most of bullet 2, except that the role of the reservoirs in mitigating downstream loads is not considered. This is untrue, as the dams-in scenarios do include reservoir detention. As was documented in previous comment responses, the net reduction in nutrients caused by the reservoirs is small. Regardless, it is necessary to attain water quality standards in both the reservoir and river reaches. The dams contribute to impairment in the reservoir reaches, as the comment acknowledges.

For the comments regarding bullet 3, please first refer to the response to Comments A6, A7, A33, A37, A38, and A39 for a description of the role of dams in changing the timing of nutrient loads. The implication that removal of the dams would worsen conditions downstream is speculative. As discussed in Appendix 2, the natural (dams out) condition would result in more frequent scouring flows and less days of accrual time between scouring events.

A42. Comment(s):
Nutrient Dynamics in the Klamath - Page 4, Paragraph 2, Lines 1-2. Will denitrification occur in a river running at 85 percent saturation? It seems like denitrification and fixation are equally unlikely. (p. 57) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
The comment misrepresents the cited text. The paragraph in question doesn't say that denitrification is occurring in the river. Rather, it merely tabulates the potential ways in which nutrient mass may be permanently removed from the system, of which denitrification is one. The Regional Water Board does not expect significant denitrification to occur within the flowing river. Page 9 of Appendix 3 explicitly states that denitrification is not likely to be of major significance in the river reaches, but may occur on a limited basis under mats of decaying periphyton. As to nitrogen fixation, the cited paragraph already states that cyanophytes capable of nitrogen fixation "are usually not dominant in flowing waters."

A43. Comment(s):
Table 3.1 and elsewhere. The Bypass-Peaking Reach is referred to as Bypass/Full Flow Reach. It is our understanding that "Fullflow" was a name for this reach that is no longer used; "Bypass Reach" refers to the stretch of the river before the powerhouse release, and "Peaking Reach" refers to the stretch of the river below the powerhouse. Hence, "Bypass/Full Flow Reach" is a misnomer that needs to be corrected for the sake of clarity and consistency. Page 3-6, Paragraph 1, Line 3. The text identifies that the TMDL model was "segmented similarly to the PacifiCorp model." Discussions with Regional Board staff and review of the code indicate that the same model geometries are used. The text suggests changes were made for the TMDL, which is erroneous. (p. 16) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
Thanks for the clarification and the document will be updated.

A44. Comment(s):
Page 3-6, Paragraph 1, Line 5: Not all tributaries to the river were represented as boundary conditions. To state otherwise misrepresents the actual setup of the TMDL model. (p. 16) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
All tributaries have been described in the updated TMDL staff report (Chapter 3).

A45. Comment(s):
Page 3-6, Paragraph 1, Line 9: Four vertical layers were chosen to represent the estuary. What was the basis for this decision? Typically this is part of geometric grid or mesh refinement wherein layers are added until results show no appreciable difference (typically a criterion is selected to define "appreciable"). Would the model be more accurate if more layers were used? Further, would the results differ significantly if the model domain was different? The answers to these questions should be included and thoroughly discussed in the TMDL and address the potential implications of these assumptions on load allowances specified by the TMDL. (p. 16). (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
Two different vertical resolutions were implemented in the model: one with 8 layers and the other with 4 layers. The 8 layer model was configured to investigate if more refined vertical stratification could be achieved, however the results did not show a significant change in the simulated vertical salinity gradient. Therefore, the 4 layer model was adopted in the final version of the model. Conditions in the estuary did not directly influence development of the TMDL load allocations.

A46. Comment(s):
Page 3-6, Paragraph 4, Line 2: The "multiple locations" at which the TMDL model was calibrated and corroborated are not listed, leaving in question the adequacy of calibration/validation, i.e., to ensure that the model functions adequately and appropriately for the purpose of TMDL formulation. (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
Calibration locations and results are presented in the Klamath River Model for TMDL Development Report (Chapter 3 and Appendices E through L).

A47. Comment(s):
Please present a detailed account and the results of the "corroboration" process. Greater transparency in this regard is needed to ensure public confidence in the TMDL model. Corroboration is not a formal modeling term and does not replace validation of the model for an independent time period, casting doubt on the applicability of the model and reducing confidence in results appropriate for a TMDL. No performance measures are provided for model calibration. (PacifiCorp – Appendix A and B.doc - Page 3-6, Paragraph 4, Line 10)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
Model corroboration was described in Chapter 3 of the Klamath River Model for TMDL Development Report, and results were presented in the Appendices. Model corroboration for the Klamath River Model was analogous to the model validation process that the commenter refers to. Regarding the performance measure comment, refer to A2.

A48. Comment(s):
The Klamath River TMDL model above the estuary is divided into eight parts or

reaches, which includes river and reservoir reaches. To call these reaches "segments" is confusing and misleading. Further, modeled reservoirs are divided into "segments" in the language of CE-QUAL-W2. (PacifiCorp – Appendix A and B.doc - Page 3-6, Paragraph 5, Line 1)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
Thank you for your perspective on this issue. We are not aware of a standard usage for these terms in the water quality modeling field.

A49. Comment(s):
Considering the availability of data and models from 2000 through 2004 that were provided to the Regional Board Staff early in the TMDL process, it is unfortunate that only data from one year are used to calibrate the TMDL model. As such, the TMDL model does not have a formal validation period. Thus, it may be fair to conclude that the TMDL model downstream of the Bypass-Peaking Reach is unreliable or of limited reliability in setting TMDL load allocations. As it stands, one can only have confidence for model applicability for 2000, and yet the TMDL model is relied upon to set load criteria for many years to come. Specifically, using only a single year on which to base the TMDL analysis provides no information on interannual variability – a considerable omission in a system with the size and complexity of the Klamath River. (p. 17) (PacifiCorp – Appendix A and B.doc - Page 3-6, Paragraph 5)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
Refer to responses for A3 and A47.

A50. Comment(s):
The draft TMDL states that 2002 simulations were restricted to the Oregon portion of the system due to resource limitations and lack of boundary conditions. Lack of boundary condition data is not a valid argument. No tributaries are modeled between Stateline and Fall Creek (entering Iron Gate Reservoir). Within Iron Gate Reservoir Fall, Jenny, and Camp Creeks are represented in the model and data from PacifiCorp for 2002 was made available to Regional Board Staff for Fall and Jenny Creek. Downstream of Iron Gate Dam, USFWS implemented a program that ran from 2002 through 2006 that included the most comprehensive water quality sampling of mainstem and tributary sites to date. Coupled with water quality sampling of PacifiCorp and the Yurok and Karuk Tribes, there is considerable data availability in years 2002 to present. This omission of additional model years when sufficient data were available to extend the models severely limits the TMDL analysis because of a

complete lack of accounting for inter-annual variability. At the inception of the TMDL process, five years of simulations were available to the Regional Board and Oregon Department of Environmental Quality: 2000-2004. The intensive estuary work of 2004 falls within the range of available years. (p. 17) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
Refer to response A3.

A51. Comment(s):
The sentence seems to imply that model sensitivity and uncertainty analysis are not "key practices." Further, one wonders why these are only considered "to a lesser extent." At a minimum an exploration of sensitivity is an integral part of model development and application. (p. 17-18) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
The Board did not intend to imply that model sensitivity and uncertainty analysis are not key practices. This section has been revised to more correctly reflect the approach taken to evaluate model uncertainty. We agree that both are key elements of model development, and the model developers and agencies employed both types of inquiry throughout the model development process.

Model calibration and corroboration (aka "validation") involved repeated adjustment of model parameters and boundary conditions (which were based on available data) in order to achieve the best match between predictions and observations. This process inherently considered the sensitivity of model processes to influencing factors. Through this process and the more than forty subsequent allocation runs, it was clear that the model results are primarily driven by the magnitude and timing of boundary condition contributions (i.e., incoming loads from upstream and lateral boundaries). Model parameter sensitivity is much less influential. Therefore, the major focus of Klamath River TMDL model refinements was on acquiring and incorporating the most accurate and comprehensive data describing boundary conditions to reduce uncertainty.

Also refer to response A2.

A52. Comment(s):
The peer reviews of the model brought up a host of comments regarding uncertainty, lack of calibration, sensitivity analysis, yet little of this critical review is reflected in

the body of the TMDL. Uncertainty analyses or even model performance metrics that allow model uncertainty to be quantified are absent from this analyses. Without a quantification and incorporation of model uncertainty into analyses, the models are insufficient to set TMDL load allocations. The fact that sensitivity analysis is presented with reference to the EPA water quality model QUAL2E indicates that even in complex systems quantification of uncertainty is feasible and necessary. As stated in the TMDL "models are suitable tools for establishing Klamath River TMDL allocations and targets," but the tools must be appropriately developed, tested, and applied to carry out this task and this TMDL does not support this level of rigor. (p. 18). (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
Refer to response A2.

A53. Comment(s):
The Draft TMDL states that "…the frequency of scouring events…would also increase in a dams-out scenario." The assumption is incorrect. As discussed in detail in the hydrology and geomorphology sections of PacifiCorp (2004b), the frequency of scouring flows has not been altered by the presence of the dams. PacifiCorp reservoirs have limited active storage and high flow events pass without appreciable attenuation. (p. 19) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
The Regional Water Board disagrees with this comment. Scouring events are made up of more than flow velocity, scour also includes movement of gravel, cobble, and sediment which have been reduced due to the impoundments.

A54. Comment(s):
There is reference to the "NNE benthic biomass scoping tool" and the reader is referred to section 2.3.2.1. Section 2.3.2.1 states that the "CA NNE scoping tools" are described in Chapter 3. There is no description of the models, data used in the models, simulation assumptions, or assessment of uncertainty. This lack of documentation and transparency provides little confidence in NNE results and is technically insufficient for use in TMDL load allocation analyses (e.g., Appendix 2 provides insufficient documentation for the application of BATHTUB to the Klamath River reservoirs). (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:

Hemstreet - PacifiCorp

Response:
The technical memorandum describing the NNE analysis is attached to the TMDL staff report as Appendix 3 and a citation to the original NNE source document is also provided. The text in Section 2.3.2.1 will be changed to reflect the original NNE source document (Tetra Tech 2006):

Tetra Tech. 2006. Technical approach to Develop Nutrient Numeric Endpoints for California. Prepared for U.S. Environmental Protection Agency (Contract No. 68-C-02-108-TO-111), and CA State Water Resources Control Board – Planning and Standards Implementation Unit. Lafayette, CA. 120 pp

In addition the data and spreadsheet analyses were provided to the commenter in June 2009 in response to a request.

A55. Comment(s):
As mentioned in previous comments, the model was only validated up to the Bypass-Peaking Reach, it may be fair to conclude that the TMDL model downstream of the Bypass-Peaking Reach is unreliable or at a minimum untested. (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
Refer to response A3.

A56. Comment(s):
The boundary conditions for the model were based on Oregon's TMDL (ODEQ 2002). Upon review, nutrient concentrations were actually set to values inconsistently low with expected conditions presented in the UKL TMDL, and possibly with expected natural conditions (Rounds and Sullivan 2009). Based on the ODEQ 2002 TMDL, mean annual average of total phosphorus is 0.11 mg/L and mean average from March to May is 0.03 mg/L. However, based on the natural condition model runs, the total phosphorus concentration at Link Dam ranges only from 0.015 to 0.045 mg/L. (p. 19) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
Refer to response A4.

A57. Comment(s):
Page 3-9, Paragraph 3, Lines 7-10. Two model simulations were made using different flow regimes, but results were compared and found "not to be substantially different." Presumably the TMDL is speaking to water quality conditions, but this is unclear. Also, the comparison of water temperatures at Stateline in Figure 4.5 is a poor example. Temperature is not a conservative constituent because of exchange across the air water interface, thus similar flows will produce similar temperatures as the river tends to converge on equilibrium temperature (i.e., that temperature which is in equilibrium with meteorological conditions). (p. 19) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
The text has been deleted from the document.

A58. Comment(s):
Further, Figure 4.5 states that "[P]ositive values represent an increase in temperatures due to reduced flow, but this figure presents water temperatures at Stateline – below the large springs below J.C. Boyle Reservoir. This is another example of a statement that has no technical basis or support presented in the document. Under these conditions, smaller flows would be influenced to a greater degree by the cold water spring inputs and may actually be cooler than under a higher flow conditions. Positive deviations in November may be due to the springs "warming" an otherwise cool river. Finally, all of these deviations are within 1°C of zero, which is probably within the resolution of the model. Without any quantification of uncertainty no definitive conclusions can be drawn from Figure 4.5 (or many other figures in the document). (p. 19) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
The figure caption has been edited for clarity. Also, see the response to comment A2.

A59. Comment(s):
Page 3-9, Paragraph 4, Line 6-7. (See also last bullet point, top of page 3-10) What is the rationale for using "natural" and "TMDL conditions" for California tributaries? Which conditions were applied to which tributaries? (p. 20) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
The description of the natural baseline conditions scenario has been moved to Appendix 7 and revised to be clear that they are based on estimates of natural conditions only, not TMDL conditions.

A60. Comment(s):
"Natural conditions assume absence of all point sources." Review of the model files suggest that this would include accretions and depletions from ungaged inflow and storm water. It does not appear that these flows are included, but would occur under natural conditions. There is no discussion of this assumption or the ramifications to flow and water quality. In standard practice such steps may be acceptable upon completion of a sensitivity analysis to truly identify such assumptions as having a minimal impact on results. (p. 20) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
Refer to response A11.

A61. Comment(s):
It is unclear if this "series of iterative simulations" was based on current conditions or natural conditions? The process and assumptions are not described in sufficient detail to fully comment on the findings. As a simple example (and not intended to be all inclusive), even a brief description of what compliance and the definition used in the analysis is necessary for the reader to interpret this sentence. (p. 20) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
The report has been updated to include a more detailed description of the scenarios and results within this section. In addition, the model scenario descriptions have been included in the TMDL staff report as Appendix 7.

A62.Comment(s):
Is the noted flow goal of 45 cfs a regulatory requirement, or simply a goal? Further, is there a specifically assigned temperature to the additional waters that will form the 45 cfs increase in the Shasta River – additional warm water will do little to ameliorate

warm water temperatures in this tributary? (2) There is no time line assigned to this goal, nor any of the tributaries, and no associated analysis indicating the uncertainty in attaining all tributary temperature goals in a consistent and coordinated fashion to attain the Klamath River TMDL. This is a considerable uncertainty in itself, and a clear and detailed discussion relating to these matters is required.

Comment(s) Made By:
Hemstreet – PacifiCorp (p. 20) (PacifiCorp – Appendix A and B.doc)

Response:
As stated in the Shasta River TMDL Action Plan, the flow goal of 45 cfs is just that, a goal. However, this flow goal is translated into a temperature load allocation, as follows: the load allocation for flow is reductions in the maximum daily stream temperatures of 1.5°C, 1.2°C, and 2.1°C from baseline at RM 24.1, RM 15.5, and RM 5.6, the temperature compliance locations for the Shasta River temperature TMDL. The time lines stated in the Shasta River TMDL Action Plan associated with the flow-related temperature allocations are quoted below:

Within two years, and again within four years, of EPA approval of the TMDL, water diverters shall report in writing to the Regional Water Board, either individually or through the Shasta Valley RCD and its CRMP, on the measures taken to increase the dedicated cold water instream flow in the Shasta River by 45 cfs or alternative flow regime that achieves the same temperature reductions from May 15 to October 15.

Within five years of EPA approval of the TMDL, water diverters shall provide a final report to the Regional Water Board, either individually or through the Shasta Valley RCD and its CRMP, on documenting dedicated cold water instream flow in the Shasta River in relation to the 45 cfs goal or alternative flow regime that achieves the same temperature reductions from May 15 to October 15.

This recommended flow measure does not alter or reallocate water rights in the Shasta or Klamath River watersheds, nor bind the Regional Water Board in future TMDLs, the State Water Board, Division of Water Rights in any water rights decision, or state and federal courts. For additional discussion on flows as it relates to the Klamath TMDL please see X1.

A63. Comment(s):
The validation results are presented, but no location is given and there is no discussion of these results. The mean absolute error of more than 3°C from 8/29/02 to 9/4/02 (location unknown) should be discussed in light of the potential implications on the Klamath River TMDL. Results at the mouth of the Shasta River are most applicable for this analysis; however, the draft TMDL makes no quantitative assessment of uncertainty and thus propagation of model error cannot be formally included in the Klamath River TMDL assessment and load allocations. (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
This section has been relocated to Appendix 7 and re-written. However, the use of the Shasta River TVA model to estimate natural Shasta River temperatures is appropriate in light of the mean absolute error statistics presented in the draft staff report for the following reasons:

- The Klamath River water quality model uses daily average temperature data to represent tributary temperatures, which this Shasta River model predicts well. The Shasta River model represents the daily minima and maxima well, compared to measured values. Much of the error is associated with simulated temperatures being out of phase with measured data.
- The Shasta River natural conditions baseline scenario simulates full natural flow. During the summer months the majority of Shasta River flow originates from Big Springs, which has a very stable flow and temperature regime. Generally speaking, the conditions modeled in the natural baseline conditions scenario (a constant, moderate level of stream flow and no tailwater) present less of a modeling challenge than the current conditions scenario (a relatively small volume of stream flow, with tailwater discharges of various and unknown flow magnitudes and temperatures).

A64. Comment(s):
Changes in climate are noted here (as noted in Van Kirk and Naman (2008)), but the draft TMDL contains no technical evaluation of climate change for tributary effects or mainstem conditions. This is especially intriguing because natural conditions assumptions of 1°C and 2°C reductions in lower Scott River tributaries may actually see notable increases – not decreases - in stream temperature due to climate change. A comprehensive assessment of climate change is necessary to determine actual implications in light of TMDL analyses and load allocations. (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
Regional Water board staff acknowledge the uncertainty associated with future stream temperatures in light of climate change. We assumed a 1°C tributary reduction because compliance with the TMDL is expected to increase shade levels in these streams that have recently experienced debris flows related to human activities. While the effects of climate change on stream temperature are difficult to forecast, the possibility of Scott River temperature increases related to climate change further supports Regional Water Board staff's decision to not propose flow-related allocations for the tributaries.

A65. Comment(s):
The model performance data is inappropriately presented. By combining the mean absolute error and bias all 18 validation sites (there is no description if calibration even occurred in this model) into a single statistic all detail is lost to the reader. Further, only the average bias of all sites at the mouth was provided – no mean absolute error was provided. Bias by itself is infamous for obscuring the true performance of a model and this is a critical omission. Finally, the average of averages in model performance statistic is poor form. Full presentation of model performance at all 18 sites (and calibration and validation data as available) should be included. (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
The document indicates that calibration occurred when it states: "The model was calibrated for the August 27 - September 10, 2003, time period using temperature data from 21 sites distributed along the longitudinal axis of the Scott River, and validated using temperature data at 18 sites during the July 28 - August 1, 2003, time period (three sites were not deployed until after August 1, 2003, and were unavailable for validation) ", (pg 3-16, paragraph 1, following bullets).

The Klamath River water quality model uses daily average temperatures to define boundary conditions, thus the daily average validation statistics are presented.

The text has been modified to include the mean absolute error at the site closest to the mouth of the Scott River (0.75 ^{o}C, 0.5 miles upstream of the mouth). Also, language has been added directing the reader to the Scott River temperature TMDL model for further calibration and validation data and discussion.

A66. Comment(s):
This paragraph provides little confidence to the reader about the data, the model, and the results, and terminates with the qualitative statement that "there is uncertainty associated with these estimates." No attempt is made to quantify that uncertainty or to assess the potential implications on the Klamath River TMDL. For the Scott River inflow temperature the draft TMDL makes no quantitative assessment of uncertainty and thus propagation of model error cannot be formally included in the Klamath River TMDL assessment and load allocations. (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
The major source of uncertainty associated with this analysis is the uncertainty associated with the natural flow estimates. Regional Water Board staff presented the temperature results associated with three alternative natural flow depictions. The uncertainty

associated with the Scott River temperature TMDL model is disclosed in the preceding paragraph.

A67. Comment(s):
The term 'de minimus' lacks technical definition in this case. No threshold values for temperature were introduced into the TMDL to define a level of significance or a level of effect for tributary contributions. Thus, the statement that changes in management of the Salmon River watershed will have no effect on the temperatures at the mouth is simply an opinion. Specific criteria should be developed for tributary contributions that can be systematically applied to the TMDL analysis. (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
The text has been modified for clarity.

A68. Comment(s):
It is unclear how temperature "data come from measured flows." Further, the Salmon River is forecast to be hard hit by climate change, and thus future flow regimes and temperature regimes will almost certainly change in timing and magnitude. Discussion of such changes is absent from the document. (p. 21) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
The data referred to hydrograph data. The text has been modified for clarity.

A69. Comment(s):
The draft TMDL states that "[N]either of these comparisons indicated a large temperature reduction at the mouth of the Trinity River would have occurred had ROD flows been implemented in 2000. Based on this comparison, we estimated stream temperature would be reduced by 0.5C under natural conditions." No information is presented to define a "large" temperature reduction, no statistics, tables, or figures are presented to illustrate the analysis data or findings. As with the other tributaries, no threshold values for temperature were introduced into the TMDL to define a level of significance or a level of effect for tributary contributions (e.g., what is "large") to support the Regional Board staff's professional judgment. The 0.5°C decrease is simply an opinion and has little basis in a technical TMDL. One could argue strongly that best available information would suggest that without

Trinity Reservoir (natural condition) stream temperatures in summer under considerably lower flows would be notable higher. As with other tributaries, specific criteria should be developed that can be systematically applied to the TMDL analysis. (p. 21-22) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
The purpose of the analysis referenced in the comment was to define the Trinity River flows and associated temperatures to use for the natural conditions baseline scenario. This scenario was run for the 2000 calendar year. We felt that the ROD flows represented natural flows in the summer and fall critical season because the reservoir releases are roughly equal to natural inflows during that time. Our assessment of recorded Trinity River temps at RM 12.5 found that on average temps were slightly lower in 2005 (the first year of ROD flows) Therefore, we determined that a 0.5°C reduction in the measured year 2000 temperatures is an adequate and appropriate estimate of stream temps under a natural condition. Regional Water Board staff acknowledge the uncertainty associated with the Trinity River temperature estimates, but find that the analysis is adequate for characterizing natural Trinity River flows and temps.

A70. Comment(s):
The draft TMDL acknowledges the complexities and uncertainties associated with the tributaries. However, there is no discussion of how this uncertainty affects the Trinity River, which carries the largest amount of nutrient loading – approximately 20 percent (see Figures.4-1 to 4-3). The implications of this load on the downstream reaches and estuary are not discussed. More detailed discussions of the Trinity River are required because these loads may be considerably more important with regards to impacts on downstream reaches due to the proximity to the estuary. (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
The comment fails to acknowledge the concept of concentration during critical period. Flows from the Trinity River dilute the concentrations present in the Klamath River mainstem. In addition the largest fraction of the Trinity River load comes during the winter and spring period when flows have generally opened the estuary and loads are discharged to the open ocean. The comment implies water quality impacts from the Trinity River on the Klamath River mainstem that have no basis in fact. Trinity River nutrient concentrations are generally low and are estimated to be minimally elevated above background conditions unlike pollutant loads and concentrations upstream in the Klamath.

A71. Comment(s):
A large number of scenarios are introduced in this section (Page 3-17, Paragraph 2) and the details quickly become confusing. Consider a table defining all simulations, acronyms and basic assumptions so the reader does not have to wade through the text trying to decipher what is what. (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
A table detailing the conditions represented in the various scenarios is included in Appendix 7.

A72. Comment(s):
Page 3-18, Paragraph 2, Line 2. How is this different from "current conditions"?

Comment(s) Made By:
Hemstreet – PacifiCorp (PacifiCorp – Appendix A and B.doc)

Response:
The dam impacts scenario (T4BSRN) was run with dams present and boundary water quality inputs based on the final compliance scenarios for Oregon and California (TOD2 and TCD2RN). While the current conditions scenario (S1) also represents dams-in condition, the water quality boundary conditions are based on the "current" year 2000 monitoring data. In some cases water quality boundary conditions for the current conditions scenario (S1) are informed from monitoring data from other recent years (e.g. 2001 through 2008).

A73. Comment(s):
This approach of developing a TMDL without dams and then adding dams dramatically limits the efficacy of the analysis. A more effective, flexible, and informative process would be utilize existing and natural conditions as two ends of the range and then start improving water quality conditions from existing conditions in an incremental fashion. As written, the TMDL simply looks at an existing condition, and some future condition with no insight provided about how to attain that condition. (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
We believe the TMDL approach is more straightforward than indicated in this comment. Consistent with the water quality standard, the natural condition baseline consists of a

free-flowing river (without dams). Then point and nonpoint source discharges are added in amounts that retain compliance with the standard. Then the dams are added and any departures from the standard are attributed to changes in assimilative capacity caused by the dams.

It is unclear how an approach to "start improving water quality conditions from existing conditions in an incremental fashion" would be consistent with a water quality standard based on an allowable departure from natural conditions.

We agree that insights on how the dams can implement changes to attain the standard are a challenge, but these inquiries are part of implementation rather than the TMDL.

A74. Comment(s):
There is no clear reason for reducing PO4 and organic matter, while holding nitrogen constant unless there is a clear strategy to seek phosphorus as the limiting nutrient as a TMDL strategy. At a minimum, a sensitivity analysis should be done here to determine the implications of (a) phosphorus limitation, (b) nitrogen limitation, and (c) the potential for co-limitation. Further, this is confounded by the fact that organic matter contains both N and P, so simply choosing to reduce phosphorus along with organic matter while holding nitrogen constant is not realistic. (p. 22) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
Nutrient TMDL development focused on phosphorus reduction, in order to adhere to applicable water quality standards. For the Klamath River, this involves reduction in algae concentrations (for both N-fixing and non-N-fixing species). As such, phosphorus reduction was deemed necessary. Nitrogen reduction attributed to control of organic matter is an added margin of safety.

A75. Comment(s):
Nutrient Dynamics in the Klamath - Page 2, Paragraph 2, Lines 2-4. Calibration was neither precise nor based on much data and results of calibration probably do not suggest "that some of the original criticisms of the model are correct." In fact, other studies cited in this TMDL suggest that original model results as presented by PacifiCorp were correct. Use of more data in a more rigorous calibration and validation are necessary to make any such statements. (p. 56) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
The recalibration of the PacifiCorp model is described in detail in Appendix 6. We disagree with the characterization that this recalibration "was neither precise nor based on much data." Instead, the recalibration represents an improvement of the original model to the extent possible with available data. The fact that the recalibration results in adjustments to estimates of retention rates is consistent with criticisms that the original PacifiCorp model tended to overestimate retention in the reservoirs.

A76. Comment(s):
Nutrient Dynamics in the Klamath - Page 2, Paragraph 3, Line 1. Models were designed to enhance analysis of systems characterized by sparse data. The lack of data makes an appropriately applied model's results more credible than direct evaluation or the scoping-level analyses described later in this appendix. (p. 56) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
The Regional Water Board staff disagrees. When data are sparse, both empirical analyses and models are uncertain. The exact values of key parameters in the model cannot be determined from first principles and have been adjusted (by both PacifiCorp and Tetra Tech) to obtain general agreement with the observed data. In such circumstances, it is imperative to take a weight of evidence approach, as has been done here.

A77. Comment(s):
"…the model predictions are strongly determined by the boundary conditions (upstream load and relative dilution provided by the downstream tributaries)." As noted, this is especially true in the Klamath River. A major flaw in this TMDL is the failure to use all available data and the misrepresentation of organic matter partitioning at the upstream boundary. A greater fraction of OM as refractory (as suggested by recent studies in the upper Klamath River) translates to even less retention in river reaches. This would markedly affect the dams-out scenario in which the Klamath is composed entirely of river reaches. (p. 57) (PacifiCorp – Appendix A and B.doc - Page 3, Paragraph 1, Lines 3-5)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
There are two assertions in this comment. First, the commenter asserts that the agencies have not used all available data for organic matter. Second, recent data calls into

question the assumptions about the refractory fraction of the organic matter at the upstream boundary.

It is unclear what available data / studies that the commenter is referring to that have not been reviewed. The project team used all available data for the year 2000 and 2002 (model calibration and validation years). USGS collected data recently and recommended that the agencies use this data to define the boundary conditions of the 2000 and 2002 models, but we believe it would be inappropriate to include data from later years in these model runs. The Regional Water Board has reviewed the two following studies and evaluated their findings relative to the existing modeling approach and results for organic matter:

Watercourse Engineering, Inc. (Watercourse). 2006. Characterization of Organic Matter Fate and Transport in the Klamath River Below Link Dam to Assess Treatment/Reduction Potential. Prepared for U.S. Bureau of Reclamation, Klamath Basin Area Office. September 30.

Sullivan, A.B., Dean M. Snyder, Stewart A. Rounds. 2009. Controls on biochemical oxygen demand in the upper Klamath River, Oregon, Chemical Geology (2009), Accessed (11/03/09) at: http://dx.doi.org/10.1016/j.chemgeo.2009.08.007

Based on model calibration and validation results the TMDL project team has determined that the existing modeling approach should not be revised at this time. The composition of organic matter is an active field of research with results recently reported by Sullivan et al. (2009). The Regional Water Board staff looks forward to working with the scientific community working on this topic to incorporate new data and findings into the TMDL thorough the ongoing TMDL reassessment process (i.e., adaptive management).

The Regional Water Board also disagrees with the assertion made in the comment regarding the impact of the current characterization of organic matter on the dams out scenario. It is not necessarily true that a higher refractory fraction would result in less retention in river reaches. This would likely be true for the dissolved fraction, but the refractory part is more likely to be in particulate form and subject to retention by settling and export to the floodplain. In any case, there are no data indicating the fraction of refractory organic matter in 2002 or 2000, and the model was therefore developed with a single lumped variable for organic matter and a single rate governing decay to inorganic (bioavailable) nutrients. These assumptions are providing a reasonable agreement between model predictions and measurements in downstream reaches.

Finally, the Regional Water Board offers the following explanation to provide a better understanding how this uncertainty could impact the TMDL findings and implementation recommendations. Development of the Klamath TMDL requires the agencies to estimate the future composition of organic matter entering the Klamath River from UKL, after implementation of the UKL TMDL. There is no data upon which to base these estimates. In particular, the bioavailability of the future OM loading may change over time. This comment suggests that the bioavailable or "labile" fraction of the OM should be lower in the future, because this fraction is more readily reduced by upstream control actions. Absent any data upon which to estimate this potential reduction, the agencies have assumed that bioavailability will be unchanged after implementation. Since this assumption increases the predicted impact on water quality from boundary inflows of OM, this can be considered a conservative assumption that supports protection of beneficial uses.

A78. Comment(s):
Nutrient Dynamics in the Klamath - Page 3, Paragraph 2, Line 1. Simulations of more years to quantify this "year-to-year" variation are needed. (p. 57) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
The Regional Water Board developed the study as an additional line of evidence to use along with other TMDL analyses. The model year selected for use in the analysis allowed the TMDL project team to make a direct comparison to the years used in other lines of evidence. Use of the NNE model tools will be expanded in future Regional Water Board Klamath River TMDL reassessment activities.

A79. Comment(s):
Nutrient Dynamics in the Klamath - Page 3, Paragraph 4, Line 2. Usefulness of the model could be greatly improved by simulating several years, not just one. (p. 57) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
The Regional Water Board staff agrees with this comment but has determined that the existing study provides a useful line of evidence for the existing TMDL. As stated in comment response A78, Regional Water board staff will make use of the NNE tools in future reassessment activities.

A80. Comment(s):
Nutrient Dynamics in the Klamath - Page 5, Paragraph 1. Watercourse also believes a mass balance/loading is the correct way to evaluate nutrient loss and retention, and that concentration trends are of little value in this evaluation. (p. 57) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
It appears that the commenter agrees with the approach used by Regional Water Board staff. No further response is needed.

A81. Comment(s):
Nutrient Dynamics in the Klamath - Page 5, Paragraph 2. The unstated implication here is that the Asarian and Kann study cited should be discarded. (p. 57) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
The Regional Water Board staff finds no evidence to support the "unstated implication" mentioned in the comment. Dr. Jon Butcher has also confirmed that there is no "unstated implication" that the Asarian and Kann study should be discarded. This study represented a valuable first step in evaluation nutrient dynamics in the river. Rather than rejecting the study, Appendix 3 recommends several ways in which it might be improved. While some refinements are possible, it is our opinion that the Asarian and Kann study provides a credible estimate of retention rates in the river. As stated in Appendix 3, "the approach taken by Asarian and Kann seems likely to provide reasonable estimates of seasonal nutrient retention over the long term."

A82. Comment(s):
Nutrient Dynamics in the Klamath - Page 7, Figure 1 and 2. These figures show no relationship between either TN or TP and flow and thus it is not clear why they are included. (p. 57) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
These figures are included to show that there is NOT a strong relationship between TN, TP, and flow, exactly as stated in the text. It is important to establish this because, if there was a strong relationship, this would have potentially introduced biases into the nutrient budget calculations.

A83. Comment(s):
Nutrient Dynamics in the Klamath - Page 7, Paragraph 1, Line 3-4. The SPARROW model of removal is very coarse and based on rivers all over the US, most of which are

of a quite different profile than the Klamath. We question the relevance of the SPARROW model in the Klamath. Also, because the SPARROW model is non-linear (exponential decay), using a median value of flow is inappropriate. It would be easy to apply the model to hourly flows and average results for a more accurate representation of removal. (p. 57) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
Regional Water Board staff find that the SPARROW application provides another line of evidence that is useful to help bound the problem of determining retention rates. We do not contend that it provides a precise quantitative estimate of retention rates in the Klamath.

The overall SPARROW procedure is designed to estimate annual average loads. Instream removal is simulated based on average time of travel as a function of flow. Therefore, it is appropriate to use a central tendency estimate of flow. It would not be appropriate to apply SPARROW exponential decay rates to hourly or daily flows, as the fitting procedure for SPARROW is based on annual loads.

References Used in A83:
Smith, R.A., G.E. Schwarz, and R.B. Alexander. 1997. Regional interpretation of water-quality monitoring data. *Water Resources Research*, 33(12): 2781-2798.

A84. Comment(s):
Nutrient Dynamics in the Klamath - Page 9, Paragraph 1, Line 5-7. The model being reviewed is not PacifiCorp's model, it is Tetra Tech's model and Tetra Tech should document "other relevant rate constants." (p. 57) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
Tetra Tech performed limited modifications of the PacifiCorp model where needed to improve calibration. Many of the model rate constants were left at the values originally set by PacifiCorp and do not appear to be fully documented in the PacifiCorp report.

A85. Comment(s):
Nutrient Dynamics in the Klamath - Page 9, Paragraph 3, Line 1-2. Nutrient cycling may not be accurate but that doesn't mean annual net retention (loss) is not. A reasonably calibrated RMA-11 can accurately represent annual net loss. (p. 57) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
A "reasonably calibrated" RMA-11 model may provide a reasonable estimate of mean annual net retention, although it may do so by compensating errors that ascribe additional retention to simulated processes to make up for processes that are not simulated. For the lower Klamath River, PacifiCorp itself contends that data are not sufficient for a rigorous calibration (see comments A75 and A76), so we don't know whether or not the model is providing a "reasonable estimate" of mean annual net retention. Given these uncertainties, it is fully appropriate to discuss the potential effects of processes that are not included in the model formulation.

A86. Comment(s):
Nutrient Dynamics in the Klamath - Page 9, Bullet point 1. Denitrification is probably not important in Klamath river reaches. Some simple estimates could put bounds on the contribution of denitrification. (p. 58) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
The item in question does not say that denitrification is occurring in the river. Rather, it merely tabulates the potential ways in which nutrient mass may be permanently removed from the system, of which denitrification is one. We do not expect significant denitrification to occur within the flowing river. Page 9 of Appendix 3 explicitly states that denitrification is not likely to be of major significance in the river reaches, but may occur on a limited basis under mats of decaying periphyton.

A87. Comment(s):
Nutrient Dynamics in the Klamath - Page 9, Bullet points 2 and 3. These processes would not affect annual retention or loss. (p. 58) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
The text does not imply that these processes would have any direct effect on *annual* retention or *loss*. Instead, these processes have the potential to cause temporary retention and a delay in the downstream transport of nutrients. As is stated on p. 10 of Appendix 3, immediately after the bullets referred to in the comment, omission of these processes could "tend to result in an underestimate of retention and an over-estimation of the downstream transport of inorganic nutrients during the algal growing season."

A88. Comment(s):
How significant is riparian vegetation in long-term sequestration on the Klamath? Probably not very but, again, some simple estimates could put bounds around it if this is of concern. (p. 58) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
The purpose of the bullet points is to provide a consideration of processes not included in the RMA-11 formulation. We suspect that uptake by riparian vegetation is not an important factor in long-term sequestration of nutrients on the Klamath. However, as noted in the text, "The net balance of these processes is unknown for the Klamath." Given the lack of information, additional speculation on the magnitude of this process (other than to say that it is not of major significance) would be irresponsible.

A89. Comment(s):
There are few ultimate sinks for nutrients in RMA-11 because there are few ultimate sinks in a fast free-flowing river like the Klamath. (p. 58) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
Regional Water Board staff fully agrees that there are few ultimate sinks for nutrients in a fast free-flowing river like the Klamath. However, that in no way implies that there is no loss of nutrients during transport, nor does it guarantee that all potential loss pathways are correctly simulated by RMA-11.

A90. Comment(s):
SPARROW is likely not very relevant because, as noted, the Klamath is unusual with increasingly steep gradients. SPARROW is based on an average river type that includes many Eastern rivers. RMA11 is physics-based with significant detail but SPARROW takes into account nothing except flow and travel time – and those only coarsely. (p. 58) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
As noted in the response to Comment A83, the SPARROW application provides another line of evidence that is useful to help bound the problem of determining retention rates. Regional Water Board staff do not contend that it provides a precise quantitative estimate of retention rates in the Klamath.

A91. Comment(s):
Page 11, Paragraph 3, Line 6-8. RMA11 matches the analysis of Armstrong and Ward. (p. 58) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
This is stated in the text, where it is noted that the Tetra Tech implementation of the RMA-11 model for the Klamath is "generally consistent with the analyses of the 2001-2005 data by Armstrong and Ward."

A92. Comment(s):
Page 11, Paragraph 3, Line 13-15. The relevant point is annual loss, so the seasonal estimates cited are of marginal value. Plus, of the two seasonal estimates, RMA11 matches one of them. (p. 58) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
Regional Water Board staff disagrees that annual loss is the only relevant measure. Rates of loss and retention during the growing season can have important effects on periphyton growth in the lower Klamath. RMA-11 results are in general agreement with one of the seasonal estimates and no claim was made that it was not.

A93. Comment(s):
Given that the other studies are of marginal relevance in estimating annual loss of nutrients on the Klamath, how does author substantiate the statement that RMA-11 "may have some tendency to underestimate nutrient losses in the free-flowing reaches of the Klamath"? (p. 58) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
Regional Water Board staff disagrees that the other studies are of "marginal relevance." Further, the author is quite clear in stating that there is not strong evidence of under-prediction of retention by RMA-11. For the lower Klamath River, PacifiCorp itself contends that data are not sufficient for a rigorous calibration (see comments A75 and A76), so we don't know whether or not the model is providing a "reasonable estimate" of mean annual net retention. The discussion on page 14 simply raises the possibility that RMA-11 *may* have some tendency to under-estimate losses. As is stated in the text, "It is possible that RMA-11 would tend to underestimate seasonal nutrient retention rates due to the omission of various processes that can enhance nutrient retention and loss. However, the data are not sufficient to determine whether such an underestimation exists or is statistically significant."

A94. Comment(s):
Page 14, Paragraph 4, Line 4-5. Is author equating deeper reservoirs with shorter retention times? Please clarify. (p. 58) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
Regional Water Board staff and the author are not equating deeper reservoirs with shorter retention times. However, the Klamath reservoirs are relatively deep and do have relatively short retention times. The paragraph in questions states that (1) retention time in Iron Gate and Copco is short, (2) algal growth in deeper reservoirs (such as Iron Gate and Copco) will consist primarily of planktonic algae rather than periphyton or macrophytes, and (3) the combination of these factors will tend to increase downstream export of algae.

A95. Comment(s):
Page 15, Paragraph 2. Another study of Kann and Asarian is considered of questionable value. Here, 2002 estimates are described as not reliable. (p. 58) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
The text in question refers to the preliminary analyses of nutrient budgets in Iron Gate and Copco. We do not describe these reports as "of questionable value". Instead, we merely point out some potential methodological flaws as part of due diligence in the analysis. These issues are now moot as Asarian et al. (2009) have produced a revised report and provided it for review. Regional Water Board staff and Dr. Butcher have reviewed the new report from Asarian et al. and concluded that the new report resolves

the significant methodological questions regarding the earlier work, and revises and confirms the magnitude of previous estimates of retention rates.

References Used in A95:
Asarian, E., J. Kann, and W.W. Walker. 2009. Multi-Year Nutrient Budget Dynamics for Iron Gate and Copco Reservoirs, California (Review Draft). Prepared for the Karuk Tribe of California, Dept. of Natural Resources. Riverbend Sciences and Kier Associates, Eureka, CA.

A96. Comment(s):
Page 15, Paragraph 3. Why should there be "large uncertainties" in flow measurements? Detailed flow should be readily available. (p. 58) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
Response: The intent of the statement is that uncertainties in flow measurements are large relative to the magnitude of the estimated retention. USGS performs regular field measurements to calibrate gage rating curves and assigns quality rankings ranging from Excellent to Poor. These are defined as follows:

- Excellent: 95% of daily discharge measurements within 5% of true discharge
- Good: 95% of daily discharge measurements within 10% of true discharge
- Fair: 95% of daily discharge measurements within 15% of true discharge
- Poor: Quality less than Fair.

Field assessments of gage quality for USGS gage 11510700 (Klamath River below J.C. Boyle Power Plant) are typically Good in summer, but frequently only Fair in winter measurements. The influent flows for the mass balance thus have an uncertainty of 10-15%. USGS gage quality for Klamath River below Iron Gate is typically rated Good in winter, but is often only Fair in summer and fall. These flow uncertainties are large in the sense that estimated nutrient retention is on the order of 5-10 percent.

A97. Comment(s):
Page 15, Paragraph 4, Line 5-8. What is the use of measures like "standard error" in this analysis? Field data have natural variation. How does that cast doubt on the results? (p. 58) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
Regional Water Board staff agrees that field data have natural variation. That is exactly the point of the discussion. The standard error is a measure of the uncertainty in the

mean. There is about a 66% probability that the true value of the mean lies within one standard error of the estimate, and about a 95% probability that the true value of the mean lies within two standard errors of the estimate. This paragraph shows that the estimated retention rates (based on a difference in influent and effluent loads) are generally of the same magnitude as the standard error on the mean. The paragraph does *not* state that this "cast(s) doubt on the results" – rather, it says that it is useful to employ a modeling approach to better understand the limited observations.

A98. Comment(s):
Page 16, Paragraph 2, Title. Are these estimates of retention or loss? (p. 58) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
Retention and loss are not mutually exclusive concepts. Retention represents the difference in inputs and outputs over a specified time period. Loss represents the ultimate difference in inputs and outputs due to permanent sequestration or removal from the system. Empirical comparisons of input and output are best represented as retention, as the extent of ultimate loss (e.g., degassing of ammonia or conversion of phosphorus to insoluble precipitates) has not been measured.

A99. Comment(s):
Page 16, Last paragraph, Line 6-8. Where do these estimates of hydraulic residence time come from? Do they come from the model or flow-volume calculations? (p. 58) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
The residence times cited in this paragraph come from the analysis of Kann and Asarian (2007) and are based on their analysis of the hydrologic mass balance.

A100. Comment(s):
Page 17, Table 5. Vollenweider (1976) is likely not appropriate. Kann and Asarian should have their work peer-reviewed. It would be useful to include W2 results to this table, as directly below:

Parameter	Method	Copco	Iron Gate
TP	W2	1.2%	6.1%

TN W2 3.6% 17.6% (p. 58)

(PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
The comment does not provide any arguments as to why the Vollenweider estimate is not appropriate. However, we agree that the Vollenweider method likely over-estimates phosphorus retention in Copco and Iron Gate. The W2 estimates of retention are not included in this table because the intent of the table is to compare estimates derived from sources other than the model. Retention results from the model are provided in Appendix 3, Section 3.3.

A101. Comment(s):
Page 18, paragraph 3. How was retention (loss?) calculated? Was this done hourly? For this analysis, only beginning and ending storage volumes were used with concentration. Why not just use Loss = QiCi - QoCo? What concentration was used – was it taken from somewhere in the reservoir? (p. 59) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
Retention was not calculated hourly; rather it was done on a monthly basis. The analysis is ultimately based on QiCi – QoCo, as provided by the model; however, it is appropriate to include a correction for change in storage due to variation in reservoir volume. The concentrations used are those provided by the model representing influent to and effluent from each reservoir.

A102. Comment(s):
Page 19-20, Table 6-9. Please explain how the ‘Whole Year Retention” was “corrected for change in storage.” (p. 59) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
Retention is equal to influent mass minus effluent mass minus change in storage. Because the reservoir volume at the end of the year is not the same as the reservoir volume at the start of the year, a small correction is needed to account for change in storage. This is estimated from the modeled concentration times the modeled storage volume.

A103. Comment(s):
Page 23, Paragraph 1, Line 1-2. "Available monitoring data (are) insufficient to produce good estimates of nutrient retention and loss." But more recent data will provide much better estimates. (p. 59) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
Regional Water Board staff fully agrees. More recent data are now available, and the new report of Asarian et al. (2009) provides the most reliable estimates of nutrient retention/loss rates.

A104. Comment(s):
Given previous discussions, denitrification is probably NOT an important loss pathway in river reaches. (p. 59) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
Regional Water Board staff agrees that denitrification is probably not an important loss pathway in river reaches. The paragraph in question states this.

A105. Comment(s):
Page 23, End of Paragraph 3, 8-10. "Presence of reservoirs in series likely limits deep burial rates." This assumes that all settleable solids are all retained in Copco reservoir. But Copco produces algae which will die and settle in Iron Gate. Also, this brings in the interesting idea of removing not all, but some of the dams. Thus, allowing nutrients to continue settling while further scientific studies are conducted and scientific plans implemented to improve water quality in the Klamath. (p. 59) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
The text says that the presence of reservoirs in series likely *limits* deep burial rates. It does not say that deep burial does not occur. Because the reservoirs are in series the sedimentation rates in the lower reservoirs are lower than would occur if there were not upstream reservoirs because the sediment supply is reduced. We agree that Copco produces algae, some of which will settle in Iron Gate. However, the reduced sediment supply due to the presence of Copco means that the probability of the nutrients contained in these algae being permanently sequestered by burial is reduced.

A106. Comment(s):
Page 23, Paragraph 5, Line 2-4. What is the basis for Asarian and Kann's contention that "there is significant retention of TN between Iron Gate and Seiad"? (p. 59) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
This estimate is based on Asarian and Kann's analysis of flow and concentration data below Iron Gate and at Seiad.

A107. Comment(s):
Page 23, Paragraph 6. The weight of evidence presented in this appendix suggests no reason to doubt model results. (p. 59) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
The comment is in agreement with the text in Appendix 3, which states: "In sum, the linked CE-QUAL-W2 and RMA-11 models of the Klamath appear to provide reasonable estimates of nutrient dynamics in the impoundments, while it is inconclusive whether or not nutrient retention and loss rates in the free-flowing reaches of the Klamath are significantly underestimated. "

A108. Comment(s):
Page 7, Section 2.2.2. Given the data provided, the value of this "two-state algae transformation" modification is questionable. A very limited number of data (3) seem to be the basis for this modification (please see discussion of Figure 2-1, below), and the data do not really support the scheme. The calibration plots for Miller Island and Hwy 66 in 2000, Figures E6 and E-16, respectively, suggest that just about any function that reduces algae concentrations from Miller Island to Hwy 66 would work just as well. Furthermore, it doesn't look as if this "phenomenon" exists in the 2002 "validation" data.

In 2002, there is no large drop in chlorophyll *a* concentrations and the healthy-unhealthy hypothesis does not seem to fit. At the very least, the Regional Board staff should bring the 2002 data that they used in "validation" into this discussion. (p. 59) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
The concept of anoxia-related algae mortality was initially communicated to the TMDL development team by PacifiCorp's consultant Watercourse Engineering. Previously, Dr. Michael Deas had extensive communications with algae experts across the world about possible impacts of low DO on algae mortality. Dr. Deas indicated that although there was no direct evidence from laboratory research, it is likely that low DO can have a negative impact on algae physiology. Dr. Deas mentioned that his group tried to modify the algae mortality and growth rate in association with DO concentration, however, the effort was not successful because the simple DO-algae parameter relationship they implemented could not address the exposure time of algae to low DO (which is essentially a Langrangian process).

To overcome this technical limitation, the TMDL development team formulated a two-state algae transformation algorithm to approximate the Langrangian process within the Eulerian CE-QUAL-W2 system. With this new algorithm, the model was able to significantly improve the spatial representation of chlorophyll-a concentrations from upstream to downstream stations in Lake Ewauna over the previous model. The model was tested for both 2000 and 2002 against extensive data, and it was able to successfully reproduce the observed patterns for both years (without parameter adjustment). This suggested that the algorithm reasonably represents the observed phenomenon. Should a more detailed, local scientific investigation be conducted and yield different conclusions, the model could be updated.

The comment suggesting that no large drop in chlorophyll a concentrations occurred in 2002 is incorrect. The Klamath River Model for TMDL Development Report Appendix E presents model calibration results (and monitoring data) for 2002 and clearly demonstrates a reduction in chlorophyll a concentrations between Lake Ewauna – South Side Bypass Bridge and Miller Island. Indeed the highest measured concentrations are reduced approximately 50% over this short distance. These data further bolster the approach implemented by the TMDL development team.

A109. Comment(s):
Page 8, Paragraph 3, last line. So many things can effect algal growth that it is hard to accept the statement that "available data show no other explanation for the observed phenomenon." What phenomenon is being referred to? (p. 59) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
The observed phenomenon refers to the sudden decrease in algae over a short distance and within a short period of time (i.e., what is described two paragraphs prior to the statement referred to by the commenter). Also refer to response A108.

A110. Comment(s):
Page 8, Figure 2-1. There are three chlorophyll *a* concentrations above 50 µg/L at Miller Island, as shown in this figure. Is this the phenomenon referred to? Are these three data points real (were they duplicated?) and are they representative of chlorophyll *a* at that time and in that location? These three data points appear to be the basis of the entire healthy-unhealthy algae hypothesis and implementation. The eleven other concentrations reported at Miller Island are all below 50 µg/L – similar in magnitude to chlorophyll *a* concentrations at Highway 66.

How does this low DO argument explain these data? Chlorophyll *a* at Highway 66 is uniformly lower than at Miller Island. (Actually only one data point at Miller Island creates a huge disparity and only three total at Miller Island are significantly higher). May to June is a period of high DO throughout the reservoir (both upstream at Miller Island and at Highway 66) but chlorophyll *a* is low at Highway 66. (p. 60) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
Refer to responses A108 and A109. Also, the high chlorophyll-a concentrations called into question by the commenter (observed at Miller Island) coincide with high concentrations in Upper Klamath Lake near Link Dam. Thus, they are assumed to be real. No other information is available to indicate otherwise. As the response to A108 notes, the observed phenomenon also occurs in 2002.

Also, on the contrary, chlorophyll a concentrations are not uniformly lower at Hwy 66 than at Miller Island. This is clear from the plots in Appendix E (E-6 and E-16). There are multiple occasions where concentrations are nearly the same or higher at Hwy 66 than at Miller Island. The commenter also noted that chlorophyll a was low at Hwy 66 during May while DO was high but failed to mention that chlorophyll a was also low at Miller Island during the same period (due mainly to the upstream boundary condition). Thus, the implication that the data contradict the phenomenon or approach is unjustified.

The TMDL development team calibrated and corroborated the model for separate years and reasonably reproduced observed concentrations with the model. A sensitivity analysis was also conducted during the calibration process that compared results of the two-algae state transformation algorithm to the existing model algorithm. The results indicated that the existing algorithm is incapable of reproducing the observed spatial variability.

A111. Comment(s):
Page 10, Equation 3. This equation is not a "Monod-type function."(p. 60) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
The terminology in the report has been corrected.

A112. Comment(s):
Page 10, Last paragraph. Is "smoother" more accurate and more representative of natural processes? Does this modification improve the model? (p. 60) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
The modification implemented is a more reasonable approximation of natural processes and thus improves the model. With the current model (prior to the modification), unrealistic results are produced where the "cut-off" is set for SOD. For example, the model may simulate that SOD is present when DO is 0.1 mg/L, however SOD is absent when DO is 0.099 mg/L. This is an oversimplification of reality and not substantiated by data. As such, the TMDL development team chose to improve representation in the model.

A113. Comment(s):
Page 11, Section 2.2.4. Watercourse ran into some problems using the pH modifications. The numerical technique is not robust and can lead to errors. (p. 60) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
The pH modifications never caused a problem in the numerous scenario analyses conducted during TMDL development.

A114. Comment(s):
Page 11, Paragraph 3, Equation (Ke). In this formula, is OM particulate or refractory or both (i.e., total)? (p. 60) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
The RMA-11 model represents only one lumped OM constituent (in the code modified by Watercourse Engineering). Therefore it represents both particulate and dissolved, and labile as well as refractory.

A115. Comment(s):
Page 12, Paragraph 2, Lines 13-19. Please clarify that the numbers given here are just an example and not values fixed for all simulations. (p. 60) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
The numbers provided were those used in the original PacifiCorp model. For the TMDL model, dynamic partitioning was used to refine the representation. Therefore the numbers were not fixed for all simulations.

A116. Comment(s):
Page 12, Paragraph 2, Line 19. Both setting and decomposition affect the OM fractions. (p. 60) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
Correct. This is why dynamic partitioning was used instead of static partitioning.

A117. Comment(s):
Page 19, Paragraph 1, Lines 2-3. Sometimes, “it is preferable to use data collected during the modeling year” but only if the site is representative of boundary conditions. (p. 60) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
The TMDL development team agrees and also believes that the data used are representative.

A118. Comment(s):
Page 19, Paragraphs 1-3. Phosphorus data seem to come from Pelican Island, Fremont Bridge, and Miller Island, inconsistently. (p. 60) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
Application of data from multiple locations was deemed the most appropriate way to construct a reasonable boundary condition for Upper Klamath Lake. Conditions at Upper Klamath Lake are highly dynamic and are very important to accurately simulate conditions downstream. Therefore, a lot of attention was given to developing the most accurate and representative dataset for the calibration period. Data were insufficient at any one location to characterize conditions.

A119. Comment(s):
Page 19, Paragraph 3. Boundary condition (BC) PO4 concentration is used as a calibration tool. This is not standard practice. (p. 60) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
On the contrary, it is not rare to indirectly derive boundary condition data from observed data (when there is a strong relationship between the data). This has been documented in peer-reviewed literature (e.g., Zou et al, 2007. An adaptive neural network embedded genetic algorithm approach for inverse water quality modeling, Water Resources Research, Vol. 43, W08427, doi: 10.1029/2006WR005158).

A120. Comment(s):
Page 19, Paragraph 4. The PO4 boundary condition is from Miller Island. But PO4 and TP used in OM boundary condition are from Pelican Marina. This is inconsistent. Please clarify whether PO4 concentrations from Pelican Island are good or not. (p. 60) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
Refer to response A118. Additionally, through model sensitivity analysis conducted during model calibration, it was found that the Miller Island PO4 data were a better approximation of the upstream boundary condition than the data at Pelican Marina. OM data from Pelican Marina, however, were deemed sufficient and appropriate. This combination of data sources may seem unconventional, however, since data were not available at the actual boundary condition location, all potential data were considered and evaluated to create the most appropriate dataset.

A121. Comment(s):
Page 20, Paragraph 1. Boundary condition TIC and alkalinity concentrations are used as a calibration tool to get pH in Lake Ewauna. This is not standard practice. (p. 60) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
The alkalinity boundary condition was configured based on a composite dataset. Only TIC was derived through the calibration process. Refer to response A119.

A122. Comment(s):
Page 20, Paragraph 1. In 2002, Miller Island data were not used to estimate PO4. Again, we question this method. Why are PO4 concentrations from UKL good to use in 2002, but not in 2000? (p. 60) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
The boundary conditions were developed on a case by case basis (i.e., separately for 2000 and 2002) and were subject to data availability for each year. All potential data were considered and evaluated to create the most appropriate dataset. Refer to response A120.

A123. Comment(s):
Page 33, Bullet Point 8, Line 1. Regional Board staff uses the assumption that "the majority of OM in the boundary condition is … labile." In fact, their assumption is that all OM in the boundary condition is labile. Available data suggest that the majority of OM in the boundary condition is not labile, but refractory. This incorrect assumption will have large consequences for water quality downstream and into the estuary. (p. 61) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
The report has been updated to clarify the characteristics of OM in the boundary condition.

It is important to first clarify that allocating OM to labile and refractory portions in a model is a simplified representation of reality. In the Klamath model, OM for the boundary was only assigned to the labile portion, meaning that all OM was represented using labile parameterization. This was done because unless the majority of OM decay relatively quickly (resulting in significant deoxygenation), the DO in Lake Ewauna would never be as low as it has been observed in the historical record (particularly near the water/air interface). Therefore, using best professional judgment, the labile parameterization was used in W2 to represent the total OM from the boundary condition. In the model, an average decay rate was used to reflect the characteristics of the OM. Because an average value was used, it can be taken to mean that a combination of both extremely labile OM and refractory OM are considered. The decay rate of the OM decreases in a downstream manner since the more labile OM fraction is lost faster than the less labile fraction.

At the time the model was developed, detailed organic matter data were not available. However, although the 2007 and 2008 data provide insight into recent organic matter characteristics, they cannot be directly applied to models for 2000 and 2002. First, the data are 5 to 8 years more recent than the modeled period. Conditions in Lake Ewauna change significantly from one year to the next. Even the 2007 and 2008 data demonstrate significant variability over only a one year period.

The review shows that the model-predicted DOC is much lower than the observed. For the 2000 calibration, however, the model reproduced the observed data for both NH4 and TKN in Lake Ewauna. This suggests a reasonable representation of organic matter since TKN=Organic N+NH4. If TKN and NH4 are reasonably predicted, organic N should also be reasonably predicted. This was the approach taken during calibration in the absence of available organic matter.

A124. Comment(s):
Page 33, Bullet Point 9, Line 1. Denitrification in rivers is not significant, and thus should not be a concern in Appendix 3. (p. 61) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
See response to Comment A74. We do not expect significant denitrification to occur within the flowing river. Page 9 of Appendix 3 explicitly states that denitrification is not

likely to be of major significance in the river reaches, but may occur on a limited basis under mats of decaying periphyton.

A125. <u>Comment(s):</u>
Page 34, Bullet Point 1, Line 3-6. We agree that the model is not good at predicting actual water quality concentration but that it "can be used to represent the overall water quality trends in response to external loading and internal stream dynamics." This being agreed upon, how good is the model for setting target concentrations and load allocations? This inability to predict values is not well incorporated in the discussion. (p. 61) (PacifiCorp – Appendix A and B.doc)

<u>Comment(s) Made By:</u>
Hemstreet - PacifiCorp

<u>Response:</u>
We believe this comment misinterprets the statements in this Appendix. The Appendix is a technical report by the model development consultant, and it does not state that "the model is not good at predicting actual water quality concentration" or that there is an "inability to predict values". The language of the bullet identified in the comment is as follows:

The model's capabilities are constrained by the limited availability and quality of monitoring data. This is particularly the case for boundary conditions to the model, but it is also the case for in-stream model calibration data. The Klamath River model is not expected to be able to mimic the exact timing and location of all water quality conditions. The model can be used to represent the overall water quality trends in response to external loading and internal system dynamics.

This language makes the basic point that models are inherently uncertain and cannot be expected to provide exact predictions. The statement in a model development report by the agencies' technical consultant that the model can be used to represent trends is a generic comment on the model performance. The decision about adequacy of the model for TMDL development lies with the agencies, not the modeling consultant.

The TMDL project team has determined that the model provides reasonable predictions and is suitable for TMDL development.

A126. <u>Comment(s):</u>
Page 34, Bullet Point 7, Line 2-3. Since the sediment diagenesis model is not activated, is there no SOD or benthic loads in the estuary model? Please clarify. (p. 61) (PacifiCorp – Appendix A and B.doc)

<u>Comment(s) Made By:</u>
Hemstreet - PacifiCorp

Response:
Yes, there is a zero-order SOD and benthic loads in the estuary model, as in all upstream models. However, due to the fast exchange between tidal water and upstream freshwater, the retention time in the estuary is extremely short. Therefore, the SOD and benthic flux are not significant nutrient contributors.

A127. Comment(s):
Paragraph 1, Lines 3-4. We agree that uncertainty is inherent in the model (especially with a limited observed data set) and that the model should only be relied upon to reproduce "general trends." (p. 61) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
Uncertainty is inherent in all water quality models. Refer to response A2. Also, refer to response A125 regarding the quoted language about "general trends".

A128. Comment(s):
Page 40, Section 3.3. Some calibrated parameters were changed during "validation." Please confirm that calibrated values were unchanged for all TMDL scenarios. (p. 61) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
The few parameters which had different values have been corrected. The 2000 and 2002 model parameters are all the same except that in the 2002 model the SOD in Lake Ewauna is changed from 3.0 gO2/m2/day to 2.0 gO2/m2/day to reflect potential inter-year variability as suggested by the data in Lake Ewauna.

A129. Comment(s):
Page 40, Last paragraph, Line 1-2. In calibration, algae and OM parameters changed from reservoir to reservoir. We question the validity of changing these values in light of the lack of data to support the changes. Please provide more justification for the actual changes made (e.g., "algae growth rates were reduced in Copco because…"). This is especially important because only one year of data were used in calibration and validation. (p. 61) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
Many characteristics, such as algal composition, can change significantly from one reservoir to the next, particularly in a complex system like the Klamath. As such, it is appropriate and defensible to change corresponding model parameters by waterbody during calibration.

A130. Comment(s):
Page 41, Paragraph 2, Line 2-5. Regional Board staff justify changing OM decay rates by stating that "as a significant portion of the more labile OM upstream in the system is lost through degradation, the remaining OM downstream becomes less labile." This is poor justification because the model already accounts for changing decay rates in partitioning between refractory and labile OM. As more labile OM is degraded upstream, the refractory fraction increases. In the model, refractory OM has a much slower decay rate. We see no reason to change OM decay rates. (p. 61) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
Refer to response A123.

The following example provides further demonstration of the concept. Labile OM in Lake Ewauna has a decay rate of 0.2/day. This doesn't mean that all the OM particles are decayed at the same rate. Rather, some of them may decay at 0.5/day while others decay at 0.08/day. It is reasonable to assume that those with a high a decay rate (e.g., 0.5/day) would be lost much faster than those with the lower rate (e.g., 0.08/day). This results in a mix of OM that has a lower average decay rate at the end of the water body. Therefore, when the OM enters J.C. Boyle, even though the OM is still referred to as "labile," the actual composition has already changed. It inherently contains fewer fast-decaying particles. This is why the average decay rate should be reduced.

A131. Comment(s):
Page 41, Table 3-3. Not mentioned in the discussion is the fact that NH4 decay and SOD parameters also change from reach-to-reach. Please explain rationale for changing these parameters reach-to-reach. (p. 61) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
It is a well-known fact that SOD frequently varies from one location to another, even over short distances. Thus, it is normal to set different values for different reaches. The NH4 decay rate is consistent between reservoir and riverine reaches in the modeling framework. That is, all reservoirs have the same value, and all riverine reaches have the same value. This approach is also typical since the physical and chemical properties of reservoir and riverine reaches are commonly quite different.

A132. Comment(s):
Page 43, Table 3-5. The table implies that parameter values remain constant reach-to-reach and for each scenario. Please confirm that this is true. Also, some parameters are not listed in this table. For example, "bed algae carrying capacity," a term added by the Regional Board to the RMA-11 model. In earlier versions of the TMDL model, this important parameter was not kept constant. Please include all important parameters and confirm that they remain constant reach-to-reach and for each scenario. (p. 61) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
Parameter value information is available in Appendix 6.

A133. Comment(s):
Page 44, last paragraph, Line 1. The model does not appear to "reproduce the supersaturation of DO during early summer well." Simulated DO is always 4-6 mg/L low in comparison to observed values in May. (p. 62) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
"Early summer" in the text refers to June. The commenter highlights the importance of judging model performance based on simulated trends and magnitudes as opposed to matching specific points in time. The model results actually show a temporal shift in the predicted peak chlorophyll a concentration due to timing of contributions from the UKL boundary condition. Although there is a shift in timing, the model predicts the trends and magnitudes well.

A134. Comment(s):
Page 44, last paragraph, Line 3. Please clarify for the reader that the statement made here is not fact, but simply a supposition. (p. 62) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
The statement noted is a fact: "…the current CE-QUAL-W2 model does not simulate sediment diagenesis…". However, the report will be updated for clarification.

A135. Comment(s):
Page 45, Paragraph 2, Lines 6-10. There is SOD in W2. It is not clear that a fully dynamic interaction between bed and water column is necessary. Similar results might be obtainable by specifying seasonal SOD. (p. 62) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
Specifying seasonal SOD is not equivalent to fully dynamic interaction between the bed and water column. Seasonal SOD designation can only be used to represent the phenomenon in a static sense (albeit for multiple time periods). Fully dynamic interaction can predict the SOD response to changes in loading conditions.

A136. Comment(s):
Page 47, Paragraph 6, Line 13-15. What is the rationale for explaining the over- and underprediction of water temperature in this reach as "likely due to differences between modeled and actual bathymetry…"? (p. 62) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
The report will be updated to address this comment.

A137. Comment(s):
Page 48, First sentence. If "the model's overprediction of chlorophyll *a* …is likely caused by inaccurate boundary conditions from UKL", then why would this overprediction of chlorophyll *a* not show up in all upstream reaches? As noted by RWB, the model simulates chlorophyll *a* "very well' in Lake Ewauna to Keno Reach (page 45, paragraph 3, line 1). Or, is the Regional Board staff saying inaccuracies in boundary nutrients led to poor chlorophyll *a* simulation downstream? Please clarify. (p. 62) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
The report will be updated to address this comment.

A138. Comment(s):
Page 48, Paragraph 4, Line 5. To say that the model "predicts concentrations within the range of observed data" is misleading and used in several places. Model results for NH4 and NO3 are not within any meaningful observed range. (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
The TMDL development team does not agree with the commenter's statement regarding NH4 and NO3 not being within any meaningful observed range. Not only are the magnitudes of the model's predictions similar to the observations, but with a few exceptions for NO3, the temporal and vertical trends are similar as well.

A139. Comment(s):
Page 48, Paragraph 5. As in other places in this TMDL, the Regional Board states that calibrating a model to observed data "indicates that water quality dynamics …are reasonably represented." Calibrating at this level (one year of data) is simply a curve fitting exercise and doesn't indicate anything about the models ability to represent the dynamic nature of surface water quality. (p. 62) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
Refer to response A3 regarding the use of one year for calibration.

It is not entirely clear what is meant by the comment that the calibration is "simply a curve fitting exercise". The calibration process does include, and must include, attempts to "fit" the model prediction "curves" (x-y plots) to measurement "curves" (x-y plots). This is why the term "calibration" is used – the model parameters are "calibrated" to produce the best fit of model predictions to measurements. This is standard practice in model development.

A140. <u>Comment(s):</u>
Page 50, Paragraph 3, Line 1-2. Apparently, 2004 data were used to calibrate the estuary model. Why weren't data through 2004 used for the rest of the river? Why weren't data gaps identified and filled for the rest of the river through at least 2004? (p. 62) (PacifiCorp – Appendix A and B.doc)

<u>Comment(s) Made By:</u>
Hemstreet - PacifiCorp

<u>Response:</u>
Refer to response A3.

A141. <u>Comment(s):</u>
Page 50, Paragraph 4, Line 7-8. Uncertainty in lab data is shown in estuary calibration figures. Why should this be done only for the estuary? It would be very useful to see error bars in the presentation of lab uncertainty throughout this TMDL. (p. 62) (PacifiCorp – Appendix A and B.doc)

<u>Comment(s) Made By:</u>
Hemstreet - PacifiCorp

<u>Response:</u>
The reason for including the error bars was explained on Page 50, as noted by the commenter. This information was readily available for the estuary monitoring data but not for all other datasets. As such, it was only included for the estuary data.

A142. <u>Comment(s):</u>
Page 6, Comment C1, Paragraph 1. Characklis expresses concerns over the model's ability to predict values well. He recommends explicit treatment and discussion of uncertainty as part of the TMDL process. The comment response states that uncertainty was minimized in other ways, but there is no real presentation of information that provides confidence to the reader that uncertainty was effectively incorporated into the modeling and load allocations.

<u>Comment(s) Made By:</u>
Hemstreet – PacifiCorp (p. 63) (PacifiCorp – Appendix A and B.doc)

<u>Response:</u>
This comment implies that the Board has not taken appropriate steps to consider uncertainty in the modeling and TMDL analysis, without describing what specifically is missing from the Board's information base and analysis. This lack of detail makes it difficult to respond to this comment. At the general level of the comment, the record is quite clear that the Board is keenly aware of model uncertainty, and uncertainty is discussed in several documents in the record. The Regional Water Board also undertook

additional model evaluation measures in response to comments received from USGS. Both qualitative and quantitative measures of uncertainty were included in this reassessment. The results of the USGS model review are included in Attachment 1 to this document (Response to USGS Comments). The commenter does not offer specific recommendations on how uncertainty might be "incorporated" into the modeling and TMDL in a manner different than the proposed TMDL. The Board does not believe the uncertainty can be captured in simple quantitative measures due to the complexity of the model.

Also see comment A2.

A143. Comment(s)
Page 6, Comment C1, Paragraph 1, Lines 12-15. "…reliance on deterministic modeling results without giving due attention to the levels of uncertainty attendant with these estimates can provide an incomplete picture to those seeking to interpret these analyses for decision making purposes." This seems to be what is happening with the natural conditions model. The model was set up with boundary conditions that are highly improbable, and this was confidently assumed without appropriate consideration.

Comment(s) Made By:
Hemstreet – PacifiCorp (p. 63)) (PacifiCorp – Appendix A and B.doc)

Response:
The Board disagrees that the assumptions for the natural conditions estimations are highly improbable. The Board understands the inherent uncertainty in the estimation of natural conditions, and decisions were made with that understanding.

A144. Comment(s):
Page 7, Comment C1, Paragraph 4. Dr. Characklis expresses concern about the limited data set used in these important simulations. His statement that "predictions based on water quality models, even the most advanced models parameterized with extensive data sets, are often highly divergent from observations…" is true and his concern about basing decisions on this model, calibrated with a limited data set and hardly validated at all, is valid. His other point is that relatively small deviations between current and natural scenario results are an inappropriate basis for load allocation and regulation. These small deviations, as noted elsewhere in our comments, are well within any inherent uncertainty and error in this model. We add our concern that, for this TMDL, the full model has only been applied to one year of observed conditions and the model has basically been customized to fit that one year of data. Four years of model data were available (2001-2004) to test this model over a considerably wider range of conditions.

Comment(s) Made By:
Hemstreet – PacifiCorp (p. 63)) (PacifiCorp – Appendix A and B.doc)

Response:
Regional Water Board staff believes the model provides reasonable predictions for this system. Contrary to the comment, the model has been tested for two years, not one. The decision to use the calibrated model to develop the TMDL is not a strictly scientific matter; rather, the full project team is part of that decision (modelers, TMDL staff, and agency management). In addition to technical concerns, policy and resource issues factor into that decision. In this case, the agencies have decided that further work on model development would have diminishing returns in terms of reduced uncertainty, in part because of the extensive peer review and model adjustments to date.

A145. Comment(s):
Page 7, Comment C1, Paragraph 5. We agree that confidence intervals could have, and should have, been evaluated for this TMDL model. For instance, many years of climate data exist for the Klamath basin. Using a variety of existing historical climate conditions would yield a range of temperature responses for the river and provide a much better basis for decision making. (p. 63)) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
The model and TMDL are based on the model estimates of actual conditions in a particular year. It is unclear how the commenters would incorporate non-model year weather conditions into the model of a specific year for the TMDL. For example, simply applying non-model year weather to the year 2000 would raise questions about how to set appropriate boundary conditions for river temperature.

A146. Comment(s):
Page 7, Comment C1, Paragraph 6. We agree with Characklis' suggestion of considering a joint modeling and monitoring approach. This implies working together with all entities in the basin, and their contractors, sharing data/files, models, and approaches and being transparent. The monitoring work being conducted under the AIP Interim Measure No. 12 should further this effort.

Comment(s) Made By:
Hemstreet – PacifiCorp (p. 63)) (PacifiCorp – Appendix A and B.doc)

Response:
Please see response to Comment A169. As stated in the response to Comment A169, EPA and the states have worked closely with PacifiCorp and Watercourse Engineering in adapting and calibrating the water quality models for TMDL development. We agree strongly that the coordinated monitoring efforts being implemented as part of the AIP Interim Measure No. 12 and the Klamath Basin Water Quality Monitoring Coordination

Group are excellent examples of cooperation among all entities in the basin, and we applaud PacifiCorp for its efforts in this regard.

A147. Comment(s):
Page 8, Response C1, Paragraph 2-3. The Regional Board staff response here seems to dismiss the Dr. Characklis' concerns about uncertainty and responds that uncertainty, even a good description of uncertainty, would take too much time and cost too much. We disagree with the Regional Board's response. Evaluation of uncertainty is necessary for a model to be useful, especially a complex model such as this one. In view of the time spent on "key best practices," and the importance of this TMDL, a description and good analysis of uncertainty should not be too much to expect and should not be significantly greater effort.

Comment(s) Made By:
Hemstreet – PacifiCorp (p. 64)) (PacifiCorp – Appendix A and B.doc)

Response:
As noted, the Board is fully aware of model uncertainty issues and has spent considerable resources to both reduce uncertainty where feasible and also provide all relevant information in the documentation of the model. Note that additional information has been included in the documentation since the time of Dr. Characklis' review. See also response to comment A2.

A148. Comment(s):
Page 8, Response C1, Paragraph 3, Line 6. Adjusting boundary conditions is not typically a part of normal calibration and doing so (i.e. calibrating by changing boundary conditions that are based on field observation) is questionable practice.

Comment(s) Made By:
Hemstreet – PacifiCorp (p. 64) (PacifiCorp – Appendix A and B.doc)

Response:
The model requires the definition of boundary conditions for a significant number of water quality parameters. The Board believes that, in an ideal world, boundary conditions should be set at the measured conditions at the boundary. When data is available, the Board has fixed the boundary conditions at the measured condition. However, when measurement data is absent or limited for a particular parameter, as in the case of the Klamath River model for some parameters, it is necessary to estimate the boundary conditions. This is a necessary practice, not a "questionable" practice. An estimated boundary condition is similar to an unknown calibration parameter (such as an algae growth rate) in that the true value is unknown, but it can be estimated by evaluating the system-wide model predictions. Like other calibration parameters, we gain confidence in the estimated boundary condition and overall model when the model predictions reasonably match the measured conditions downstream of the boundary.

A149. <u>Comment(s):</u>
Page 9, Response C1, End of Paragraph 3. If the focus was on "acquiring and incorporating the most accurate and comprehensive data," then why was only one year (2000) incorporated in this model? More years of data should have been incorporated into the model to reduce uncertainty and improve confidence about the model's ability to make predictions.

<u>Comment(s) Made By:</u>
Hemstreet – PacifiCorp (p. 64)) (PacifiCorp – Appendix A and B.doc)

<u>Response:</u>
Contrary to the assertion in the comment, two years (2000, 2002) were evaluated and calibrated as part of model development. The Board believes that the body of information considered in model development covers a range of river conditions that is sufficient to calibrate the model parameters and evaluate model performance. There is no end to the number of years that can be evaluated in model development. The Board must balance the need for thorough model evaluation with project schedules and resources, as well as the likelihood that additional model development analysis will change the course of the TMDL. In this case, the Board does not believe adding additional model years would significantly alter the TMDL outcome.

A150. <u>Comment(s):</u>
Page 9, Response C1, Paragraph 5. In making its case for not incorporating uncertainty analyses, the Regional Board staff exaggerates the difficulty of uncertainty analysis. "Interval number, fuzzy parameter, Monte Carlo, and Bayesian analyses" are not required. Further, "4 days of continuous simulation" are not required to run the Klamath models, at least not in an efficient manner. Sensitivity can be performed in a systematic and limited manner, particularly with guidance from an experienced modeler who has performed calibration on the system. A straightforward and functional sensitivity analysis could be completed in a variety of ways, including:

- Identifying a subset of modeling parameters and boundary conditions to be tested (i.e., do not perform sensitivity on every single parameter),
- dividing the domain into sub-reaches for certain tests,
- running the model for shorter periods of time during critical periods of the year

Hundreds of scenarios are not required. At the very least a modest set of runs quantifying and bounding the uncertainty should have been performed. (p. 64)) (PacifiCorp – Appendix A and B.doc)

<u>Comment(s) Made By:</u>
Hemstreet - PacifiCorp

<u>Response:</u>

We reiterate our response to the peer review comment. With regard to these additional comments, we agree that "sensitivity can be performed in a systematic and limited manner" – and this is what has been done for the Klamath River model. For a complex model that applies dozens of model variables in a dynamic solution over a large scale system, we disagree that there are readily apparent ("straightforward and functional") sensitivity analyses. On the contrary, we believe there are endless options for sensitivity analysis that carry the risk of information overload and "analysis paralysis".

The commenter believes our method was too limited and offers ideas for additional analysis. We agree that additional analysis could be done. However, we do not believe additional model sensitivity tests would lead to substantive changes to the model or our understanding of the model sensitivity and prediction uncertainty.

In addition, please refer to response A2.

A151. Comment(s):
Page 10, Response C1, Paragraph 7. The Regional Water Board staff state their belief that "the TMDL models are performing well and are suitable tools for establishing Klamath River TMDL allocations and targets." In agreement with Dr. Characklis' comments, we do not see the basis for this belief. These models have not been completely documented. Nor has uncertainty been quantified in any significant way. At present, these models are inadequate to describe the Klamath River system in the detail required for this TMDL.

Comment(s) Made By:
Hemstreet – PacifiCorp (p. 64)) (PacifiCorp – Appendix A and B.doc)

Response:
The Board continues to believe the Klamath model is suitable for TMDL development. Our basis for this belief is the project team understanding of the model capabilities and limitations after a rigorous model calibration and application process. Further, the model has been peer-reviewed by several experts in water quality modeling, including stakeholder consultants, and these reviews have helped the Board identify weaknesses and alternatives in the model development, and to improve the model and its representation of water quality conditions. As noted earlier, the issue of uncertainty has been a central issue throughout the model development process, and it has been fully considered in developing the TMDL.
Also, the model documentation has been revised and improved in response to comments, including those provided by USGS, as documented in Attachment 1.

A152. Comment(s):
Page 10, Comment C2, Paragraph 1. We agree that the algae models, as applied in this TMDL, do not represent algal (chlorophyll *a*) response to nutrients well enough to form the basis for specific nutrient targets.

Comment(s) Made By:
Hemstreet – PacifiCorp (p. 64)) (PacifiCorp – Appendix A and B.doc)

Response:
This comment misrepresents the comment made by the peer reviewer, Dr. Characklis. Dr. Characklis' comment does not say that the models applied for the TMDL do not perform well enough to form the basis for setting nutrient targets. Dr. Characklis' does comment that the choice of chlorophyll-a, *Microsystis aeruginosa*, and microcystin targets are reasonable. Regional Water Board staff believe that the TMDL models are the best available tools for setting nutrient targets associated with meeting the chlorophyll-a, *Microsystis aeruginosa*, and microcystin targets.

A153. Comment(s):
Page 11, Response C2, Paragraph 1. What is "modern" water quality modeling technology as opposed to "dated" water quality modeling technology? More importantly, the statement that "algal biomass in riverine reaches is not related to nutrient concentrations" is misleading. For benthic algal growth this is very important. Further, the implications for the lower river and, in particular, the estuary, of these nutrients are paramount.

Comment(s) Made By:
Hemstreet – PacifiCorp (p. 65)) (PacifiCorp – Appendix A and B.doc)

Response:
"Modern" water quality modeling technology is simply a reference to the fact that the TMDL models are based on the most current available water quality modeling tools, particularly with respect to prediction of nutrient and algal biomass response. In the context of the entire response provided, the statement "algal biomass in riverine reaches is not related to nutrient concentrations" is clearly in reference to phytoplankton biomass within the riverine reaches, which generally is not related to nutrient concentrations, but is related to export of phytoplankton from reservoir reaches. Regional Water Board staff certainly agree that nutrient concentrations are very important with respect to benthic algal growth.

A154. Comment(s):
Page 11, Response C2, Paragraph 3. Calibration results are not predictions. Further, the response clearly states that Copco and Iron Gate reservoirs were not validated (or "corroborated" in the language used here). Further, a simple graphic showing unquantified "increases" during summer and fall provide no quantitative, or technical basis for load allocations, i.e., having "more" at one period than another hardly makes the model a useful tool for load allocations. A quantitative sensitivity and uncertainty analysis is required, with corresponding model performance metrics so decision makers have a clear grasp of the model and data capabilities. From the perspective of

conservative assumptions for the margin of safety, this information provides little useful data. (p. 65)) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
Refer to response A2.

A155. Comment(s):
Page 22, Response T6, Paragraph 1. The statements is made that the "temperature calibration…demonstrates the model's ability to represent both observed magnitude and trend." However, due to the undocumented 20 percent reduction in solar radiation to all reaches except the Project reservoirs, the calibration and subsequent application of the models to natural conditions is invalid. (p. 66) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
Refer to response A10.

A156. Comment(s):
Page 23, Response T12, Paragraph 1, Line 6-7. The model was not calibrated for multiple years for the California portions, and because parameters were changed between the calibration and validation years, the outcome is suspect. Again, the model has simply demonstrated an ability to be somewhat calibrated to one year of observed data. It has not been fully or adequately calibrated for multiple years. We question the statement that "the year 2000 exhibited poor water quality, and thus was deemed a key consideration for TMDL development." Elsewhere, the document states that the year 2000 was chosen because it contained the only available data. How would one know that 2000 was a year of poor water quality without other years of data and where is that analysis? Would a range of conditions provide a better test for the model than a single year? (As a matter of note, the estuary model was not reviewed due to the limited public comment period.) (p. 66) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
Refer to responses A3 and A9.

A157. Comment(s):
Page 35, Comment K18, Paragraph 1. Again, uncertainty should be included when presenting model results and the model was not validated in California reaches. (p. 67) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
Refer to response A2.

A158. Comment(s):
Page 5-9, Paragraph 2, Line 5. It is claimed that the model takes advantage of "data collected over multiple years," but the model was only calibrated based on 2000 data. It is true that data from multiple years was used to form certain boundary conditions where limited data were available, but the hydrology and meteorology – two principal drivers – were from 2000. Using multiple years of data may improve certain elements of model inputs, but may also lead to increased uncertainty by mis-matching in time hydrology and meteorological conditions with actual water quality responses. This is not discussed in the draft TMDL. (p. 44) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
The commenter first notes that the model was only calibrated based on 2000 data and implies that data for multiple years would be more useful. The commenter then contradicts the first comment and states that using multiple years of data may improve certain elements of the model inputs, but may also lead to increased uncertainty.

The model was calibrated for 2000 and for 2004 in the estuary. It was corroborated for 2002. And, data from multiple years were used to support designation of boundary conditions. So, data for multiple years were most definitely used in the analysis.

Refer to response A120 regarding using multiple years to derive the boundary conditions.

A159. Comment(s):
Page 5-9, Paragraph 2, Line 9-11. What is the basis for the statement that "the largest source of uncertainty in this system is the highly variable and dominant loading from UKL?" There is no analysis, no documentation, no citation, no quantification, or other description of this issue. Further, how does this relate to downstream reaches all the way to the estuary? This statement would mean that UKL boundary conditions have a larger impact on the estuary, than say Trinity River flows, lack of detailed estuary geometry, lack of detailed estuary data, etc. This line of questioning can be

applied to all river reaches downstream. (p. 45) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
This will be updated in the report.

A160. Comment(s):
Page 5-17, Paragraph 2 (and Figure 5.8). Presuming that the models can effectively represent increase of 0.1°C, i.e., that the accuracy of these models is 0.1°C, is erroneous. PacifiCorp (2004) provides extensive calibration statistics that indicate the models are probably accurate to 1.0°C. Misapplication of the model in this manner not only points to a clear need for uncertainty quantification, but also suggests that Regional Board staff do not fully appreciate the realistic application of numerical models.

Page 5-18, Table 5.7. The load allocations for reservoir tailrace waters are less than the model accuracy. Further, what is the proposed method used to measure the 0.1°C increases in Iron Gate daily average and maximum temperature? Standard temperature measuring devices (and the same ones used to collect calibrate data for the model) are on the order of 0.2°C. Given model accuracy and the accuracy of the data collected for model calibration, load allocations of 0.1°C are not supportable. (p. 50) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
In regards to uncertainty, please see response to comment A2. The 0.1 °C estimated temperature increase attributed to Iron Gate reservoir is a calculated value based on the best available information. As a practical matter, temperature limits will be addressed in any regulatory action that implements the TMDL, based on the technological capabilities that exist at that time.

A161. Comment(s):
Page 5-19, Paragraph 4, Line 4. The 85% saturation value referred to is calculated at what pressure and air temperature? (p. 50) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
The 85% saturation values would be calculated at local pressure and water temperature.

A162. Comment(s):
Page 5-23, Figure 5.11. Please provide a table or explanation of why "CA compliance with dams" scenario would result in such a large change in CBOD load as compared to other scenarios. (p. 51) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
The CA compliance with dams scenario needs to meet the 10 ug/L chlorophyll a target in the CA reservoirs. This requires further nutrient/organic matter load reductions upstream of Copco Reservoir.

A163. Comment(s):
Also, Copco 2 does not stratify and how the compliance lens concept applies is unclear. Why are allocations for all other locations monthly averages, but for the compliance lens the calculations are based on instantaneous DO mass? Insufficient information is provided in the TMDL to allow the reader to determine how the DO mass was calculated. (p. 51) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
The instantaneous DO mass estimate, which was in the June staff report, has been removed from the December edition of the report. The requirement is to have a zone within the reservoir where both supporting DO and temperature conditions are met simultaneously during critical periods (i.e., summer). If it can be demonstrated that Copco 2 meets that condition then the allocation has been satisfied. The instantaneous mass included in the June draft of the staff report was meant as an example of the supplemental oxygen that would need to be provided to achieve supporting conditions. Because daily conditions change and the subsequent volume of the zone changes, a more dynamic method of calculation will be necessary to meet the daily requirements. The compliance lens is a compromise solution to supporting conditions, requiring that only a portion of the reservoir meet the prescribed conditions. The actual method for calculating the required mass supplement and the engineering required to deliver and create the compliance lens will need to be addressed in the PacifiCorp TMDL implementation plan.

A164. Comment(s):
Total nitrogen, total phosphorus, nitrate and ammonia concentrations in the model boundary conditions for the Scott River seem consistent with field data collected in 2000; however there appears to be a potential discrepancy between the boundary conditions contained in the Existing Conditions boundary condition file "IG-Turwar2000EC.xls"

and what is stated in the text of the TMDL in Table 5.18 (Nutrient and Organic Matter Seasonal Monthly Mean Concentration Allocations (mg/L) for Tributaries to the Klamath River). (p. 11)

The TMDL states that no nutrient reductions are required for the Scott River, which should mean that the nutrient concentrations in the Existing Condition scenario should be the same as in the Natural Conditions scenario and the TMDL allocations; however, the Scott River TP allocations in Table 5.18 are 0.019 mg/L for November-April and 0.28 for May-October (Table 2), but the annual mean TP concentration calculated from the Existing Conditions boundary condition file is 0.0855, *several times higher than both the dry and wet seasons allocations*. Similarly, the mean TN concentration calculated from the Existing Conditions boundary condition file is 0.5420*, substantially higher than the values listed in the allocation table*. The Natural Conditions scenario nutrient concentrations do match those shown in the allocation table. (p. 11)

<u>Comment(s) Made By:</u>
Spain – Institute for Fisheries Resources & Pacific Coast Federation of Fishermen's Associations

<u>Response:</u>
The text has been revised to provide the correct compliance conditions for the Scott River.

A165. <u>Comment(s):</u>
The concentrations use to represent ungaged tributaries are 0.02 mg/L NH3, 0.01 NO3, 0.00 NO2, and 0.0469 organic (calculated as [algae+OM]*0.07), for a total nitrogen concentration of 0.0769. In our opinion, the boundary condition concentrations appear to be slightly too high for ammonia (NH3, a form of nitrogen), since ammonia was non-detect (<0.01 mg/L) in all samples of small Klamath tributaries on 5/29/2005, 8/22/2006, and 9/20/2006. In those same samples, nitrate+nitrite (NO3+NO2) concentrations were still mostly non-detects (<0.01 mg/L) but there were quite a few samples that were above detection (2 of 6 on 5/29/2006, 2 of 8 on 8/22/2006, and 3 of 9 on 9/20/2006), with the highest value being 0.025. Given those sampling results, it is unclear why the boundary conditions for NH3 are higher than for NO3. In future modeling efforts, we suggest that the NH3 boundary condition be reduced from 0.02 to 0.01, and that the NO3 boundary condition remain at 0.01. This is a very minor difference, and the change would have essentially no effects on the TMDL; we mention it here only for the sake of completeness. (p. 12)

<u>Comment(s) Made By:</u>
Spain – Institute for Fisheries Resources & Pacific Coast Federation of Fishermen's Associations

Response:
The comment is correct in noting that this would not have a significant effect on TMDL allocations. The Regional Water Board will make the noted correction in any future modeling scenarios.

A166. Comment(s):
It is our understanding based on previous inter-agency/inter-Tribal meetings that in the natural conditions (T1BSR) and the temperature compliance in California (TCT1 and TCT2) model scenarios, the small tributaries between Iron Gate Dam and the Klamath River estuary had their temperatures reduced by 2°C; however, this is not mentioned in this section of the TMDL, nor is there any presentation in Chapter 4 of modeling results indicating what effect this 2°C decrease had on mainstem temperatures. (p. 6)

Comment(s) Made By:
Crosby – Karuk Tribe
Fetcho – Yurok Tribe
Bowman – Quartz Valley Indian Reservation

Response:
The 2 °C reduction in minor tributary temperatures is represented in Appendix 7. The natural conditions baseline scenario was run with the same tributaries represented with their current temperature estimates (i.e., without the 2 °C reduction) and the results compared to the natural conditions baseline scenario results. The comparison showed that the change in minor tributary temperatures had a negligible effect on Klamath River water temperatures. Thus, the Klamath River is not sensitive to the temperature of the minor tributaries.

A167. Comment(s):
We are unclear what is meant by the statement "The ~30% export is likely a high estimate because the TMDL model retention does not account for the nitrogen exported downstream within living algal biomass from algae growing within the reservoir and taking up nitrogen from the water column." (p. 4-19). Is this an artifact of how retention is calculated from the model outputs? If so, is there a better way to calculate it, or is it an inherent characteristic of the model? And, if so, what are its implications for interpreting model outputs? (p. 9)

Comment(s) Made By:
Crosby – Karuk Tribe
Fetcho – Yurok Tribe
Bowman – Quartz Valley Indian Reservation

Response:
The statement has been revised, it was not correct.

A168. Comment(s):
PacifiCorp provided its water quality model to the Regional Board with the understanding that refinements to the models would be developed cooperatively between the agencies' consultant and Watercourse Engineering in an open and transparent manner with the expectation and understanding, as documented in our July 25, 2005 letter to the State Water Resources Control Board, Regional Board, ODEQ and U.S. EPA, that: 1) the TMDL model would incorporate the latest water quality monitoring and data collection in formation: 2) modifications, additions, and recalibrations of the model would be identified and shared: and 3) model scenarios and assumptions necessary to enhance model calibration, identify data gaps, and lead to model improvements would be identified and shared. Unfortunately, despite PacifiCorp' sand Watercourse's efforts, this collaboration did not occur and PacifiCorp's review of the water quality models relied upon to develop the draft TMDL has been limited to review of the modeling information only recently produced during the public comment period for the TMDL. (cover ltr p.1)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
Klamath TMDL Model Team cooperation with PacifiCorp and their contractor has been extensive, and EPA has expressed its strong disagreement with this comment in a separate letter to PacifiCorp, dated November 30, 2009. This letter has been included as Attachment 2 to these comments.

A169. Comment(s):
Regulatory Requirements- 6.1.4: The Report indicates, "Whenever possible natural and nonpoint source loads should be distinguished." However, the Report makes no attempt to do that, even though much of the data already exists. (p.3)

Comment(s) Made By:
Cantrall – Modoc County Board of Supervisors

Response:
In our existing source analysis the Regional Water Board identifies loads by source area not source category. We do make estimates of natural background loading using the natural baseline conditions TMDL model run. What the Regional Water Board does not do is then parse out the above background loading by source categories or entities. There is a rationale for not identifying nonpoint source loads by source category or by individual. That is, everyone is required to control their own portion of the above background loading through NPS best management practices (BMPs). Nonpoint source TMDL implementation will be carried out through the Regional Water Board nonpoint source regulatory programs' waste discharge requirements and conditional waivers of waste discharge requirements (permits). The conditions of those permits only address human caused sources of pollution by requiring the discharger to implement reasonable

and effective management practices to address their discharges. Dischargers will not be required to address natural sources of pollution on their land.

A170. Comment(s):
Appendix 7: Several of the Peer Reviewers rightly took the draft document to task for its flawed modeling approach. The County agrees with Dr. Characklis (C-l) that comparisons between model estimates of "natural" background levels and model estimates of current conditions are shaky at best, given the lack of data. The County suspects the reviewer would have taken an even tougher stand had he known that much of that data did exist but the Board's staff did not provide it. He also states, and the County agrees that "the degree to which this impairment is occurring and the level to which current conditions deviate from natural conditions is very difficult to determine using modeling as a primary analytical tool". (p.5)

The Reports responses to this reviewer's comments were very weak and off the point. They acknowledged the problems associated with modeling a complex system like the Klamath River, but were disingenuous by saying it was the best that could be done with the available data. The County's problem with this statement was there was a wealth of additional data that the draft document did not include. (p.6)

Comment(s) Made By:
Cantrall – Modoc County Board of Supervisors

Response:
The Board is employing a reasonable modeling approach for this TMDL. The Board agrees with Dr. Characklis that determining the degree of impairment using modeling is difficult and uncertain. However, the Board is not aware of a better analytical tool to accomplish this task, nor has Dr. Characklis pointed to one. The Board has subjected the model to extensive review to assure that it performs as well as can be expected for this complex system. Where the Board has received specific recommendations for changes to the model setup, the Board has fully considered those recommendations prior to moving ahead with the modeling work. In addition, the Regional Water Board staff used multiple lines of evidence for both the impairment assessment and in setting targets and allocations. These other lines of evidence are consistent with the model analysis.

Regarding available data, the Board collected and incorporated all relevant and available data for 2000 and 2002 into the model development process, and the model documentation identifies a number of data limitations that impact model performance.

A171. Comment(s):
We have not yet been able to examine the most recent model outputs in detail. We expect (though reserve the right to be pleasantly surprised) that when we do obtain and examine the model outputs, they will show that while model performance has improved due to improved boundary conditions, the model will continue to under-represent nutrient

reduction in free flowing river reaches (an issue that Work Group members have been bringing to the attention of the TMDL team for several years now). (p. 6)

Comment(s) Made By:
Crosby – Karuk Tribe
Fetcho – Yurok Tribe
Bowman – Quartz Valley Indian Reservation

Response:
No response necessary. Nutrient retention has also been addressed through empirical analyses and has been included in the TMDL as a line of evidence.

A172. Comment(s):
It is our opinion that on the whole, the model is robust enough to serve its intended purposes in the TMDL (i.e. setting load allocations). It is abundantly clear that the current nutrient concentrations in the river are far higher than natural background and that substantial reductions are necessary to restore water quality. (p. 6)

Comment(s) Made By:
Crosby – Karuk Tribe
Fetcho – Yurok Tribe
Bowman – Quartz Valley Indian Reservation

Response:
No response necessary. .

A173. Comment(s):
Our review of the model has focused on the model's representation of longitudinal trends in the river's nutrient concentration. In this area, while improved from previous versions, comparison of the model outputs with field data show that the model still clearly under-represents the natural removal of nutrients that occur in the free-flowing river reaches downstream of Iron Gate Dam. (p. 2)

Comment(s) Made By:
Spain – Institute for Fisheries Resources & Pacific Coast Federation of Fishermen's Associations

Response:
Regional Water Board staff have also included an empirical analysis of nutrient retention as a line of evidence in the TMDL staff report. Our own analysis suggests that the TMDL model may underestimate nutrient loss and retention within the Klamath River. The underestimate does not appear to be large. However, this potential underestimate results in more conservative allocations upstream and can be considered as an implicit margin of safety within the TMDL.

A174. Comment(s):
Despite this one shortcoming (of under-representing natural nutrient removal) we consider the model to be good enough to adequately fulfill its core role in TMDL development. (p. 2)

Comment(s) Made By:
Spain – PCFFA & IFR

Response:
Thank you for the comment. Every model has some level of uncertainty associated with is predictions. The Regional Water Board has considered the uncertainty associated with the TMDL model and determined that for estimating pollutant load reductions that these uncertainties are acceptable and manageable within the TMDL adaptive management framework. That is, it is clear that large reductions of nutrient and organic matter loadings are necessary to restore supporting water quality conditions within the Klamath River. It is also clear that the targeted levels are above background conditions. Water quality conditions within the river will continue to be monitored and evaluated to reassess pollutant reduction goals as a regular part of the adaptive management process.

A175. Comment(s):
In our opinion, the TMDL model uses the best available data to represent the Link River boundary condition. (p. 10)

Comment(s) Made By:
Spain – Institute for Fisheries Resources & Pacific Coast Federation of Fishermen's Associations

Response:
Thank you for the comment – no response necessary.

A176. Comment(s):
The TMDL model now correctly predicts that total nitrogen and total phosphorus *concentrations* decrease from Iron Gate to Turwar; however, the magnitude of the modeled decrease is somewhat less than is observed in field data. For instance, TN concentrations at nutrient samples collected at Orleans are typically less than 50% of what they are at Iron Gate. In contrast, TN concentrations at Orleans in the TMDL model are about 60-80% of Iron Gate TN concentrations. (p. 13)

Comment(s) Made By:
Spain – Institute for Fisheries Resources & Pacific Coast Federation of Fishermen's Associations

Response:
Every attempt was made to reproduce the observed data using the model, both spatially and temporally. And, the calibration results demonstrate the success of the model in reproducing the observations. It is possible that the difference in ratios between the upstream/downstream model results and observations is an artifact of the time periods covered by each dataset. That is, the model predicts concentrations throughout time, however the observations generally reflect distinct periods, at a lower frequency. Any bias in the observation data (regarding season, time, etc. the data were collected) would not be seen in the model results since they cover the continuum.

A177. Comment(s):
Examination of total nitrogen loads further illustrates this problem. Even though tributaries add small loads of nutrients (the tributary water has much lower concentrations than the mainstem, but still has some load) the river's ability to remove nutrients overcomes those additional tributary loads. This pattern is consistently observed in all years with data. In contrast, the TMDL model predicts that nitrogen loads increase from Iron Gate to Orleans during the warm low-flow summer months. This indicates that the model is underestimating the capacity of the river to remove nutrients. Thus, it is likely that the TMDL's "Natural Conditions" scenario (in which all dams are removed, and nutrient inputs are decreased) will predict nutrient concentrations higher than historically occurred. (p. 16)

Comment(s) Made By:
Spain – Institute for Fisheries Resources & Pacific Coast Federation of Fishermen's Associations

Response:
The Regional Water Board agrees that it is possible that the TMDL model may under predict retention and or loss of nutrients within the river. However, this uncertainty would lead to more conservative (lower load) allocations and actually serves as a margin of safety within the TMDL. However, directly using the somewhat limited observed nutrient data to derive longitudinal trends for the Klamath River requires additional data and further analysis to address this uncertainty. Available data do not completely reflect the high temporal variability (either on a very small scale – diurnal, or for a large scale - annually) exhibited by the river. Without high resolution data, it is not possible to characterize the true variability – particularly on a loading basis.

A178. Comment(s):
The TMDL model outputs show a much different picture for TIN than field samples. In TMDL model outputs, there is ample TIN throughout the Klamath River from Iron Gate to Turwar, with median concentrations ~0.19 mg/L or greater at all sites (Fig. 15). Median values for TIN as a percent of TN are ~49% or greater at every site (Fig. 16). In contrast, median values for TIN as a percent of TN in field samples were <10% at all sites except Iron Gate and Turwar (Fig. 14). Given that nitrate/nitrite and ammonia (the

components of TIN) are the nutrients available for periphyton, this difference in TIN between model data and field data could have substantial impact on model results. The TMDL model indicates that nutrients are seldom the factor limiting growth of periphyton in the Klamath River, but perhaps this is caused by the model's over-prediction of TIN concentrations. (p. 22)

Comment(s) Made By:
Spain – Institute for Fisheries Resources & Pacific Coast Federation of Fishermen's Associations

Response:
The Klamath contains periphyton at many locations. And, periphyton usually results in diurnal TIN variability. Diurnal variability would show lower concentrations during the day time and higher concentrations at night. Since most, if not all, TIN data were collected during day (when TIN is low), it is not surprising that the observed data would show low TIN concentrations. The model does show that the periphyton is limited by nutrients, alternating between N and P.

A179. Comment(s):
The fact that the TMDL model does not include denitrification in the RMA-11 model's simulated river reaches (although it may be included in CE-QUAL-W2 in reservoirs?) may explain why the TMDL model appears to do a better job of predicting longitudinal trends in TP than TN. The feasibility of incorporating denitrification into the TMDL water quality model should be explored. While we recognize that it is likely too late in the TMDL process to make substantial changes to the model, it could be helpful for future water quality modeling efforts if the TMDL text were to recommend that future efforts consider this modification. (p. 24)

Comment(s) Made By:
Spain – Institute for Fisheries Resources & Pacific Coast Federation of Fishermen's Associations

Response:
Refer to response A178 regarding longitudinal TN trends. Additionally, denitrification is not expected to be significant based on the physical characteristics of the Klamath River.

A180. Comment(s):
The model appears to dramatically under-predict nitrification (conversion of ammonia to nitrate) between Keno Dam and Copco Reservoir. In contrast to field data, the Klamath TMDL model predicts that no massive conversion of ammonia to nitrate occurs, and predicts that substantial ammonia (e.g. median 0.4 mg/L in 2000) enters Copco Reservoir (Fig. 19). Adjusting RMA model coefficients governing nitrification could potentially improve model performance in this area. (p. 24)

Comment(s) Made By:
Spain – Institute for Fisheries Resources & Pacific Coast Federation of Fishermen's Associations

Response:
Predictions of all nutrient components were evaluated holistically. Although Figure 19 shows over-prediction of NH4, the subsequent figure shows that NO3 predictions are reasonable. Also for multiple locations between Keno Dam and Copco Reservoirs there are data in 2002. Model results show that with the same parameters as for 2000, the model was able to reproduce the observed NO3 and NH4 well. This suggests that the parameters are reasonable.

A181. Comment(s):
Examination of ammonia and nitrate concentrations between Iron Gate Dam and Turwar (near the mouth of the Klamath River) provides further evidence that nitrification rates may be too low in the TMDL model. (p. 25)

Comment(s) Made By:
Spain – Institute for Fisheries Resources & Pacific Coast Federation of Fishermen's Associations

Response:
It is unclear how this conclusion was made. Based on the 2000 calibration results, it was shown at the NH4 and NO3 are both reasonably reproduced by the model. Additionally, the nitrification rate used in the model is 0.3/day for this riverine reach, and this is relatively high.

A182. Comment(s):
The Regional Board has 'filled in' data and assumptions when needed to determine specific conclusion with the illusion of scientific validity (e.g. the use of repeatedly proven flawed single layer temperature 'models' for the mainstem Klamath in 'conjunction' with a three dimensioned 'estuarine' model, in which limited 'forcing factors' data variables critical to final results were 'presumed' forming the basis for regulatory determination.) (p. 2)

Comment(s) Made By:
Cozzalio

Response:
The Regional Water Board does not agree with this comment. The Regional Water Board has not filled in data or assumptions to reach pre-determined conclusions. The modeling practices employed in this modeling effort are consistent with professional standards and were demonstrated to achieve a reasonably accurate level of predicting conditions. The model was used appropriately in the TMDL decision making framework.

A183. Comment(s):
Current computer modeling does not consider many natural variable conditions (including supersaturation, pulsed movement, periphyton refugia, etc.) allowing salmon survival and movement under parameters which those models say the salmon in the river cannot be alive. Given the flawed Klamath model and assumptions, these 'estimates' upon which the 'impairments', regulations, and 'objectives' are based render the entire TMDL defective, had 'improvement' truly been the objective. (p. 2)

Comment(s) Made By:
Cozzalio

Response:
The TMDL team uses dynamic models that account for changes in many naturally variable conditions. However the comment is correct in the observation that the model does not simulate on a spatial scale consistent with individual refugia. The model also does not predict fish mortality or morbidity. The model predicts water quality conditions, which are then compared against what would be supporting conditions for sensitive species (e.g., salmonids). The use of the model in the TMDL decision making process is to evaluate the allowable pollutant loads while still achieving water quality objectives. Because of the high background loads, the allowable increase above background is small. All the lines of evidence in the TMDL analysis, including models and other forms of assessment, are consistent, suggesting that there has been an increasing trend of pollutant loading creating existing conditions that have impaired beneficial uses, and therefore that TMDL management actions must be put in place to reverse these trends. The exact levels are estimates and progress will be monitored over time to determine if estimated changes in allocations can be considered. Regarding refugia, the Thermal Refugia Protection Policy is explicit recognition of the importance of small-scale features not well represented in the modeling framework, but which clearly play an important role in cold water fish persistence and survival in the Klamath River system.

Klamath River TMDL Development Team Draft Response to USGS Review of Klamath River TMDL Models from Link River Dam to Keno Dam

Under contract to the U.S. Bureau of Reclamation (Reclamation), and in consultation with Watercourse Engineering, Inc., the U.S. Geological Survey - Oregon Water Science Center (USGS) was hired to review the Klamath River TMDL models, with a particular focus on the reach from Link River Dam to Keno Dam in Oregon. The USGS' Administrative Report titled "Review of Klamath River Total Maximum Daily Load Models from Link River Dam to Keno Dam, Oregon" (Rounds and Sullivan, 2009) was submitted to the Regional Water Board by Reclamation as part of their comments on the Regional Water Board's June 2009 *Public Review Draft Staff Report for the Klamath River TMDLs and Action Plan Addressing Temperature, Dissolved Oxygen, Nutrient, and Microcystin Impairments*. The following draft responses were written jointly by US EPA's contractor, TetraTech, Oregon Department of Environmental Quality, Regional Water Board, and US EPA staff, with reference to the comment numbers presented in the USGS report.

A1. Comment(s):

Raw boundary data. The model input files were provided for this review, but not the measurements from which those inputs were derived. As a result, this review does not include a consistency check between the raw data and the model boundary inputs. For some inputs such as the meteorological data, other data sources were available and those data were compared to the model inputs. For many water-quality time-series inputs, comparisons were made to available data from ODEQ and USGS. Lack of access to the original raw data used by the modelers, however, imposed some limits on the scope of this review.

Response:

The raw data are included in the Klamath River water quality database and is part of the administrative record.

A2. Comment(s):

Boundary temperatures. The stormwater inflow, point-source accretion, and distributed tributary input temperatures were all set to a constant 12ºC all year long. It seems that a better approach would be to include some seasonal variation in those temperature inputs. The stormwater input is small, so it is unlikely that a constant year-round temperature would have a large effect on simulated temperatures in the Klamath River. Conversely, the point-source accretion and distributed tributary inputs make up an appreciable fraction of total inflows at certain times in 2000; therefore, inflow temperatures become important at those times. Depending on the fraction of river flow that is derived from these sources, the incurred error may be significant to the river's heat budget.

Response:

The boundary temperature for accretion/depletion flows was originally set to 12ºC. This has been changed to reflect seasonal variability and is now based on simulated temperatures entering from upstream modeling segments. The effect on the calibration is not significant.

A3. Comment(s):

TDS inputs. The concentration of total dissolved solids (TDS) assigned to the Klamath Straits Drain was 0 mg/L. The TDS concentration in this tributary, however, is actually higher than in most other tributaries to the system. Field conductivity data (which can be used to estimate TDS: Hem, 1985) for the Klamath Straits Drain and for Link River in 2000 are shown in **figure 3**. An incorrect TDS concentration will affect the modeled water density, pH, and the computed concentration of carbonate species. This misassignment in TDS may not produce large errors in most of the important modeled constituent concentrations, but it should be fixed.

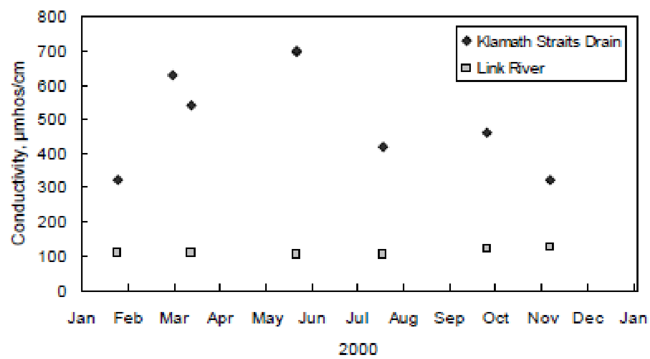

Figure 3. Graph showing field conductivity data in the Klamath Straits Drain and Link River, Oregon, during 2000. Data were collected by Oregon Department of Environmental Quality. Values in this graph are roughly equivalent to total dissolved solids concentrations of 60 to 420 mg/L.

Response:

TDS is not a parameter of concern or relevance to the TMDL. In the model, it is simply a dummy constituent that has no affect on the modeling results.

A4. Comment(s):

Ammonia inputs. The upstream boundary condition for ammonia at Link River in the 2000 current conditions CE-QUAL-W2 model has a seasonal pattern that is different from that in measured datasets from ODEQ and USGS (**fig. 4**). The lowest ammonia concentrations in the model boundary conditions are during January through June and November through December, and the highest values are during summer (greater than 1.9 mg/L). In contrast, the measured ODEQ and USGS datasets show an opposite seasonal pattern at Link River, with the highest ammonia concentrations in winter and values generally less than 0.3 mg/L during summer.

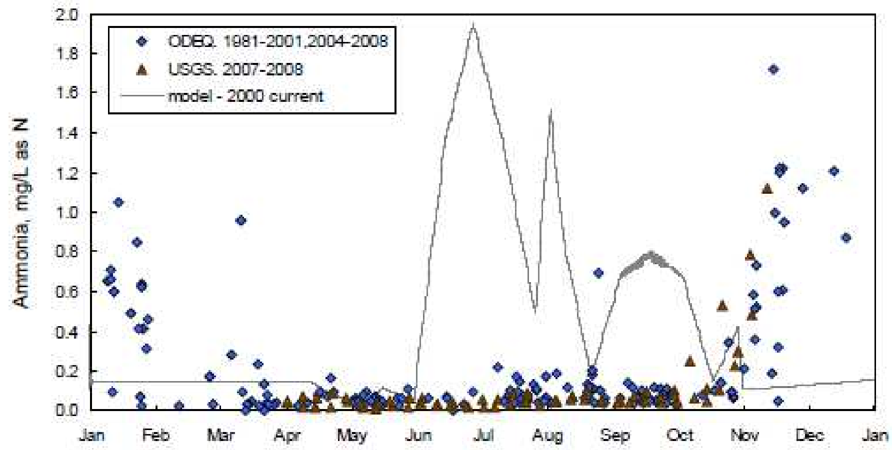

Figure 4. Graph showing year 2000 CE-QUAL-W2 model boundary condition ammonia concentrations at Link River compared to measured data from Oregon Department of Environmental Quality (ODEQ) and U.S. Geological Survey (USGS). ODEQ data were collected approximately six times a year, and data are shown only for those that were reported in units of mg/L as nitrogen. USGS data were collected weekly from April through November.

According to the draft modeling report (Tetra Tech, Inc., 2008), the ammonia inputs to the Link River RMA model were derived from data collected at Pelican Marina in Upper Klamath Lake (UKL), and the ammonia concentrations do not change much within the RMA Link River model. The poor fit to the measured ammonia concentrations at the downstream end of Link River indicates that either (1) the Pelican Marina ammonia data are not representative of the ammonia concentrations exported from UKL to Link River, or (2) the Link River model is not simulating an appropriate level of ammonia nitrification or algal uptake. Regardless of the reason, the result is that the ammonia inputs to the CE-QUAL-W2 model at the downstream end of Link River do not match the measured data.

This error in the pattern and magnitude of boundary ammonia concentrations represents a significant modeling problem, as concentrations of ammonia greater than 1.0 mg/L can affect dissolved oxygen concentrations and other instream processes in addition to the inorganic nitrogen load. In fact, this large simulated ammonia load may account for part of the underprediction of dissolved oxygen concentrations downstream (see E.2). The source of this inconsistency needs to be determined and resolved.

Response:

Contrary to the comment, we believe the upstream boundary conditions for ammonia are reasonably estimated for the year 2000. We recognize that there is uncertainty in these conditions, but the comment does not provide a better alternative. It is focused on data from different years than the calibration year (2000) and does not consider key information on the performance of the ammonia calibration at Lake Ewauna.

Figure 4 in the comments shows a plot of the NH4 pattern at Link River for the periods from 1981-2001 and 2004-2008. Data for the calibration year (2000) at this particular location, however were quite limited and do not match the trends observed in Figure 4. Due to data limitations at Link River, the ammonia boundary condition was configured using data available at Pelican Marina for the year 2000, and the model was calibrated using data at Lake Ewauna. The concentrations of nutrients at Pelican Marina and Upper Klamath Lake outlet were compared for dates with duplicate samples and found to be similar. We don't know the reason for the disparity pointed out in the commenter's review; possibilities include measurement error and localized water quality conditions.

Regardless, the model results show that with the Pelican Marina-based boundary condition, along with reasonable parameter settings, the model was able to reproduce the observed NH4 in Lake Ewauna. The fact that the model reasonably captures the trend in 2000 data in Lake Ewauna indicates that the boundary condition and model kinetics were reasonably represented. Furthermore, the model was also setup using 2002 data using a much more robust dataset for ammonia and corroborated the year 2000 parameterization. Discussion of the 2002 representation is absent in your comments.

A5. Comment(s):

Organic matter fractionation. The CE-QUAL-W2 model defines and simulates four types of organic matter (OM): labile and refractory particulate organic matter (LPOM, RPOM), and labile and refractory dissolved organic matter (LDOM, RDOM). The labile components decompose rapidly, but the refractory components are more resistant to decomposition. At the time of model development, few direct measurements of OM concentrations were available. Input OM data had to be indirectly estimated from other data, using, for example, total phosphorus, dissolved phosphate, chlorophyll, and literature-based conversion factors. With limited information, the modelers considered all OM to be labile, and the RDOM and RPOM compartments were set to zero for the upstream boundary.

The draft modeling report (Tetra Tech, Inc., 2008) justifies the assumption that all OM was labile by attributing most organic matter from UKL to phytoplankton blooms and associated metabolism. Although phytoplankton strongly affects OM in UKL, especially particulate organic matter (POM), plankton are not the only source of OM. Wetlands in the upper areas of the watershed as well as wetlands adjacent to the lake provide dissolved organic matter (DOM) to UKL, and that OM may be more refractory than the algae-derived OM. For example, during one sampling period in May 2007, 20.3 mg/L of dissolved organic carbon was measured in the Williamson River, a major tributary to UKL, which receives drainage from the Klamath Marsh (U.S. Geological Survey, unpub. data, 2007.)

The labile OM concentrations at the boundary inputs were fractionated differently. The single-group OM output from the Link River RMA model was divided into 20 percent LDOM and 80 percent LPOM for input to the downstream CE-QUAL-W2 model. OM associated with the two wastewater treatment plants, the Lost River Diversion channel (**fig. 2**), the point-source accretions, and the distributed tributary also were divided into 20 percent LDOM and 80 percent LPOM. The Klamath Straits Drain OM, however, was set to 70 percent LDOM and 30 percent LPOM, and the Collins Forest Products, Columbia Plywood, and stormwater runoff inputs were set to 100 percent LDOM. Some model scenarios were run by Tetra Tech to determine the sensitivity of the model results to these fractions, but documentation of those results was not available for this review.

Based on more recent datasets (Sullivan and others, 2008; 2009), the OM concentrations and fractionation among groups in the Lake Ewauna to Keno Dam model are not representative of actual conditions. For example, the modeled input of DOM at the upstream boundary at Link River is lower in concentration and has a different seasonal pattern compared to the fairly consistent timing and concentrations of two years of weekly data collected at that site during 2007 and 2008 (fig. 5). Concentrations of the sum of modeled POM and algae appear to generally match the concentrations and seasonal patterns of measured particulate organic matter.

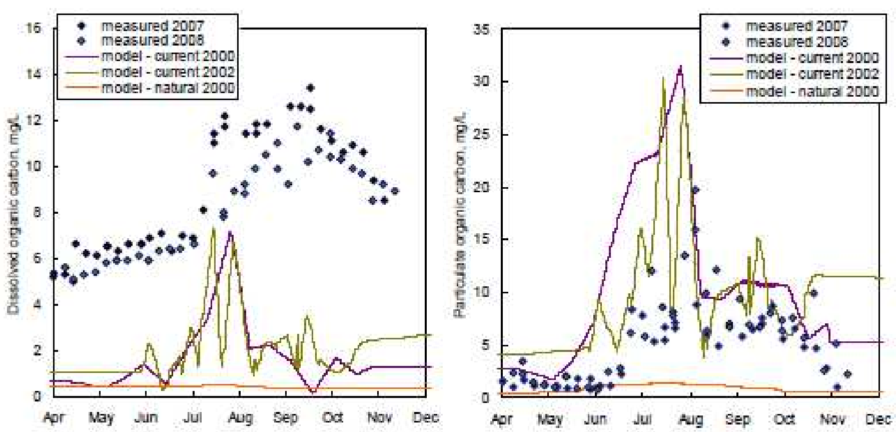

Figure 5. Graphs showing measured dissolved (left) and particulate (right) organic carbon concentrations at Link River in 2007-08, compared to boundary inputs to the Lake Ewauna model. Model LDOM was converted to dissolved organic carbon using the 0.45 organic carbon to organic matter ratio specified in the model control file. Modeled LPOM (nonliving particulate organic matter) plus modeled algae (living particulate organic matter) were converted to particulate organic carbon for comparison to measured particulate organic matter, which includes nonliving and living matter, using the 0.45 organic carbon to algae and organic matter ratio specified in the model control file.

Whatever the assumptions may have been, recent data show some significant discrepancies compared to model inputs relative to the magnitude, seasonal pattern, and distribution of OM between dissolved and particulate forms. Organic matter is a large and important input to the Klamath River from UKL that affects dissolved oxygen concentrations and nutrient loads. These model inputs need to be re-evaluated to provide a better description of water quality n the Lake Ewauna to keno Dam reach.

Response:
The comment does not accurately describe the handling of organic matter (OM) in the model. While the OM was ostensibly divided into 20% labile and 80% refractory, the same decay rate value was applied to both, so there is no differential handling of two types of OM.

The 20/80 division in the input files is an artifact of the early calibration process, when the effect of splitting the OM into two fractions was evaluated. During the calibration process, it became clear that, unless the majority of OM decay relatively quickly (resulting in significant deoxygenation), the DO in Lake Ewauna would never be as low as it has been observed in the historical record (particularly near the water/air interface). Therefore, a single decay rate was used in W2 to represent all OM at the upstream boundary. A mid-range decay rate was used to reflect the characteristics of the OM. This value can be taken to represent a combination of both extremely labile OM and refractory OM. The decay rate of the OM was reduced incrementally downstream since the more labile OM fraction is lost faster than the less labile fraction.

No detailed organic matter data are available for the model calibration years (2000, 2002). While the 2007 and 2008 data depicted in the comment provide insight into recent organic matter characteristics, they cannot be directly applied to models for 2000 and 2002. First, the data are 5 to 8 years more recent than the modeled period, and activities affecting organic matter trends over that time are unknown. Second, conditions in Lake Ewauna change significantly from one year to the next; therefore, use of data from different years simply substitutes one source of uncertainty (data-limited estimates of calibration year OM) for another (uncertainty in annual variability). Even the 2007 and 2008 data demonstrate significant variability over only a one year period.

Additionally, NH4 and TKN data and model predictions were not considered by the commenter, and these data indicate that the use of off-year data would not improve the model. The comment asserts that the model-predicted DOC is much lower than the observed conditions 5 to 8 years later. However, for the 2000 calibration, the model reproduced the observed data for both NH4 and TKN in Lake Ewauna. This indicates that the model has a reasonable representation of organic matter, since TKN=Organic N+NH4. If TKN and NH4 are reasonably predicted, organic N should also be reasonably predicted. This was the information used during calibration in the absence of organic matter data.

Aa. Comment(s):

Wind speed. In the meteorological model input file for the year 2000, on day 39.292, the wind speed (22.05 m/s) is much higher than the value for the previous hour (0.82 m/s) or the subsequent hour (0.55 m/s). This and other elevated wind speeds (near days 82.5, 85.7, 96.6, 97.7, 100.8, and 103.8) in the current conditions meteorological input file were removed from the corresponding natural conditions meteorological input file. These high wind speeds may or may not have been real, but if they were deemed unreasonable to include in the natural conditions scenario, then they probably should have been removed from the current conditions scenario as well. These wind gusts affect near-surface mixing and evaporative heat losses, although the effects are transient and probably minor.

Response:

Wind speed does not significantly impact model results. There were a number of extreme values in the existing conditions run that were not included in the natural conditions run. The extreme values were removed from the natural conditions run primarily to avoid instability issues.

The wind inputs were identical for all modeling scenarios used for setting the TMDLs, so the allocation estimates are independent of wind speed.

Ab. Comment(s):

ISS estimates. The draft modeling report (Tetra Tech, Inc., 2008) states that the CE-QUAL-W2 inputs for inorganic suspended solids (ISS) were set to measured values of total suspended solids (TSS) for the Klamath Straights Drain, Klamath Falls wastewater treatment plant, and South Suburban Sanitation District. This practice would overestimate the ISS concentration, because TSS includes not only inorganic particulate matter, but also organic particulate matter, which is plentiful in this system and is included separately in other model inputs. The report and input files do not indicate how ISS concentrations were set for the other model boundary inputs.

Response:

Further documentation of the ISS has been provided in the final Klamath River Model for TMDL Development Report (Model Report).

Ac. Comment(s):

Upstream inflow. The draft modeling report (Tetra Tech, Inc., 2008) states that the flow in Link River that feeds into the Lake Ewauna model was determined using measured flow at the USGS streamflow-gaging station (site 11507500) minus flow from the PacifiCorp West Turbine (powerhouse) gage, which is downstream of the USGS gage. The powerhouse flow should have been added rather than subtracted from the USGS flow. This seems to be an inaccuracy in the report rather than the model. Although PacifiCorp flow data were not available, modeled flows were greater than the USGS gaged flows, so the powerhouse flows probably were added to the USGS gaged flows to create that flow boundary condition.

Response:
The model setup was correct, but the wording in the report was inaccurate. This has been corrected in the final Model Report.

Ad. Comment(s):
Shading. The shade inputs were used by Tetra Tech to turn off all topographic and vegetative shading in the Lake Ewauna to Keno Dam CE-QUAL-W2 model. Given the relatively flat nearby topography, the paucity of significant riparian vegetation, and the large width of the river, simulating no shade is probably a good choice. Tetra Tech made changes to the model's Fortran source code, however, to decrease the incoming solar radiation by 20 percent for this reach. The nearby topographic features and streamside vegetation are not large enough to justify a 20-percent decrease in short-wave solar radiation. This change is discussed further under comment number C.4 in the Model Source Code section of this review.

Response:
Shading has been removed for this reservoir in the model.

B1. Comment(s):
Reach length. According to USGS topographic maps, the Lake Ewauna to Keno Dam reach is 19.7 miles in length, but the CE-QUAL-W2 model grid for the same reach is 22.2 miles, about 12 percent longer than the mapped channel. The length of the model grid may or may not be accurate. The model bathymetry was based on a relatively recent bathymetric survey (Watercourse Engineering, Inc., 2004). The length of the modeled reach affects the simulated storage and travel time, which in turn have a large and important effect on simulated concentrations of dissolved oxygen, algae, and all other constituents. This is a potentially important point, and the reach length needs to be verified.

Response:
There is inherent uncertainty in reach length estimation and representation in models. The resolution of the model grid and the resolution of the data collection for mapping of river mile are usually not equivalent. Maps commonly differ in river mile representation. For example, while the comment notes a disparity with a USGS map, an Oregon Water Resources Department map show approximately 21 river miles between Keno Dam and mouth of Link River, which is closer to the model length (22.2 miles).

The grid is exactly the same as in the original PacifiCorp model. Compelling data that would refute the representation in the PaciCorp model are not identified in the comment. Additionally, the PacifiCorp model had been subject to a peer review, and no issues were raised regarding the physical configuration.

B2. Comment(s):

Layer widths. The layer widths in the CE-QUAL-W2 model grid do not vary smoothly with depth. Instead, a number of layers at a given location often are assigned the same width (fig. 7). With water surface elevation changes, the modeled river could simulate a large change in width that would not be realistic. Such large changes affect the heat budget through the surface width; almost all of the river's heat gains and losses during the course of a day occurs at the air-water interface, and the surface width is a critical component that determines heat fluxes and the temperature of the river. The simulated width also affects all processes that occur at the sediment-water interface, such as sediment oxygen demand. The larger the surface area, the larger the effect.

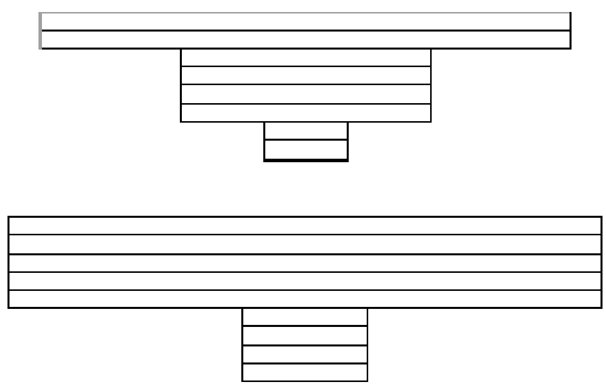

Figure 7. Typical cross sections extracted from the CE-QUAL-W2 model grid. The distance from left to right represents the distance from left bank to right bank. Each layer is 0.61 m (2 ft) high. The top cross section is segment 2 at the upstream boundary, and the bottom cross section is segment 86 at RM 237.5 near the KRS 12a sampling site (see fig. 2).

Under the current and natural condition scenarios, the river surface elevation is maintained at a fairly constant elevation, so it is possible that these cross-sectional width issues may not be important, depending on whether the water surface is near a layer interface that has large width changes. However, if different conditions were imposed that affected the water-surface elevation and the variability of that elevation in this reach, then this issue may become more important and have significant ramifications for the heat and oxygen budgets.

Response:

Refer to discussion of Pacificorp grid in B1.

Ba. Comment(s):

Shallow location. The CE-QUAL-W2 model grid contains the expected variability in depth, but a notable shallow segment is present approximately 4 km (2.5 mi) upstream of Keno Dam (**fig. 6**). That segment is 304.8 m (1,000 ft) long, and 4.3 m (14 ft) higher than the immediately adjoining upstream and downstream segments. The presence of this shallow area in the raw bathymetric survey data was verified during this review. Shallow features such as this can be important for the modeling of thermal stratification and vertical mixing, so it is good that this feature was included in the model's bathymetric representation.

Response:
Refer to discussion of Pacificorp grid in B1.

C1. Comment(s):

Model choice. CE-QUAL-W2 is a widely applied model with a strong record of success in simulating flow and water quality in rivers, lakes, and reservoirs around the world (Cole and Wells, 2002). This model generally is a good choice for the reservoir-like Lake Ewauna to Keno Dam reach of the Klamath River. Of some concern is the fact that CE-QUAL-W2 is not capable of simulating the recirculating current that sometimes occurs in Lake Ewauna. Most of the downstream flow in that reach occurs on the western edge because the channel is deeper near that bank. Depending on flow and wind conditions, however, upstream flow can occur along the shallower eastern side of that reach upstream of the railroad bridge. Measurements of this phenomenon on August 27 and 28, 2008, by USGS verified that this type of recirculation occurs (**fig. 8**). If this sort of recirculation occurs frequently, then the CE-QUAL-W2 model will be unable to properly represent the distribution of residence times experienced by parcels of water that traverse this reach. The median residence time may still be captured by the model, but the model will not capture some of the variability in water quality that results from shorter or longer residence times in Lake Ewauna.

Figure 8. Map showing the measured circulation pattern in Lake Ewauna just downstream of Link River, Oregon, during August 27 and 28, 2008 (U.S. Geological Survey, unpub. data). Arrows show the mean direction of flow at each measurement location (sites marked by green circles).

The residence time in this reach has an important effect on materials that settle or decompose rapidly, and on the effects of sediment oxygen demand. Despite this problem, and although a three-dimensional flow model might be better able to capture some of the more detailed circulation patterns in the Lake Ewauna area, CE-QUAL-W2 should be able to capture the most important flow and water-quality processes that occur in the Lake Ewauna to Keno Dam reach of the Klamath River.

<u>Response:</u>
The TMDL team agrees that CE-QUAL-W2 should be able to capture the most important flow and water-quality processes that occur in the Lake Ewauna to Keno Dam reach of the Klamath River.

C2. <u>Comment(s):</u>
Code version. Version 3.12 of CE-QUAL-W2, as released by the development team on August 15, 2003, formed the basis of the model applied to the reservoir reaches of the Klamath River for the TMDL. That version subsequently was modified by Tetra Tech to add new and customized algorithms and outputs. Version 3.12 from August 15, 2003, is a widely used and relatively bug-free version of CE-QUAL-W2. Overall, this model version is a good choice as a starting point for a W2 application.

Although version 3.12 was a good modeling framework at the time, the CE-QUAL-W2 development team has continued to improve the model over the years. The current version stands at 3.6 and has changed greatly since the release of version 3.12. Dozens of bug fixes, code improvements, and new capabilities have been added. The code used in this Klamath River application has not been modified to keep up with the developers' improvements. Where problems exist in the version 3.12 code, it is important that they be recognized and either fixed or avoided through judicious and informed use. The development team posts their updates and bug fixes with each new release, and many of those fixes can be applied by the model user to older versions of the code without undue effort. The following list is a summary of some of the more important bugs that have been identified by the developers, but remain in the code used in this study, since the release of version 3.12.

1. The phosphorus sorption code in version 3.12 is incorrect. Several somewhat involved fixes to the code are needed, and have been applied to certain subsequent versions of the code. This problem affects the available phosphorus for algal growth, the amount that settles with particulate materials, etc. The easiest solution for the modeler is to avoid the use of phosphorus sorption and set the PARTP input parameter to zero. Although PARTP was not set to zero in the Tetra Tech models, its value was relatively small (0.001) and therefore should have little effect on the results.

2. Calculations of total phosphorus in the version 3.12 code double-count the amount of sorbed phosphorus. This should not result in a large error, given the small amount of phosphorus sorption used in the Tetra Tech model.

3. Evaporation calculations use the wrong river width if the water surface is above the KT layer of the model. The fix is simple and has been corrected in later versions of the model. For the Lake Ewauna to Keno Dam model, evaporation effects on the water budget were turned off (but ON in the heat budget), so this error is not encountered. Turning evaporation off for the water budget affects only the mass of water lost to the atmosphere through evaporation, which is a small component of the water budget in this reach, so the effect should be minimal.

4. In the pH calculations, formulations for the dependence of equilibrium constants on temperature have been updated in later versions. This will not affect the results significantly.

5. The variable WINTER is not set correctly in version 3.12, resulting in errors if ice calculations are turned on. Such calculations are turned off in the Tetra Tech model, but potential model users should be informed of this problem, or the problem should be fixed in the code.

6. An error in the LATERAL_WITHDRAWALS subroutine may set the depth of a withdrawal incorrectly. This is an easy bug to fix and has been fixed in later versions. Lateral withdrawals are used in the Lake Ewauna to Keno Dam model, and although this error may prove inconsequential, the effect has not been quantified.

7. The SEDIMENTS subroutine has changed greatly since the release of version 3.12 to correct several problems. For example, the accumulation of sedimentary organic matter from epiphytic sources counted only the contribution from the last epiphyton group. This application used a sedimentary organic matter decomposition rate of zero, however, which avoids these coding problems.

These are just a few examples, but illustrate that modelers need to be aware of bugs and shortcomings in the code, and apply the model appropriately.

Response:
The TMDL team agrees that it is generally a good practice to use the most recent code version for a modeling study. However, for the Klamath River modeling effort, it was not feasible to update the model code over the course of the project since significant modifications and improvements were made to the version originally selected. Updating versions would be resource-intensive and could lead to inconsistencies and human error in model setup. As noted in the comment, the new updates in the W2 code would not likely have a significant impact on the processes simulated in the Klamath River.

C3. Comment(s):
Version control and documentation. Different versions of the model were applied to the current conditions and natural conditions scenarios. The source code reviewed for this report was from the natural conditions model. A comparison of the control files and the program sizes indicated that code differences between the current and natural conditions models probably were small, and the natural conditions code could have been applied to the current conditions model runs with just one small change to the current conditions control files. This was not done, however, and the result is that different versions of the model program (the .exe file) were used for different model runs. This is not necessary, adds complexity and is not good practice, but is easily fixed. Optimally, only one version of CE-QUAL-W2 should be applied to the various model runs, and tighter control over the model versions should be exercised in the future.

When code changes are made, those changes should be documented in the source code and in any reports so that model users know of the changes and are aware of their implications. Although some changes in model algorithms were documented in a draft report (Tetra Tech, Inc., 2008), such documentation for many of the important changes to the model code are absent. Tighter control also should be exercised over the source code versions used for these models. Apparently, the source code for the current conditions models was not archived after it was compiled, and therefore was lost when later code changes were made to the model. Such a practice is not optimal—source code should be properly archived and documented with all model versions that are used for any purpose.

Response:
In order to overcome limitations of off-the-shelf models for representing unique characteristics of the Klamath River, source code modifications were implemented. This is typical of highly complex modeling applications. Modifications were based on environmental science and documented in the Klamath River Model for TMDL Development Report. In response to this and other comments, we have improved the documentation in the final Model Report so that all aspects of the work are transparent.

The model source code was subject to multiple peer reviews and made available during the public review of the TMDL Report. We recognize that there were minor source code variations among the model files available for review. While none of the variations impacted the model results or limited review of the code, we have conducted the final model runs with a single source file for ease of future model review and use.

C4. Comment(s):
SC10 error. Tetra Tech modified the CE-QUAL-W2 model source code to add a new variable named SC10. This variable was used to reduce the incoming short-wave solar radiation by 20 percent for the Lake Ewauna to Keno Dam model, but the change was hard-coded only for that model (models with 115 segments and 15 layers) and only if the user chose the term-by-term heat balance equations as opposed to the equilibrium temperature equations.

If a 20-percent reduction in solar radiation was desired as part of the calibration process, a static shade coefficient of 0.8 could have been imposed in the shade input file. It was not. No topographic or vegetative shading was set in the shade input file. If the solar radiation input data were known to have a positive bias of 20 percent, then those data could have been adjusted outside of the model. If the incoming solar data are accurate (and they appear to be accurate based on comparisons to other nearby data), however, then a 20-percent reduction in that input for the heat budget seems unjustified, given the lack of topographic and vegetative shading in the Lake Ewauna to Keno Dam reach of the Klamath River. If 20 percent of the incoming solar radiation was discarded in order to adequately simulate the measured water temperatures, then perhaps the surface widths in the model grid are too wide. Other items to check in the water-temperature calibration are the simulated travel times and extinction coefficients as well as simulated versus measured vertical temperature profiles.

Not only was a 20-percent loss in solar radiation hard-coded into the model, but the code changes were applied inconsistently. The reduction in short-wave solar radiation was applied only to the radiative part of the heat budget. The full amount of short-wave solar radiation flux was used in the model for layer-by-layer light extinction and for computations of available light for photosynthesis by phytoplankton and epiphyton. As a result, the heat budget for the surface layer cells is incorrect—the short-wave heat flux entering the top of the river is inconsistent with the downward moving short-wave heat flux and the light energy converted to heat within that layer.

No documentation was provided to justify this significant change in the code, but the change will affect the temperature simulations and the vertical distribution of heat in the Lake Ewauna to Keno Dam reach. Most importantly, the change severely damages the robustness of the model; even if the model matches measured temperatures under current conditions, the model algorithms to predict temperatures under other sets of conditions (other than those for which the model was calibrated) have been significantly compromised.

The only way to address this problem is to remove the changes to the code that arbitrarily reduce solar radiation by 20 percent, and then recalibrate the model for water temperature. Water temperature is an important factor that affects the rates of many other water-quality processes in the model. If recalibration of the heat budget produces significant changes in simulated water temperatures (or widths in the model grid), further recalibration of the water-quality components of the model will be needed.

Response:
The 20% reduction to short-wave solar radiation that the commenter refers to was configured in the model during temperature calibration. This reduction was applied to all riverine segments in the system (i.e., RMA) and initially to Lake Ewauna/Keno. The 20% reduction for Lake Ewauna/Keno was ultimately removed, however one remnant of the adjustment still remained when the model was distributed. This remnant is the focus of the comment. This remnant has been removed from the model for Lake Ewauna/Keno, however the 20% setting for the riverine segments has not been changed.

The 20% reduction was applied to riverine segments because the model does not accurately predict temperature between J.C. Boyle Dam and Copco Reservoir without this reduction. Using the solar radiation code in the original RMA-11 model resulted in simulated temperatures that were consistently higher than observed values. It was suspected that for the riverine sections (or at least significant portions of the riverine sections), the previously used solar radiation in the RMA-11 models was too high due to biases in the equations used relating solar radiation to latitude, longitude, and elevation of the modeled area. Since RMA-11 internally calculates solar radiation for use in temperature and biological calculations, it is possible that the internal calculation of solar radiation may deviate from actual conditions. During calibration solar radiation was calculated between J.C. Boyle and Copco Reservoirs and compared with the observed solar radiation incorporated into the Copco Reservoir model. It was found that the internally calculated solar radiation was approximately 20% higher than the observed values. Therefore during the calibration process solar radiation was reduced, and predictions were significantly improved.

Modification of the predicted solar radiation boundary condition, which inherently has associated uncertainty (since it is not measured data), was justified to achieve consistency with observed data and thus more accurate temperature predictions. Although the over-estimation of temperature and solar radiation was not necessarily consistent along the length of the river, the 20% reduction was deemed appropriate for all riverine segments to maintain consistency in assumptions used for the RMA model segments.

It should also be noted that although the model was calibrated to historical conditions, its primary use is for relative comparisons in the TMDL scenarios. The reduction percentage was applied for all scenarios, and not solely for calibration. This approach maintains the integrity of the model and consistency for application to regulatory purposes. Although other factors were considered when calibrating temperature, including the shade coefficients mentioned in the comment, the solar radiation reduction was deemed most appropriate based on the findings described above.

The rationale for solar radiation modification has been included in the final Model Report.

C5. Comment(s):

Healthy/unhealthy algae. Code modifications were made by Tetra Tech to allow a fraction of the algae to become stressed or “unhealthy” as a result of low dissolved-oxygen conditions and thereby respond differently from healthy algae. These code changes and related issues are discussed under comment D.1 later in this review.

Response:

Refer to D1

C6. Comment(s):

Reef spillway flow. Prior to the construction of Keno Dam in 1967, a shallow reef was present in the river where the dam was constructed. The reef was notched or removed when the dam was constructed. Agreements in place between PacifiCorp and other parties specify that the reef must be restored if Keno Dam were to be removed (Bureau of Reclamation, oral commun., 2009). Therefore, the natural conditions model scenario was set up to simulate the river without Keno Dam but with the Keno reef in place.

Bureau of Reclamation staff, using pre-dam data collected prior to 1910 (Hoyt and others, 1913), derived a quadratic stage-discharge relation for the Keno reef. CE-QUAL-W2 did not have a built-in spillway flow function that was compatible with this new stage-discharge relation, however, so Tetra Tech modified the code to implement a quadratic spillway formula. The code modifications were assessed in this review and should work properly.

Response:
This comment confirms that the reef representation is correct.

C7. Comment(s):
Sediments code. In the Tetra Tech model, the coding for sedimentary organic matter decomposition was modified in several ways. Nutrient releases from this compartment were added under hypoxic conditions, in much the same way that such releases are made from the zero-order sediment oxygen demand (SOD) compartment. The release of nitrogen and phosphorus from sedimentary organic matter decomposition under oxic conditions was removed from the code, although this process does occur in the environment. The code revisions also are incomplete and sometimes incorrect because they do not include an oxygen concentration dependence for all uses of the SEDD() term, an important rate variable in the model.

Because the sedimentary organic matter decomposition rate (SDK) in the control file of these model runs was set to zero, thus zeroing out the SEDD() term, these changes in the source code are inconsequential for these applications. However, should these models be run with a non-zero SDK term, the results would not be as intended. These code modifications are incomplete and need to be corrected and updated.

Response:
The sediment modification was not intended to be used, nor was it used, in this study. As such, it has no implications on the analysis that was performed.

Ca. Comment(s):
Light extinction. Tetra Tech modified the model source code to add new dissolved organic matter (DOM) terms, for both labile and refractory DOM, to the calculation of light extinction. Light extinction coefficients affect the vertical distribution of heat and light in the water column, thus affecting the vertical distribution of algae and dissolved oxygen as well. Due to the amount of DOM in the Klamath River downstream of Upper Klamath Lake, and its variation over the season, this code change appears to have been warranted. However, a light extinction coefficient of 0.05 m-1(g/m3) -1 was added directly to the source code for the DOM components, rather than read in as an input parameter like the rest of the extinction coefficients, thus restricting flexibility for future model users. No

documentation was provided to justify the use of this value for a DOM light extinction coefficient. Justification might have included laboratory or field measurements to support the selected value, or the results of model calibration and sensitivity testing. In addition, no information was provided to determine whether the baseline extinction coefficient (EXH2O) in the model was adjusted downward to account for the fact that extinction due to DOM was applied separately.

Response:
The light extinction due to DOM, as due to other components of OM, was determined through the calibration process. The value of EXDOM was set to be slightly less than EXPOM. The EXH2O was set to a constant 0.45/m in all the reservoir models, and this is a reasonable value based on previous W2 applications. Documentation has been added to the final Model Report.

Cb. Comment(s):
ISC coding errors. Tetra Tech modified the model source code in many ways to create customized outputs, compute customized quantities, perform specialized calculations, and add new algorithms. A few of these modifications have minor coding errors, which can be ignored and remain unused or should be fixed. For example, specialized code was added to the model to adjust boundary inputs of temperature and water-quality constituents through a new input variable (ISC) and several new internal variables. These adjustments are activated when ISC is set to a value greater than or equal to 2, a condition that never occurred in the set of model runs provided for this review. The new code, however, has errors associated with ISC in the TIME_VARYING_DATA subroutine that would affect the intended adjustments near the beginning of a model run.

Response:
ISC is a parameter that is not used in the TMDL modeling study, therefore it has no impact on the model results.

Cc. Comment(s):
Compiler options. Tetra Tech used the "CVF" or Compaq Visual Fortran version of the CE-QUAL-W2 code, and used the Compaq Visual Fortran compiler to create the program executable file from the source code. Tetra Tech used the standard "release" compiler options when compiling the program, which are: /compile_only /nologo /warn:nofileopt /module:"Release/" /object:"Release/" Experience has shown, however, that the following compiler options are helpful in producing faster and more accurate code for some programs: /fast /nodebug /real_size:64 /warn:(argument_checking,nofileopt,unused,nousage) All compiler options used when releasing compiled code should be documented.

Response:

The compiling of code was done in the integrated development environment of Compaq Visual Fortran, using the default “release” option.

Cd. Comment(s):

Source line length. Many Fortran compilers, including the Compaq Visual Fortran compiler, have a source line length limit of 132 columns. Some modifications made by Tetra Tech resulted in source lines that exceeded the 132 column limit. It may be that the Compaq Visual Fortran compiler is somewhat forgiving about this limit and that the compiled code was unaffected by this non-adherence to convention. The CE-QUAL-W2 model development team, however, adheres to this convention, and it would be wise to do the same with all code alterations, in case a compiler is used that does not allow source line lengths greater than 132 columns.

Response:

The TMDL development team appreciates the reviewers recommendations regarding code formatting practice.

Ce. Comment(s):

Flux calculations. Changes were made in the Tetra Tech code that affect the computation of flux outputs. These values are computed for the convenience of the model user, have absolutely no effect on simulated flows, temperatures, or concentrations, and their output can be turned on or off by the user. Flux computations were turned off in the model runs that were reviewed. Should they be turned on, however, the code changes appear to introduce new errors, beyond the problems that already existed in the version 3.12 flux computation code. Model users should be aware of this problem and keep the flux outputs turned off; if user requirements dictate that these calculations be turned on, the code would first need to be fixed.

Response:

The flux calculation introduced into the code was not intended to be used, nor was it used, in this TMDL modeling study. As such, it has no implications on the analysis that was performed.

Cf. Comment(s):

TSR outputs. Time series output files are missing column headings for epiphyton (a problem with the original version 3.12 code). Additionally, if ice computations are turned on, the Tetra Tech code modifications will output the phosphorus, nitrogen, and light limitation factors for algae twice. Those factors are output only for the first algae group. These problems do not affect model computations.

Response:

The TMDL development team appreciates the reviewers comments and recommendations.

D1. Comment(s):

Algae. Processes associated with phytoplankton are some of the most important in determining the water quality of the Klamath River in the Lake Ewauna to Keno Dam reach. In the Tetra Tech model, in an effort to simulate the spatial and temporal patterns of algae, phytoplankton were divided into two groups. This grouping was not based on any species difference or on different responses to light, nutrients, or temperature. Rather, one group was deemed “healthy” and the second group was deemed the same collection of species, but in an “unhealthy” or stressed state. The unhealthy algae were hypothesized to be stressed as a result of exposure to low dissolved oxygen concentrations. New algorithms were added to the model to allow the healthy algae to be converted to unhealthy algae at a user-defined rate upon exposure to a low dissolved-oxygen environment. Similar algorithms allow the unhealthy algae to “recover” and be converted to healthy algae at a different user-defined rate.

The user-defined rates that convert algae between the two groups were set to be functions of the simulated dissolved oxygen (DO) concentration. The calibrated model has four input parameters that determine these conversion rates for phytoplankton, and an additional four that define the conversion rates for epiphyton. The rates used in the Lake Ewauna to Keno Dam model are shown in **figure 9** as a function of DO concentration.

Tetra Tech noted in their draft modeling report (Tetra Tech, Inc., 2008) that this conversion between healthy and unhealthy algae is simply a hypothesis (although they indicate that some support for this idea is available in published research), and that more research is needed on this topic. Although this approach is intriguing and may have some value, it is clear that more research is needed. The two citations provided in the draft Tetra Tech modeling report do not, in fact, appear to support their approach. The first is a fisheries report that gives an overview of algae and water quality in Upper Klamath Lake (National Research Council, 2004), but does not show that anoxia causes poor algal health. The second study cited, by Baric and others (2003), describes an algal mortality event in a small saline lake that is a different environment than the Klamath River. Baric and others (2003) reports on a water-column mixing event that also exposed the algal community (diatoms and microflagellates, not blue-green algae) to large changes in salinity, hydrogen sulfide, temperature, and other chemical parameters, in addition to low dissolved oxygen. The observational study does not attempt to make conclusions about which factor(s) produced the elevated algal mortality. At this point, it has not been demonstrated that the decline of algal health is caused by low dissolved oxygen concentrations in the Link River Dam to Keno Dam reach.

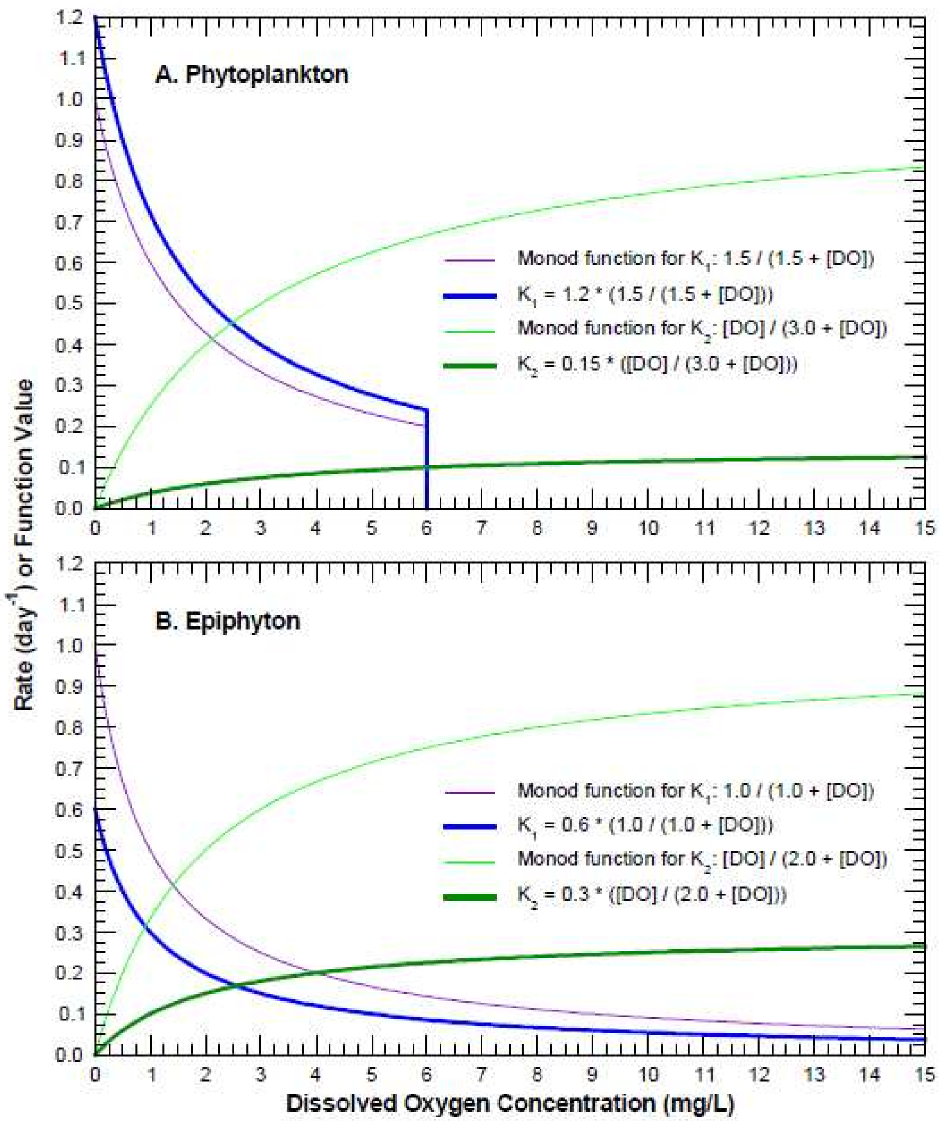

Figure 9. Graphs showing the Monod-like functions and the resulting conversion rates from "healthy" algae to "unhealthy" algae (K_1) and back (K_2) for (A) phytoplankton and (B) epiphyton as modeled by the Tetra Tech Klamath River model for Lake Ewauna to Keno Dam, Oregon. The K_1 rate for phytoplankton is zero when the dissolved oxygen concentration is greater than 6 mg/L.

Regardless of the validity of the approach, a number of questions regarding the selected parameter values are unanswered in the documentation:

• What is the basis for the chosen conversion rates between the two groups?
• Why are the rates so different for epiphyton as compared to phytoplankton?
• Why are healthy algae being converted to unhealthy algae at a significant rate (0.24/day) when the DO concentration is as high as 6 mg/L?
• What is the basis upon which that conversion is truncated to zero above 6 mg/L?

• Why was that 6 mg/L cut-off implemented for phytoplankton but not for epiphyton?
• If all of these parameter values (four for phytoplankton and four more for epiphyton) were set as the basis of a calibration process, how was that calibration process implemented? Was an optimizer used?
• What assurance does the model user have that the calibrated values offer the “best” solution?
• Does a unique solution exist, given this number of calibration parameters? It is highly likely that this solution is not a unique solution. That does not detract, by any means, from the value of a model that matches the measured data; however, it may affect the ability of the model to extrapolate to different conditions (such as natural conditions) and to offer insight into instream processes.

In addition to the rates used to convert algal biomass from one group to another, the two algae groups (healthy/unhealthy) were simulated with different growth, respiration, excretion, and mortality rates. The growth and respiration rates were set to zero for the unhealthy phytoplankton and epiphyton. The mortality rates of the unhealthy phytoplankton and epiphyton groups were set to values that are 5 or more times higher than the mortality rates of their healthy counterparts. No documentation was provided for the method used to establish these rates. Certainly if the algae are stressed, one might believe that they should have a higher mortality rate and perhaps a zero growth rate, but a zero respiration rate does not seem to be supported by either data from this site or published results from other regions.

The variable buoyancy of *Aphanizomenon flos-aquae* (AFA), often the dominant algal species in UKL that is exported to the Klamath River, makes the algae in the river even more difficult to model. The physiological processes in AFA that lead it to be buoyant under certain conditions and non-buoyant under other conditions are not yet well understood, and certainly have not been translated into usable model algorithms. At this time, CE-QUAL-W2 allows only a constant settling rate to be assigned to each simulated algae group, and although newer versions of the model allow a negative settling rate (to simulate buoyancy), algae in this Klamath River TMDL model were simulated only with positive settling rates. It may be that the algae exported to the Klamath River are not in an ideal environment for them to express such buoyancy variations; indeed, the strong settling of some algae in the Lake Ewauna to Keno Dam reach may mean that buoyancy considerations are not particularly important in this reach. The fact remains, however, that the algal communities in the Klamath River are poorly understood and the water-quality models only include algorithms that are a gross simplification of aggregate processes. It is possible that the model simulates the right patterns but for the wrong reasons. Further research into algal dynamics and processes is needed.

In summary, while Tetra Tech’s approach of simulating healthy and unhealthy groups of algae seems interesting and may hold some promise for capturing some of the responses of the algal community to low DO concentrations that heretofore were not represented by CE-QUAL-W2, the additional model calibration parameters that are not tied to published research probably result in a model whose solution is not unique or robust. The uncertainty in the values of these new model parameters leads to additional uncertainty in the model predictions.

Response:
The concept of anoxia-related algae mortality was initially communicated to the TMDL development team by PacifiCorp's consultant Dr. Michael Deas of Watercourse Engineering. The following summarizes these communications between Dr. Deas and Tetra Tech. Previously, Dr. Deas had extensive communications with algae experts across the world about possible impacts of low DO on algae mortality. Dr. Deas indicated that although there was no direct evidence from laboratory research, it is likely that low DO can have a negative impact on algae physiology. Dr. Deas mentioned that his group tried to modify the algae mortality and growth rate in association with DO concentration, however, the effort was not successful because the simple DO-algae parameter relationship they implemented could not address the exposure time of algae to low DO (which is essentially a Langrangian particle-tracking process, whereas the CE-QUAL-W2 framework applies a Eulerian fixed-grid system). To overcome this technical limitation, the TMDL development team formulated a two-state algae transformation algorithm to approximate the Langrangian process within the Eulerian CE-QUAL-W2 system. This new algorithm significantly improved the spatial representation of chlorophyll-a concentrations from upstream to downstream stations in Lake Ewauna over the previous model. The model was tested for both 2000 and 2002 against extensive data, and it successfully reproduced the observed patterns for both years (without parameter adjustment). This suggested that the algorithm reasonably represents the observed phenomenon. Should a more detailed, local scientific investigation be conducted and yield different conclusions, the model could be updated.

The comment includes numerous questions in bullet form about the selection of parameter values used in this algorithm. The crux of the matter is found in the last bullet, when the commenter asks: "Does a unique solution exist, given this number of calibration parameters? It is highly likely that this solution is not a unique solution." In fact, there can be no unique solution to this particular set of equations, nor is there a unique solution to the scores of other equations that are simultaneously solved in the CE-QUAL-W2 model or any other dynamic water quality model. The model developer faces the difficult task of selecting individual parameter values from a reasonable range of possible values, building a number of candidate parameter "suites", running the model repeatedly, and checking its predictions against measured conditions. Through trial and error, a reasonable model setup is eventually obtained. The parameter set arrived upon through this process is not, nor can it be, a "unique solution". The test is whether the parameter set represents a reasonable and plausible characterization of system dynamics. For this reason, the answers to the questions on why specific parameter values were selected are (1) the values are individually and collectively plausible, (2) through trial and error, the selected suite of parameter values results in model predictions that generally agree with the measured conditions, and (3) uncertainty is inherent in all the parameter value estimates, and this uncertainty influences the overall model uncertainty.

The TMDL development team agrees that further research would be beneficial. However, in the absence of additional data or research, the team used best professional judgment to proceed with code modifications related to algae representation. It is important to note that although the healthy-unhealthy algae algorithm is based on DO concentration, it doesn't mean that only DO factors into the equation. That is, other issues that are either associated with low DO (such as hydrogen sulfide) or are manifested through low DO would also inherently be represented by the algorithm.

Finally, the DO-algae algorithm does not have any effect on the TMDL allocations. While necessary to develop the calibrated model for 2000 and 2002, this algorithm does not come into play in the TMDL scenarios, because DO concentrations are significantly higher in the TMDL scenarios due to reduced pollutant discharges.

D2. Comment(s):

D.2. **Sediment Oxygen Demand.** The Lake Ewauna to Keno Dam model is one of four CE-QUAL-W2 models used in the Klamath TMDL to simulate a series of reservoirs on the Klamath River. Although this review focuses only on the most upstream model, it is useful to compare selected model parameters among these four models, and the sediment oxygen demand (SOD) rate provides an interesting example.

The zero-order SOD rate was set to 3.0 g/m2/d in the Lake Ewauna to Keno Dam model, 2.0 g/m2/d for the JC Boyle and Copco models, and 1.1 g/m2/d for the Iron Gate model (in downstream order). The base SOD rate is set by the user through a multiplication of the SOD values and the FSOD factor that are set in the model control file. An examination of the control files also shows that the temperature dependence functions for SOD are different for each of these reservoir models (**fig. 10**).

Measurements by Eilers and Raymond (2003) show that the SOD rate does decrease from one reservoir to the next downstream, thus providing some basis for the pattern in the modeled rates. However, measurements of SOD rates in the Lake Ewauna to Keno Dam reach by USGS in 2003 showed a range of 0.3 to 2.9 g/m2/d with a median rate of 1.8 g/m2/d, as adjusted to a temperature of 20°C (n=22; Doyle and Lynch, 2005). So, although some USGS measurements of the SOD rate approach the modeled baseline value of 3.0 g/m2/d in the Lake Ewauna to Keno Dam reach, the modeled SOD rate in that reach may be too high. The temperature function used for the Lake Ewauna to Keno Dam model results in a modeled SOD rate of 2.8 g/m2/d at 20°C, which is still well higher than the USGS-measured median value adjusted to the same temperature. The temperature adjustment function used with the USGS measurements is different from those shown in **figure 10**, but the modeled rate still appears to be higher than the measured rate.

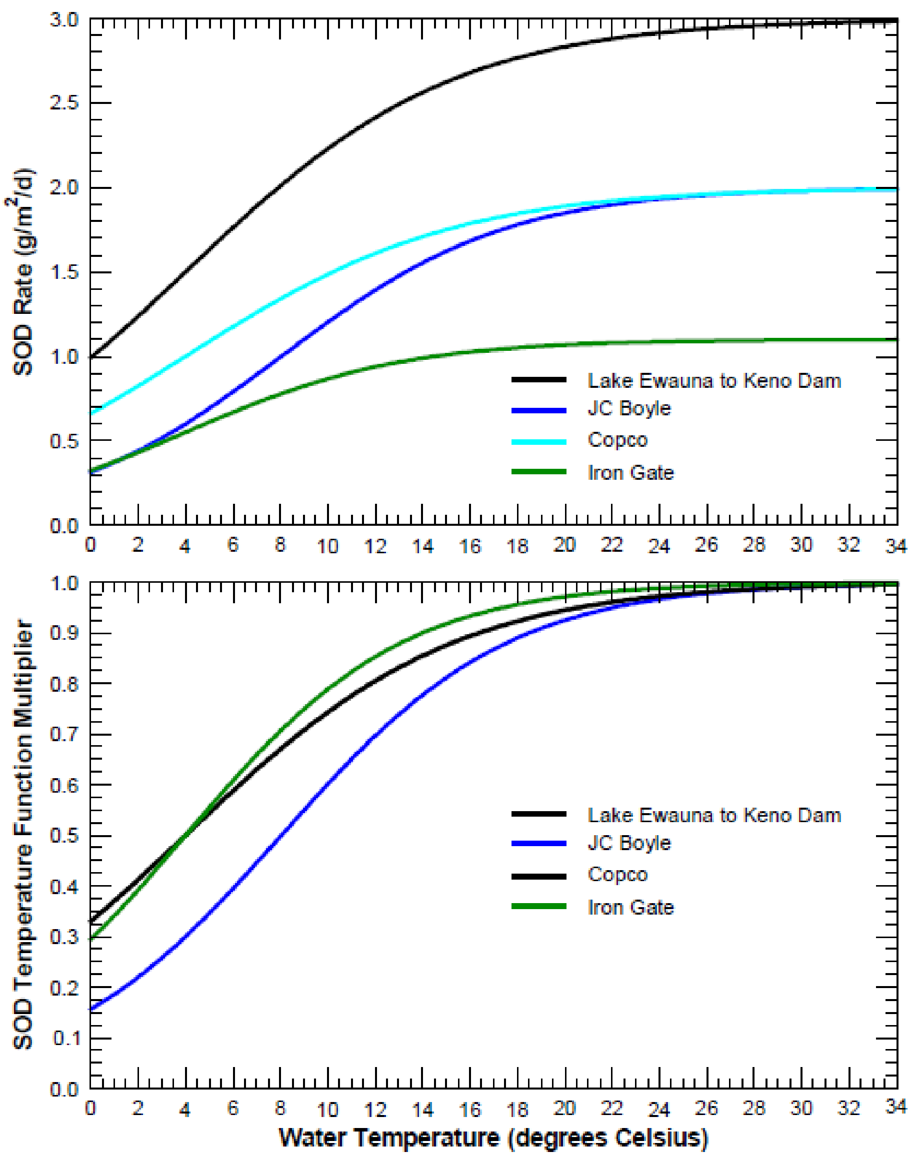

Figure 10. Graphs showing the zero-order sediment oxygen demand (SOD) rate and the SOD temperature rate multiplier function used by the Tetra Tech Klamath River reservoir models.

<u>Response:</u>

The SOD in the Klamath River model is configured as a zero-order oxygen demand, which essentially represents the highest possible oxygen demand imposed by the sediment on the water contacting the bed. As seen in the temperature-SOD plot in the comment, the temperature modification algorithm reduces the SOD at lower water temperatures in the range of temperatures in this system. Therefore, the value set in the model should usually be similar to the largest measured value, which is 2.9 gO2/m2/day. In reality, SOD can change significantly from site to site and from time to time due to heterogeneity in sediment composition and OM depositional flux variability. Setting uniform SOD across an entire reach of a waterbody, when detailed data are not available, is a gross approximation, but it is the most warranted approach (unless the value results in a poor calibration). The calibration results for dissolved oxygen indicate that the selected SOD values are reasonable.

D3. Comment(s):

2000 vs. 2002 parameter values. A model is considered most robust when the same set of model parameters and rates is able to predict conditions for multiple years and environmental conditions where measured data are available. The Lake Ewauna to Keno Dam model was calibrated to conditions that occurred in 2000, and tested against conditions that occurred during 2002. For the 2000 and 2002 current conditions models, most of the model parameters applied to the 2 years were the same, but several differences were notable. For example, the 2002 model used an ammonia nitrification rate that was one-half that used in 2000 (**table 1**), but the basis for the difference is not documented. It seems unreasonable that the nitrification rate would change to one-half of its original value in only 2 years and that the population of nitrifying bacteria would be so different only 2 years later. The use of different parameter values in different years results in a less robust model and reduces confidence in the model's predictive ability.

Table 1. Model parameters from the CE-QUAL-W2 control file that differ between the 2000 and 2002 current conditions runs and the natural conditions scenario.

Model parameter	Parameter description	Current conditions 2000	Current conditions 2002	Natural conditions 2000
NH4DK	Ammonia nitrification rate, 1/day	0.10	0.05	0.10
O2LIM	Dissolved oxygen half-saturation constant for decomposition processes, mg/L	0.1	2.0	0.1
LDOMDK	labile DOM decay rate, 1/day	0.25	0.25	0.20
LPOMDK	labile POM decay rate, 1/day	0.25	0.25	0.20
POMS	POM settling rate, m/day	0.80	0.80	0.05

The 2002 model used a DO half-saturation constant for decomposition processes (O2LIM) that was 20 times higher than that used in the 2000 models (**table 1**). This was probably an oversight, because Tetra Tech significantly altered the use of this variable in the model source code and prior to that alteration, its value in some previous model runs for the Klamath River had been set to the value used in the 2002 model run. Still, this mistake has a significant effect on decomposition processes that occur in the river, and this inconsistency needs to be corrected. Moreover, some basis for choosing 0.1 mg/L versus 2.0 mg/L for this parameter would be useful; at this time, no such basis has been documented.

Differences also exist for some of the decomposition and settling rates used for organic matter in the 2000 current conditions and natural conditions models (**table 1**). The reason these different values were selected was not documented. If the sources and nature of organic matter truly are expected to be different under the natural conditions scenario, then it is possible that the decomposition rates might be smaller than those that occur under current conditions. However, the available data for organic matter in this system was sparse during model development, and going further to predict how decomposition rates might change in the future, without well-documented literature and/or laboratory research to back-up the new rates, is speculative. Furthermore, the very nature of particulate organic matter in the system would have to change greatly to support a decrease in the settling rate from 0.8 to 0.05 m/d. The 0.8 m/d rate for current conditions already may be biased low. Preliminary unpublished findings from recent measurements of particulate settling rates in the Lake Ewauna to Keno Dam reach of the Klamath River may show even higher settling rates (Watercourse Engineering, Inc., written commun, 2009). Further research and measurements may be necessary.

Response:

The inconsistent values noted have been corrected and documented in the final Model Report, and these corrections did not result in major changes in model predictions. The 2000 and 2002 model parameters are all the same with the exception that in the 2002 model the SOD in Lake Ewauna is changed from 3.0 gO2/m2/day to 2.0 gO2/m2/day to reflect potential inter-year variability as suggested by the data and calibration for Lake Ewauna. Previously, the OM settling velocity in the TMDL scenarios was set to a relatively low value (0.05 m/day) to account for the fact that when the TMDL is achieved upstream, the majority of the OM would become dissolved. The model has been revised, and the settling velocity has been restored to the calibrated value (0.8 m/day), but the partitioning of UKL, LRDC, and KSD has been changed to 90% dissolved and 10% particulate.

Da. Comment(s):

ISOURCE error. For the Lake Ewauna to Keno Dam model, the user-supplied input values of IDAG1 and IDAG2 (or ID1 and ID2 on the ALGAL RATE input card) combined to cause the value of the ISOURCE2(2) variable in the source code to remain at its initial value of 0. With some Fortran compilers, this might have resulted in a subscript out-of-range error when values such as

AKR2(ISOURCE2(2)) and HDOAG2(ISOURCE2(2)) were used, because Fortran array indices normally start at 1 rather than 0. No such run-time error was reported in this case. Perhaps these values were set to zero by the program at run-time. If so, then the correct result was obtained. It appears that IDAG2 for the first algal group should have been set to 2 rather than 1 in the control file. Setting the value of IDAG2(1) to 2 and re-running the model showed identical results, so this error in the control file did not affect the model output.

The same type of subscript problem also occurs in the code for ALG(K,I,ISOURCE2(2)). Because the ALG() array points to the C2() array, a subscript problem here might cause a subscript out-of-range error, or the compiler might set the value to zero, or an unintended value from the C2() array might be assigned to the algal concentration. This highlights the need to be careful with the IDAG1 and IDAG2 values in the control file. The same error was present in the control file for the epiphyton groups. IDEG2(1) should have been set to 2 rather than 1.

Response:
As noted by the reviewers, this doesn't have impact on the model results.

Db. Comment(s):
Light extinction. Baseline light extinction coefficients were set to 0.60/m in the Lake Ewauna to Keno Dam model and the JC Boyle model, and 0.25/m in the Copco and Iron Gate models. Watercourse Engineering has some data to show that light extinction varies considerably along the course of the river. Some documentation of these effects, if not already in place, would be useful.

Response:
In the absence of documented information suggesting that variable light extinction coefficients should be applied, all the EXH2O values have been set to 0.45/m for all the reservoirs. Although a uniform background light extinction value (for EXH2O) is set for all the reservoirs, the total light extinction varies considerably from one waterbody to the next. This is due to differences in OM concentration, algae concentration, and ISS concentration.

Dc. Comment(s):
AHSN. The nitrogen half-saturation constant for phytoplankton growth was set to 0.014 mg/L for the Lake Ewauna to Keno Dam, JC Boyle, and Iron Gate models, but was set to 0.021 mg/L for the Copco model. The reason for these differences was not documented. Note that the modeling report (Tetra Tech, Inc., 2008) states that these parameter inputs are all the same and set to 0.014 mg/L.

Response:
The value of AHSN in the Copco model has been set to be the same as other

reservoirs in the system.

E1. Comment(s):

Calibration time period. The Link River to Keno Dam models were calibrated to conditions that occurred during 2000 and checked with data from 2002. It has been noted that the 2002 test period was not an independent check of model performance because several model parameters were altered for the 2002 model runs. Still, an assessment of the 2002 test period is useful. Additional years of data were available for further calibration checks, but those additional data were not used.

Although all modeling studies are limited by available data and staff time, and necessary limits must be placed on the amount of effort expended, the use of data from only 1 year for model calibration can be a problem. Typically, 1 year of data is insufficient to represent the wide range of hydrologic, meteorologic, and water-quality conditions that can occur in the Klamath River. Previous work by Wood and others (2006), for example, indicates that water-quality in UKL is affected by inputs and climate conditions that vary from year to year, resulting in year-to-year variations in the water quality that enters Link River. Building a model on only 1 or 2 years of data results in a model that is less robust than if it were built on multiple years of data. Extrapolation becomes more necessary when using a model that is based upon only 1 year of calibration data, and the results, therefore, become more uncertain.

Recognizing the limitations imposed by timelines and available data, it would be appropriate, as more data become available and a better understanding of this river starts to take focus, for the modeling to be revisited in order to build a more robust predictive tool for the better management of this important river system. Staff at Watercourse Engineering, Inc., for example, have extended the modeled time frame for these models to include 4 or 5 years of data. Additional years of data, therefore, are available for testing. Note that USGS has not evaluated the Watercourse Engineering models, and this reference to that effort does not imply endorsement by the USGS.

Response:

The few inconsistent parameters between simulation years have been corrected. Regarding the calibration period, the TMDL development team disagrees with the comment that the TMDL is severely weakened by the use of a single model year. TMDLs are frequently developed using a single, “design” year selected by the project team. The year chosen for developing the model and establishing the TMDL was selected because it included periods of critical low flow and poor water quality conditions. This is consistent with the margin of safety requirement and the goal of developing environmentally conservative allocations.

The comment does not account for the documented capability of the model to capture within-year variability in this highly managed and variable system. The Klamath River TMDL model development process has been heavily focused on capturing seasonal variability to the extent practicable. The TMDL development team does not believe that adding more model years to the model development process would significantly change the model parameters, given the within-year variability in this system.

It should also be noted that the Oregon portion of the model was calibrated using two model years. There was not sufficient data to evaluate the California portion of the model for the second year (2002).

E2. Comment(s):

Error statistics. Goodness-of-fit statistics can be useful in assessing model performance, but no such statistics were provided in the draft Tetra Tech modeling report (Tetra Tech, Inc., 2008). In order to make a performance assessment, a quantitative comparison between simulated and measured data was made in the course of this review to compute goodness-of-fit statistics for the model's predictions of water temperature and dissolved oxygen concentrations (**table 2**).

Table 2. Goodness-of-fit statistics for the Tetra Tech model of Lake Ewauna to Keno Dam, Oregon, using data from May 1 through November 1.

[Model data were compared to measurements made 1 m below the river surface. Site locations are shown in figure 2.]

Parameter	Site	Year	Mean error	Mean absolute error	Root mean squared error
Water temperature (°C)	Miller Island	2000	0.08	1.13	1.50
		2002	0.42	1.09	1.48
	Keno	2000	0.36	0.76	0.98
		2002	0.78	0.92	1.13
Dissolved oxygen (mg/L)	Miller Island	2000	-0.52	1.89	2.48
		2002	0.38	2.14	2.71
	Keno	2000	-0.67	1.61	2.08
		2002	-0.03	2.15	2.68

Previous studies indicate that a CE-QUAL-W2 model is capable of matching measured water-temperature data with a low bias (mean error) and a mean absolute error approaching 0.5°C and certainly less than 1.0°C (Sullivan and Rounds, 2005; Sullivan and others, 2007). This model comes close to that criterion for the mean absolute error at Keno, but not at Miller Island, and the model exhibits a positive bias that is larger than optimal. Moreover, this bias likely would be larger if the hard-coded 20-percent reduction in solar radiation, discussed in section C.4, were removed. As it is, the model captures the seasonal pattern in water temperature well and is adequate for framing the rates of chemical and biological reactions used by the model. These goodness-of-fit statistics indicate, however, that the model simulates water temperature with good, but not excellent, accuracy. Improvements are possible based on points made earlier in this review.

The simulation of dissolved oxygen concentrations by the model shows that large prediction errors on the order of 1.6 to 2.2 mg/L are present, although bias appears to be low most of the time, as the mean error ranges from near 0 to about -0.7 mg/L. Simulating dissolved oxygen is difficult in a system like the Klamath River where algae dominate many water-quality processes; however, it has been demonstrated that CE-QUAL-W2 can simulate dissolved oxygen concentrations with a mean absolute error of less than 1 mg/L in other aquatic systems (Rounds and Wood, 2001; Sullivan and Rounds, 2005). Additional work is needed to identify the process(es) that are not being simulated with sufficient accuracy, or the erroneous boundary conditions that cause DO prediction errors. The performance of the model should be assessed in more detail using goodness-of-fit statistics for these and other modeled constituents, and sensitivity tests should be used to assess the importance of some of the model input parameters.

When assessing model error, two issues are paramount. First, the model errors should not be so large that they compromise the ability of the model to answer the user's questions about flow, water temperature, and water quality in the reach of interest. The user must determine how much error is acceptable and incorporate the model's uncertainty and error into their assessment of model predictions. Second, it is important to remember that goodness-of-fit statistics do not provide a complete assessment the robustness of the model algorithms. Although small errors are indicative of algorithms that are simulating the most important processes in an accurate manner, they are no guarantee that those algorithms can be extrapolated accurately to a different set of conditions. For that reason, it is important the model algorithms are based on the best science and the model is tested over as wide a range of conditions as possible.

Response:

We do not agree with the USGS comments on error statistics and model performance. First, we disagree with the exclusive use of quantitative measures (error statistics) to evaluate model performance and uncertainty. While error statistics are often used in evaluating model calibration, they are not the only source of information for model performance evaluations, and they are not the best source of information for the Klamath model. Second, we disagree with the premise that the error statistics for the Klamath system should be directly compared to the statistics from a model of another waterbody, because different systems pose different challenges that alter the prospects for achieving a particular levels of corroboration between simulations and measurements. As noted in the TMDL and modeling documents, the Klamath system presents significant challenges for model development compared to more simple systems and/or systems with more robust data collection.

In focusing solely on error statistics as indicators of model performance, USGS misses the critical importance of qualitative comparison of time series plots as a key element of model evaluation for a dynamic (time-varying) model. Ironically, other comments submitted by USGS support this viewpoint. In its comments regarding boundary input uncertainty for organic matter, for instance, the commenters present graphical plots to support its concerns about varying patterns of the model inputs compared to measurements. The commenters did not calculate error statistics to argue that the difference in organic matter representations was significant; rather, they referred the agencies to graphical plots that readily show differences in the magnitude and time-varying patterns in the data. This is because the graphical comparisons provide: (1) excellent depictions of difference in time-varying data; and (2) complete depictions of these differences (see below for discussion of potential shortcomings of error statistics for point data). Yet in discussing model performance, the commenters narrow its concerns to the values of error statistics, failing to give equal or greater weight on the voluminous graphical comparisons provided in the model report to depict model performance.

Making a “point-by-point“ comparison (i.e. a comparison of a water quality observation for a given date and time versus the modeled value for the same date and time) can result in relatively poor error statistics even when the overall model performance is relatively good, particularly in a highly productive and variable system such as the Klamath River. This problem occurs because the underlying data for the model does not include the precise timing of the physical, chemical, and biological phenomenon occurring in the system. Thus, a change on a short time scale in the real world is not included in the model input data, and this problem manifests itself in the error statistic. This error may be irreducible. Thus the model parameters (e.g., growth rates, decay rates) may be well-estimated, but the error statistics will still be relatively high compared to errors in models for less variable waterbodies. Another factor in the error evaluation is measurement error. Errors in measurements are usually discovered in qualitative review of graphical plots of data versus model simulations and may be completely missed if error statistics alone are used to evaluate calibration.

While we understand the desire for model acceptance criteria that employ error statistics, we do not believe such criteria are feasible or appropriate for TMDL model development. USGS suggests that, on average, temperature errors should be less than 1 deg C and dissolved oxygen errors should be less than 1 mg/l. We agree that these error values can be a reasonable starting goal for model development, but the unique features of the system and the available data will ultimately determine the error range. It is unrealistic to set an across-the-board acceptance criterion for water quality models. The goal of TMDL development is to develop the best model possible given the constraints of time, agency resources, and available information.

To summarize, evaluation of time series plots of modeled versus observed data provides more insight into the nature of the system and is more useful in water quality calibration than a statistical comparison. Time series plots allow review of trends and time-varying patterns in the observed data and model predictions. The features of the system and model representation are not captured well in tabular listings of model error statistics. Thorough review of the trends, relationships, and magnitudes of parameters of interest can lead to a good overall calibration, better understandings about model uncertainty and limitations, and a model that can be successfully applied to assess management alternatives. We believe the graphical comparisons provided in the model report clearly demonstrate that the model reasonably captures the overall trends and patterns in the data for this highly-variable system.

Finally, as indicated above, we are concerned about the inclination to set unrealistic model acceptance criteria on water quality models for this TMDL and others. Nonetheless, to provide information for future model development teams in complex systems like the Klamath River,,a representative set of error statistics have been calculated and presented in the final Model Report.

E3. Comment(s):

Nitrate calibration data. Nitrate concentrations in the Tetra Tech calibration datasets at Miller Island and Highway 66 in 2000 show a seasonal pattern that is different from data collected by ODEQ and USGS at the same location and during the same time period. The ODEQ and USGS datasets, including the long-term 1981–2007 ODEQ dataset, show remarkably consistent low concentrations of nitrate during summer, less than 0.2 mg/L from June through early September, with higher concentrations in winter (**fig. 11**). Model output shows the opposite pattern, with low concentrations in winter and high concentrations (greater than 0.8 mg/L) during summer. The draft modeling report (Tetra Tech, Inc., 2008) also questions the validity of the nitrate calibration data, but the model apparently still was calibrated in an attempt to match that dataset. The reason for the discrepancy between the Tetra Tech and the ODEQ and USGS nitrate data should be investigated, and the model should be calibrated to the most reliable data.

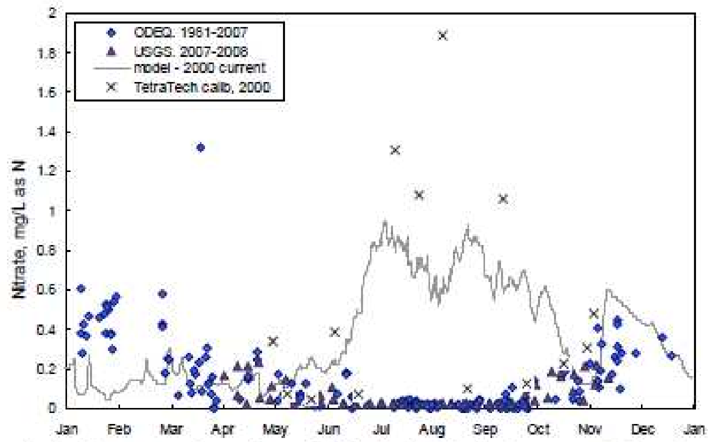

Figure 11. Graph showing comparison of year 2000 simulated nitrate concentrations to measured data from ODEQ and USGS from the Klamath River above Keno at Highway 66. ODEQ data were collected approximately six times per year, and only data reported in units of mg/L as N are plotted. USGS data were collected weekly from April to November during 2007 and 2008.

Response:
The USGS review overlooks the fact that the modeled NO3 concentrations match the observed NO3 concentrations for the 2002 simulation. 2002 has low NO3 concentrations in Lake Ewauna, but the 2000 NO3 data in the database show that there are several very high NO3 concentrations during the summer at the Hwy66 station. This contradicts the USGS conclusions. The model simulates the trends shown in the data for both years reasonably well.

E4. Comment(s):
Organic Matter. At the time of model development, no data on dissolved and particulate organic carbon were available with which to calibrate the model. Data collected in 2007 and 2008 (**fig. 12**) at Miller Island and Keno show that the concentration and timing of seasonal cycles for dissolved organic carbon was similar between sites and years, with maximum concentrations in late summer of 12–13 mg/L. Model results for 2000 and 2002 show lower concentrations and different temporal patterns.

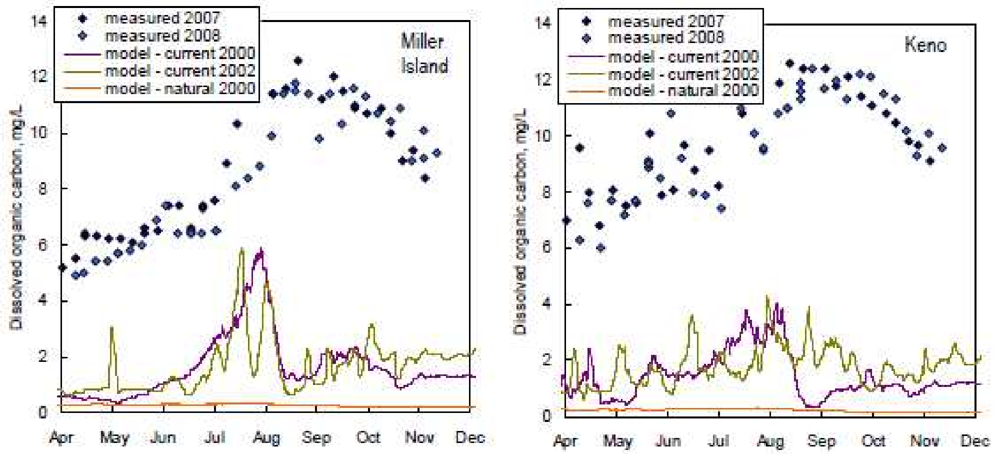

Figure 12. Graph showing measured 2007–08 dissolved organic carbon concentrations at Miller Island (left) and Keno (right) along with model output at the same locations. Modeled LDOM was converted to dissolved organic carbon using the 0.45 organic carbon to organic matter ratio specified in the model control file.

Organic matter, nutrients, algae, and dissolved oxygen are closely linked in aquatic systems, and these dependencies are included in the model code. Because the concentrations, fractionation, cycles, and decay rates of organic matter are not adequately captured in the current conditions models, it is likely that the calibrated organic matter parameters in the model, such as decay or settling rates, also are not correct. This results in less confidence in the model results for organic matter, nutrients, algae, and dissolved oxygen when the model is extrapolated to theoretical scenarios such as natural conditions.

<u>Response:</u>
Refer to A5.

F1. <u>Comment(s):</u>
Natural condition boundary flows. The natural conditions scenario has three sources of inflow: Link River, the Lost River Diversion Channel, and the Klamath Straits Drain. The North and Ady Canal withdrawals from the current conditions models were retained, but at slightly different flow levels. All point source, stormwater, accretion flow, and distributed tributary flows were set to zero. Although it is reasonable to remove anthropogenic inflows (such as point sources) in a natural conditions scenario, the purpose of some of these inputs was to account for natural ungaged tributaries and any groundwater inputs. Removing all of them, and having a system whose only inflows are Link River, the Lost River Diversion Channel, and the Klamath Straits Drain is overly simplistic. Furthermore, the difference in flow makes the results more difficult to compare to the current conditions scenario. Management and regulatory agencies regularly determine flow boundary conditions for natural conditions scenarios that are consistent with

their needs and policies. Groundwater inflows should be retained in those scenarios to realistically simulate natural conditions.

Response:
The purpose of the natural condition baseline scenario was to provide a baseline to estimate the impact of different loading scenarios (not simply as a comparison to current condition). Keeping the hydrology consistent between these scenarios allowed us to focus on how pollutant loading to the system impacts water quality rather than how a change in hydrodynamics would impact water quality. We decided not to include the accretion / depletion flows of Keno Reservoir in these scenarios because of their potential to alter concentrations in the stream. These accretion / depletion flows are highly variable but their impact on the overall water balance is minimal. Because of this variability, they do not likely represent groundwater but more likely represent imperfectly measured boundary conditions.

F2. Comment(s):
Keno reef flows. Bureau of Reclamation staff, using pre-dam data collected prior to 1910 (Hoyt and others, 1913), derived a stage-discharge relation for the Klamath River at the Keno reef. Those data and the Bureau of Reclamation's quadratic fit to the data are shown in **figure 13**. The stage-discharge equation was provided to Tetra Tech, and they made code modifications to CE-QUAL-W2 to implement a new quadratic spillway flow formula to accommodate this stage-discharge relation.

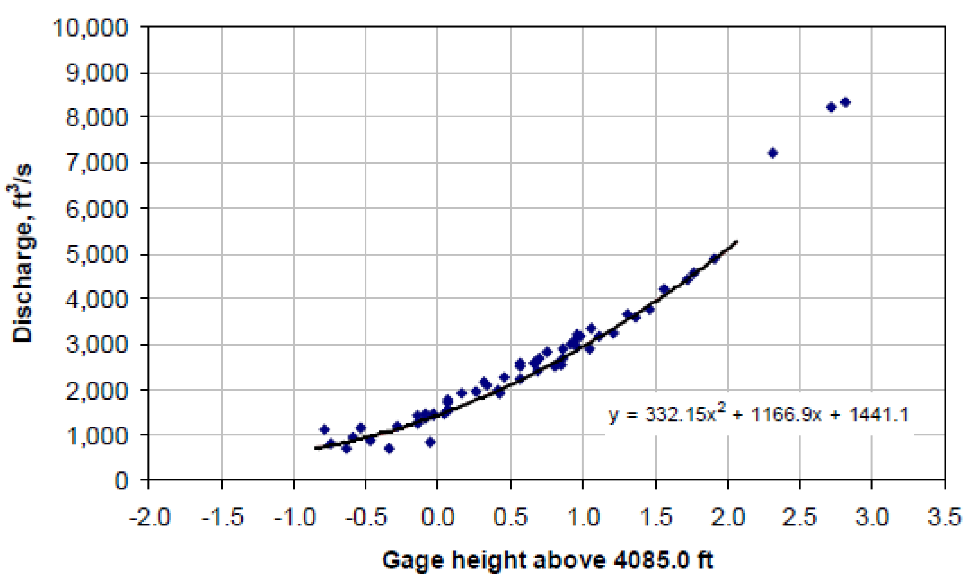

Figure 13. Graph showing stage-discharge relation generated by Bureau of Reclamation staff for the Klamath River at the Keno reef, using pre-dam data from the U.S. Geological Survey.

The natural conditions model scenario uses this new formula to calculate the flow at the Keno reef, but Tetra Tech implemented the stage-discharge relation in a slightly modified fashion. First, they had to convert the equation coefficients to metric units to be consistent with the units used by CE-QUAL-W2. Second, they translated the equation so that the stage would be relative to a datum of 4,083.0 ft rather than the datum of 4,085.0 ft used by Bureau of Reclamation, presumably so that the stage used in the model equation would always be positive. The resulting equation is:

y = 101.239 x2 – 15.022 x + 12.343,

where y is discharge in m3/s and x is gage height in meters relative to a datum of 1,244.5 m (4,083.0 ft). Indeed, these three coefficients are very close to those specified in the natural conditions scenario. To preserve the functional form of the stage-discharge relation from the Bureau of Reclamation, however, the elevation of the spillway (ESP) must be set to the reference elevation of 1,244.5 m (4,083.0 ft). It was not. For some reason, the elevation of the spillway was set to 1,244.82 m (about 4,084 ft).

Simulated water surface elevations at Keno for the year 2000 show that the natural conditions levels were higher from January through March, but lower by about 0.5 m from June through December, relative to the current conditions model. Re-running the natural conditions model with a Keno reef spillway elevation of 1,244.5 m (4,083.0 ft) resulted in simulated water levels that, as expected, were about 1 ft lower (**fig. 14**).

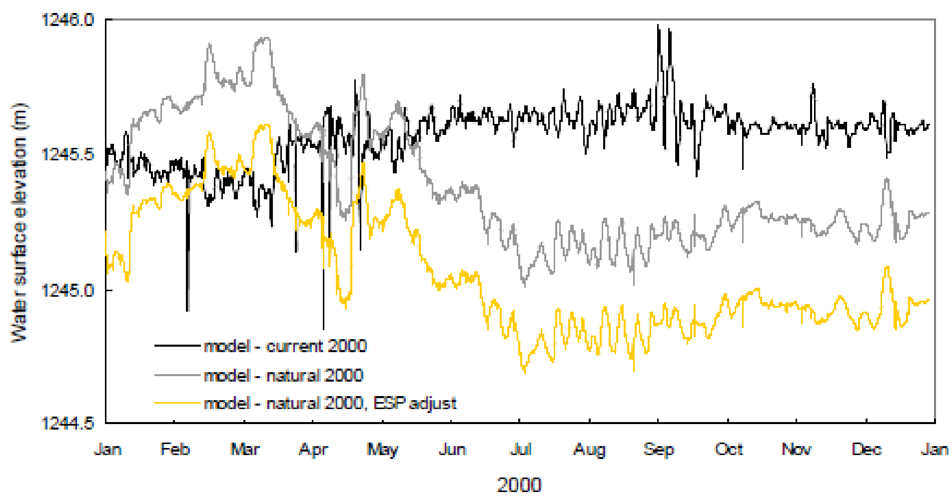

Figure 14. Graph showing water surface elevation at segment 107 (the location of Keno Dam) from the current and natural conditions model scenarios in 2000. The natural conditions model was rerun with a lower Keno reef spillway elevation to produce the "ESP adjust" results. (ESP is the model input spillway elevation.)

The Keno reef keeps the Lake Ewauna to Keno Dam reach pooled at about the same, but perhaps slightly lower, level in the absence of Keno Dam. Because the reach remains pooled, it seems appropriate to ask whether removing Keno Dam has much of an effect on the simulated residence time. CE-QUAL-W2 has the ability to track the average "age" of water that traverses its grid. When all new sources of water to the model reach are given an age of zero, and the age of all water within the grid is increased at the same rate as the elapsed simulation time, then the simulated age becomes the average time that a parcel of water has spent in the model reach. Extracting this information from the water that is discharged at the downstream boundary reveals the average residence time of the water. That average residence time is compared for the current and natural conditions scenarios for the year 2000, along with the re-run natural conditions scenario, in **figure 15**.

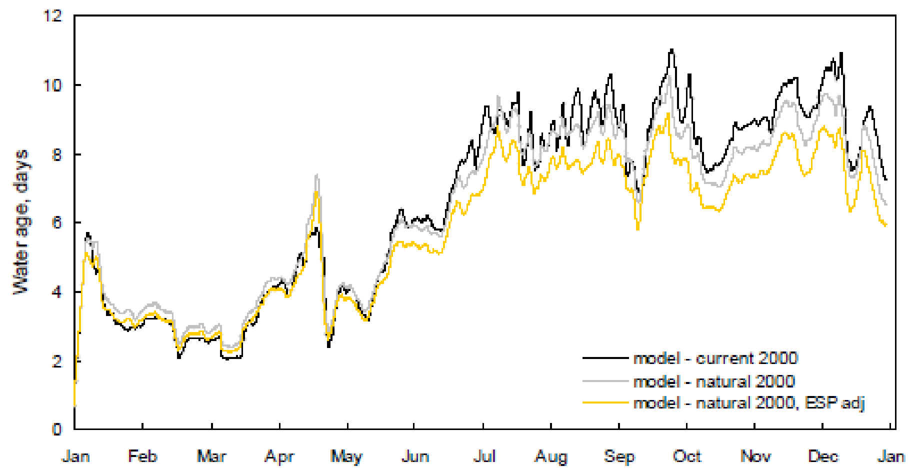

Figure 15. Graph showing average simulated residence time in the Lake Ewauna to Keno Dam model under current and natural conditions for the year 2000. The natural conditions model was rerun with a lower Keno reef spillway elevation to produce the "ESP adj" results.

The simulated residence times indicate that the current and natural conditions scenarios retain water in the Lake Ewauna to Keno Dam reach for approximately the same amount of time. The residence time is slightly shorter for the natural conditions scenario late in the year, which is consistent with the slightly lower pool level. Given that the residence times are similar, the processes of particle settling, algal growth and respiration, ammonia nitrification, and organic matter decomposition, to name just a few, will have approximately the same amount of time to exert their effects. An examination of simulated dissolved oxygen concentrations for the two natural conditions scenarios (original and rerun with a lower Keno reef spillway elevation) showed little difference at the Keno reef location. Differences in water quality between the current and natural conditions scenarios, therefore, likely are caused mainly by differences in boundary inputs rather than by removing the Keno Dam. It would be good to determine what the best Keno reef spillway elevation is for the natural conditions scenario, but the effects on residence time may not greatly affect the simulated water-quality results.

Finally, this stage-discharge relation and the accompanying code modifications were not documented by Tetra Tech in any of the materials provided for this review. Documentation for the Keno reef flow calculations needs to be included in any future model documentation.

Response:
The minor shift in the Keno reef datum was caused by a unit conversion from feet to meters when using a lower resolution conversion factor. The model was updated using a higher resolution conversion factor, i.e., 1 meter = 3.281 feet, to obtain the same datum as indicated in this comment.

F3. Comment(s):
Natural conditions TDS. Total dissolved solids (TDS) concentrations were set to 0 mg/L for the Lost River Diversion Channel and the Klamath Straits Drain inputs in the natural conditions scenario. Although dissolved solids may decrease under "natural" conditions, the concentration is unlikely to decrease to near 0 mg/L. Errors in TDS concentrations can lead to errors in simulated water density and pH, but should have little effect on important constituents such as dissolved oxygen, algae, nutrients, and organic matter.

Response:
Refer to A3.

F4. Comment(s):
Natural conditions OM. At the time of model calibration, few measurements of the concentration and nature of organic matter were available for the Lake Ewauna to Keno Dam reach. As a result, the way that organic matter is represented in the current conditions model does not match the data that now are available in this reach. Of particular note is the underestimation of dissolved organic matter concentrations in the current conditions model (see comments A.5 and E.4).

In the natural conditions scenario, all inflow (Link River, Lost River Diversion Channel, Klamath Straits Drain) dissolved organic matter (DOM) concentrations were decreased to concentrations less than 0.8 mg/L (0.4 mg/L as dissolved organic carbon, **figure 5**). These extremely low concentrations of DOM are unlikely in this reach of the Klamath River, given historical conditions where wetlands, which tend to be a source of refractory DOM, were plentiful (Hoyt and others, 1913). Rivers and lakes usually have concentrations of dissolved organic carbon in the range of 2 to 10 mg/L, whereas swamps, marshes, and bogs tend to have higher concentrations, from 10 to 60 mg/L (Thurman, 1985). Although DOM can be less reactive than particulate organic matter, it still contributes to the nitrogen, phosphorus, carbon, and oxygen cycles in the river and model (**fig. 16**), so any misassignments in the DOM concentration will affect these other constituents as well.

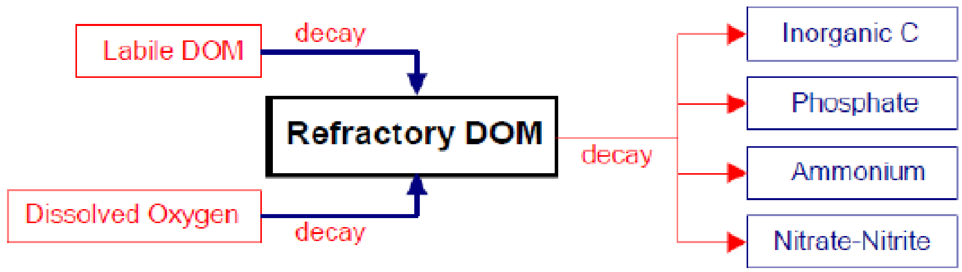

Figure 16. Diagram showing connections between refractory dissolved organic matter (DOM) and other water quality parameters in the CE-QUAL-W2 model (from Cole and Wells, 2002). Labile dissolved organic matter connections are similar, but also include sources from algal and epiphytic excretion and mortality.

The natural conditions model scenario sets much lower particular organic matter concentrations than those used in the current conditions model (see **fig. 5**). This represents a significant extrapolation from calibrated conditions, which is not a problem as long as the modeled instream processes are captured accurately. If the TMDLs for UKL are successful, however, the nature of the organic matter being delivered to Link River from UKL likely will change as the amount and type of algae change in the lake. It is difficult to know the characteristics of that organic matter in a future condition; at the least, the model predictions for the natural conditions scenario have a greater uncertainty.

Response:
The natural condition baseline scenario has been revised and represents organic matter using 90% dissolved and 10% particulate based on Thurman (1985) and the commenter's proposal that the nature of organic matter leaving Upper Klamath Lake will change.

Reference used in Response F4:
Thurman, E.M.. 1985. Organic geochemistry of natural waters. Durdrecht, The Netherlands. Nijhoff/Junk Publishers. 497 pp.

F5. Comment(s):
Natural conditions N and P. The nitrogen and phosphorus upstream boundary conditions imposed for the natural conditions scenario are greatly decreased from those in the current conditions scenario (**fig. 17**). Annual average upstream boundary concentrations for the natural conditions scenario are 0.006 mg/L phosphate (as P), 0.007 mg/L nitrate (as N), and 0.068 mg/L ammonia (as N). These concentrations, though presumably set to be consistent with upstream TMDL criteria from UKL, seem rather unlikely in light of the high-phosphorus

content of soils in upstream areas as well as historical data from UKL and the surrounding wetlands. The specified nitrogen and phosphorus concentrations represent conditions that probably would be classified as oligotrophic or near-oligotrophic. In contrast, paleolimnological investigations of sediment cores from UKL have reported that the lake was eutrophic and productive for the entire history embedded in those cores (hundreds of years), although recent times indicate a shift to higher nutrient and sediment inputs and new plankton species (Eilers and others, 2003; Bradbury and others, 2004). Regardless of whether these nutrient concentrations are realistic, achievable, or consistent with historical data, it is clean that these concentrations are highly uncertain. These low concentrations also are lower than most concentrations that were encountered during the model calibration process; therefore, additional uncertainty results from this extrapolation of the model.

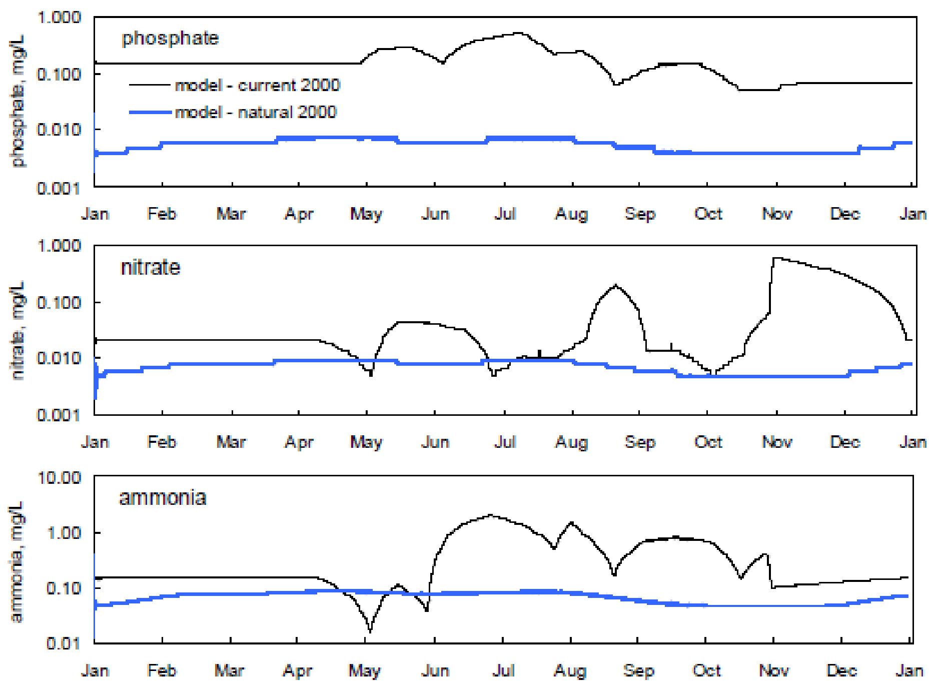

Figure 17. Graphs showing boundary input concentrations of phosphate, nitrate, and ammonia for current and natural conditions scenarios for the year 2000. Note that the graphs are on a logarithmic scale.

Response:

The representation of the Upper Klamath Lake (UKL) boundary condition for the natural condition baseline scenario is consistent with Oregon Department of Environmental Quality's (ODEQ) Upper Klamath Lake TMDL and predicted natural conditions. A detailed description of the representation of Upper Klamath Lake will be included in ODEQ's Klamath River TMDL document, which will be released for public comment in early 2010. Briefly, the UKL TMDL model predicts a range of conditions which can be expected and one set of those conditions representing the median was chosen as a boundary condition for the models used compute allocations. For this median year condition, the UKL model predicted average total phosphorus concentrations during the spring and summer of 25 µg/L and the average summer chlorophyll a concentration of 30 µg/L. These concentrations are considered “eutrophic” based on the classification system presented in Wetzel (1983). Therefore, we believe that this representation is consistent with the paleolimnological investigations referenced in your comment. We agree that the representation increases the uncertainty of the model results, however we used the best available representation of Upper Klamath Lake and an appropriate Margin of Safety to account for this unavoidable uncertainty.

Fa. Comment(s):

Natural initial conditions. Although boundary water-quality inputs were set with nutrient concentrations that are notably lower than the current conditions inputs, initial conditions, which are set in the CE-QUAL-W2 control file, have values that are higher, closer to current condition values. For example, the initial ammonia concentration was set to 0.61 mg/L, whereas inputs from the three natural conditions inflows are mostly less than 0.1 mg/L. Similarly, initial nitrate concentrations were set to 0.21 mg/L, whereas inflow concentrations are less than 0.01 mg/L. This is not a major concern because initial conditions are quickly flushed out by inflows in this type of river model. The settings are worth noting, however, and perhaps could be decreased if further model development occurs.

Response:

The initial conditions for the natural condition case have been changed to reflect lower values as suggested in the comment.

ATTACHMENT 2

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10
1200 Sixth Avenue, Suite 900
Seattle, WA 98101-3140

OFFICE OF
WATER AND WATERSHEDS

November 30, 2009

Mr. Tim Hemstreet, P.E.
Senior Project Manager
PacifiCorp Energy
825 Multnomah, Suite 1500
Portland, Oregon 97232

RE: Sharing of Klamath River Water Quality Model

Dear Mr. Hemstreet:

This letter is in response to your August 27, 2009 transmittal letter to the California North Coast Regional Water Quality Control Board (NCRWQCB) presenting your comments on the Draft TMDL for the Klamath River in California. In that letter you allege that the states of California and Oregon and EPA regions 9 and 10 are in breach of an agreement reached regarding the water quality model being used in development of the states' TMDLs. We would like to clarify the record in this matter.

In your letter you state: "PacifiCorp provided its water quality model to the Regional Board with the understanding that refinements to the models would be developed cooperatively between the agencies' consultant and Dr. Mike Deas of Watercourse Engineering in an open and transparent manner..." "Unfortunately, despite PacifiCorp's and Watercourse's efforts, this collaboration did not occur and PacifiCorp's review of the water quality models relied upon to develop the draft TMDL has been limited to review of the modeling information only recently produced during the public comment period for the TMDL."

We strongly disagree with this characterization. During the period of January 2004 to August 2005 (a year and a half), EPA and PacifiCorp exchanged a series of correspondences to negotiate EPA's access to the models developed by PacifiCorp's consultant, Watercourse Engineering. I would like to stress that those discussions focused on the base (current condition) model and dams-out (without project) model developed by Watercourse Engineering. PacifiCorp eventually made the base model available to Tetra Tech on April 8, 2005; the dams-out model was made available in October 2005. In our correspondence, it was agreed that an open and transparent process would be involved in our development of the base model and the dams out model, and we welcomed Dr. Mike Deas' role (Watercourse Engineering) as a technical reviewer. We firmly believe that EPA, the states, and our consultant have met the terms of this agreement and, further, that this agreement has been mutually beneficial to all parties.

Since the agencies started the model development in 2004, as expected, there have been revisions to the model assumptions and boundary conditions as new data and better interpretation became available. From April 2005 to the present, EPA's contractor, Tetra Tech, had numerous technical exchanges with Watercourse Engineering presenting revisions and adaptations to the original model. We have detailed exchanges in our records between Watercourse and Tetra Tech from October 2005, January 2006, November 2007, December 2007, and several times during 2008. Where the model revisions did occur (e.g. revision to the nutrient representation of the springs in the Klamath River in May 2007 and addition of a reef near Keno Dam in the natural conditions model in November 2008), Watercourse Engineering was provided with all the relevant information.

Watercourse was also provided copies of the executable model and asked to provide technical review of the model on several occasions. For example, on October 4, 2005, Watercourse Engineering was provided a copy of the EPA base model requesting Watercourse Engineering provide peer review comments on the model. According to our records, EPA did not receive any peer review comments from Dr. Deas. Our records show Watercourse was also provided executable copies of the model in November 2006 and February 2007.

In addition, EPA and the states have held numerous workshops and meetings with stakeholders (including PacifiCorp) explaining their scenario approach and asking for relevant input on the process. Workshops were held in August 2005, July 2008, and again during the public comment period in July 2009. Meetings and conference calls have been also held between the states of California and Oregon and PacifiCorp over the last four years: including in January 2006, January 2008, July 2008, October 2008, and November 2008. The agencies and PacifiCorp have not always agreed on the revisions to and assumptions in the model. That is not unusual in a complex, controversial project.

The purpose of this coordination was to inform PacifiCorp and Watercourse Engineering of the adaptations being made to the original model, and to facilitate your technical review of the base model and associated model calibrations. It was not the intent of EPA or the states that the internal deliberative analysis supported by the model, such as running scenarios for determination of draft wasteload and load allocations for the TMDLs, would be made available to Watercourse or PacifiCorp during their development. The agencies have always retained the authority for deciding on how to best adapt the model for TMDL development. The scenario and wasteload and load allocation development process the states must go through for TMDLs is not consensus-based. It would be inappropriate for the agencies to grant access to internal deliberations and draft scenario analysis to a stakeholder during the TMDL development process. The states and EPA must remain objective in these important portions of the TMDL process. The states of California and Oregon have maintained integrity in this process to the benefit of all of the stakeholders. It would not be in anyone's interest to jeopardize this objectivity.

After California completed their scenario runs in the winter of 2009, NCRWQCB presented the model and scenario runs for their internal Peer Review Process. When this was completed, California and EPA made available all relevant data and scenario assumptions on a continual and ongoing basis as they came available. This information was made available to both PacifiCorp and the USGS on behalf of the Bureau of Reclamation as rapidly as possible during the comment period. This took some time due to the massive collection of files that comprise the model and supporting data. The comment period was extended to allow all parties more time to review the TMDL information. The breadth and depth of your comments on the draft TMDL are a clear indication that you have a high level understanding of the model and the scenarios used to determine allocations. We acknowledge the work you put into these comments, and the State will consider and respond to all your comments.

We have been cooperative and open in our TMDL development process and sharing revisions to the model. We believe both parties have enjoyed the benefits of the technical skills of Tetra Tech and Watercourse Engineering working together to develop the best model possible. When the TMDL development process is completed, EPA intends to release the final model for public and stakeholder use. We hope this model will be of use to PacifiCorp during the process of implementation of the TMDLs. We also expect the model to be of use to many of the other stakeholders in the basin as we move forward in the important work of restoring the Klamath River to a level that meets each states' and tribes' water quality standards. We agree with the stated objective in your August 27, 2009 letter, "...to ensure that the models are the best scientific tools available to inform policy and management decisions in the basin." We look forward to working with you on this important process.

Very truly yours,

Mark Filippini
TMDL Coordinator

cc: Gail Louis, EPA Region 9
Steve Kirk, Oregon Department of Environmental Quality
Eric Nigg, Oregon Department of Environmental Quality
Matt St.John, NCRWQCB
Catherine Kuhlman, NCRWQCB

IMPAIRMENT ASSESSMENT

Editors note: Information on new references are provided below each comment. References that are already included in the TMDL staff report are not repeated below each response.

B1. Comment(s):

Page 2-16, Paragraph 1, Lines 5-6. The Draft TMDL incorrectly indicates that the Klamath headwaters are eutrophic. Upper Klamath Lake, which is the headwaters of the Klamath River, is well known to be hypereutrophic (e.g., Kann and Smith 1993, Eilers et al. 2001, Walker 2001, ODEQ 2002, Kann and Welch 2005, Wee and Herrick 2005, PacifiCorp 2006).

Comment(s) Made By:

Hemstreet – PacifiCorp

Response:

The Regional Water Board disagrees with this comment. The text identified in the comment refers to natural (undisturbed conditions) not current conditions. The text is not meant as definitive classification but rather as background information as part of the rationale for selecting secondary indicator targets at the high end of the range. However, as described by Eilers (2003) there have been clear shifts in UKL productivity and species composition in the past 100 years, consistent with large scale land disturbance activities, which can be strongly implicated as the cause of the lake's current hypereutrophic character. Also the following text, extracted from the Upper Klamath Lake TMDL (ODEQ 2002), further demonstrates that the original text should remain unchanged:

> The term eutrophic is often associated with adverse water quality condition (pollution), whereas in reality, a body of water may be both ecologically "healthy" and eutrophic. Historically UKL [Upper Klamath Lake] was a productive (eutrophic) and diverse ecosystem. It is presently a hypereutrophic system that frequently experiences such poor water quality as to be lethal to its native species (Saiki and Monda 1993). Thus statements such as UKL [Upper Klamath Lake] has always been a eutrophic system" should not be used as an excuse for inaction nor construed to mean that the system was polluted or unhealthy... The argument that it is useless to reduce nutrient loading because the lake will still be eutrophic indicates a misunderstanding of trophic level classifications. - Gearheart et al. 1995

References used in Response B1:

The following references have been added to the text and list of references:

Eilers, J.M., J. Kann, J. Cornett, K. Moser, and A. St. Amand. 2004. Paleolimnological evidence of change in a shallow, hypereutrophic lake: Upper Klamath Lake, Oregon, USA. Hydrobiologia. 520:7-18.

Gearheart, R. A., J.K. Anderson, M.G. Forbes, M. Osburn, and D. Oros. 1995. Watershed strategies for improving water quality in Upper Klamath Lake, Oregon - Volumes I, II and III. Humboldt State University, August 1995.

Oregon Department of Environmental Quality. 2002. Upper Klamath Lake Drainage Total Maximum Daily Load (TMDL) and Water Quality Management Plan (WQMP). Portland, OR. Accessed November 2, 2009. Available at: <http://www.deq.state.or.us/wq/TMDLs/docs/klamathbasin/ukldrainage/tmdlwqmp.pdf>.

B2. Comment(s):
Page 2-16, Last Paragraph 1, Lines 2-3. The Draft TMDL states that "Chlorophyll *a* is a response variable to both water quality stressors (e.g., nutrients) and to impoundment conditions". However, the Draft TMDL presents no analysis and makes no references to support this statement.

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
Regional Water Board staff disagrees that no analysis is provided in the staff report. The following additional references have been added to the text and list of references:

Tetra Tech. 2006. Technical approach to Develop Nutrient Numeric Endpoints for California. Prepared for U.S. Environmental Protection Agency (Contract No. 68-C-02-108-TO-111), and CA State Water Resources Control Board – Planning and Standards Implementation Unit. Lafayette, CA. 120 pp.

Paerl, H.W., 2008. Nutrient and other environmental controls of harmful cyanobacterial blooms along the freshwater-marine continuum. In: Hudnell, H.K. (Ed.), Cyanobacterial Harmful Algal Blooms: State of the Science and Research Needs, Adv. Exp. Med. Biol., 619, Chapter 10. Springer Press, New York, pp. 218–237. http://www.epa.gov/cyano/habs_symposium/ accessed November 12, 2009.

Paerl, H.W., Valdes-Weaver, L.M., Joyner, A.R., Winkelmann, V., 2007. Phytoplankton indicators of ecological change in the eutrophying Pamlico Sound system, North Carolina. Ecol. Appl. 17 (5 Suppl.), S88–S101.

B3. Comment(s):
Page 2-16, Last Paragraph 1, Lines 6-7. The Draft TMDL states that "Consistently high or episodic chlorophyll *a* concentrations indicate the occurrence of algal blooms, which

can be harmful to aquatic organisms". However, the Draft TMDL presents no analysis and makes no references to support this statement.

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
Regional Water Board staff disagrees that no analysis is provided in the staff report. There are many discussions in the scientific literature regarding the impact of algal blooms on aquatic organisms both from eutrophication and potential exposure to blue-green toxins. However for a general discussion related to the effects associated with the eutrophic conditions described in the cited text please refer to: Section 7.3.4 of *Pollutant Effects in Freshwater: Applied Limnology – Third Edition.* 2004. E.B. Welch and J. M. Jacoby. Spon Press. New York.

B4. Comment(s):
Page 2-16, Last Paragraph 1, Lines 8-9. The Draft TMDL states that "Prolonged conditions of high levels of chlorophyll *a* are typical of hyper-eutrophic water bodies ". This sentence should be deleted. While this statement is relevant to Upper Klamath Lake, it is not relevant to the reservoirs (the subject of this paragraph), which are eutrophic, not hypereutrophic.

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The Regional Water Board does not agree with this comment.. The reservoirs do qualify as hypereutrophic based on a multitude of parameters. For example, surface concentrations of TP, TN and chlorophyll *a* exceed levels designated as hypereutrophic (e.g., see Welch and Jacoby 2004: *Pollutant Effects in Freshwaters*).

B5. Comment(s):
Page 2-37, Paragraph 1, Lines 3-5: There is no evidence to support the Draft TMDL's statement that there is increased deposition of organic matter below the dams in the river channel below the dams or that, if there were, it would increase polychaete habitat. This statement is purely speculative.

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The Regional Water Board is unaware of any studies that specifically measure organic matter loading from the Klamath River Project Reservoirs. However, as has been clearly demonstrated in many studies and years of monitoring, the project reservoirs allow

phytoplankton (including blue-green algae) to convert nutrients into organic matter that would not be produced in such abundance in the absence of the reservoirs. A very rich compilation of limnology research demonstrates the relationship between water flow, nutrient budget and organic matter production. This much is not contestable. The chlorophyll *a* monitoring data collected along the Klamath River consistently shows lower concentrations above Copco and higher concentration below Iron Gate. One example of this phenomenon is included in Chapter 2 of the TMDL staff report (Figure 2.21). To further assess this linkage, Regional Water Board staff interviewed Richard Stocking who has conducted extensive research on polychaete habitat in the Klamath River. Based on years of direct observation (though not measured), it is his view that organic matter deposition is highest near the reservoirs (e.g., I-5 Bridge) and decreases with distance downstream (personal communication Stocking 2009). Mr.. Stocking has also identified and observed large amounts of *Aphanizomenon flos-aquae* decomposing in the main-stem Klamath River immediately below the project reservoirs.

Based on the measured levels of chlorophyll-*a* and the observations of a leading researcher, it is reasonable to state that the reservoirs are allowing nutrient conversion into organic matter and some portion of this organic matter is getting into the main-stem river. To say that organic matter levels in the Klamath River would be less in absence of the project reservoirs is not an unreasonable risk hypothesis as incorporated into the TMDL water quality conceptual model.

Increased organic matter does not increase polychaete habitat per se, it enriches it. Fine particulate organic matter (FPOM) is the primary diet of the polychaete and is also used as a substrate for building its rearing tubes. Indeed, recent data (Stocking unpublished – personal communication November 2009) indicates a very direct and positive correlation between organic matter abundance and polychaete density. This additional preliminary information again moves the risk hypothesis challenged in the comment beyond the realm of speculation and well into the realm of informed interpretation. There are limitations though: why wouldn’t the polychaete be present throughout the Keno Reservoir where organic matter is abundant? It appears that the polychaete is limited by current velocity and dissolved oxygen (Stocking and Bartholomew, 2007).

<u>References used in Response B5:</u>
The following references have been added to the text and list of references:

Stocking, R.W. 2009. Telephone conversations and email exchange between Clayton Creager (Regional Water Board staff) and Richard W. Stocking regarding review of TMDL staff report Chapter 2 – specifically water quality and fish disease conceptual models. November 20, 2009.

Stocking, Richard W. and Jerri L. Bartholomew. 2007. Distribution and Habitat Characteristics Of *Manayunkia Speciosa* and Infection Prevalence With The Parasite *Ceratomyxa Shasta* In The Klamath River, Oregon–California. *J. Parasitol.* 93(1):78–88.

B6. Comment(s):

Page 2-19 to 2-25. Starting on page 2-19, the Draft TMDL cites at length an analysis (in Draft form) by Kann and Corum (2009) that purports to show that increasing chlorophyll *a* concentration leads to increasing likelihood of exceeding the WHO guidelines for *Microcystis aeruginosa* abundance or microcystin concentration. The analysis by Kann and Corum (2009) suffers from several problems that call into question its conclusions. The most problematic is an error of logic that reverses cause and effect. The entire analysis is based on the observed correlation between chlorophyll *a* concentration and *Microcystis* abundance (cells/mL). In both the design of the graph (Figure 2.1 on page 2-19) and the explanation of it, the Draft TMDL implies that *Microcystis* abundance is the response factor and chlorophyll *a* the independent variable, that is, that chlorophyll *a* causes the *Microcystis* abundance. This is obviously wrong. Chlorophyll *a* is not the independent variable, it is the response variable. In fact, *Microcystis* is not even necessarily the primary cause of chlorophyll *a*. A greater abundance of *any* algae or cyanobacteria will cause the abundance of chlorophyll *a* to increase. To demonstrate this point, Figure A1 below shows the correlation between chlorophyll *a* and algal biovolume in samples collected from the Project vicinity in 2000 through 2008 between January 1 and June 30 when *Microcystis* is typically not present. Figure 2.1 (on page 2-19) is based on data from samples collected only in July through October, the time of year when *Microcystis* is most likely to be at its greatest abundance. The fact is that there is no causal relationship between chlorophyll and microcystin toxin, only a correlation.

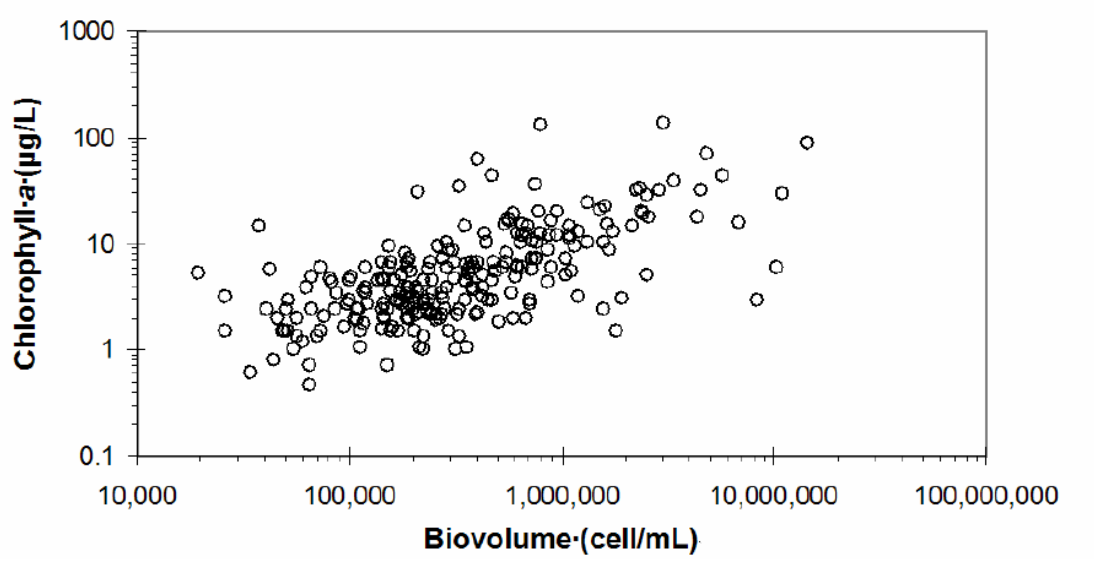

Figure A1. Correlation between chlorophyll a and algal biovolume in samples collected from the Project vicinity in 2000 through 2008 between January 1 and June 30 when Microcystis is typically not present.

Comment footnote: 1 It is not possible to ascertain if the correlation is statistically significant because the TMDL shows only a graph with a logarithmic scale. There is no indication of the correlation coefficient or the P value. The wide spread of the data, and the substantial numbers of chlorophyll values with MSAE cell density = 0 may tend to weaken the significance of the correlation.

The Draft TMDL goes on to state "The relationship illustrated in Figure 2.1 indicates that as chlorophyll *a* concentrations reach 10 µg/L and above, there is a sharp increase in Microcystis aeruginosa cell density above 20,000 cells/mL" (page 2-19). However, this is not what Figure 2.1 in the Draft TMDL shows. Instead, what Figure 2.1 shows is that between July and October for any particular range of *Microcystis* cell density that is greater than 20,000 cells/mL, the chlorophyll *a* values could range from less than 10 µg/L to more than 100 µg/L. To illustrate this point, the bar chart in Figure A2 below presents the results of a cross tabulation contingency table of the same data used in Figure 2.1. Figure A2 shows the percent of samples (i.e., the probability) in various ranges of biovolume at specified chlorophyll *a* values. For example, when chlorophyll *a* is less than 10 µg/L, 97 percent of samples are less than 1,750,000 biovolume units. To turn this around to the way the Draft TMDL uses the Kann and Corum (2009) data, Figure A2 shows that when chlorophyll *a* is greater than 80 µg/L, the probability is the same (i.e., 33 percent) that corresponding biovolume is greater than 14,000,000 and less than 1,750,000. Further, for chlorophyll *a* between 50 and 80 µg/L, the probability that corresponding biovolume is greater than 14,000,000 is zero. Figure A2 shows that the Draft TMDL analysis is biased by the choice of data analyzed, and if analyzed data instead had included data from different times, the results would have been different.

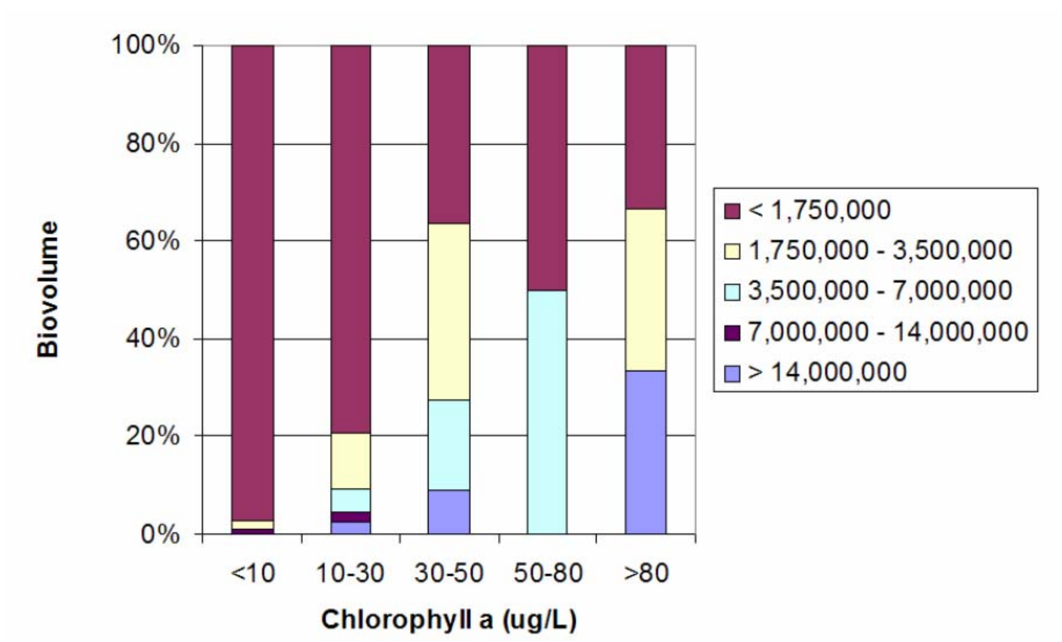

Figure A2. Bar chart showing the results of a cross tabulation contingency table of the same data used in Figure 2.1 of the Draft TMDL.

<u>Comment(s) Made By:</u>
Hemstreet – PacifiCorp

Response:
The Regional Water Board does not agree with this comment. The reference explaining the statistical procedure will be added to the TMDL staff report and is an accepted method used to evaluate relationships between water quality variables (Kann and Smith 1999). The relationships cited in the comment were not presented to imply a cause and effect relationship between chlorophyll *a* which causes *Microcystis* abundance. These relationships show that when chlorophyll *a* is elevated in the Copco/Iron Gate systems during the months presented, that the probability for chlorophyll *a* (which indicates total algal biomass) to be comprised of *Microcystis* increases. Using chlorophyll *a* as a public health guidance value for toxic cyanobacteria is a common occurrence throughout the world and in the literature. For example, the World Health Organization (WHO) uses chlorophyll *a* to relate to the probability of health effects; and indicates that values of 10 µg/L or greater are associated with a moderate probability of acute health effects (Graham et al. 2009; Table 1 reproduced below). Similarly, Lindon and Heiskary (2009) describe the same relationship for blue-green algal toxin [microcystin] levels in Minnesota lakes. The analysis combined microcystin and chlorophyll *a* classes to provide a basis for describing the risk of encountering microcystin as a function of bloom intensity. Bingham et al. (2009) reported on a survey of toxic algal [microcystin] distribution in Florida lakes. This study also provides an analysis of the probability that microcystin concentrations will exceed WHO guidance values as a function of chlorophyll, and conclude that as chlorophyll increases the probability of encountering elevated microcystin concentrations increase.

Thus, chlorophyll *a* clearly provides a reasonable and robust variable to estimate the potential risk of encountering microcystin or *Microcystis* levels that pose a risk with respect to public health. The Kann and Corum (2009) analysis clearly uses valid logic, with conclusions well supported by the literature (Kann and Smith 1999).

And finally, the Regional Water Board fails to see how Figure A2 "turns this around to the way the Draft TMDL uses the Kann and Corum (2009) data". Figure A2 simply demonstrates that with increasing Chlorophyll class that the probability of having higher biovolume also increases; as the commenter states, when chlorophyll *a* is between 50 and 80 ug/L there is a 0% probability of biovolume being greater than 14 million, but when chlorophyll is greater than 80 ug/L the probability increases to 33%.

This says nothing about the choice of data analyzed in the TMDL, nor does it demonstrate any bias. The time period utilized for data analysis in the TMDL was specifically chosen to determine public health risk during the period when *Microcystis* is prevalent, and demonstrates that as chlorophyll increases that the probability for *Microcystis* and microcystin toxin levels to exceed public health guideline values also increases.

Table 1. World Health Organization guidancevalues for the relative probability of acute health effects during recreational exposure to cyanobacteria and microcystins, based on information presented in Chorus and Bartram 1999.

Relative Probability of Acute Health Effects	Cyanobacteria[1] (cells/mL)	Microcystin-LR[2] (μg/L)	Chlorophyll-*a*[3] (μg/L)
Low	< 20,000	< 10	< 10
Moderate	20,000-100,000	10-20	10-50
High	100,000-10,000,000	20-2,000	50-5,000
Very High	>10,000,000	>2,000	>5,000

[1] The WHO guidelines were developed for *Microcystis* dominated samples with an assumed toxin content of 0.2 picograms of microcystin per *Microcystis* cell or 0.4 micrograms of microcystin per microgram of chlorophyll-a with a minimum criteria of at least cyanobacterial dominance.

[2] Although the WHO guidelines are specifically for microcystin-LR, enzyme-linked immunosorbent assays (the most commonly used measure of microcystins) do not separate microcystin and nodularin congeners. Therefore, total microcystin and nodularin concentrations often are used to assess the probability of acute health effects instead of microcystin-LR concentrations.

[3] Chlorophyll-*a* measurements serve as a surrogate and may be used singly, in the absence of additional information, or in addition to cyanobacterial abundance and microcystin measurements.

From: Graham, J.L., K. A. Loftin, and N. Kamman, 2009. Monitoring Recreational Freshwaters. LakeLine 29:16-22

References used in Response B6.

Bigham, D. L., Hoyer, M. V. and Canfield Jr., D. E. 2009. Survey of toxic algal (microcystin) distribution in Florida lakes. Lake and Reservoir Management. 25(3)264-275.

Graham, J.L., K. A. Loftin, and N. Kamman. 2009. Monitoring Recreational Freshwaters. LakeLine 29:16-22

Lindon, Matt and Heiskary, Steven. 2009. Blue-green algal toxin (microcystin) levels in Minnesota lakes. Lake and Reservoir Management, 25(3):240-252.

Kann, Jacob, VH. Smith. 1999. Estimating the probability of exceeding elevated pH values critical to fish populations in a hypereutrophic lake. Can. J. Fish Aquatic Sci. 56:2262-2270.

B7. Comment(s):

Pages 2-21 to 2-24, Figures 2.3, 2.4, and 2.6. These figures are misleading. The use of a logarithmic scale for chlorophyll *a* concentration makes the change in probability appear to be substantially more severe than it otherwise is. A logarithmic scale is typically used to fit data on one graph when the data ranges over several orders of magnitude. In this case, the data appear to range from 2 to less than 50, a range that would easily fit on a linear scale.

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The Regional Water Board does not agree. The stated results and interpretation of the graphs are the same whether the graphs are shown with a logarithmic or linear scale.

B8. Comment(s):
The chlorophyll *a* data used to develop Figures 2.3, 2.4, and 2.6 are not necessarily comparable to the data used as the primary basis for the 10 µg/L target value (i.e., Walker 1985). The Kann and Corum (2006) data (used to develop Figures 2.3, 2.4, and 2.6 in the Draft TMDL) were not collected in the same manner as most of the chlorophyll *a* data used by Walker (1985). The Kann and Corum (2006) data were collected with the intent of finding the maximum probable concentration of *Microcystis* at a particular location, and consisted of skimming the scum from the surface in areas of very dense wind-blown shoreline accumulations (see Kann and Corum 2006, page 23). The data used by Walker (1985) were from samples collected in a more standard manner, i.e. typically below the surface, or integrated over depth, at open water lake or reservoir sites.

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
This statement is not accurate. The Regional Water Board consulted with the Dr. William Walker regarding data collection techniques for the chlorophyll *a* data used in the impairment analysis and he confirmed that the data collection techniques used for the samples included in the data analysis by Kann and Corum 2006 and Kann and Corum 2009) are consistent with the methods used in the original analysis (i.e., Walker 1985). All reservoir chlorophyll *a* data presented in Figures 2.3 and 2.4 where collected from open-water locations and were collected at a depth of 1m. Figure 2.6 does not include chlorophyll *a* as a variable.

B9. Comment(s):
Page 2-26, Paragraph 2, Line 1: The Draft TMDL states "The threshold analysis…supports the numeric targets proposed by the Regional Board…." This statement is not accurate. The threshold analysis *illustrates* the relationship between chlorophyll *a* and *Microcystis* in the Klamath reservoirs during the summer, and shows that when *Microcystis* is abundant chlorophyll *a* is high. It does *not*

demonstrate that when chlorophyll *a* is high, *Microcystis* is abundant. The analysis in the Draft TMDL on this matter suffers from incorrect logic. The probability statements throughout this section make it seem as though the chlorophyll concentration causes the presence of toxic blooms, when in fact it is the reverse. The likelihood of chlorophyll *a* exceeding 10 µg/L increases when algal blooms are present. This is true without regard for the species involved. In this case the relation between chlorophyll and toxic blooms is greatly influenced by the decision to consider only months (June-August) when cyanobacteria are the dominant species in the community. By choosing a different period (Feb-May) it may be possible to say, in the style of this paragraph, that the likelihood of diatom dominance increases as chlorophyll increases above 10 µg/L.

<u>Comment(s) Made By:</u>
Hemstreet – PacifiCorp

<u>Response:</u>
The Regional Water Board does not agree with this comment. See response for B8 with regard to the use of chlorophyll *a* to evaluate both *Microcystis* and microcystin. Moreover, the summer period was specifically chosen because that is when *Microcystis* and associated microcystin toxin are prevalent, and when public health protection is an issue. Note that September and October were also included in other analyses. If, as the commenter suggests, other months when *Microcystis* is not dominant are included, the deflated probability would not be protective of public health, even though reservoir conditions in the summer period would pose a high probability of acute health affects. The Regional Water Board fails to see the relevance of diatom dominance in the Feb-May period to summer probability of toxic cyanobacteria.

B10. <u>Comment(s):</u>
Page 2-59 to 2-61. The Draft TMDL discusses chlorophyll *a* conditions and effects attributed to the Project reservoirs. As discussed in detail in the cover document of PacifiCorp's comment package, the Draft TMDL's chlorophyll *a* analysis and recommended target of 10 µg/L for the reservoirs is inappropriate, particularly in light of the naturally eutrophic nature of the upper Klamath River system, and the unrealistically large nutrient reductions that would be required for the target to be achieved. The 10 µg/L target was not selected with the naturally eutrophic Klamath River system in mind. Rather, it was selected for the Draft TMDL by the Regional Board as the most restrictive of several possible targets under the general, statewide Nutrient Numeric Endpoints (NNE) approach (Tetra Tech 2006).

<u>Comment(s) Made By:</u>
Hemstreet – PacifiCorp

<u>Response:</u>
The Regional board does not agree with this comment. The recommended chlorophyll *a* target for the reservoir is appropriate. The target would be met under current conditions

in a free-flowing Klamath River. Please see response comments elsewhere regarding the clear increase in chlorophyll *a* within and below the reservoirs relative to upstream of the reservoirs. The river upstream rarely exceeds 10 ug/L, despite the eutrophic nature of the system. PacifiCorp's data show that mean chlorophyll *a* was below 10 ug/L at Shovel Creek above the reservoirs, but above 10 ug/L below the reservoirs at the Hatchery Bridge in 2008 (Table 6 and Figure 6 in Raymond 2009: *Phytoplankton Species and Abundance Observed During 2008 in the vicinity of the Klamath Hydroelectric Project.* Report prepared for CH2MHILL and PacifiCorp). The reservoirs as controllable factors have created conditions more susceptible to nuisance algal blooms dominated by blue-green algal species. The rationale for the target has been demonstrated through the site-specific analysis presented in the TMDL staff report. Also, please refer to responses: B4, B6, B8, B9, and B11.

B11. Comment(s):
As the Draft TMDL describes, the 10 µg/L target was chosen by Regional Board staff at a workshop, based on recommendations under the general NNE approach for the most restrictive of the 18 beneficial uses that have been designated for Copco and Iron Gate reservoirs – that is, Cold Freshwater Habitat (COLD) and Municipal Water Supply (MUN) beneficial uses. The Draft TMDL further acknowledges that the NNE-derived chlorophyll *a* target for the reservoirs is the most restrictive and is much lower than if based on other beneficial use categories, and states "10 µg/L summer average chlorophyll *a* provides one potential target for managing these reservoirs" (Appendix 2, page 6).

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
TMDLs are designed to be protective of all beneficial uses. The use of the term *restrictive* by the commenter is inappropriate relative to the goals, objectives, and requirements of the TMDL. The targets were selected to ensure protection of the most sensitive beneficial uses. In addition to the beneficial uses cited in the comment, the Water Contact Recreation (REC 1) use is also impacted at levels above the 10 µg/L summer average chlorophyll *a* target level. While the initial basis of the target was the California NNE framework, the Regional Water Board has also developed a site-specific analysis to support the selected targets.

B12. Comment(s):
Page 2-59 to 2-61. The Draft TMDL discusses chlorophyll *a* conditions and effects attributed to the Project reservoirs. As discussed in detail in the cover document of PacifiCorp's comment package, the Draft TMDL's chlorophyll *a* analysis and recommended target of 10 µg/L for the reservoirs is inappropriate, particularly in light of the naturally eutrophic nature of the upper Klamath River system, and the unrealistically large nutrient reductions that would be required for the target to be

achieved. The 10 µg/L target was not selected with the naturally eutrophic Klamath River system in mind. Rather, it was selected for the Draft TMDL by the Regional Board as the most restrictive of several possible targets under the general, statewide Nutrient Numeric Endpoints (NNE) approach (Tetra Tech 2006).

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The Regional Water Board does not agree with this comment. This comment is similar to several previous comments and the responses to those comments address the issues raised in this comment. Please refer to responses: B4, B6, B8, B9, B10, and B11

B13. Comment(s):
The 10 µg/L chlorophyll *a* target is not appropriate for the naturally eutrophic Klamath River system. Throughout the Draft TMDL, it is acknowledged that higher concentrations of nutrients results in higher levels of chlorophyll *a*, or that high levels of chlorophyll *a* are typical of nutrient-enriched water bodies (e.g., page 2-16). For example, as the Draft TMDL analyses show, achieving a chlorophyll *a* concentration of 10 µg/L would require total phosphorus load reduction of to the reservoirs of 90 percent, resulting in an average growing-season phosphorus concentration of 0.03 mg/L (Appendix 2, page 17). As previously discussed above, such phosphorus loads reductions are infeasible and unachievable. That, in turn, means that 10 µg/L chlorophyll *a* is not a reasonable target in this naturally-enriched system.
Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The Regional Water Board does not agree with this comment. This comment is similar to several previous comments and the responses to those comments address the issues raised in this comment. Please refer to responses: B4, B6, B8, B9, B10, and B11

B14. Comment(s):
As a key rationale for the 10 µg/L chlorophyll *a* target for the reservoirs, the Draft TMDL incorrectly states that the 10 µg/L chlorophyll *a* target is "achieved above the reservoirs but not within the reservoirs, thus the reservoirs themselves are the cause of these impairments" (page 4-20). But, in apparent contradiction, based on modeling analyses, the Draft TMDL concludes that the Klamath River entering Copco reservoir (at Shovel Creek) "exhibit high chlorophyll-a concentrations in the middle of the year"…"largely due to upstream conditions being carried downstream", and "in many of these situations, chlorophyll-a data are not available for comparison" (Appendix 7, page 11). (p. 15) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The Regional Water Board does not agree with this comment. The quotes above regarding Appendix 7 appear to be taken out of context. The TMDL does not "conclude" "based on modeling analyses" that the chlorophyll-*a* levels in the Klamath River entering Copco reservoir (at Shovel Creek) are high. The TMDL states that the model appears to over-predict chlorophyll-*a* levels in the free-flowing river reaches, and cites the Klamath River above Shovel Creek as an example of the apparent over-prediction. Samples collected at the site from 2005-2007 indicate that the vast majority of the May-September samples current do not exceed the 10 µg/L target (see Targets and Allocations response to comments for more detail). The TMDL model is one line of evidence used in the determination of TMDL targets. As cited in several of the responses above, the Klamath River under existing conditions meets the chlorophyll *a* target. The TMDL model calibration was excellent for DO and temperature. The TMDL technical team made the decision to use empirical methods to develop the chlorophyll *a* targets for the reservoirs. In future iterations of the TMDL model careful attention will be given to ensure that model estimates for chlorophyll *a* are more consistent with empirical analyses.

B15. Comment(s):
The 10 µg/L chlorophyll *a* target for the reservoirs is inappropriate given the chlorophyll *a* levels in the river waters flowing into the reservoirs from upstream are frequently higher than 10 µg/L. Therefore, advected input of chlorophyll *a* alone could prevent achieving the target in the reservoirs. Data presented in the Draft TMDL clearly shows very high levels of chlorophyll *a* in the river from sampling sites above J.C. Boyle reservoir, at Keno dam, and at the Link River mouth (near the outlet of Upper Klamath Lake). The Draft TMDL states that "the high concentrations at these three stations are due in large part to residual algal biomass from Upper Klamath Lake" (page 2-60). Furthermore, the modeling analyses performed for the Draft TMDL to develop recommended TMDL allocations shows chlorophyll *a* levels in the river upstream of Copco reservoir ("Klamath River at Shovel Creek") that are much higher than 10 µg/L, particularly during summer, when the target is to be applied (as a "summer mean"). Figure 2 shows the Draft TMDL's model results for chlorophyll *a* levels in the river upstream of Copco reservoir (from Appendix 6, pages H-16 and H-19).

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The Regional Water board does not agree with this comment. Responses above document this position (i.e., B4, B6, B8, B9, B10, B11, and B14). Additionally, it is possible that "advected input of chlorophyll a alone could prevent achieving the target in the reservoirs" on occasion, but field samples indicate that despite high levels of chlorophyll-*a* below Keno and J.C. Boyle Dams, chlorophyll-*a* concentrations decreases

markedly during the river water's turbulent journey downstream to Copco Reservoir, apparently because the phytoplankton released from the UKL and the reservoirs upstream do not fare well in the steep river. Samples collected at the site from 2005-2007 indicate that the vast majority of the May-September samples currently do not exceed the 10 µg/L target (see Targets and Allocations response to comments for more detail).

B16. Comment(s):

Page 2-61, Paragraph 2, Lines 8-10. The Draft TMDL makes the totally baseless statement that Iron Gate reservoir is "the source of blue-green algae that continues to grow in backwater and slower sections within the river reaches below the dams". The implication is based on conjecture with no direct evidence. Unless supported by data or other credible references, this statement should be deleted.

Comment(s) Made By:

Hemstreet – PacifiCorp

Response:

The Regional Water Board does not agree with this comment. The basis for the statement can be found in many of the Kann and Corum memos and reports cited in the TMDL, and additionally in PacifiCorp's data showing that both *Microcystis* and microcystin are substantially higher within and below the reservoirs than they are directly upstream. For example, see Raymond (2009; *Phytoplankton Species and Abundance Observed During 2008 in the vicinity of the Klamath Hydroelectric Project* (Report prepared for CH2MHILL and PacifiCorp) Figures 13 and 15 showing an increase within the reservoirs and downstream of both *Microcystis* and microcystin toxin. The Iron Gate/Copco Reservoir complex greatly increases the quantity of innoculant supplied to the river below Iron Gate Dam; therefore, it is not unreasonable to conclude that this innoculant would contribute to downstream blooms.

B17. Comment(s):

Page 2-62, Paragraph 1, Line 1. The Draft TMDL states "The consistent presence of high concentrations of *Microcystis aeruginosa*…." (MSAE). The assumption of a "consistent presence" of high concentrations of MSAE is not supported by data. MSAE is highly variable in both time and space and is not consistent. For example, while Iron Gate and Copco reservoirs have had MSAE levels that met the health advisory guidelines annually since 2005, concurrently, sections (not all public access areas) of the Klamath River have been posted in 2005, 2008 and 2009.

Comment(s) Made By:

Hemstreet – PacifiCorp

Response:

The Regional Water board will refine the text to make clear that there are consistently a high number on incidences with high concentrations that occur at multiple locations during the summer season over the course of several years. The information to document this statement has been included in the TMDL staff report.

B18. Comment(s):
Page 2-62, Paragraph 3, Line 1. The first sentence, "Every year since 2004 *Microcystis aeruginosa* counts have exceeded…" is wrong (see above comment) and contradicts Table 2.10.

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The comment is incorrect. The data summarized in Table 2.10 of the June 2009 draft report is for 2006, 2007, and 2008. However, data supporting the statement that exceedances occurred in 2004 and 2005 are available in Table 2 of the following report: Kann, Jacob, and Susan Corum. 2006. Summary of 2005 Toxic *Microcystis aeruginosa* Trends in Copco and Iron Gate Reservoirs on the Klamath River, CA – Technical Memorandum. Prepared For: Karuk Tribe Department of Natural Resources. PO Box 282, Orleans, CA 95556. March, 2006.

B19. Comment(s):
Page 2-33, Paragraph 2, Line 2: No evidence is presented to support the statement that algae, especially diatoms, and organic matter are elevated below Iron Gate reservoir. This statement must be supported with data or citations. Actual data collected by PacifiCorp suggest that suspended matter is not increased below Iron Gate dam compared to above Copco dam (see Figure A4 below). Examination of phytoplankton samples taken above and below Iron Gate dam does not support the statement that excess diatoms are released from the dam.

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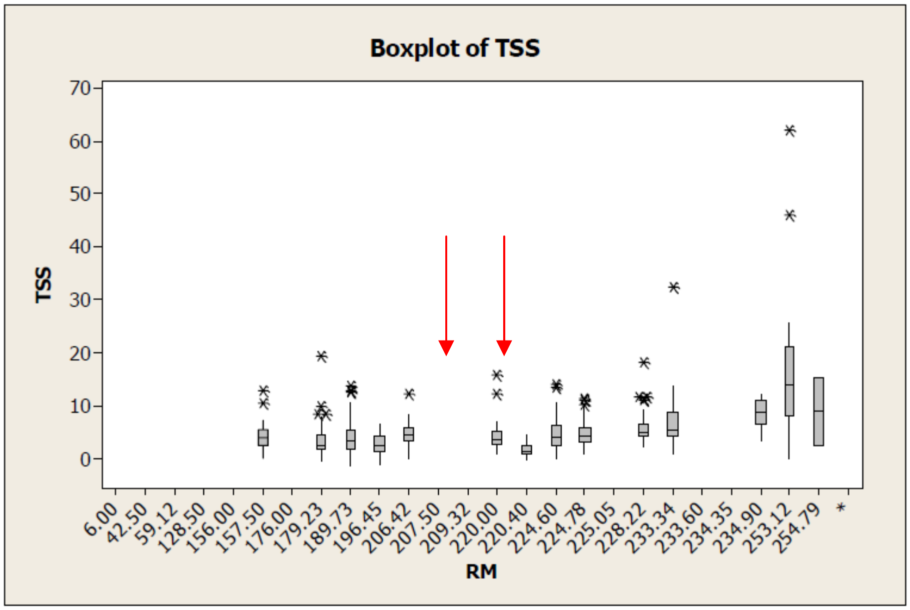
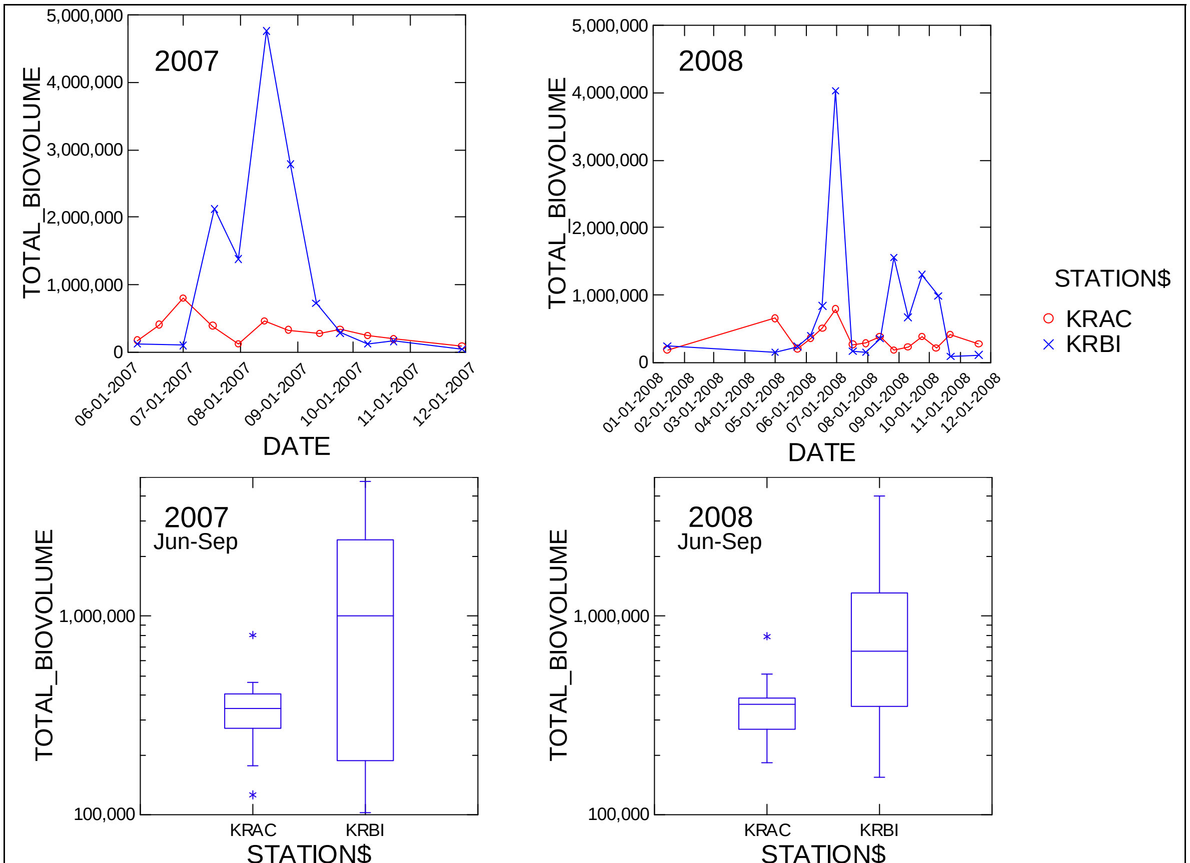


Figure A4. Suspended solids measured in the Klamath River in 2000 through 2008. (RM 206.42 = above Copco Reservoir, RM 189.73 = below Iron Gate dam).

<u>Comment(s) Made By:</u>
Hemstreet – PacifiCorp

<u>Response:</u>
The Regional Water board does not agree the graph presented in the comment clearly demonstrates that suspended matter is not increased below Iron Gate; the graph shows that the upper quartile values are similar between the above Copco station and the below Iron Gate station (see added arrows), but that the below Iron Gate station shows several high values not observed above Copco. Furthermore, Kann and Asarian (2006; Technical Memorandum: Longitudinal analysis of Klamath River Phytoplankton Data 2001-2004. Prepared by Kier Associates and Aquatic Ecosystem Sciences for the Yurok Tribe Environmental Program, Klamath, California) using PacifiCorp phytoplankton data from 2001-2004 show that total algal biovolume was elevated below Iron Gate relative to above Copco (see p. 8 Figure 4 of report). In addition, the Regional Water Board has analyzed data provided by PacifiCorp from Raymond (2009) for the critical summer period (June – September) with the results illustrated below. There is clearly a large difference in biovolume between the station. upstream of Copco Reservoir versus the station located below Iron Gate Dam.



Total biovolume for the period June through September for 2007 and 2008 comparing Above Copco with below Iron Gate Dam. Data provided by PacifiCorp from -- Raymond, Richard. 2009. Phytoplankton Species and Abundance During 2008 in the Vicinity of the Klamath Hydroelectric Project. Prepared for: CH2MHill and PacifiCorp Energy. Portland, Oregon.

B20. Comment(s):

Page 2-36, Paragraph 36, First Bullet under "Impoundments". The Draft TMDL states that the Project reservoirs "have a small net retention of nutrients". However, even the Draft TMDL's own analysis indicates that nutrient retention by the reservoirs is significant. On page 4-19, the Draft TMDL states "[t}he TMDL model estimates are reasonably consistent with the estimates developed by Asarian and Kann (2009) through statistical analysis of empirical monitoring data" in which Kann and Asarian (2009) estimated that the reservoirs retain 8.3 percent of the inflowing load of total phosphorus and 13 percent of the inflowing load of total nitrogen on an annual basis. Further, Table 4.5 (page 4-20) in the Draft TMDL shows that annual nutrient retention in the reservoirs could be as much as 29 percent for total phosphorus and 33 percent for total nitrogen…These observations support the conclusion that Iron Gate and Copco reservoirs act as a net sink for both total nitrogen and total phosphorus over the long term.

The Draft TMDL also does not recognize the beneficial role of the reservoirs in shifting the timing of inflowing summertime nutrient "peaks" from upstream sources, notable Upper Klamath Lake… The lag effect from the reservoirs displaces the peak influx of nutrients further into the future. With the reservoirs, the simulations indicate that peak TN conditions are lagged by several weeks into late summer and early fall when the benthic algae community is in overall senescence due to lower solar altitude and decreased day length. Conversely, in the absence of the Copco and Iron Gate reservoirs, it is likely that attached benthic algae (periphyton) would increase in the river downstream of Iron Gate during the peak algae growing season. Nutrients released to the river system below Iron Gate dam in mid-summer rather than in late summer and early fall would have a considerably greater potential for being sequestered in algal biomass.

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The comment raises a point that has long been an assumption regarding the role of the reservoirs on nutrient dynamics on the Klamath River. As more monitoring data becomes available for updated analyses (e.g., Asarian et al. 2009) a more realistic assessment of that role is emerging. Regional Water Board staff agrees with some aspects of the comment and have stated that the reservoirs do retain nutrient loads. We have provided a range of estimates that include general estimates from literature and other estimates based on more site-specific analyses. From the lowest retention estimate to the highest retention estimate the level of significance regarding downstream impacts is low to moderate. Any retention benefits have to be weighed against other water quality impacts of the reservoirs which are very significant. The Regional Water Board has presented a well balanced assessment of the role of reservoirs on the Klamath River in the TMDL staff report. The following points are also offered in response to this comment.

1. The comment seems to accept the rates given in the most recent report by Asarian et al. (2009), which is used in the TMDL staff report as one of the lines of evidence evaluating reservoir nutrient retention.
2. The mass amounts retained are large on an absolute basis. When Regional Water board staff say that the retention is "small" and "limited" we are referring to the percent retained, which is a small fraction of the total and is limited relative to other reservoirs of similar size.
3. The 29% number for phosphorus that is cited in the comment "Range of 5 methods cited by Kann and Asarian (2007)" referring to the table from the TMDL staff report comes from a simple empirical regression model from a cross-sectional study of many lakes, and the retention estimate is much higher than any of the other estimates, and should be considered less accurate than other rigorous site-specific methods such as the Asarian and Kann (2009) mass-balance studies. Also note that the "1.9% - 29%" values for Iron Gate TP in the table should be "-1.9% - 29%". This will be corrected in the draft final staff report.

4. For phosphorus, it is somewhat misleading to look only at annual retention, as the majority of the retention occurs in Winter-Spring, when more of the phosphorus is in particulate form. Nitrogen retention seems to occur throughout the year.
5. It is clear that the reservoirs spread out event-driven spikes of nutrient loads. However, this is not necessarily a good thing in regard to algal response in the lower river. Without the dams, much of the nutrient load would move in event-driven pulses (as stated by the commentor) and a good portion of such load would flush through the system without elevating concentrations for long enough to allow full periphyton response. With the dams in, the influent load pulses are smoothed out, resulting in lower peaks, but longer periods of elevated concentrations in the river.
6. The model simulations of "lag" by Watercourse have not been fully documented. It is clear that across all reservoirs a lag would be accumulated in the transmission of peak concentrations from Upper Klamath Lake. However, the example that is presented is not representative. This example shows peak concentrations leaving Upper Klamath Lake in mid August, with low concentrations through the winter and spring. The 2005-2007 monitoring above Copco reported by Asarian et al. (2009) suggests that concentrations entering Copco often increase in the fall and remain elevated through about April – contrary to the pattern shown in the simulated example. In such cases the lag and associated spreading of peak concentrations caused by the reservoirs may actually serve to increase nutrient concentrations at the start of the simulation. The concentration pattern used in the simulation is apparently at least partially based on the last figure provided in the comment, for 2003. This appears to show an August peak in TN concentration leaving Link, with concentrations declining at the end of the year. However, this is based on a single measurement in early November. Further, the monitored concentrations in 2003 show winter concentrations of TN leaving Link in the range of 2 mg/L, whereas the model simulation used in the example has TN of only about 0.25 mg/L for the winter period.
7. Earlier work of Asarian and Kann is criticized for its day-by-day comparison of inflows and outflows. These criticisms have now been addressed by the refined analysis provided in Asarian et al. (2009).
8. The statement that "in the absence of the Copco and Iron Gate reservoirs, it is likely that attached benthic algae (periphyton) would increase in the river downstream of Iron Gate…" is not supported. As noted above, loads downstream might increase, but not necessarily median concentrations. Further, the argument made here neglects the fact that absence of the dams would result in more frequent scouring flows which would suppress periphyton growth.
9. Empirical data also indicate the reservoirs do cause a temporal lag in nutrient concentrations (Asarian and Kann 2009), as well as somewhat reduce nutrient concentrations on an annual and seasonal basis. The effect of this downstream is unclear, as nutrients are probably not limiting for reaches directly below Iron Gate (maybe be more limiting downstream). It is unclear if the removal of the reservoirs would result in increased growth of periphyton downstream, because the factors governing this are complex and include: flow, light, substrate, nutrients, and temperatures. Of these five factors, the reservoirs have a periphyton-retarding effect on only one (decreasing nutrient concentrations) and a periphyton-promoting effect

on four. The reservoirs promote increased periphyton downstream in the following four ways:

- Reduce light limitation downstream (PacifiCorp 2008)
- Coarsen the substrate. [see discussion in QVIC 2008: http://www.klamathwaterquality.com/documents/2009/QVIC_draft.klam.tmdl%20(Chpt%201-5).comments.%2009.25.08.pdf]

"Dam construction typically halts the downstream transport of gravel, resulting in more coarse substrates (Biggs, 2000). The Klamath Hydroelectric Project has had this effect on the Klamath River below Iron Gate Dam (FERC 2007). Larger substrates like cobble and boulder require higher flows to scour them than smaller substrates like gravel and sand. These coarse substrates are more stable, increasing the amount of periphyton and aquatic macrophytes than can grow (Biggs, 2000; Anderson and Carpenter 1998)."

- Thermal lag warms water in summer and fall.
- Stabilize flows by capturing occasional summer and early fall rainstorms.

<u>Reference:</u>

PacifiCorp (2008) Application for Water Quality Certification Pursuant to Section 401 of the Federal Clean Water Act for the Relicensing of the Klamath Hydroelectric Project (FERC No. 2082) in Siskiyou County, California Klamath Hydroelectric Project (FERC Project No. 2082). Prepared for: State Water Resources Control Board Division of Water Quality Water Quality Certification Unit. Prepared by: PacifiCorp. Portland, OR. September 26, 2008.

B21. <u>Comment(s):</u>

Page 2-61, Paragraph 2, Lines 2-6. The Draft TMDL states "Elevated levels of suspended algae in the Iron Gate reservoir outlet waters are then available as a food source for polychaetes in the river….", and "…fine particulate organic matter discharged from the outlet of Iron Gate reservoir is deposited in the river bottom sediments below the reservoir…" These statements are purely speculative.

<u>Comment(s) Made By:</u>

Hemstreet – PacifiCorp

<u>Response:</u>

Chlorophyll-a values, a proxy measurement of algal biomass, are higher below Iron Gate and Copco reservoirs than above them (Asarian and Kann 2009).

The conceptual model developed by the Regional Water Board that serves as a framework for the impairment assessment is constructed of a series of hypotheses that are then evaluated. The conceptual model was provided to the independent peer review team and to members of the Klamath River fish health research group including Dr. Jerri Bartholomew. The peer review response was that the conceptual model represents the state of the science in terms of our understanding of these processes. The Regional Water Board has had several follow up conversations with Dr. Bartholomew regarding various aspects of the relationship between water quality conditions and fish disease including the linkage cited in the comment above. Dr. Bartholomew suggested that the cited phrase be revised to state "elevated levels of fine organic material including suspended algae in the Iron Gate Reservoir outlet waters are then available as a food source for polychaetes in the river….." In addition, it is her understanding that the reservoir is a source of the fine particulate organic matter in the river bottom sediments below the reservoir (personal communication Dr. Jerri Bartholomew Oregon State University October 2009). The statements are essentially correct and have been corroborated through the extensive experience of a primary researcher familiar with the system which the Regional Water Board believes provides an adequate basis for the assessment hypothesis. Also refer to biovolume comparison figure in comment response B19.

B22. <u>Comment(s):</u>
Page 2-60, Paragraph 2, Last line. The "very high means" noted on the graph (Figure 2.23) is likely attributable to different sampling objectives (e.g. public health vs. ecological). Lumping all data regardless of sampling objectives is inappropriate. In other words, differences are at least partly explainable by biased sampling techniques. Since Figure 2.23 uses data from a report that is unavailable to PacifiCorp, we cannot verify how the data were collected.

<u>Comment(s) Made By:</u>
Hemstreet – PacifiCorp

<u>Response:</u>
The Regional Water Board disagrees with this comment. The data used to develop Figure 2-23 includes only open water samples (0 to 1 meter) and does not include any public health near shore samples. The analysis does not use or rely upon a "biased" sampling technique. The data for the analysis is available to PacifiCorp upon request. The dataset includes many samples taken by PacifiCorp contractors.

B23. <u>Comment(s):</u>
Statement: Chapter 2, Section 2.3.2.2, Page 2-19 states: "Figure 2.2, which uses the same data as 2.1, demonstrates that the same relationship exists between chlorophyll-a and microcystin. As chlorophyll-a concentrations exceed 10 μg/L concentrations of microcystin rapidly increase above 4 μg/L."
Comment: If looked at closely it appears most of the river stations, all of the reservoir stations Oct-Nov, and all of the river stations Oct-Nov are above 10 μg/L and below 4 μg/L. Please identify which months the data was collected for the River stations and the Reservoir stations?

<u>Comment(s) Made By:</u>
Hicks – U.S. Bureau of Reclamation

Response:
The comment does not accurately describe the distribution of data points within Figure 2.2. Less than half of the river stations are above 10 µg/L of chlorophyll *a* and some of those that are above 10 µg/L chlorophyll *a* exceed the microcystin threshold criteria of 4 µg/L. Over 50% of the October – November river stations are below chlorophyll *a* of 10 µg/L. Also most of the Oct-Nov reservoir stations are below 10 µg/L chlorophyll *a*. The data collection period for the majority of the samples occurred from the end of June to the beginning of November. The purpose of the analysis was to include all of the available data to capture the full range of natural variability in the probability estimates. Please refer to the original source report for a more detailed description of the data set used in the analysis and methods.

The Oct-Nov months are already identified on the graph (solid red circles), the other months are July-September and are shown as open circles. The pattern of high Chlorophyll (usually comprised of a high proportion of MSAE) coupled with low toxin during the fall months is a common pattern in the system (i.e., there is often a decrease in toxin produced per unit MSAE cell during the later part of the season).

B24. Comment(s):
Statement: Chapter 2, Section 2.3.2.2, Page 2-22, states "The probabilities of microcystin concentrations exceeding the critical values of 4 µg/L (red), 8 µg/L (blue), and 20 µg/L (green) at a chlorophyll-a concentration of 10 µg/L (dashed line) are approximately 30%, 18%, and 13% respectively."
Comment: It appears in Figure 2.4 that the probability for critical values of 4 µg/L (red) is 28%.

Comment(s) Made By:
Hicks – U.S. Bureau of Reclamation

Response:
The percentage values in the TMDL staff report are in error and will be revised accordingly: The probabilities illustrated in Figure 2.4 for microcystin concentrations exceeding the critical values of 4 µg/L (red), 8 µg/L (blue), and 20 µg/L (green) at a chlorophyll-a concentration of 10 µg/L (dashed line) are approximately **24%, 15%, and 10%** respectively

B25. Comment(s):
The TMDL quotes extensively as to what "CDFG hypothesized" with respect to the significant fish mortality that occurred near the mouth of the Klamath River in 2002. It would add credibility if the draft TMDL recited other hypotheses as well as the conclusions of the National Research Council as to this issue.

Comment(s) Made By:
Addington and Danosky – Klamath Water Users Association & Tulelake Irrigation District

Response:
There were two government reports released on the Klamath River fish kill of 2002: one by the California Department of Fish and Game (CDFG) and the other from the U.S. Fish and Wildlife Service (USFWS). These are the leading sources of scientific information about the 2002 fish kill and both reports were utilized in the Klamath River TMDL's discussion of the event.

CDFG performed an in-depth evaluation of the causative factors and impacts of the September 2002 Klamath River fish kill. The report was peer reviewed by professors of fisheries biology at both Humboldt State and Oregon State University, numerous tribes, state and federal agencies, and stakeholders for accuracy and content before release in its final form. Additionally, the National Research Council utilized the conclusions and hypotheses of the CDFG report in their discussion of the 2002 fish kill.

USFWS also evaluated the environmental factors that contributed to the September 2002 Klamath River fish kill, and independently came up with many of the same conclusion as the California Department of Fish and Game about the causative factors. The USFWS report was peer reviewed by numerous members of academia and federal agency personnel before being finalized.

Given the extensive peer review of these two science-based government documents, Regional Water Board staff did not feel it was necessary to search for other resources detailing the 2002 fish kill.

B26. Comment(s):
The Draft TMDL states that the 2002 fish kill was directly responsible for fishery restrictions in 2006. There does not appear to be any source cited for this specific statement.

Comment(s) Made By:
Addington and Danosky – Klamath Water Users Association & Tulelake Irrigation District

Response:
The text in Chapter 2 has been edited so that it no longer states explicitly that the fish kill in 2002 is responsible for the fisheries restrictions in 2006. With that said, the potential offspring of the 2002 Chinook stocks, the four year age class, is that cohort of fish that were predicted to have subsequently returned to the Klamath River as spawners in 2006. The loss of over 33,000 salmonids in 2002, mostly fall Chinook (USFWS 2003), was a contributing factor to the low return and resulting fishery restrictions in 2006.

<u>Reference used in B26:</u>
United States Fish and Wildlife Service (USFWS). 2003. Klamath River Fish Die-off, September 2002, Report on Estimate of Mortality. Arcata Fish and Wildlife office. Arcata, CA. Report Number AFWO- 01-03. 28pp.

B27. <u>Comment(s):</u>
The NCWQCB must meet with the CDFG and come up with the desired ratio of spawners to out migrants that will indicate a healthy fishery.

<u>Comment(s) Made By:</u>
Fowle

<u>Response:</u>
The determination of the ratio of spawners to out migrants which indicate a healthy fishery is beyond the purview of the Regional Water Board, and is best left up to the fisheries agencies.

B28. <u>Comment(s):</u>
The Klamath River TMDL states that beneficial uses in the Klamath River are impacted by factors not directly addressed through the TMDL such as the presence of hatchery raised fish with the potential for disease and genetic effects. The initial statement regarding the controversy between “natural" and "hatchery" fish was made in a report by Busack and Currens in 1995, wherein they stated, "Interbreeding with hatchery fish might reduce fitness and productivity of a natural population". According to Mr. Michael Rode of the California Department of Fish and Game at a Hatchery Evaluation meeting on September 19, 2002 at Iron Gate Hatchery disclosed that less than a 2% genetic survey has been taken to date and no genetic differences have been noted between "hatchery" or "natural" Coho Salmon.

<u>Comment(s) Made By:</u>
Gierak

<u>Response:</u>
The issue of the differences between hatchery raised fish and natural fish is beyond the purview of the Klamath River TMDL. The section of Chapter 2 referenced in the above comment is merely stating that there are factors not addressed through the TMDL process which may have an impact on beneficial uses, natural versus hatchery raised fish being one of them.

B29. <u>Comment(s):</u>
In order to increase natural salmonid populations, all hatcheries should operate at full capacity as the cost would be minimal for only the food is a factor since the facilities can handle more than they are producing at this time. Collection of salmonids for hatchery

mitigation goals to be collected at various times during the runs and not to exceed more than 10% of their collection goals. Fish ladders would be closed between collections and uncollected salmonids to be allowed to spawn naturally.

Comment(s) Made By:
Gierak

Response:
This comment is beyond the scope of the Klamath River TMDL as it pertains to suggestions for operation of the Iron Gate Hatchery.

B30. Comment(s):
Salmonid populations are declining due to warming ocean conditions and the effects of El Nino, and predation by Pinnipeds (California Sea Lions and Pacific Harbor Seals). Mortality of salmonids from natural predators run as high as 98 percent (Fresh in Steward and Bjornn 1990). Yuroks traditionally harvested marine mammals (McEvoy 1987), but today many of these species are protected by the Marine Mammals Protection Act." In the typical logic of fisheries scientists, the report proceeds to ignore its own stated facts in favor of the politically correct. Allow the tribes which traditionally hunted pinnipeds to resume their customs, which will result in larger salmonid populations.

Comment(s) Made By:
Gierak

Response:
The conditions above (warming ocean conditions, effects of El Nino, and predation by pinnipeds) are naturally occurring conditions that have been occurring throughout the centuries and are beyond the scope of the Klamath River TMDL, as is the harvest of marine mammals by the Yurok Tribe. The decline of salmonid populations in the Klamath River is well documented (see Chapter 2, section 2.6.1 and Appendix 5) and while the above referenced factors may contribute to the natural rise and fall of salmonid populations, it has been well established that temperature and dissolved oxygen conditions in the Klamath River are not fully supporting salmonids and contribute to their declining numbers.

B31. Comment(s):
Poor water quality in the mainstem Klamath River is one of the key factors limiting restoration of Klamath River salmon and steelhead populations, and more of the remaining salmon and steelhead stocks in the Klamath River upstream from the Trinity River confluence will go extinct unless water quality in the Klamath River is improved soon.

Comment(s) Made By:
Grunbaum

Response:
The Regional Water Board has not conducted an analysis to develop a probability of extinction estimates based on water quality conditions. However, we do attribute significant impairment of fish populations in the Klamath River to water quality conditions. The Klamath River TMDLs are set at a level to restore water quality conditions to be protective and supporting of all beneficial uses, including salmonids.

These TMDLs will be implemented as stated in the Implementation Chapter (Chapter 6). The Action Plan to the TMDL, which will contain these implementation measures, will be adopted by the Regional Water Board as part of the Basin Plan. Upon adoption the TMDL implementation measures laid forth in the Action Plan will be mandatory actions that, when implemented, are expected to improve water quality conditions and result in protection of salmonids.

The inclusion of engineered treatment and large scale wetland treatment options in the implementation plan is driven in part because the Regional Water Board believes that water quality improvements are needed sooner rather than later due to a significant probability for further serious impacts on salmonid populations.

B32. Comment(s):
Statement: Chapter 2, Section 2.1, Page 2-2 states "The purpose of Section 2.6 is to describe how poor water quality conditions are impairing beneficial uses in the Klamath River. The focus is on the status of the elements that are essential to each beneficial use. For example, to evaluate the Cold Freshwater Habitat (COLD) beneficial use, the historical and current status of cold-water fish populations and the associated fishery is compared to demonstrate a significant degradation of cold water fish and fishery related beneficial uses."

Comment: This statement implies that water quality impairment has caused a significant degradation of the fishery. Data, analyses, and/or citations need to be presented to support this statement. Reclamation staff is not aware of any research that definitively identifies poor water quality as the driving factor associated with the decline of the salmon fishery. For example, variability in ocean productivity has been shown to affect fisheries production both positively and negatively. Research has showed a strong correlation between North Pacific salmon production and marine environmental factors. Warm ocean regimes are characterized by lower ocean productivity, which may affect salmon by limiting the availability of nutrients regulating the food supply, thereby increasing competition for food.

Comment(s) Made By:
Hicks – U.S. Bureau of Reclamation

Response:
The variability in ocean productivity is a naturally occurring condition that is beyond the scope of the Klamath River TMDL. The decline of salmonid populations in the Klamath

River is well documented (see Chapter 2, section 2.6.1 and Appendix 5) and while ocean conditions contribute to the natural rise and fall of salmonid populations, it has been well established that temperature and dissolved oxygen conditions in the Klamath River are not fully supporting salmonids and contribute to their declining numbers.

B33. Comment(s):
Statement: Chapter 2, Section 2.4.2.1, Page 2-32 states "…increased nutrient loading (NA1) -> elevated periphyton/macrophyte growth (NB1) -> increased polychaete habitat (NB4) -> increased polychaete population and C. *shasta*…"
Comment: This statement implies that water quality impairment has caused a significant increase in the polychaete population. Data, analyses, and/or citations need to be presented to support this statement. Reclamation staff is not aware of any research that definitively identifies poor water quality as the driving factor associated with the increase in the polychaete population and C. *shasta*.

Comment(s) Made By:
Hicks – U.S. Bureau of Reclamation

Response:
The section of Chapter 2 that is referenced in the above comment states, "Based on the above information there may be a linkage between the proliferation of *C. shasta* in the mainstem Klamath River and elevated nutrient concentrations. **Elevated nutrient concentrations (NA)** result in **increased periphyton ($_{N}$B1) and increased suspended algae and blue-green algal growth ($_{N}$B2)** in the river, which have been identified as prime habitat for the polychaete. **Increased habitat ($_{N}$B4)** leads to an **increased abundance of the polychaete ($_{N}$B9)**, which in turn leads to a high infectious spore load in the river. This results in a high probability that adult and juvenile salmonids migrating and rearing in the river will be infected by *C. shasta*." The "above information" referenced are studies by Bartholomew and Bjork (2007), Stocking and Bartholomew (2004), Stocking and Bartholomew (2007), and Stocking (2006) about the presence and abundance of the polychaete that is the intermediate host for *C. Shasta*. Regional Water Board staff are utilizing the information provided in these studies to draw a linkage between elevated nutrient concentrations and an increased abundance of the polychaete. In addition, the independent peer review panel was asked to specifically review these aspects of the Klamath River TMDL water quality conceptual model. The response from peer reviewers was that this model represents the "state of the science" regarding the current understanding of these processes.

B34. Comment(s):
Statement: Chapter 2, Section 2.7, Page 2-87 and 2-88 states "Nutrient concentrations in much of the Klamath River watershed are well above natural background levels and contribute to excess periphyton and suspended algae growth, which in turn contributes to poor DO and pH conditions, and also contributes to increased abundance and exposure of fish to parasites (e.g., *C. shasta*)."

Comment: This statement implies that water quality impairment has caused a significant increase in the polychaete population. Data, analyses, and/or citations need to be presented to support this statement. Reclamation staff is not aware of any research that definitively identifies poor water quality as the driving factor associated with the increase in the polychaete population and C. *shasta*.

Comment(s) Made By:
Hicks – U.S. Bureau of Reclamation

Response:
See response to Comment B34.

B35. Comment(s):
New research by the Karuk and Yurok tribes shows a higher-than-expected reliance on the mainstem as a travel corridor during freshets between floodplain winter habitats for coho, thus emphasizing the importance of cleaning up and protecting not just the tributaries but also the mainstem Klamath River.

Comment(s) Made By:
Terence – Klamath Riverkeeper

Response:
The Klamath River TMDL addresses impairments in both the mainstem Klamath River and its tributaries.

B36. Comment(s):
Statement: "In 2003 a study by Stocking and Bartholomew (2004) found the highest densities of the polychaete living in periphyton (commonly made up of *Cladophora*). Study results from 2006 at sites located between Iron Gate Dam and Interstate-5 in California revealed that polychaete populations at habitat locations identified in 2004 and 2005 were not present in 2006, or were present in numbers too low to be considered significant (Bartholomew and Stocking 2006). According to Bartholomew and Stocking (2006), the substrate at these locations was new in 2006 and devoid of periphyton (*Cladophora)*, most likely due to scour caused by winter flushing flows. It appears that the lack of available habitat for the polychaete in 2006 led to their absence from these locations in the Klamath River.
Response: This is one of the primary 'studies' rationalizing a hypothetical link between the dams and polychaete. 1 year out of those 3 by this assessments own acknowledgement contradicted the apparently predetermined objective resulting in a best case scenario of 1/3rd failure of theory. Being on and in that exact stretch of river the entire time, I can unequivocally state there was no scouring occurring in 2006. Also, there was no significant difference in periphyton density in 2006 relative to the other years.

<u>Comment(s) Made By:</u>
Cozzalio

<u>Response:</u>
According to Bartholomew and Stocking (2006), the only year during which there was an area devoid of both polychaetes and periphyton (*Cladophora*) was in 2006. In 2004 and 2005 polychaete populations were present in the study area, as was periphyton. The point of this statement, is that once the primary habitat of the polychaete (periphyton primarily made up of *Cladophora*), was removed from and area, the polychaete were absent or present in numbers too low to be considered significant.

B37. <u>Comment(s):</u>
Stocking (2006) suggests that the Project reservoirs are beneficial in reducing the effects of *C shasta* infection… Stocking states that, if high spore densities resulted in the high mortality documented in exposure groups held in the Lower Klamath River, then it seems likely that continuity of water flow (absence of obstructions) is an important factor in explaining the differences between the Upper Klamath River and the Lower Klamath River results.

<u>Comment(s) Made By:</u>
Hemstreet – PacifiCorp

<u>Response:</u>
The assertion made in the comment is incomplete and not consistent with the most current understanding of fish disease dynamics in the Klamath River. The Regional Water Board recognizes that research into the epidemiology and ecology of fish diseases, especially *C. shasta* and the disease it causes in Klamath River salmonids, was still in its early stages at the time of this publication. The Regional Water Board contacted Dr. Stocking for assistance in addressing this and other comments related to fish disease dynamics in the Klamath river since much of the discussion is based on his original research. Though Dr. Stocking suggests that the comment above is still regarded as true, the statements made in Stocking et. al. 2006 are now considered only a partial explanation for the differences in disease severity between the Upper Klamath River and the Lower Klamath River. The upper basin lacks another very important factor explaining these differences and that being a run of anadromous salmon. The Regional Water Board wants to make clear that we do not believe that this is an argument to keep salmon out of the upper basin. Rather the following explanation, which is completely consistent with the proposed water quality and fish disease conceptual models used in the TMDL staff report, suggests other mitigation measures would better address the issue.

There are reasons why *C. shasta* is so unnaturally aggressive in the Lower Klamath River which are based on an emerging understanding of the biology of these animals (both hosts and parasite). As salmon near their spawning grounds, their immune system begins to shut down and all energy is directed towards reproduction. The parasite, *C. shasta*, takes advantage of its hosts weakened immune response and begins to proliferate within the hosts tissues in preparation for the next step in its life-cycle: infecting the polychaete host. To do so, the parasite must be swept up by passing currents from a decomposing salmon carcass and be deposited within a population of polychaetes. Under normal circumstances (e.g. a pristine river system), this random event would result in failure for the majority of *C. shasta* parasites because the salmon would be more widely dispersed. Below Iron Gate Dam, dense spawning redds (Toz Soto, Karuk Tribal Fisheries Biologist, Personal Communication 2009) and salmon carcasses can be found on top of, or very near, dense populations of the polychaete host. The parasite simply takes advantage of the proximity.

The question isn't whether those spawning redds should be so dense in the location mentioned above, rather should those polychaete host populations be as dense as they are? Dr. Stocking has compiled accurate density estimates (unpublished data) for these and many other polychaete populations in the Lower Klamath River. The general conclusions drawn by Dr. Stocking from these data and field observations are such that polychaete population densities appear to be strongly correlated with the abundance of fine particulate organic matter.

Therefore the Regional Water Board proposes that the following conditions would more effectively reduce the incidence and risk of fish disease in the Klamath River: 1) reduced phytoplankton production in the reservoirs; 2) more dynamic flushing flows; 3) decreased densities of spawning salmon (expected with increased range); 4) improved water quality conditions through reduction of nutrients and organic matter from upstream sources; and 5) improved temperature conditions within the basin including mainstem and tributary refugia. These actions will not only better protect but will also serve to increase and expand salmon populations in the Klamath River

B38. Comment(s):
The Draft TMDL also erroneously suggests that the Project reservoirs may cause nutrient enrichment that contributes to increased *Cladophora* growth that in turn provides habitat for the *C. shasta* polychaete host *M. speciosa*. The Project reservoirs created by the dams (Iron Gate, Copco, and J.C. Boyle) help protect water quality in the lower basin by retaining a substantial portion of the enormous loads of nutrients and organic matter from upstream sources, notably Upper Klamath Lake. Also, the abundance and distribution of *Cladophora* in the Project area would be much greater in the absence of the Project reservoirs.

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The Regional Water Board disagrees with several aspects of this comment. There is substantial evidence that during the critical summer growth period (June – August) for *Cladophora* the reservoirs do not retain nutrients (Asarian et al. 2009). Also while there is a net annual retention of nutrients, to characterize it as a substantial portion is not

consistent with the majority of retention estimates. In addition, there are other aspects of the reservoirs that contribute to increased densities of *Cladophora* that are summarized in response B20. The comment relating to the abundance and distribution of *Cladophora* in the project area without reservoirs is not substantiated. The Regional Water Board stands by the linkages illustrated and described in the water quality conceptual model.

In addition, Fine Particulate Organic Matter (FPOM), which is retained quite well by *Cladophora*, appears to be a critical factor determining distribution and abundance of *M. speciosa*. Published research indicates that FPOM makes up a significant portion of the Fabriciinae diet and personal observations (Stocking) show that *M. speciosa* (Sabellidae: Fabriciinae) is no exception. Sparse amounts of *Cladophora* found near Saints Rest Bar (above the confluence with the Trinity River) possessed almost no organic matter and very low polychaete densities. *Cladophora* found near I-5 was saturated with FPOM and polychaetes (Stocking, unpublished data). Data results of numerous polychaete populations between these two locations indicate a solid trend. To the extent that project reservoirs have altered the distribution and abundance of organic matter in the Klamath River, there can be no doubt that it has also altered the abundance of *C. shasta's* polychaete host (Richard W. Stocking Personal Communication 2009 – see B5 references above).

B39. Comment(s):

On page 2-32, the Draft TMDL presents no evidence or citations that such pathways "have resulted in major documented fish mortalities in the Klamath River", resulting in a statement and a subsequent discussion that is speculative.

Comment(s) Made By:

Hemstreet – PacifiCorp

Response:

The comment refers to the following series of ecological risk assessment hypotheses from the June 2009 Public Review Draft:

The pathways that have resulted in major documented fish mortalities in the Klamath River in the last several years are illustrated as follows: **increased nutrient loading (NA1) → elevated periphyton/macrophyte growth (NB1)** and **elevated suspended algae and blue-green algal growth (NB2) → increased polychaete habitat (NB4) → increased polychaete population and Ceratomyxa shasta (C. shasta) population and dosing (NB9)**. This pathway is not complete without consideration of the combination of increased parasite densities with stressful water quality conditions (e.g., high temperatures, low DO) which results in an increased incidence of disease and mortality.

The independent peer review panel was asked to specifically review these aspects of the Klamath River TMDL water quality conceptual model. The response from peer reviewers was that this model represents the "state of the science" regarding our current understanding of these processes. The development of a conceptual model that explains the decline of fisheries in the Klamath River was identified as a priority in the National Research Council of the National Academies (NRC) 2004 report, "*Endangered and Threatened Fishes in the Klamath River Basin*". The TMDL staff report provides information conditions for each one of the identified linkages. The Regional Water Board acknowledges that additional research is necessary and that uncertainties regarding specific aspects of this model exist. However, the characterization offered by the commenter that the model linkages and associated discussion are speculative is wrong.

B40. Comment(s):
The Draft TMDL describes that salmon below Iron Gate dam have a high parasite load, but should clarify that the "hotspot" (page 2-40) of *C. shasta* density is actually located in the reach extending from the Shasta River to the Scott River, and that the reach just below Iron Gate dam has relatively low *C. shasta* density. The Draft TMDL fails to mention that a major source of myxospores is from salmon spawners in Bogus Creek downstream of Iron Gate Hatchery.

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The clarification regarding the location of the "hotspot" of *C. shasta* density will be included in the draft final staff report. The comment does not modify the conclusion that water quality conditions are a primary cause of the severity of the *C. shasta* density and infection rates as described in the impairment assessment water quality conceptual model. Note will also be made in the TMDL staff report of other sources of myxospores. Please refer to comment response B38 for more complete discussion of this issue.

B41. Comment(s):
This is a warm water system there is no way that humans can make it COLD.

Comment(s) Made By:
Bennett – Siskiyou County Supervisor, Distinct 4

Response:
The WARM and COLD designations refer to the types of beneficial uses present in the system. The WARM beneficial use designates the warm freshwater habitat beneficial use, whereas the COLD beneficial use designation refers to the cold freshwater habitat beneficial use. Both of these beneficial uses are present in the Klamath River and Copco and Iron Gate Reservoirs.

B42. Comment(s):
Lake Copco is naturally warm.

Comment(s) Made By:
Bodnar

Response:
The conditions in Lake Copco can not be considered natural. Please see section 5.2.3 of the staff report for further discussion.

B43. Comment(s):
Within the Klamath Basin, Wooley Creek provides the best reference stream for monitoring purposes since it is 97% within wilderness. Portions of Wooley Creek have experienced wildfire and reflect the natural disturbances common to all inland watersheds in California. In order to provide a benchmark to show progress towards compliance, it is vital that Wooley Creek be delisted under the TMDL process.

Comment(s) Made By:
Kelley – U.S. Forest Service, Six Rivers National Forest

Response:
This is a 303(d) listing issue. Please submit any relevant information, in accordance with direction previously given by the Regional Water Board and staff, during the next 303(d) data solicitation period.

B44. Comment(s):
We very much appreciate that the draft Klamath TMDL lists in Table 6.5 the many tributaries that provide thermal refugia from the mainstem Klamath peak temperatures. Given that these watersheds are listed as thermal refugia, it would be helpful if statements were made in the TMDL that these same watersheds were not considered temperature impaired and that the emphasis is on maintaining these thermal refugia and not on improving impaired stream temperatures. A number of papers have identified thermal refugia where salmonids have been known to escape detrimental water temperatures within the mainstem Klamath (references attached). Water temperature data in these studies indicate unimpaired temperatures within these tributaries. These tributaries typically have a 2 to 5 centigrade temperature differential with the mainstem. Without these refugia, juvenile mortality during migration would likely have been greater, contributing to further population declines.
Comment(s) Made By:
Kelley – U.S. Forest Service, Six Rivers National Forest

Response:
Please see the response to comment L16.

SOURCE ANALYSIS

C1. Comment(s):
Page 4-2, Paragraph 3, Line 1 and remainder of paragraph. This “river of renewal” is apparently taken from Stephan Most’s book, River of Renewal – Myth and History in the Klamath Basin (citation) and subsequent documentary film. Not only does the draft TMDL fail to reference Mr. Most’s work, but these sources have little technical basis. The subsequent discussion in this paragraph which uses “renewal process” and “renewal capabilities” is inappropriate in a technical document. These terms are undefined within the TMDL and not standard technical terms for aquatic system processes or analyses. Further, descriptions such as “less eutrophic” have little meaning in a technical analysis. There are standard technical terms (e.g., hypereutrophic, eutrophic, mesotrophic, oligotrophic) to define system limnological trophic status. However, the TMDL has failed to define even the most basic categorization for the river reaches in terms of trophic status (with the exception of Upper Klamath Lake which is described throughout the document as “naturally eutrophic”), making it difficult to describe spatial and temporal conditions in this large complex river. Such a categorization would be immensely useful in describing today’s conditions in a scientific manner, as well as describing the status of the river under a fully implemented TMDL to indicate measurable improvement in water quality conditions. Finally, this paragraph is an overly simplistic discussion of the implications of mechanical reaeration, tributary dilution, nutrient cycling, and other factors leading to variability in longitudinal water quality conditions throughout the Klamath River, providing little useful scientific information to support TMDL analyses and load allocations.

Comment(s) Made By:
Hemstreet – PacifiCorp (p. 23-24) (PacifiCorp – Appendix A and B.doc)

Response:
The commenter is incorrect in assuming that the use of the phrase is a direct reference to the book River of Renewal – Myth and History on the Klamath Basin (Most 2006). The title of the book and the use of the phrase in the TMDL staff report are based on its common usage by residents within the basin familiar with the high reaeration potential and dilution by tributaries that allow the Klamath River to process the high nutrient and organic loads from the upper basin. The TMDL staff report serves many objectives and audiences. One objective is to educate North Coast Regional Water Quality Control Board members and citizens (who often may not possess a technical background) regarding historical and current conditions within the Klamath basin. Regional Board staff use the phrase in conjunction with other terms to provide a more complete narrative description of the Klamath River. However, Mr. Most’s book does include much valuable background information about the Klamath basin and staff will add it as a reference to the staff report.

The reference to the terms used to describe trophic status are meant to provide a general understanding regarding trends over time, which does not require a more precise discussion of the various trophic classification approaches. Conditions in the river have been described in detail in chapter 2 relative to beneficial use support status. In addition

TMDL targets and allocations that can be used to measure progress towards support status have also been provided in Chapter 2 (Impairment Assessment) and Chapter 5 (Targets and Allocations).

C2. Comment(s):
Page 4-3, Paragraph 1, Lines 1-2. The draft TMDL identifies that source categories are "difficult to quantify exactly" – a statement that begs for uncertainty analysis in both the qualitative and, in particular, the quantitative tools employed in the analyses and load allocation. Given the complexity and size of the basin, not to mention interstate issues, it is hard to imagine that load allocations and robust implementation strategies and timelines can be developed without uncertainty analysis. (p. 24) (PacificCorp – Appendix A and B.doc)

Comments Made By:
Hemstreet – PacifiCorp

Response:
The Regional Water Board acknowledges, as evidenced by the quoted comment, that there is uncertainty inherent in the source analysis. However given the magnitude of the loads, more precise estimates are not needed to understand priority sources, magnitudes of necessary reductions, or the types of management actions that are needed to achieve required nutrient reductions. Uncertainty must be evaluated against what is known and how decisions would be impacted by uncertainties that have been identified. While the Regional Water board will continue to address all uncertainties associated with the Klamath River TMDL through the adaptive management process, the uncertainties identified in the comment have been considered adequately within the current form of the TMDL.

The Regional Water Board strategy was to more completely quantify loads from source areas. In our existing source analysis the Regional Water Board identifies loads by source area not source category. We do make estimates of natural background loading using the natural baseline conditions TMDL model run. What the Regional Water Board does not do is then parse out the above background loading by source categories or entities. There is a rationale for not identifying nonpoint source loads by source category or by individual. That is, everyone is required to control their own portion of the above background loading through NPS best management practices (BMPs). Nonpoint source TMDL implementation will be carried out through the Regional Water Board nonpoint source regulatory programs' waste discharge requirements and conditional waivers of waste discharge requirements (permits). The conditions of those permits only addresses human caused source of pollution by requiring the discharger to implement reasonable and effective management practices to address their discharges. Therefore there is no need to undertake a source category loading analysis or any associated uncertainty analysis. Dischargers will not be required to address natural sources of pollution on their land.

C3. Comment(s):

Even the Draft TMDL's model outputs clearly show that the reservoirs substantially reduce large nutrient pulses emanating from the Klamath River upstream of the Project (in response to bloom conditions in Upper Klamath Lake). As the Draft TMDL admits, compliance with the Draft TMDL would essentially require removal of the Klamath Hydroelectric Project. However, Project removal before UKL TMDL goals are met would result in increased water quality impairment in the Klamath River. Implementation of a TMDL (in this case the Klamath River TMDL) that results in degradation to water quality is inconsistent with the Clean Water Act. (cover ltr p.3)

Comment(s) Made By:

Hemstreet – PacifiCorp

Response:

The rationale for conducting a collaborative Klamath River TMDL involving Oregon Department of Environmental Quality, North Coast Regional Water Quality Control Board, and EPA Regions 9 and 10 was to ensure that nutrient related stressors are dealt with comprehensively. The Klamath TMDL team recognizes that water quality conditions upstream of the reservoirs and water quality conditions within the reservoirs must both be addressed to achieve the desired water quality outcomes. Section 4.2.2.2 of the TMDL staff report describes the role of the Klamath Hydroelectric Project reservoirs in California (Iron Gate and Copco Reservoirs) regarding nutrient dynamics (including nutrient retention) in the Klamath River. This assessment uses several lines of evidence to evaluate the nutrient dynamics and nutrient retention of Iron Gate and Copco Reservoirs. To date the Regional Water Board assessment indicates that Iron Gate and Copco reservoirs provide at best a minor benefit in reducing total nutrient loads to the Lower Klamath River. The effect of the reservoirs on water quality is complex and involves more than net annual retention of nutrients. As described in 2.4.2.3 of the TMDL staff report, the reservoirs also present risk cofactors for biostimulatory response because of the environment they create (quiescent waters dominated by nuisance levels of toxic blue-green), and the change in form and timing of nutrients exported downstream. The Regional Water Board has balanced in reservoir water quality problems and their role in nutrient dynamics in developing nutrient allocations for the reservoirs. The Regional Water Board analysis determined that without reservoirs the chlorophyll a and blue-green algae related targets would be met in a free flowing river. Currently chlorophyll a targets at Klamath River above Copco are met >95% of the time from May-September, and thus is currently likely to be met even more often if upstream nutrients are reduced. Given that dams are present the nutrient allocations assigned by the Regional Water Board in the staff report are required to meet desired water quality conditions. It was not the purpose or intent of the allocations to require the removal of the Klamath Hydroelectric Project reservoirs. Regional Water Board staff agrees that if PacifiCorp decides to remove the dams as a result of the FERC relicensing process, or as part of the Klamath Hydropower Settlement Agreement, or as one means of compliance for the TMDL, that careful consideration should be given to potential downstream impacts. While the dams do provide some net annual retention for both phosphorous and nitrogen, the downstream water quality impacts related to lost retention due to dam removal could be evaluated and may not be significant. Removing the dams in the absence of other actions would not solve water quality problems downstream of the dams, upstream pollutant reduction targets would also need to be met.

Sections 2.4.2.3 and 4.2.2.2 will be updated to reflect the findings presented in the final report: "*Multi-Year Nutrient Budget Dynamics For Iron Gate and Copco Reservoirs, California"* (Asarian et. al 2009).

C4. Comment(s):
Page 4-11, Paragraphs 1-3. Discussion of Fig 4-4 is confusing. There seems to be a distinction made between "discharge of irrigation return flows" and "impacts caused by irrigation diversion." Please clarify. Also, are the temperatures of return water from KSD and LRDC the same in natural and current conditions? If not, these should be clearly identified as sources of potential heat. A more fundamental issue is that temperature is one of the least conservative constituents because of the constant heat exchange across the air-water interface. There is no discussion of (a) if the river is at or near equilibrium temperature for this assessment (Figure 4.4), but presumably it is, (b) if the return flows from irrigation are at or near equilibrium, presumably they are, (c) the volume of irrigation return flows compared to the receiving water, and (d) the distance from Stateline to these return flow points is notable. The river will seek equilibrium temperature and this may make any difference in irrigation return flow negligible. A more focused discussion is necessary to interpret these results. (p. 27) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The distinction between a discharge and a diversion is that a discharge involves putting something into the river, whereas a diversion involves taking water out of the river. The purpose of this discussion is to disclose the possible sources of heating upstream of California. The relative contribution of those sources and their load allocations will be addressed in the State of Oregon's Klamath River TMDL.

C5. Comment(s):
Page 4-12, Paragraph 2, Line 2. TP and TN loads include algae, correct? (p. 27) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
Yes, the TN and TP model estimates include nutrients incorporated into phytoplankton algal tissue.

C6. Comment(s):
Page 4-13, Paragraph 1. In discussing Copco and Iron Gate it would be useful to see a graph and table showing current condition loads attributable to the other two sources discussed in this TMDL - these are California tributaries and reservoirs. PacifiCorp believes that reservoirs contribute no net load of either total phosphorus (TP), total nitrogen (TN), or organic matter (OM). Since the argument for nutrient load reductions in the reservoirs is that they change the "timing and form" of nutrients, perhaps these tables and graphs should show net load. (p. 28) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The nutrient load reduction allocations assigned to the reservoirs in the TMDL staff report are necessary to meet the TMDL numeric targets for chlorophyll a, *Microcystis aeruginosa*, and microcystin within the facilities. For this reason the comparison to tributary source analysis and by extension tributary allocations is not a meaningful comparison. In addition, reservoir nutrient allocations have been simplified and condensed in the draft final staff report to allow PacifiCorp more flexibility in meeting their nutrient reduction targets. That is, a specific allocation for nutrient sediment release has been incorporated into a single overall nutrient reduction allocation assigned to Iron Gate and Copco reservoirs to ensure supporting conditions in the reservoirs.

C7. Comment(s):
Page 4-13, Paragraph 1, Lines 6-11. The discussion on the Klamath Project nutrient load reductions is an important element of the TMDL and should be presented more fully herein. Please define annual and seasonal reductions/increases. There seems to have been an analysis or data review but the information is not reported in the draft TMDL and no references are cited. Although there is reference to the Lost River TMDLs (Oregon and California), a comprehensive assessment is not included in those documents. This seems to be a critical omission. (p. 28) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The Regional Water Board believes that the description referenced in this comment is adequate for the purposes of this portion of the source assessment. However, for a more

complete description, please reference response to comment C21, which will be added to the TMDL staff report.

C8. Comment(s):
Page 4-15, Paragraph 4, Lines 1-2. There is no presentation of existing dissolved oxygen conditions to support this first sentence. Providing a chart of the dissolved oxygen conditions in Copco 1 and 2 and Iron Gate Reservoirs through the year with associated volume would be beneficial. Labeled on the chart should also be the required water quality standards. This statement could be supported by field data as well to get around the fact that only the year 2000 was modeled for the TMDL. Such data would also illustrate the inter-annual variability in volumes of water where dissolved oxygen conditions are undesirable. (p. 30)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The first two line of the paragraph directs the reader to Chapter 2 where dissolved oxygen conditions for Iron Gate Reservoir are presented and discussed. A specific reference to Tables 2.11 and 2.12, and Figures 2.25 and 2.26 will be added. A reference to PacifiCorp reports containing additional depth profile information will also be added.

PacifiCorp. 2008. Water Quality Conditions During 2007 in the Vicinity of the Klamath Hydroelectric Project. Prepared by: Richard Raymond, Ph.D. Prepared for: PacifiCorp Energy, 825 N.E. Multnomah, Suite 1500 Portland, OR 97232.

PacifiCorp. 2009. Water Quality Conditions During 2008 in the Vicinity of the Klamath Hydroelectric Project. Prepared by: Richard Raymond, Ph.D. Prepared for: CH2M Hill 2020 SW 4th Avenue, 3rd Floor Portland, OR 97201 and PacifiCorp Energy, 825 N.E. Multnomah, Suite 1500 Portland, OR 97232.

Volumes (deficits) have not been calculated for the source analysis. The instantaneous mass for the oxygen deficit has been calculated and presented as part of the compliance lens calculation in Chapter 5 of the TMDL staff report.

C9. Comment(s):
Page 4-16, Paragraph 1, Lines 10-12. Temperature and dissolved oxygen conditions under existing and natural conditions scenarios are not presented for critical summer periods in the Copco and Iron Gate Dam reaches, nor are associated standards. Presentation of this information is required to support the statement that co-occurring dissolved oxygen and temperatures would meet standards under natural conditions. (It is not clear if this sentence refers to a “natural free flowing condition” or the TMDL natural conditions baseline – if there is a difference.) (p. 30) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The values used in temperature and dissolved oxygen evaluation for the reservoirs were 18.7 ^{0} centigrade and 6.0 mg/L dissolved oxygen. The temperature value is the natural conditions baseline summer mean (May to October) for the free flowing stream at what is now the longitudinal mid point of the reservoirs. The dissolved oxygen value of 6 mg/L was selected because it is the point at which fish begin to exhibit avoidance behavior. The natural conditions baseline (free flowing) for mid-point Iron Gate Reservoir summer mean dissolved oxygen is 8.2 mg/L. This information will be included in the draft final staff report. Depth profile example data for existing conditions is included in Chapter 2 (Impairment Assessment). However as noted in comment response C8 above, additional examples of existing conditions from PacifiCorp annual water quality reports will be added to Chapter 4.

C10. Comment(s):
Page 4-16, Paragraph 2, Lines 1-4. Internal nutrient loading in stratified reservoirs does little to exacerbate dissolved oxygen conditions because for internal loading to occur, anoxia must be present. Anoxia occurs primarily because of seasonal stratification and is largely driven by organic matter loading and sediment oxygen demand. Resulting loading from the sediments is generally limited to the hypolimnion. When the reservoir attains an isothermal condition in the fall, dissolved oxygen conditions are typically no longer of concern. Likewise any available nutrients that were contributed from the hypolimnetic volume during turnover are of minimal consequence because the shorter days and cooler temperatures limit algal growth. Copco and Iron Gate Reservoirs have very short residence times in the winter due to the relatively small storage, large inflows, and isothermal condition, so carryover of hypolimnetic nutrients from one season to the next is most likely insignificant. (p. 30) (PacificCorp – Appendix A and B.doc) (This comment is also included and addressed in TMDL Model Comments A.33)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The remarks presented here are generally true. Stratification does limit the transport of nutrients derived from anoxic bottom sediments to surface waters – but does not eliminate their transport. Whether or not this is significant must be based on an analysis of the processes, not on a value judgment that the internal loading “does little” to impact oxygen conditions. Two important considerations must be added to the view presented in the comment. First, both molecular and turbulent diffusion do occur across the thermocline, resulting in gradual mixing of hypolimnetic nutrients into surface waters even under stratified conditions. Second, it has long been recognized that many cyanophytes (blue-green algae) possess gas vacuoles that enable the organisms to

regulate their position in the water column. As summarized by Wetzel (2001), "…blue-green algae are able to regulate buoyancy and undergo limited vertical migration to poise themselves within vertical gradients of physical chemical gradients favorable to growth… The population maximum, coupling population growth with movement downward, apparently often occurs as epilimnetic nutrient concentrations are depleted in summer. Movement to lower strata of low light and temperatures and increased nutrient availability occurs." Thus, cyanophytes under bloom conditions may actively "pump" nutrients from the thermocline, derived from bottom sediments, into surface waters.

The comment ignores the capability of cyanophytes to migrate within the water column to retrieve nutrients from the hypolimnion during the evening and return to the surface during the day. This phenomenon has been documented in Copco Reservoir by Pia Moisander. Samples taken at station CRSC02 in August 2008 clearly show a *Microcystis aeruginosa* population shifting their population to lower depths in the night and early morning hours, with the 6 AM population peak coinciding with the maximum vertical extent of elevated ammonia concentrations derived from the hypolimnion (Figure C10.1). As described in Moisander (2009):

"Both Microcystis and Aphanizomenon are able to use vertical migration for nutrient acquisition (Rabouille et al., 2005; Chu et al., 2007), a strategy that could be very useful in Iron Gate and Copco Reservoirs which have a permanent anoxic bottom layer maintaining high NH4 + and DIP in the summertime (Kann and Asarian, 2007). Riverine inputs from the upper watershed serve as another abundant source of DIN, potentially supporting Microcystis blooms."

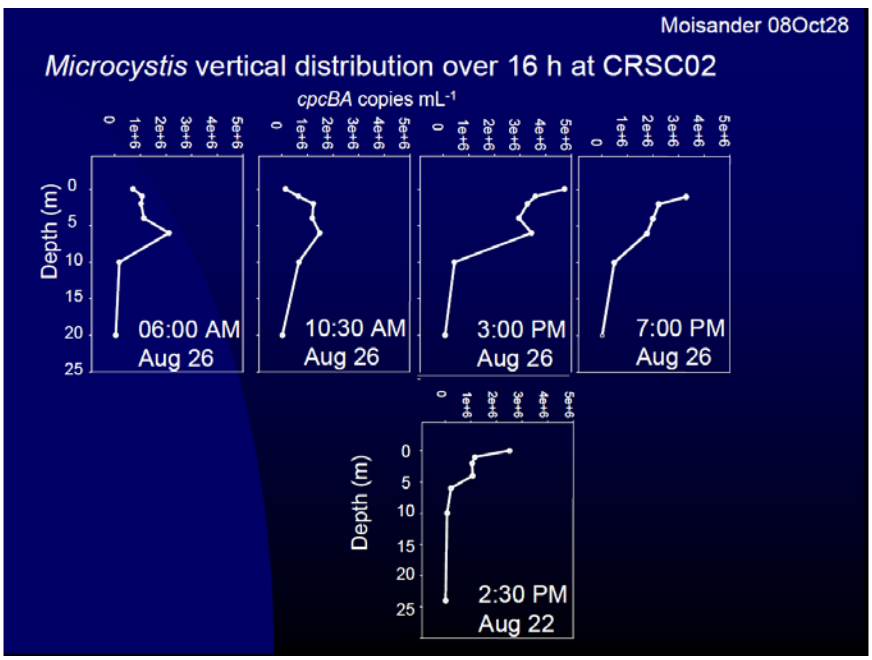


Figure C10.1 Vertical migration of *Microcystis* over a 16 hour period in Copco Reservoir on August 26, 2006. From: Diversity and nutrient limitation of *Microcystis*in Klamath

River reservoirs, a slide presentation by Pia H. Moisander, University of California Santa Cruz, Ocean Sciences Department.

Regarding "When the reservoir attains an isothermal condition in the fall, dissolved oxygen conditions are typically no longer of concern.", DO at deepest depths is near-zero even after temperature stratification breaks down. For example, at Copco Reservoir on 9/21/2005, there was only a 5 degree C difference between surface and bottom temperatures, but DO at 25m depth was near-zero. Similarly on 10/4/2005, there was only a 2 degree C difference in surface and bottom temperatures, but DO at 25m was near-zero)(see Appendix A1 of Asarian and Kann 2009). Conditions at Copco were similar in 2006 and 2007. The same phenomenon also occurs in Iron Gate, but later (November).

Actually, dissolved oxygen concentrations can be a concern in late September and October, when fall chinook spawn. In 2008, D.O. concentrations below Iron Gate Dam were lower in late September than at any other time in the months June-September, with mean D.O. concentrations less than 7 mg/L (see Figures C10.2 from Karuk Tribe 2008).

It is probably true that releases of low D.O. water from Iron Gate are more driven by stratification than by internal loading, but does not eliminate internal loading as a potential contributing factor.

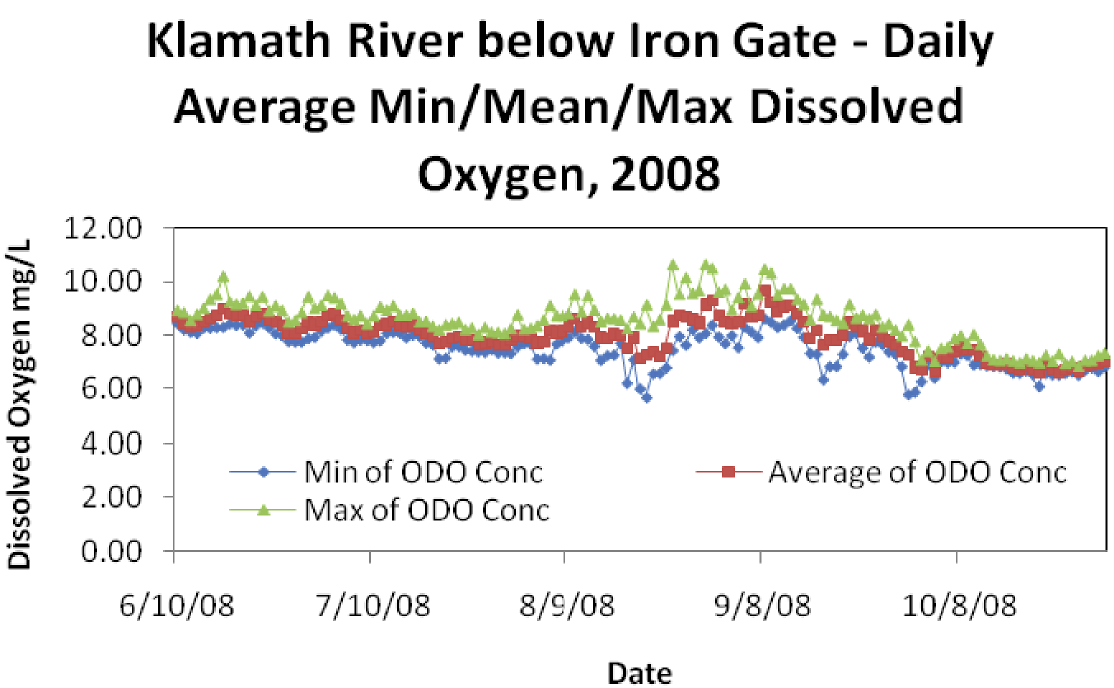


Figure C10.2 Daily Average, Minimum and Maximum DO Conditions below Iron Gate Dam for June – October 2008

References cited in C10 Response:

Asarian, E., J. Kann, and W.W. Walker. 2009. Multi-Year Nutrient Budget Dynamics for Iron Gate and Copco Reservoirs, California (Review Draft). Prepared for the Karuk Tribe of California, Dept. of Natural Resources. Riverbend Sciences and Kier Associates, Eureka, CA.

Karuk Tribe. 2008. Water Quality Assessment Report 2008. Karuk Tribe Department of Natural Resources, Orleans, CA. 75 p. Available online at: http://www.klamathwaterquality.com/documents/2009/2008_WQReport_Karuk.pdf

Moisander, P.H., et al. 2009. Nutrient limitation of Microcystis aeruginosa in northern California Klamath River reservoirs. Harmful Algae (2009), accessed at: http://dx.doi:10.1016/j.hal.2009.04.005

Wetzel, R.G. 2001. Limnology: Lake and River Ecosystems, 3rd ed. Academic Press

C11. Comment(s):

Page 4-17, Paragraph, Bullet points. The listed bullet points are largely not applicable to Iron Gate and Copco reservoirs, and the implications of internal loading on these reservoirs should be explained in the context of their physical and chemical characteristics. Basic processes information can be found in any basic limnology textbook and readily presented in light of conditions at Copco and Iron Gate reservoirs. Specifically, anoxia occurs primarily because of seasonal stratification and is largely driven by organic matter loading and sediment oxygen demand. Resulting loading from the sediments is generally limited to the hypolimnion. When the reservoir attains an isothermal condition in the fall, dissolved oxygen conditions are typically no longer of concern. Likewise any available nutrients that were contributed from the hypolimnetic volume during turnover are of minimal consequence because the shorter days and cooler temperatures limit algal growth. Copco and Iron Gate Reservoirs have very short residence times, on the order of days, during elevated flow conditions in winter due to the relatively small storage, large inflows, and isothermal condition, so carryover of hypolimnetic nutrients from one season to the next is most likely insignificant. This is an important distinction of the Klamath River reservoirs: lakes with longer residence times allow nutrients from the hypolimnion to mix throughout the entire water column during the fall and the onset of stratification in the subsequent spring captures some of these nutrients in the epilimnion making them available for primary production. Through time this cycle can shift a reservoir from a lower trophic state to a higher trophic state (i.e., eutrophication). Loading from the sediments is just over one percent of influent loads (as shown in Figures 4.1 to 4.3) and does not contribute widely to the reservoir water quality impairment (nor does it affect the river downstream to an appreciable degree because the contributions are small and any increases will occur later in the year during the waning periods of the annual algae growth season).

Before addressing each of the five bullet points, it should be noted that all of the process may happen somewhere in a lake or reservoir or river, but the important question is whether they are driving water quality conditions in these reservoirs.

Bullet 1 – Wind driven currents are important in water quality and mixing considerations in lake environments. However, sediment disturbance by wind is a process that is more of a factor in shallow lakes. Copco and Iron Gate reservoirs are impoundments located in steep canyon areas and thus are deep with sloping sides. Because they are maintained at stable levels for hydropower purposes, macrophytes tend to ring these reservoirs dissipating wind energy and minimizing resuspension of sediment. This process (along with degassing and bioturbation) is probably small in the reservoirs.

Bullet 2 – This bullet point describes the basic process of sediment release under anoxic conditions.

Bullet 3 – High pH at the sediment surface may affect sediment flux, but under anoxic conditions pH is typically low under reduced conditions in the reservoir bottom waters. Both Copco and Iron Gate bottom waters during summer have pH values typically below 7.5 and sometimes well below 6.0. This may occur in shallow margins areas of the reservoir, but is probably not a dominant process.

Bullet 4 – This bullet point erroneously suggests that shallow lakes experience seasonal stratification. Shallow lakes (e.g. Upper Klamath Lake) do not experience seasonal stratification because wind mixing imparts sufficient energy into the system to overcome density differences. The result is that shallow lakes often have weak, intermittent stratification, but not persistent stratification. Important to this discussion is that even short duration, weak stratification can produce anoxia and sediment nutrient release, which under subsequent mixing conditions can be introduced into the photic zone and support primary production. However, the main stem reservoirs are deep and experience strong seasonal stratification that precludes this condition from representing a dominant process.

Bullet 5 – Reservoirs can produce large standing crops of BGA that are nitrogen fixers. However, nitrogen fixation does require energy and there has been no analysis to date if this process is occurring. The mere presence of heterocysts is not conclusive of actual nitrogen fixation. In addition, both reservoirs experience the persistent presence of considerable standing crop of both non-nitrogen fixing BGA (e.g., *Microcystis*) and nitrogen fixing BGA (e.g., *Aphanizenmenon*) which suggests that this is not a dominant process in the Project reservoirs.

In sum, these are valid points for UKL, but in the context of Chapter 4 discussions, they appear to be aimed at PacifiCorp reservoirs, where they are not readily applicable in describing dominant water quality processes. From an internal loading perspective, the critical process of fall turnover to reintroduction nutrients to the near-surface waters from deeper waters is not even mentioned in the draft TMDL. As noted above, the short residence time of the reservoirs in winter indicates that these nutrients would be exported downstream and not have notable carryover effects on water quality in subsequent years. This comment reflects an overall concern with the TMDL - that Regional Board staff may not fully grasp the complex interrelationships at work in the Klamath River and reservoir reaches and are oversimplifying critical components in the TMDL analysis, leading to inappropriate load allocations. (p. 31-32) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
This comment largely repeats Comment A.34, with the addition of further material relative to the bullet points presented on p. 4-17. Please refer first to the response to Comment A.34.

The TMDL document does not contend that internal recycling of nutrients is the major factor "driving water quality conditions in these reservoirs." Instead, the TMDL document clearly acknowledges that the majority of the nutrient load is derived from upstream. However, additional incremental contributions do occur from internal loading. Regulations require that the TMDL attempt to account for all sources, stating that the TMDL should include "Load Allocations for any nonpoint sources of pollution and natural background sources, tributaries, or adjacent segments" (40 CFR §130.2(i)).

The comment mischaracterizes the five bullet points on p. 4-17. The document does not contend that all five processes are active and significant at all times in Copco and Iron Gate. Rather, it says that, under stratified conditions with an anoxic hypolimnion, a "reservoir is subject to one or more of the following processes that can lead to the transfer of nutrients from the reservoir bottom sediments back into the water column; processes collectively referred to as internal nutrient loading."

Regarding the individual bullets:

- Bullet 1 is acknowledged but characterized as "probably small in the reservoirs." This is likely true. Nonetheless, wind driven currents do contribute to the regeneration of nutrients and so are appropriate to consider as one of various potential mechanisms for contributing to internal nutrient loading. Iron Gate Reservoir is indeed a canyon, composed mostly of deep areas, but Copco is a wide flat valley (see Bathymetry map below from Eilers and Gubala 2003), with substantial portions of the reservoir being quite shallow, particularly at the upstream end.

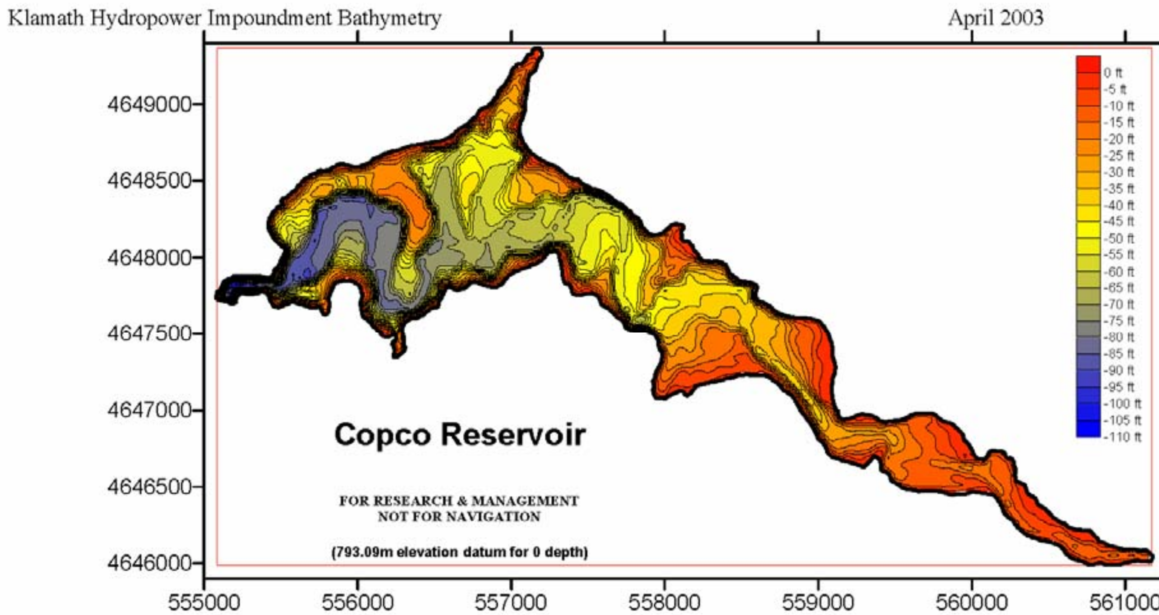


Figure 5. Bathymetric map of Copco Reservoir up to bridge crossing.

- Bullet 2 is acknowledged without comment.
- Bullet 3 refers to high pH at the sediment surface, which can enhance phosphorus release. The comment says that in Copco and Iron Gate "bottom waters during summer have pH values typically below 7.5." This in no way negates the bullet point. Indeed, a pH of 7.5 is above neutral conditions. Jacoby et al.'s (1982) study of Long Lake, WA demonstrates that equilibrium total dissolved P tends to increase rapidly above a pH of 6, while at a pH of 7.5 the total dissolved P concentration in midlake sediments was about twice that observed at a pH of 6.
- Bullet 4 is said to "erroneously suggest [s] that shallow lakes experience seasonal stratification." In fact, this bullet describes the phenomenon of algal vertical (active or passive) migration that enables algae to transport nutrients from the thermocline to surface waters (see response to Comment A.34). This phenomenon is not dependent on the lake being shallow. Indeed, it is more likely to be of importance in deeper, stratified lakes. The text will be corrected to say "In *stratified* lakes…" rather than "In *shallow* lakes…" With this correction, the phenomenon clearly does apply to Copco and Iron Gate.
- Bullet 5 comments acknowledge the likelihood of nitrogen fixation by cyanophytes in the reservoirs but "suggests that this is not a dominant process in the Project reservoirs." The point of the bullet is that the process does occur, and does contribute to internal nutrient loading. There is no attempt to imply that it constitutes a major part of the total nutrient mass budget, only that it is a source and thus should be considered as a part of the total loading under the TMDL regulations. This also becomes an important point when considering management strategies. For example, if the nutrient reduction strategy was targeted to nitrogen only, a shift could occur to population dominance by nitrogen fixing cyanophytes.

References for C11:

Eilers, J.M. and C. P. Gubala. 2003. Bathymetry and Sediment Classification of the Klamath Hydropower Project Impoundments. Draft Technical Report. Prepared for PacifiCorp by JC Headwaters, Inc. April 2003. <http://www.pacificorp.com/File/File28024.pdf>. Accessed 2004 1 August.

Jacoby, J.M., D.D. Lynch, E.B. Welch, and M.A. Perkins. 1982. Internal phosphorus loading in a shallow, eutrophic lake. *Water Res.*, 16:911-919.

C12. Comment(s):

Page 4-18, Figure 4.9. Review of draft TMDL Appendix 6, Appendix K illustrates that DO plots for model calibration can readily be used to define the "critical growth period." Specifically, the diurnal range of DO is minimal (well under 1 mg/L) until approximately mid-May. Subsequently the diurnal range begins to expand notably at sites throughout the Klamath River, wherein the diurnal range may extend from less than 2 mg/L to over 4 mg/L through August. As solar altitude and day length decrease more rapidly by mid-August, all traces show a reduction in diurnal DO, indicating the seasonal reduction in standing crop. By the end of September there is little or no diurnal range in DO. Important in assessing this information is that after approximately early-to mid-August the decline in standing crop may still produce notable diurnal variation in dissolved oxygen and pH, but that additional nutrient loading will most likely have minimal impact because standing crop is being constrained by light limitation (day length). Thus by early- to mid-September, by a conservative estimate, increased nutrient loading as shown in Figure 4.9 will have a negligible biostimulatory effect on standing crop. Figure 4.9 clearly indicates that much of the load will occur well outside of the biostimulatory period– on the order of half the load occurs after October 1. Further, these very modest increases in concentration prior to that date (typically less than 0.005 mg/L) are probably having little effect on a system that is typically nitrogen limited from June -September. In sum, the statement in paragraph 2 stating this "increase in bio-available phosphorus occurs during the growth period (see subsequent comment), contributing to biostimulatory conditions downstream of the reservoirs" is misleading because much of the load occurs after the growth season and is probably an overstatement of impacts. Further, any impacts of this small increase identified in Figure 4.9 on biostimulatory conditions downstream are not quantified and would probably have little or no effect due to the naturally elevated levels of phosphorus in the Klamath River system. (p. 32) (PacificCorp – Appendix A and B.doc) (This comment has also been included in TMDL Model - A36.)

Comment(s) Made By:

Hemstreet – PacifiCorp

Response:
The Regional Water Board staff disagrees with this comment which is misleading on a number of levels. Photosynthesis will decline as light availability decreases and temperatures drop. However, the statement that "By the end of September there is little or no diurnal range in DO" is simply untrue. Examination of the figures in Appendix K to Appendix 6 shows that significant diurnal DO fluctuations on the order of 1 mg/L occur into early October and the size of these fluctuations is validated by observed data in mid September at numerous locations. Positive pH fluctuations also persist into October, indicating active photosynthesis. Although growth rates have generally declined by mid September, it is not safe to conclude that increased nutrient loading "will have a negligible biostimulatory effect on standing crop." That assertion can only be made relative to the pre-existing nutrient status of periphyton biomass prior to the onset of fall.

The comment then goes on to discuss Figure 4.9, claiming that this figure "clearly indicates that much of the load will occur well outside of the biostimulatory period." This makes little sense, as Figure 4.9 does not present loads, but only concentration differences due to the assumptions about phosphorus benthic flux. The TMDL report clearly acknowledges that the load contribution due to benthic flux is small relative to the total phosphorus load transported in the river: "While these bottom sediment nutrient flux loads are relatively small compared to the current total loadings entering the reservoirs, they do represent a controllable increase in nutrient loading that would not occur in the absence of anoxic conditions created by the presence of the reservoirs." Further, the increase in concentration shown in Figure 4.9 becomes noticeable by about the first of August, and clearly co-occurs with peak growth conditions in the river. Whether or not "the majority of these loads occur during the summer months" depends on how the summer months are defined. As can be determined from Table 4.2, 73 percent of the benthic phosphorus flux from Copco and Iron Gate occurs during the May to October period. The fraction would of course be less if October was omitted from the "summer" designation.

C13. Comment(s):
Page 4-19, Paragraph 3: Role of Copco and Iron Gate Reservoirs in Klamath River Nutrient Dynamics. To reiterate earlier comments, the TMDL definition of the critical growth period from May through October masks critical intra-seasonal dynamics in the Klamath River. Reservoirs do affect both timing and form of source load. Discussions have focused on annual or six month loading assessments presented in the draft TMDL and have missed critical within season dynamics. The fundamental flaw in this analysis is the omission of carefully examining TMDL model outputs which clearly show that the reservoirs dramatically reduce large nutrient pulses emanating from Oregon (in response to bloom conditions in UKL). As described in detail in section III.D of the cover document preceding this appendix, PacifiCorp's water quality modeling consultant (Watercourse Engineering) performed model runs (using the Draft TMDL models recently obtained from Tetra Tech for review) that clearly show that TP and TN loads at Iron Gate dam are substantially lower under current conditions than under conditions assuming the dams are absent. This is due to the significant retention and loss

of inflowing organic matter in the reservoirs that would not occur without the reservoirs.

As described in detail in section III.D of the cover document preceding this appendix, the peak nutrient loads coming from upstream sources are also shifted later into the fall than would occur without the reservoirs. This shift into the fall is important because, with dams in place, nutrients tend to leave the reservoirs later in the season after benthic algae standing crop in the river has started to diminish. The simulation models used in the Draft TMDL have the ability to effectively characterize the impacts of the reservoirs on the dynamics of nutrient loads, but have not been used in the Draft TMDL to more fully account for these important processes. Detailed discussion of nutrient dynamics in the project area presented in detail in PacifiCorp (2006) provides additional information based on both model results and field data, none of which was referenced in the draft TMDL. (p. 33) (PacificCorp – Appendix A and B.doc) (This comment has also been included in the TMDL Model A37.)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The cited model runs conducted by Watercourse Engineering have not been provided for peer review, and the Regional Water Board is unable to comment on their accuracy. Simulated retention and delay of nutrient pulses depends not just on the model parameters but also on the assumptions regarding nutrient speciation in the boundary conditions. For example, nutrients in particulate organic form will be much more likely to settle and be retained than nutrients in dissolved form. The existing model runs for 2000 clearly show that nutrient retention rates in the reservoirs are low on an annual basis (less than 10 percent except for nitrogen in Iron Gate – see Appendix 3). Further, the modeled estimate of nitrogen retention in Iron Gate in 2000 (about 18 percent) does not appear to be representative of typical nitrogen retention rates in this reservoir. Asarian et al. (2009) recently completed a detailed empirical analysis of the reservoir nutrient budgets over a 2 ½ year period of intensive monitoring of the reservoirs (May 2005 – December 2007). For total phosphorus, this report estimates an annual retention rate of 11 percent in Copco and 7 percent in Iron Gate – with negative retention rates over the May – September period. For total nitrogen, this report estimates an annual retention rate of 7 percent in Copco and 5 percent in Iron Gate, with somewhat higher retention rates over the May – September period, likely due to denitrification losses. There is variability in retention from month to month. However, examination of Figures 23 – 26 in Asarian et al. (2009) and copied below shows that reservoirs have at most a minimal effect on the timing of the delivery of loads to the lower river.

References Used in Response C13:
Asarian, E., J. Kann, and W.W. Walker. 2009. Multi-Year Nutrient Budget Dynamics for Iron Gate and Copco Reservoirs, California (Review Draft). Prepared for the Karuk Tribe of California, Dept. of Natural Resources. Riverbend Sciences and Kier Associates, Eureka, CA.

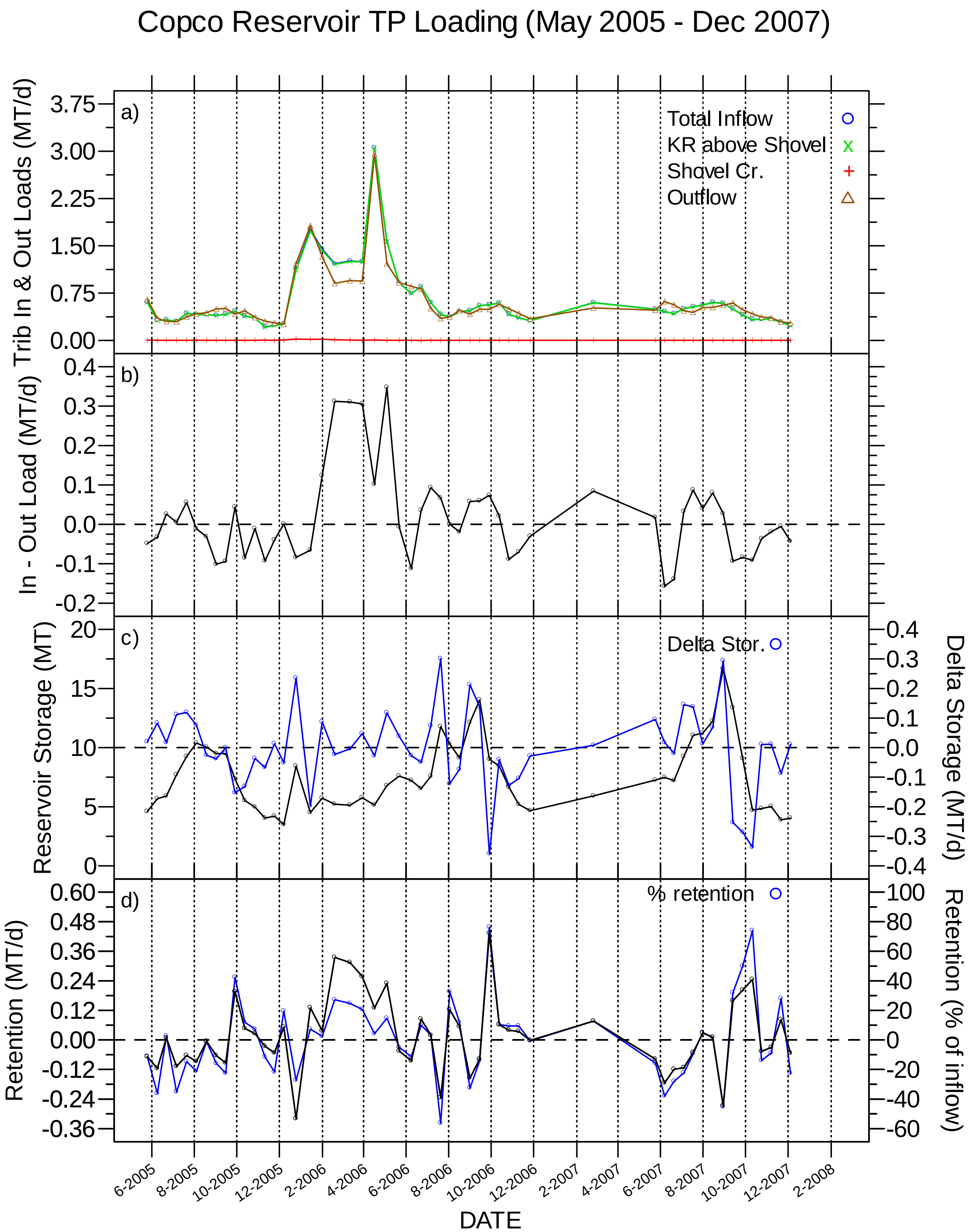


Figure 1. Tim e series of Copco Re servoir total phosphorus loading, May 2005 – Dec 2007. Ea ch point represents data from an entire sam pling interval (~biweekly) and is placed at the m idpoint of the two adjacent sampling dates. Horizon tal dashed lines are placed at zero fo r ΔStorage and retention.

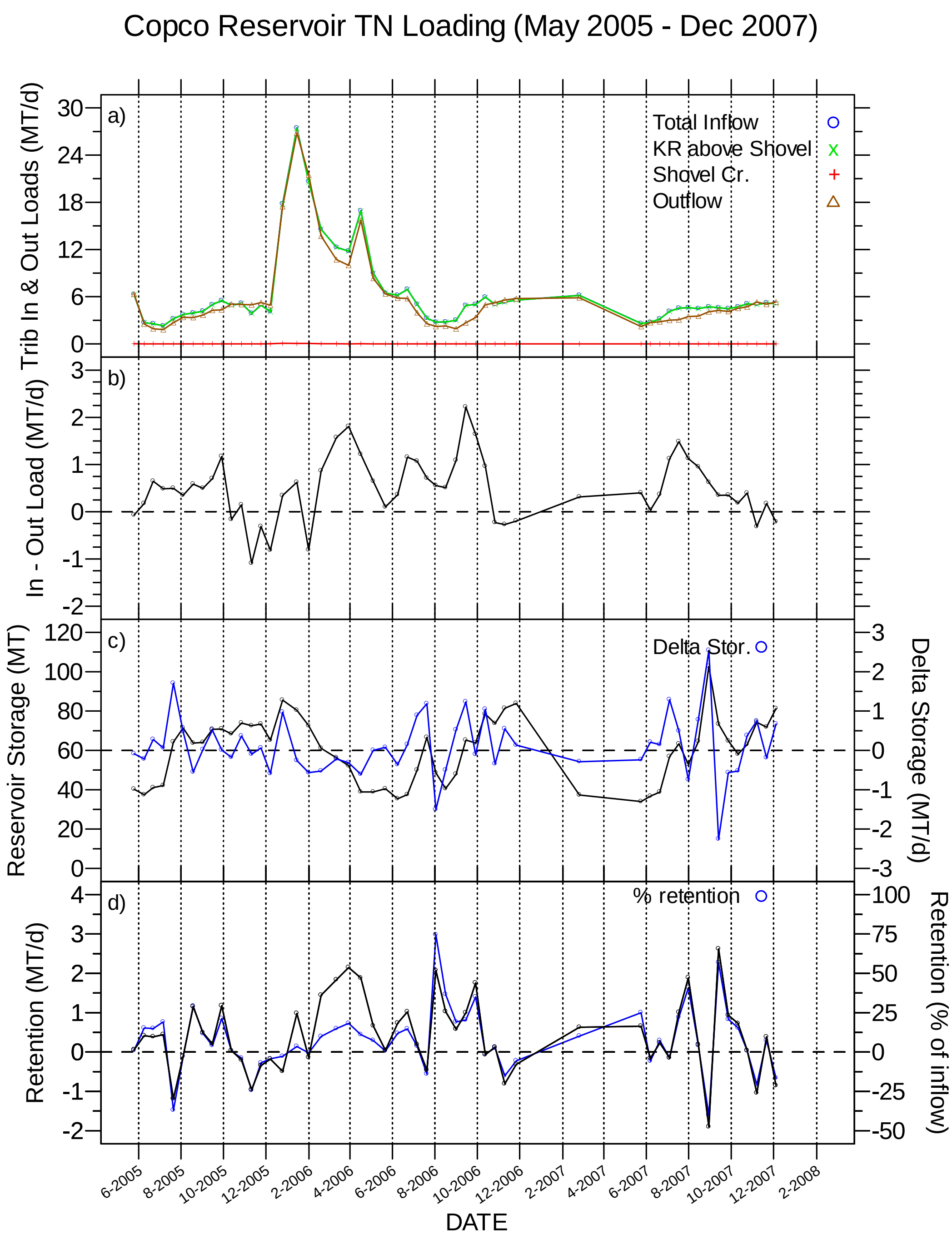


Figure 2. Time series of Copco Reservoir total nitrogen loading, May 2005 – Dec 2007. Each point represents data from an entire sampling interval (~biweekly) and is placed at the midpoint of the two adjacent sampling dates. Horizontal dashed lines are placed at zero for ΔStorage and retention.

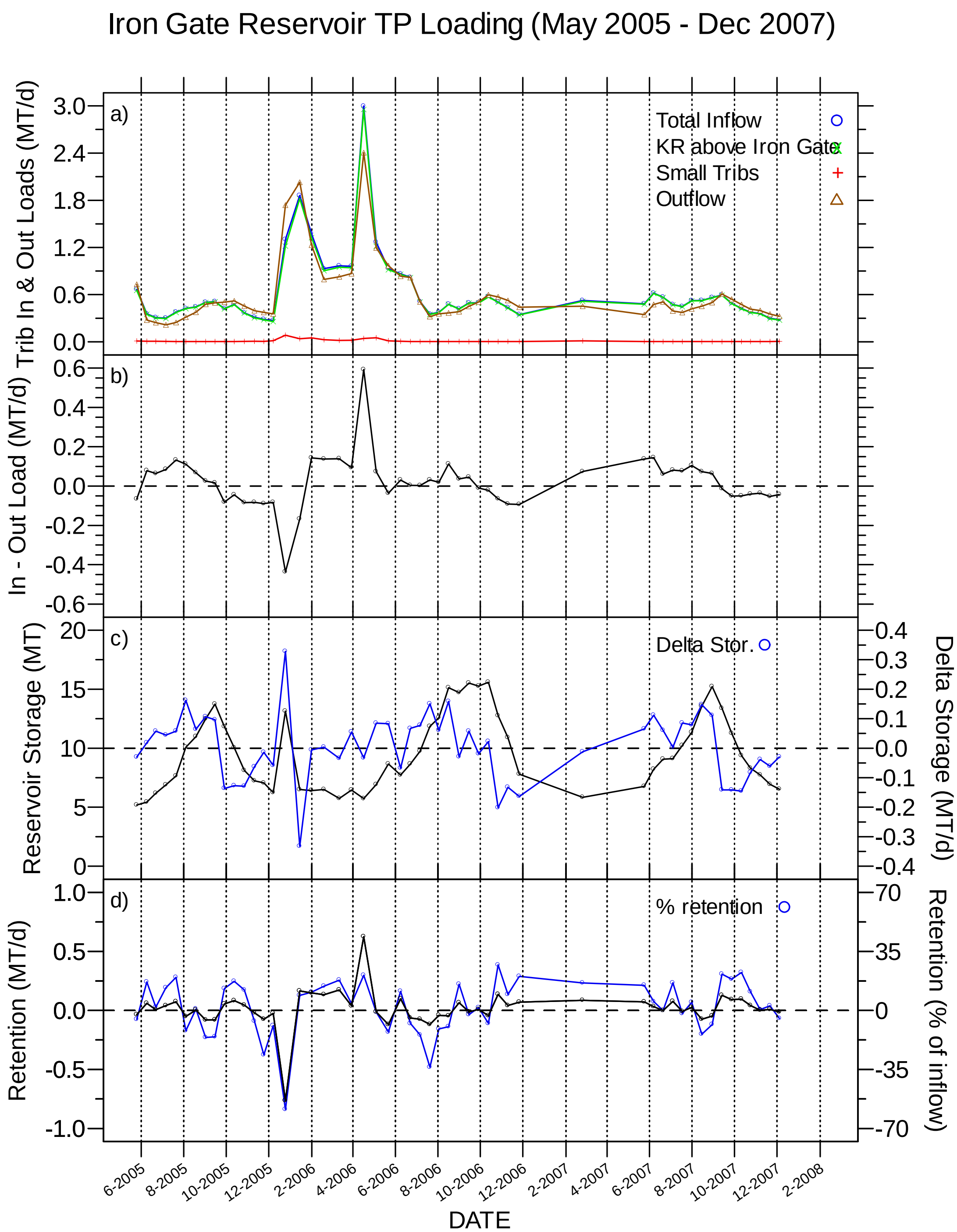


Figure 3. Time series of Iron Gate Reservoir total phosphorus loading, May 2005 – Dec 2007. Each point represents data from an entire sampling interval (~biweekly) and is placed at the midpoint of the two adjacent sampling dates. Horizontal dashed lines are placed at zero for ΔStorage and retention.

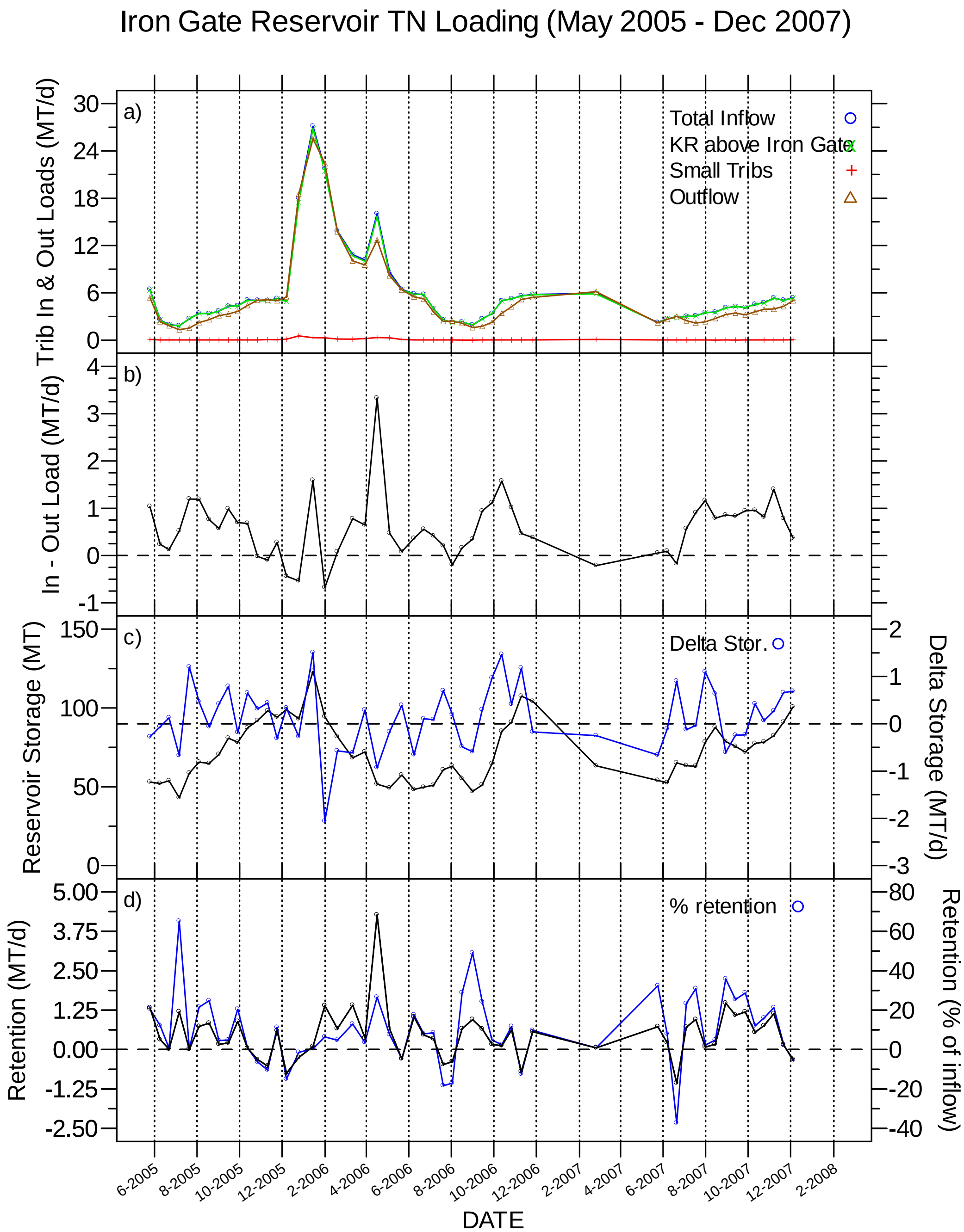


Figure 4. Time series of Iron Gate Reservoir total nitrogen loading, May 2005 – Dec 2007. Each point represents data from an entire sampling interval (~biweekly) and is placed at the midpoint of the two adjacent sampling dates. Horizontal dashed lines are placed at zero for ΔStorage and retention.

C14. Comment(s):
Page 4-19, Paragraph 5, Lines 10-11. Why would the TMDL model retention "not account for nitrogen exported downstream within living biomass?" All nitrogen forms (including algal biomass) are included in model output and the calculation is straightforward. Clearly, reservoirs can retain significant amounts of nutrients, all methods cited, and overall the table on page 4-20 represents clear positive retention, yet this information is not used in the TMDL to identify any positive implications the reservoir may have on nutrient conditions in the system. Finally, the terminology identified herein should be defined: a certain portion of nutrients entering the reservoir are lost through sedimentation and denitrification, while others are retained, but may be exported in a future time period. Please clarify terminology and consider quantifying loss versus retention to allow more complete consideration in TMDL analysis. (see also comment Page 4-19, paragraph 3: Role of Copco and Iron Gate Reservoirs in Klamath River Nutrient Dynamics). (p. 33-34) (PacificCorp – Appendix A and B.doc) (This comment and response has also been included in the TMDL Model section – A38.)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The cited text is in error and has been corrected. The section has also been amended to include the most recent nutrient budget analysis from Asarian et al. 2009. The positive retention characteristics of the reservoirs are clearly described and characterized within the TMDL staff report. However many aspects of this comment are also incorrect and these are addressed below.

Table 4.20 is cited as showing "clear positive retention". In fact, the retention rates shown in this table are generally small, and in some cases negative. As noted in the response to Comment A.38, the revised multi-year analysis of Asarian et al. (2009) shows for total phosphorus an annual retention rate of 11 percent in Copco and 7 percent in Iron Gate, and, for total nitrogen, an annual retention rate of 7 percent in Copco and 5 percent in Iron Gate.

The statement that reservoir retention "is not used in the TMDL" is incorrect, as the TMDL runs (with dams in) include retention, and indeed may over-estimate nitrogen retention in Iron Gate.

As to the terminology, it is best to work in terms of *net* retention, which is the difference between influent and effluent loads. The net retention includes both permanent losses to the atmosphere and deep burial along with temporary storage and exchanges with the active sediment and gains from the atmosphere due to nitrogen fixation. However, only the net effect of these processes can be resolved and validated from observed water column concentration data. In the end it is the net retention – the difference in loads and the resulting differences in concentration – that controls eutrophication response in the reservoirs and export of nutrients downstream.

C15. Comment(s):
Page 4-20. Table 4.5. Given the above discussion, it appears that the information in this table is incomplete – failing to capture considerable reductions during critical periods of the year. Presenting annual and semiannual (or longer) averaging periods and failing to account properly for travel time serves to significantly reduce beneficial impacts the reservoirs have on water quality. The simple model simulation exercise of placing the TMDL existing conditions (with dams) boundary conditions into the TMDL natural conditions baseline (no dams) indicates that the reservoirs have a profound impact on water quality all the way to the estuary in late-spring well into summer – the most critical period of primary production in the river. These findings indicate that reductions above Stateline need to occur early in the process and are paramount to any successful implementation actions in California. (p. 34) (PacificCorp – Appendix A and B.doc) (This comment has also been included in the TMDL Model A39)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The Regional Water Board staff have compared the model output from Table 4.5 and it appears that the TMDL model may over-estimate the temporary retention of TN during the summer. This may be attributable to a difference between years. However because the Assarian et al. (2009) estimates are based on an analysis of monitoring data, the estimates in Table 4-5 will be updated using the results included from their report. It is also important to note that the results from Assarian et al. (2009) do not show significant delay of nutrient load peaks. The Regional Water Board staff agrees that reductions above Stateline need to occur to achieve the TMDL; however, independent applicability means that the reductions within CA should not be dependent on first achieving reductions in Oregon.

C16. Comment(s):
Page 4-20, Paragraph 1 and Table 4.5. The Draft TMDL cites Kann and Asarian (2009); however, Kann and Asarian (2009) is only a Powerpoint presentation of preliminary information that specifically states "do not cite". In addition, the information presented in the Draft TMDL includes information that is not included in the Powerpoint presentation. The report by Kann and Asarian (2009) is not available. The Draft TMDL should delete reference to this information unless and until a report has been made available for public review. There have been substantial flaws with previous nutrient loading analyses by these authors (i.e., Kann and Asarian 2005, Asarian and Kann 2006, Kann and Asarian 2007) as described in PacifiCorp (2006), PacifiCorp (2008b), and Butcher (2008). (p. 34) (PacifiCorp – Appendix A and B.doc) (This comment has also been included in the TMDL Model – A40**)**

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
This comment is no longer relevant, as Asarian et al. (2009) have produced a full report and provided it for review. It is incorrect to characterize the previous efforts and of Kann and Asarian as having "substantial flaws"; however, there were some valid concerns regarding methodology. Dr. Butcher reviewed the new report from Asarian et al. and concluded that the new report resolves the significant methodological questions regarding the earlier work, and revises and confirms the magnitude of previous estimates of retention rates.

References Used in Response A40:

Asarian, E., J. Kann, and W.W. Walker. 2009. Multi-Year Nutrient Budget Dynamics for Iron Gate and Copco Reservoirs, California (Review Draft). Prepared for the Karuk Tribe of California, Dept. of Natural Resources. Riverbend Sciences and Kier Associates, Eureka, CA.

C17. Comment(s):
Page 4-20. Bullet Points.
Bullet 1 – The section addresses nutrients, but bullet 1 discusses oxygen allocations and implications for fisheries. This point is out of place or needs additional information to make it relevant to this section. Further, the draft TMDL is vague about where and when oxygen depletion occurs and which fishery (COLD or WARM) is affected.

Bullet 2 – Two useful points are presented herein. First, that excessive nutrient loads from upstream are responsible for biostimulatory conditions. Second, that a reservoir environment is a biostimulatory condition. The draft TMDL states that the reservoir condition creates impairment, without considering the ability of the reservoirs to reduce upstream nutrient loads that would create additional impairment downstream of the reservoirs if not retained. Benthic chlorophyll *a* targets will probably not be met in river reaches, indicating that even under extreme nutrient reductions (as presumed under the natural conditions baseline) challenges will remain. Thus, stating that the reservoirs cause the impairment is arbitrary.

Bullet 3 – The nutrient retention and export information in Table 4.5 is insufficient and misleading. Reservoirs provide substantial benefits and retention and loss plays a dominant role in regulating the amount and timing of nutrient loads downstream. The implications of markedly increased nutrient loads under the dam removal condition (natural baseline) on river reaches and the estuary needs to be more comprehensively and accurately assessed to determine implications of dam removal prior to achievement of TMDL goals.

Further, a more comprehensive and appropriate representation of actual reservoir dynamics in the TMDL would allow better assessment of potential implementation actions and key intermediate milestones en route to compliance. (p. 34-35) (PacificCorp – Appendix A and B.doc) (This comment has also been included in the TMDL Model – A41)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The comment does not raise any substantive issues regarding bullet 1. This bullet is of course included here because nutrient loads cause excessive algal growth which in turn is one of the causes of oxygen depletion.

The comment appears to agree with most of bullet 2, but complains that the role of the reservoirs in mitigating downstream loads is not considered. This is untrue, as the dams-in scenarios do include reservoir retention. As was documented in previous comment responses, the net reduction in nutrients caused by the reservoirs is small. Regardless, it is necessary to attain water quality standards in both the reservoir and river reaches. The dams contribute to impairment in the reservoir reaches, as the comment acknowledges.

For the response to the comment regarding bullet 3, please first refer to the response to Comment A.39 on the role of dams in changing the timing of nutrient loads. The implication that removal of the dams would worsen conditions downstream is speculative. As discussed in Appendix 2, the natural (dams out) condition would result in more frequent scouring flows and less days of accrual time between scouring events potentially decreasing the mean density of periphyton in the channel..

C18. Comment(s):
Page 4-21. Paragraph 2 (before section 4.2.3), line 3. Oxygen deficits are presented here as if they occur throughout the reservoir during summer months. The TMDL should identify the location where deficits occur, e.g., hypolimnion. (p. 35) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The text has been revised to specify that the oxygen deficits occur within the hypolimnion during the summer months.

C19. Comment(s):
Page 4-32, Paragraph 5 (last paragraph). This single paragraph represents the entire description of the nutrient and organic matter analysis carried out for the Shasta River

contributions to the Klamath River. No data are given, no analysis assumptions are provided, no uncertainty analysis was completed, and no documentation on methods is included. Determining nutrient and organic matter loads for the Shasta River – or any Klamath River tributary for that matter – is not a trivial exercise. How Regional Board staff calculated nutrient and CBOD loads from the Shasta River based on TMDL compliant conditions should be fully explained and presented. To further confuse matters, the text describes the data in Figure 4.21 as the "current and California dissolved oxygen compliance scenario" yet the figure identifies this information as current and natural conditions baseline. Are the California dissolved oxygen compliance scenario and natural conditions baseline the same? Which case was used in the TMDL? (p. 41) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
A description of the analysis is included in Appendix 7 of the TMDL staff report. The text has been amended to more clearly identify the TMDL model scenarios that are the basis of the figures. The narrative text and figure description are now consistent.

C20. Comment(s):
Page 4-9, Table 4.2. There is no explanation through data or citations for the magnitude of the loads attributed to Copco and Iron Gate reservoir. The total (presumed) sediment load from the reservoirs listed in this table amounts to 0.5% of the total load from other sources. This small percentage likely is well within the error of the model and thus indistinguishable from zero. This error and associated uncertainty should be provided to the reader. Presentation of data in this table to a precision of single pounds appreciably overstates the precision of the model. The TMDL provides no information about the precision of the model for any constituent. (p. 26) (PacificCorp – Appendix A and B.doc)

Comments Made By:
Hemstreet – PacifiCorp

Response:
The sediment flux load referred to in the comment relates to nutrient (TN and TP) release from the sediments not a sediment load. Reporting the estimated amount to single pounds is not meant to reflect a level of accuracy, rather it is reporting the model estimate as generated. This is consistent with all other model estimates for other sources. Please refer to Appendix 7 of the TMDL staff report for a discussion of model uncertainty.

C21. Comment(s):
Statement: Chapter 2, Section 2.5.3.1, Page 2-54 states "Several sources within the Klamath and Lost River watershed contribute to nutrient loads. Some of the key sources include irrigated agriculture return flows, internal nutrient cycling from…"

Comment: There is no evidence or research showing that irrigated agriculture within the Klamath Project is increasing nutrient loads to the Klamath River. In fact, there is evidence and research that shows significant nutrient load reduction as water moves through the Klamath Project.

Rykbost and Charlton (2001) found the Klamath Project to be a net sink for nutrients in 1999 and 2000. Rykbost and Charlton (2001) also attributed the nutrient loads discharged to the Klamath River through the Klamath Straits Drain to be wholly or in large part due to the high background nutrient inputs to the Klamath Project from Upper Klamath Lake and the Klamath River.

In addition, Reclamation has performed extensive analysis of existing nutrient data and found that particulate organic matter that originates or is a result of nutrients released from Upper Klamath Lake is overwhelmingly the largest source of nutrients relative to other nutrient sources, including agricultural, municipal, and industrial inputs in the Klamath Falls area. *Although the water returned to the Klamath River from the Klamath Project typically has higher nutrient concentrations than Upper Klamath Lake or the Klamath River, the net nutrient load of the diverted water is significantly reduced as it flows through the Klamath Project.* Table 1 summarizes nutrient concentrations observed at the Upper Klamath Lake and Klamath Straits Drain outlets.

Nutrient loads diverted into the Klamath Project and discharged to the Klamath River, from Upper Klamath Lake and the Klamath Project, were estimated for the period of April to October 2002, except for nitrate plus nitrite, which is estimated for the period of April to August 2002. The nutrient loading estimates show that the Klamath Project is a net sink for nutrients and provides substantial nutrient reduction of diverted waters. The nutrient load reduction is estimated at 83 percent , 69 percent , 85 percent , 62 percent , and 73 percent for ammonia, nitrate plus nitrite, total Kjeldahl nitrogen, orthophosphate, and total phosphorous, respectively.

Table 1. Summary of 2002 Upper Klamath Lake and Klamath Straits Drain Nutrient Concentrations.

Location	Ammonia mg/L	TKN mg/L	NO_2+NO_3 mg/L	Total P mg/L	Ortho P mg/L
Median Observed Concentrations					
UKL at Link Dam	0.13	2.45	0.07	0.20	0.08
KSD at Hwy 97	0.31	2.60	0.15	0.43	0.38
Minimum Observed Concentrations					
UKL at Link Dam	0.06	0.40	0.03	0.11	0.03
KSD at Hwy 97	0.07	1.90	0.06	0.22	0.03
Maximum Observed Concentrations					
UKL at Link Dam	0.97	3.50	0.25	0.42	0.46
KSD at Hwy 97	0.80	3.60	1.40	0.85	0.68

All nutrient concentrations, except for nitrate plus nitrite, are estimates for the period of mid-April 2002 through October 2002. Estimated nitrate plus nitrite (NO_2+NO_3) concentrations are for the period of mid-April through mid-August.

The 2002 estimates show that approximately 133.2, 32.1, 978.9, 57.6, and 105.9 metric tons of ammonia, nitrate plus nitrite, total Kjeldahl nitrogen, orthophosphate, and total phosphorous, respectively, were diverted into the Klamath Project and 22.3, 10.0, 147.3, 21.8, and 28.2 metric tons of ammonia, nitrate plus nitrite, total Kjeldahl nitrogen, orthophosphate, and total phosphorous, respectively, were returned to the Klamath River. This equates to a net nutrient load reduction of 110.9, 22.1, 831.6, 35.8, and 77.7 metric tons of ammonia, nitrate plus nitrite, total Kjeldahl nitrogen, orthophosphate, and total phosphorous, respectively. Table 2 summarizes 2002 nutrient loading to the Upper Klamath River and the Klamath Project.

The assumption that irrigated agriculture is "contributing to nutrient loading above background levels" is incorrect. Only a fraction of the nutrient load diverted into the Klamath Project is returned to the Klamath River through the Klamath Straits Drain. If not diverted, the nutrient load to the Klamath River

Table 2. Upper Klamath Basin Nutrient Loading 2002.

Location	Ammonia Metric Tons	NO_2+NO_3 Metric Tons	TKN Metric Tons	Ortho P Metric Tons	Total P Metric Tons
Nutrient Load from Upper Klamath Lake to the Klamath River					
UKL at Link Dam	107.0	26.3	778.4	41.4	81.6
Nutrient Load diverted to the Klamath Project from Upper Klamath Lake and Klamath River					
A-Canal	87.7	24.3	678.6	39.6	70.6
LRDC	16.3	4.7	131.0	5.8	14.2
North Canal	11.9	0.8	55.7	4.2	6.9
Ady Canal	17.4	2.2	113.7	8.0	14.2
Total Load to KP	133.2	32.1	978.9	57.6	105.9
Nutrient Load Returned to the Klamath River from the Klamath Project					
KSD at Hwy 97	22.3	10.0	147.3	21.8	28.2
Nutrient Load Reduction Within the Klamath Project					
Net Reduction	-110.9	-22.1	-831.6	-35.8	-77.7
All nutrient loads, except for nitrate plus nitrite, are estimates for the period of mid-April 2002 through October 2002. Estimated nitrate plus nitrite (NO_2+NO_3) loads are for the period of mid-April through mid-August.					

would be approximately twice the current level. The comparison of "natural background" nutrient concentrations in the Klamath River with current nutrient concentrations of agricultural drainage from the Klamath Project is inappropriate. It's likely that the delivery of source water to the Klamath Project at "natural background" nutrient concentrations would continue to result in significantly reduced nutrient loads exiting the Klamath Project. In addition, the Klamath River TMDL needs to consider the load reduction provided by the Klamath Project under existing conditions.

Comments Made By:
Jon Hicks – U.S. Bureau of Reclamation – (page 3 – Specific Comments)

Response:
Because this comment addresses portions of the Klamath River TMDL within Oregon, the Regional Water Board has collaborated with the Oregon Department of Environmental Quality (ODEQ) in formulating the following response.

The Lost River Diversion Channel (LRDC) and Klamath Straits Drain (KSD) are part of United States Bureau of Reclamation's (USBR's) Klamath Project and discharge into the Klamath River in the impounded reach upstream of Keno Dam. These facilities, along with water withdrawal canals, hydrologically connect the Klamath River to the Link

River system (for this document the "Lost River system" refers to the hydrologically connected natural and constructed portions for the Lost River, Tule Lake, Lower Klamath Lake, Klamath Straits Drain and other associated canals and drains). DEQ is also developing a TMDL to address water quality impairments within the Lost River system in Oregon and EPA has promulgated a TMDL for the lower Lost River drainage in California (US Environmental Protection Agency (USEPA). 2008. Lost River, California Total Maximum Daily Loads - Nitrogen and Biochemical Oxygen Demand to Address Dissolved Oxygen and pH impairments). The Klamath River TMDL investigates the impact of discharge from LRDC and KSD to the Klamath River while the Lost River system TMDL investigates water quality impacts the of Klamath Project on the Lost River drainage .

USBR's Klamath Project supplies water to approximately 240,000 acres of cropland (38% of it in California and 62% of it in Oregon) (USBR 2009). Water is supplied from Upper Klamath Lake and Klamath River along with reservoirs and tributaries within the Lost River system. Included in the project are reclaimed lands of Tule Lake and Lower Klamath Lakes and facilities related to flood control. In terms of its relationship with the Klamath River, the Klamath Project withdrawals water Upper Klamath Lake via A-canal and the impounded reach of the Klamath River behind Keno Dam via the Lost River Diversion Channel. The LRDC can transfer water to or from the Klamath River and pump stations at the western end of KSD transfer water to the Klamath River. Except during extreme flows, historically there was no surface water connection between the Klamath River and the Lost River system prior to construction of the Klamath Project (NRC 2008, http://books.google.com/books?id=ZlEnDjVsjkkC&pg=PA108&lpg=PA108&dq=lost+river+slough+NRC&source=bl&ots=nIPQsrsTPN&sig=jRKLuMxGClUV7FpdgrA20p9GS38&hl=en&ei=bCTrSpHSO4iosgOQ3oncCA&sa=X&oi=book_result&ct=result&resnum=7&ved=0CCkQ6AEwBg#v=onepage&q=lost%20river%20slough%20NRC&f=false).

A number of studies have concluded that the USBR's Klamath Project is a net sink of nutrients in relation to the Klamath River (Rykbost and Charlton 2001, Danosky and Kaffka 2002 and Hicks 2009). ODEQ extended the Hicks 2009 analysis to include an entire year, 2002, using DEQ data to supplement the USBR dataset. Daily flow estimates were obtained from USBR's website. When concentration data were not available for a specific canal, a nearby river concentration was used as a surrogate. For this analysis, sources of nutrients to the Klamath River are Klamath Strait Drain and Lost River Diversion Channel and extractions from the Klamath River are A-canal, Lost River Diversion Channel, North Canal and Ady Canal.

Even when examining an entire year of 2002, the Klamath Project appears to be a sink of nutrients in relation to the Klamath River (Figure). Despite the higher phosphorus concentrations returning to the Klamath River than leaving it, the loading is strongly influenced by the flow and only 30% of the flow that enters the Lost River system from the Klamath is returned to the Klamath River. In 2002, total phosphorus removed from the Klamath River was 2.8 x 10^5 pounds (130 metric tons) while 1.4 x 10^5 pounds (64 metric tons) was returned, equivalent to a 50% decrease in load. Total nitrogen removed from the Klamath River was 2.8 x 10^6 pounds (1300 metric tons) while 9.6 x 10^5 pounds (440 metric tons), equivalent to a 66% decrease in load.

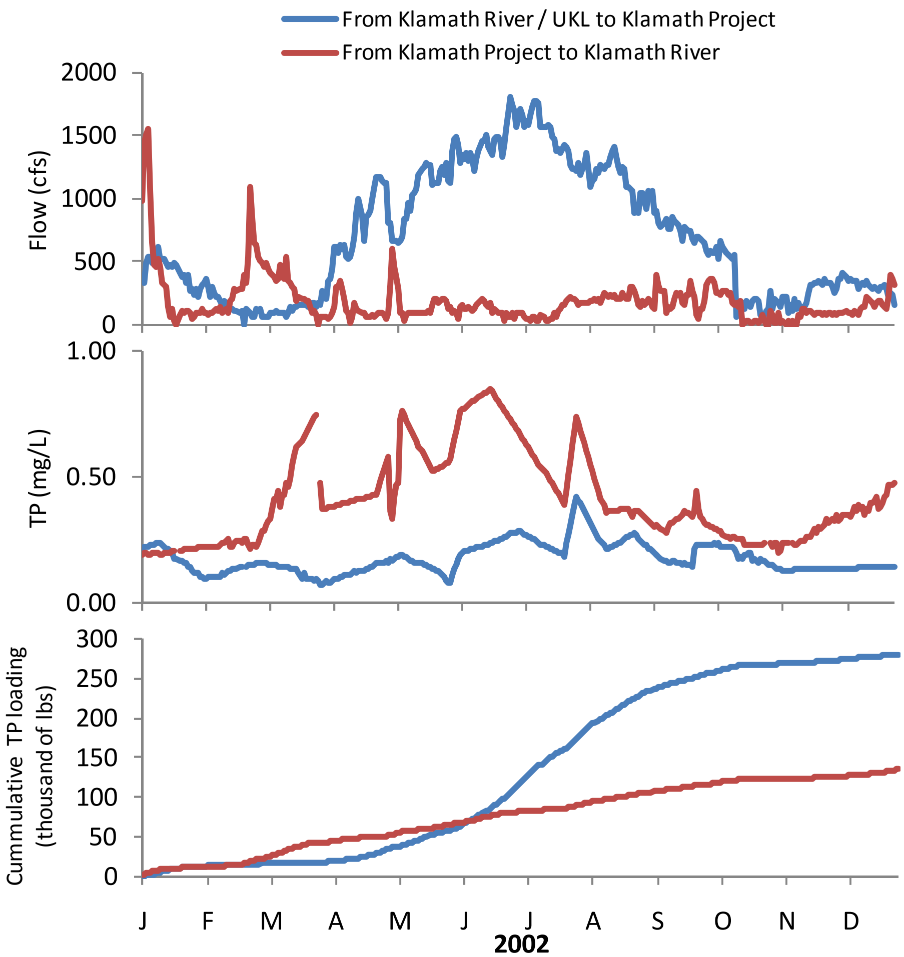


Figure C21.1. Flow, concentration and cumulative loading analysis of USBR's Klamath Project. Total phosphorus (TP) concentrations weighted based on relative flow rates.

Even though USBR's Klamath Project appears to be a net sink of nutrients, it also appears to have detrimental impacts to the water quality of Klamath River. Based on mean August 2002 flows, approximately 1255 cfs was diverted out of the Upper Klamath Lake and the Klamath River, leaving approximately 182 cfs in Keno Reservoir just upstream of Klamath Straits Drain (Figure C21.2). Klamath Straits Drain discharge then is able to make up approximately half the flow of the Klamath River at Keno Dam. Therefore, its higher concentration of nutrients relative to the Klamath River, increases the nutrient concentration (Figure C21.) which in turn contributes to water quality degradation in the Keno impoundment.

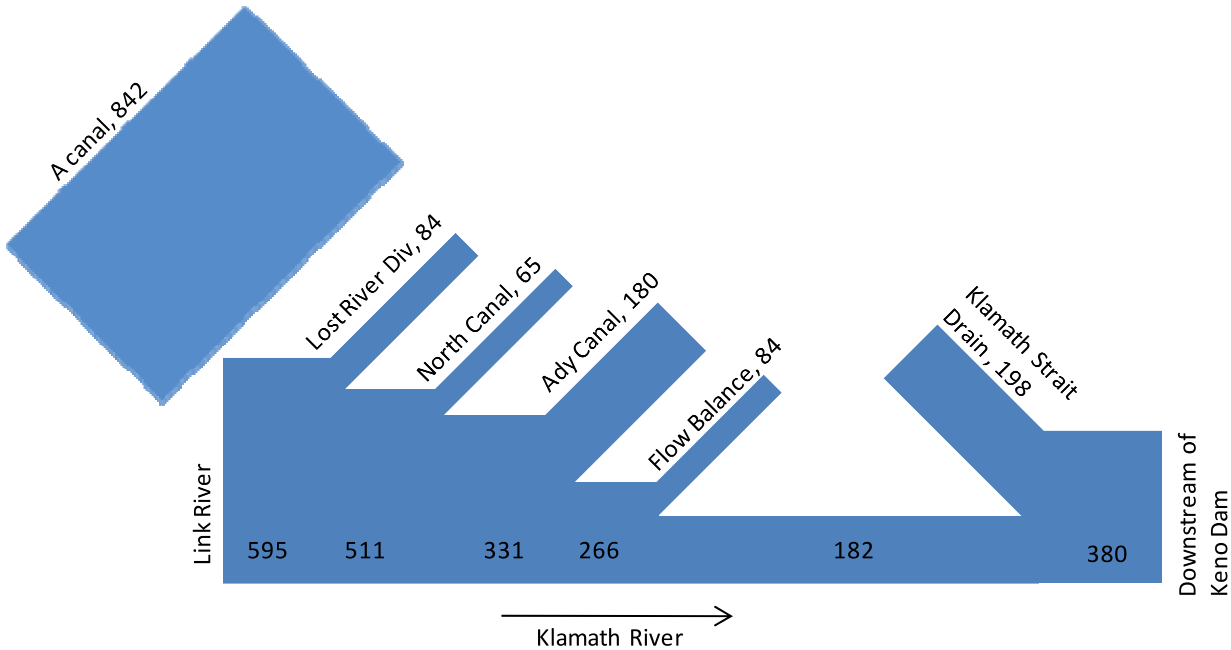


Figure C21.2. Schematic of an example flow balance in cubic feet per second for Keno Reservoir (August 2002). Flows are represented by the thickness of each box. The flow balance portion was derived by subtracting the outflow from the other measured flows.

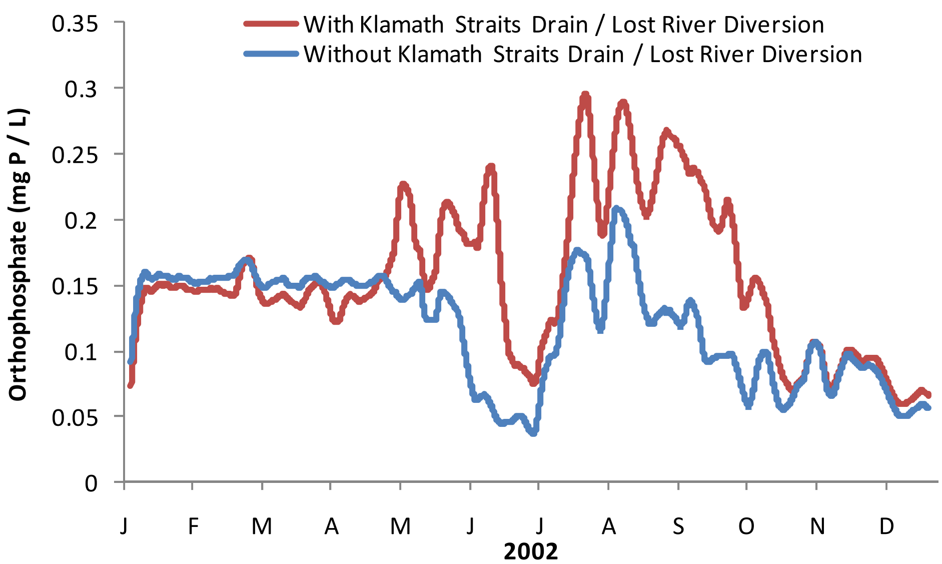


Figure C21.3. Klamath River (Keno Reservoir) model results from just downstream of Klamath Strait Drain discharge. The "With Klamath Straits Drain / Lost River Diversion" results are from the 2002 calibration model. The "Without …" results are from a scenario exactly like the 2002 calibration except the constituent concentrations of parameters for Lost River Diversion and Klamath Straits Drain were set to the same constituent concentrations as Link River.

The following information is provided regarding the potential for agricultural operations within the Lost River drainage to affect nutrient dynamics and thus impact water quality within the Klamath basin.

A water quality study in the Tule Lake irrigation district by the University of California Davis concluded : “The differences in water quality between tiles and drainage ditches suggest that the ditches and water management infrastructure itself has a role in regulating nutrient transfers and can contribute nutrients (especially TP) to the system: from internal hydrologic cycles present in the ditches and canals, from agitation of sediments, from the death and decay of aquatic plants, from N fixation by blue green algae, and from N fixation of sediments due to pumping and transfer of water” (Danosky and Kaffka 2002).

These results are consistent with a water quality investigation by USGS in the Yakima basin (McCarthy and Johnson, 2009). That water quality investigation indicated that combining irrigation and artificial-drainage networks may exacerbate the ecological effects of agricultural runoff by increasing direct connectivity between fields and streams and minimizing potentially mitigating effects of longer subsurface pathways such as denitrification and dilution.

"Nutrient loading in Klamath Lake is unquestionably enhanced by the drainage of irrigation water from agricultural properties adjacent to the lake. Prior to reclamation, all of these properties were either permanent or seasonal wetlands. Following construction of dikes and drainage systems, the properties were managed for pastures and/or crop production. Soils are high in organic matter content and native fertility; therefore pastures and hay crops on these lands are generally not fertilized. Natural processes associated with mineralization of these soils release nutrients subject to transport in drainage water."

-Rykbost and Charlton, 2001

References Used in C21:

Danosky and Kaffka, 2002, Farming Practices and Water Quality in the Upper Klamath Basin, Final Report to the California State Water Resources Board.

Rykbost, K.A and Charlton, B.A, 2001, Nutrient Loading of Surface Waters in the Upper Klamath Basin: Agriculture and Natural Sciences, Special Report 1023, Agricultural Experiment Station, Oregon State University, March 2001. Can be accessed at http://ir.library.oregonstate.edu/jspui/handle/1957/6244

Hicks, 2009, Comments to North Coast Regional Water Quality Control Board on Public Review Draft of Klamath River TMDL and Action Plan. United State Department of the Interior, Bureau of Reclamation, Klamath Basin Area Office, Klamath Falls, Oregon. Accessed at http://www.swrcb.ca.gov/northcoast/water_issues/programs/tmdls/klamath_river/klamath_river_tmdl_comments.shtml on 10/27/2009.

McCarthy, K and Johnson, H.M, 2009. U.S. Geological Survey Scientific Investigations Report 2009–5030, Effect of Agricultural Practices on Hydrology and Water Chemistry in a Small Irrigated Catchment, Yakima River Basin, Washington

C22. Comment(s):
Statement: Chapter 4, Section 4.2.1.2, page 4-13, states "While current condition mass loading estimates indicate the Klamath Project area provides some seasonal net nutrient load reductions, compared to natural conditions baseline, current practices within the Klamath Project area contribute loading to the Klamath River at Klamath Straits and intermittently at the Lost River Diversion Channel."
Comment: Given that source water to the Klamath Project comes from nutrient rich Upper Klamath Lake and that water travels through two National Wildlife Refugees, it is not clear what practices in the Klamath Project are causing loading to the Klamath River via the Klamath Straits drain. This statement needs to be backed up with facts (i.e., data) current practices needs to be adequately defined and specific to each potential source in the sentence (e.g., agricultural, inputs from wildlife, septic systems, etc).

Comments Made By:
Hicks – U.S. Bureau of Reclamation – (page 8 Specific comments)

Response:
Please refer to response C21.

C23. Comment(s):
Statement: Chapter 4, Section 4.2.1.2, Page 4-13 states "irrigated agricultural practices within the Klamath Project area contribute loading to the Klamath River at Klamath Straits Drain and intermittently at the Lost River Diversion Canal."
Comment: There is no evidence or research showing that irrigated agriculture within the Klamath Project is increasing nutrient loads to the Klamath River. In fact, there is evidence and research that shows significant nutrient load reduction as water moves through the Klamath Project. See the previous Statement above for Chapter 2, Section 2.4.3.1, Page 38 for a thorough discussion concerning nutrient loads to and from the Klamath Project.

Comments Made By:
Hicks – U.S. Bureau of Reclamation – (page 8 Specific comments)

Response:
Please refer to response C21.

C24. Comment(s):
Statement: Chapter 6, Section 6.4.3, page 6-18, states "While on a seasonal basis, the KIP diverts more nutrient and organic matter loads from the Klamath River than it returns to

it, the KIP discharges contribute to exceeding the Klamath River water quality standards."
Comment: Although some water is diverted from the Klamath River via the Lost River Diversion channel and privately owned North and Ady Canals, the primary source of diversion is via the A-Canal from Upper Klamath Lake prior to entering the Klamath River. This water is nutrient and organic matter rich and is the primary source water for the Lost River System. Thus, the water returned via the Klamath Straits is primarily Upper Klamath Lake which is the main contributing factor to poor water quality in the Upper Klamath River Basin.

Comments Made By:
Hicks – U.S. Bureau of Reclamation – (page 11 Specific comments)

Response:
Regional Water Board staff agree and find the comment consistent with the text in the staff report. The staff report discusses the diversions in a general sense in the preceding paragraph. Regarding the water quality impacts of the return of these diverted waters to the Klamath River please refer to response C21.

C25. Comm ent(s):
As alluded to in the draft TMDL, but for the Klamath Project, nutrient loading to the Klamath River would far exceed current conditions. Put simply, the Klamath Project is a nutrient sink. (p. 5)

Comment(s) Made By:
Addington and Danosky – Klamath Water Users Association & Tulelake Irrigation District

Response:
Please refer to the response C21.

C26. Comm ent(s):
KWUA notes the following informational gaps in the Draft TMDL: The Draft TMDL refers to estimated unimpaired flows at Seaid Valley, citing a 2005 Reclamation report (see e.g., Figure 1.11.). The proposed TMDL does not recognize that the National Research Council conducted a review of the estimates in the cited USBR report, which significantly calls into question the reliability of the estimates. (See National Research Council, Hydrology, Ecology, and Fishes of the Klamath River Basin, 2008].) (p. 5-6 footnote)

Comments Made By:
Addington & Danosky – Klamath Water Users Association & Tulelake Irrigation District

Response:
Figure 1.11 has been replaced with a similar figure from the National Research Council's 2004 report comparing measured flows in the recent time period to measured flows from 1905 to1912.

C27. Comm ent(s):
The Board has not been proactive in seeking out the available science that indicates that the Klamath Project (Project) is a nutrient "sink" and that the Klamath River is far cleaner after Project tail water is returned to the river than if it had not been diverted. Instead the Board assumes that irrigated agriculture is making a contribution to the loading of the river without any data to validate this position. (p.1)

Comments Made By:
Cantrall – Modoc County Board of Supervisors

Response:
Please refer to response C21. The statement that the Klamath River is far cleaner after Klamath Project tailwater is returned to the river is a misstatement of Reclamation's position that the nutrient loads returned to the river are less than the loads diverted to the Project, particularly from A-Canal, as described in comment C21.

C28. Comm ent(s):
The County finds that it is almost unbelievable that the Report would ignore the data that shows that the Klamath River is cleaner because the Project diverts water and instead rely on a model that many experts find significantly flawed. (p.7)

Comments Made By:
Cantrall – Modoc County Board of Supervisors

Response:
The Klamath River TMDL technical team (i.e., ODEQ, NCRWQCB, EPA Regions 9 and 10) considered available data when developing allocations for Klamath Project return flows to the Klamath River. The required reductions in nutrient and organic matter loading are necessary to achieve water quality standards. Please refer to comment 21 and the response provided to comment C21.

C29. Comm ent(s):
Our members are aware of and have participated in the collecting and documenting of data that shows the Klamath Project does not contribute to loading the river system. Nowhere in document is there any evidence presented to counter the existing data that shows the Klamath River would be dirtier if the Project diversions did not take place. (p.2)

Comments Made By:
DePaul - Modoc County Farm Bureau

Response:
Please refer to response C21.

C30. Comment(s):
We are aware of no evidence or scientific research supporting the notion that irrigated agriculture within the Klamath Project increases nutrient loading to the Klamath River. Given that Klamath Project source water comes from the nutrient-rich Upper Klamath Lake and passes through two wildlife refuges, it is unclear what Klamath Project irrigation practices cause loading to the Klamath River via the KSD. (p. 5)

Comment(s) Made By:
Addington and Danosky – Klamath Water Users Association & Tulelake Irrigation District

Response:
Please refer to response C21.

C31. Comment(s):
Nonpoint Source Land Use Activities- 6.1.3
The Report refers to irrigated agriculture as being one of the threats to water quality in the Klamath River Basin. There is no data provided to back up that claim, yet the Report would impose significant regulations upon agricultural producers. Commenters have provided input to the Board since the beginning of the Report development process that there was data showing the Klamath Project was, in fact, an aid to improving water quality in the river. U.S. Geological Survey and the Bureau of Reclamation have water quality data that shows an improvement in water quality as the water moves through the Project. (p.3)

Comment(s) Made By:
Cantrall – Modoc County Board of Supervisors

Response:
Please refer to comment 21 regarding the distinction between nutrient loading and water quality and to the response to comment C21.

C32. Comment(s):
Regulatory Requirements- 6.1.4: The County believes it is unacceptable to be designing required mitigation for irrigated agriculture without any evidence that agriculture is contributing to the impairment of water quality in the river. (p.3)

Comment(s) Made By:
Cantrall – Modoc County Board of Supervisors

Response:
Please refer to response C21. The Regional Water Board looks forward to working with the agricultural community in developing mitigation approaches that reduce water quality impacts to the Klamath River

C33. Comm ent(s):
Allocations and Targets-Lost River~6.4.3: The Report says, "While on a seasonal basis, the KIP diverts more nutrients and organic matter loads from the Klamath River than it returns to it, the KIP discharges contribute to exceeding the Klamath River water quality standards". The Report has no evidence to support this claim while there is ample evidence to the contrary. The County is troubled at the Board's staff s reluctance to research this issue as it serves as the basis for all the proposed regulations that would impact the Project irrigators. It is unacceptable to continue to ignore the ample evidence that the water quality of the Klamath River would be poorer if the Project did not divert water. (p.4)

Comment(s) Made By:
Cantrall – Modoc County Board of Supervisors

Response:
The Regional Water Board staff has reviewed available studies and data in developing their recommendations. In addition, the monitoring plan includes a sampling plan that will support further analysis of the KIP nutrient mass balance question to address known uncertainties. Finally, please refer to comment 21 regarding the distinction between nutrient loading and water quality and to the response to comment C21

C34. Comm ent(s):
Implementation of Allocations and Targets-Watershed Wide-6.5
The Report identifies grazing and irrigated agriculture as two of the primary sources of pollution in the Klamath River basin. There is no evidence presented that shows that irrigated agriculture or grazing within the Project contributes load to the river system. (p.4)

Comment(s) Made By:
Cantrall – Modoc County Board of Supervisors

Response:
Please refer to comment 21 regarding the distinction between nutrient loading and water quality and to the response to comment C21

C35. Comm ent(s):
Irrigated Agriculture-Water Quality Management Plans-6.5.6
Water Quality Management Plans should not be required until such evidence is presented that shows there is any contribution from the Project's irrigated agriculture to poor water quality in the river. Again the Report chooses to use the model, rather than the science based evidence that is available. (p.5)

Comment(s) Made By:
Cantrall – Modoc County Board of Supervisors

Response:
Please refer to comment 21 regarding the distinction between nutrient loading and water quality and to the response to comment C21

C36. Comm ent(s):
Page 4-2, Paragraph 2, Bullet point 2. Is it valid to treat Copco 1 and 2 “as a single source” since there is no data in Copco 2? Copco 2 has fundamentally different water quality response than Copco 1. For example, because the reservoir is small, does not stratify, and does not have hypolimnetic anoxia (because it does not stratify). The TMDL is silent on whether processes and water quality impairments identified for Copco 1 are automatically applied to Copco 2, where they may not be applicable. (p. 23)
(PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
Treating Copco 1 and Copco 2 as a single source area is a simplifying modeling assumption for the TMDL analysis that was also used by PacifiCorp in their FERC modeling analysis. Moving forward to the implementation plan PacifiCorp will have the option of submitting a plan to the Regional Water board that addresses separately each of the facilities within the California portion of the KHP (Copco 1, Copco 2, and Iron Gate).

C37. Comm ent(s):
Page 4-4, Paragraph 1, Lines 6-7. The Draft TMDL states that “…the upper Klamath basin was characterized by high levels of nitrogen and phosphorus demonstrating the high natural background loading of nutrients.” Here the Draft TMDL clearly admits that the upper Klamath Basin and Upper Klamath Lake has long been known for natural eutrophic conditions and high levels of organic matter. Upper Klamath Lake is the source of the Klamath River, and provides those eutrophic conditions and high loads to the Klamath River. Therefore, the Draft TMDL’s recognition of this high natural background loading of nutrients fundamentally contradicts the Draft TMDL’s allocations that assume and set “natural” conditions in the Klamath River for nutrient concentrations

that are in the oligotrophic to mesotrophic range. See Figures 2.16 and 2.17. (p. 24-25) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The Regional Water Board makes the distinction between eutrophic (historical conditions) and hypereutrophic (existing conditions). Quite simply we note the high background levels to alert all stakeholders that the assimilative capacity within the basin is small in terms of managing nutrient and organic matter loadings. The allocations do not contradict the high background loads acknowledged in the TMDL staff report. The TMDL allocations address those portions of the load over and above the natural background loads that have driven Upper Klamath Lake and the upper portion of the Klamath River to unnaturally high levels of productivity (i.e., hypereutrophic). The TMDL allocation levels are not intended and will not move either Upper Klamath Lake or the Klamath River to an oligotrophic state. The targets and allocations were set in recognition of the naturally eutrophic / mesotrophic status of the system.

C38. Comm ent(s):
A more fundamental flaw with Figure 4.21 is the fact that the natural conditions baseline is unattainable at a minimum for phosphorus. Year-round data from Jeffres et al (2008 and 2009) throughout the Shasta Valley identify total phosphorus concentrations on the order of 0.15 mg/L as typical background river concentration. This background concentration in spring contributions (e.g., Big Springs, Carrick Spring, Boles Creek spring, Beaughan Creek spring, Hole in the Ground spring) , to the Shasta River typically ranges from 0.15 mg/L to 0.20 mg/L. With a mean annual flow of 180 cfs, and an average background total phosphorus concentration of 0.15 mg/L (with winter season averages being similar when biological activity is at an annual minima) – largely derived from geologic sources – the load to the Klamath River is over 100,000 lbs/yr. Thus a natural conditions baseline load of roughly 30,000 lbs/yr is unachievable. Further, annual average concentrations of total N are on the order of 0.5 mg/L (with winter season averages being similar when biological activity is at an annual minima), leading to a load of approximately 300,000 lbs per year – well above the estimate of approximately 200,000 lbs/yr included in Figure 4.21. Winter concentrations are similar to annual values suggesting that a reasonable background concentration is also on the order of 0.5 mg/L, indicating that the natural conditions baseline load of approximately 80,000 lbs/yr background is probably unachievable. To the extent that the Jeffres et al (2008, 2009) data disagree with the Shasta River TMDL assumptions, the more recent, extensive, and detailed year-round monitoring of Jeffres et al work is probably the more appropriate as a starting point for TMDL analysis, and suggests that the Shasta River TMDL should be reexamined and load allocations reviewed in light of more recent data. (p. 42) (PacificCorp – Appendix A and B.doc) **(**This comment has also been inserted A164.)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The comment references Jeffres (2008 and 2009) and states that under natural conditions that the loading of total phosphorous to the Klamath River would be over 100,000 pounds. The Klamath River TMDL analysis of existing conditions, based on current concentrations, is under 100,000 pounds. Some of this difference may be due to consumptive uses in the Shasta River downstream of the spring complexes. However it is also possible that not all sinks for phosphorous have been identified in the Jeffres study. Additionally the Jeffres data points may be representative of the tributaries in this part of the watershed but may not be representative of other portions of the watershed, especially west side streams such as Yreka Creek, Greenhorn Creek, and Parks Creek. Not all of the Shasta River watershed is in volcanic terrain.

The Klamath River TMDL modeling strategy is to use approved TMDLs, such as the Shasta River TMDL, for boundary conditions and that remains unchanged. TMDLs do undergo a periodic reassessment in which targets and allocations can be adjusted based on new data and or information from scientific studies. The Jeffres data (2008 and 2009) which became available after the development of the Shasta River TMDL, represents the type of information that will be included in a reassessment of the Shasta River TMDL. That is, there is sufficient uncertainty regarding the natural conditions load proposed by PacifiCorp that modifications to the Klamath River TMDL boundary conditions are unwarranted.

Two other points: 1) if there is an underestimate of Shasta River nutrient loads the impact is that remaining assimilative capacity and more stringent allocations for the Klamath River will be required downstream; and 2) any increase in the estimated background loads does not change the implementation plan and action plans for the Shasta River or Klamath River since they are primarily composed of nonpoint source best management practices meant to address individual discharges above background.

C39. Comm ent(s):
Page 4-6 to 4-8, Figures 4.1-4.3. There is no discussion about the reductions in all three figures through the reservoirs. At a minimum, clear identification of in reservoir processes that reduce loading to downstream reaches would be important for near-term implementation strategies to ameliorate water quality impairment. Also, the figures report data to single pounds and single kilograms. This is misleading to the reader that the analysis is accurate to this level. Because there is no uncertainty analysis in the draft TMDL, there is no method for determining the appropriate significant figures in these figures or in Table 4.2. (p. 25) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The reservoirs are discussed in the overview paragraph (fifth sentence). The more complex nutrient dynamics associated with the reservoirs is discussed in other sections of the report. The purpose of the figures is to provide the reader with a very simple conceptual model illustrating the point that a large fraction of the mass loadings occur in the upper basin. Regional Water Board staff does not believe changing model output is the appropriate solution to alert the reader to the approximate nature of any model output. A disclaimer has been added regarding the approximate nature of model output.

C40. Comm ent(s):
Page 4-4, Paragraph 1, Line 1 Volcanic geology is identified as a source of natural phosphorus and may suggest the Upper Klamath Lake is nitrogen limited , which may also explain why *Aphanizomenon flos aquae*, a nitrogen fixer, dominates in UKL. Regardless of the limiting nutrient, there is no discussion on nutrient management strategies in the TMDL. Similar to a previous comment on the lack of defining trophic status through the system (Page 4-2, Paragraph 3), that lack of a clear nutrient management strategy (e.g., N:P ratios and seeking a limiting nutrient to manage) provides little direction for successfully attaining water quality improvements within a TMDL framework. (p. 24) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The paleoliminological study conducted by Eilers et al. (2004) suggest that *Aphanizomenon flos aquae* may not have been present within Upper Klamath Lake in the 19th century and that its increasing dominance in the 20th century coincided with increasing levels of phosphorus. The increasing levels of phosphorus also coincided with a dramatic increase in land disturbance activities in the upper Klamath basin. In addition, within the Klamath basin the limiting nutrient is not constant, rather it is dynamic switching between nitrogen and phosphorous (Asarian et al. 2009). The nutrient and organic matter allocations (i.e., management strategy) is based on achieving water quality objectives (e.g., DO) during critical periods and not overloading the estuary. The modeling analysis to determine nutrient levels includes numerous compliance points from Link River through the estuary. The TMDL staff report also includes other numeric targets for the reservoirs (e.g., chlorophyll *a*) and river reach below the Salmon River (i.e., benthic algal biomass) that are tailored to desired trophic conditions. The management strategy is quite clear as identified in the TMDL allocations and in the Implementation and Action Plan. The control strategy involves addressing sources of both phosphorous and nitrogen through a mixture of nonpoint source best management practices with other innovative treatment and restoration projects. There is strong support in Welch (2009), in which he reviews large scale lake restoration efforts, for controlling total phosphorous for long-term restoration strategies in hypereutrophic systems. The clear message from Moses Lake and the other large scale restoration

projects reviewed as part of this report demonstrates that inflow phosphorus, not nitrogen, should be reduced to effect long-term recovery of eutrophic lakes, despite observed short-term limitation by nitrogen.

References used in C40:

Eilers, J.M., J. Kann, J. Cornett, K. Moser, and A. St. Amand. 2004. Paleolimnological evidence of change in a shallow, hypereutrophic lake: Upper Klamath Lake, Oregon, USA. Hydrobiologia. 520:7-18.

Welch, Eugene, B. 2009. Should nitrogen be reduced to manage eutrophication if it is growth limiting? Evidence from Moses Lake. *Lake and Reservoir Management*, 25:401–409, 2009

C41. Comm ent(s):

Page 4-4, Paragraph 2, Lines 5-6. As stated in the comment above (Page 4-2, Paragraph 3), eutrophic is a state of a water body and "improving" a eutrophic condition has little meaning. In reality the river shifts to a lower trophic status. However, even here the trophic condition varies dramatically in space and time. The dynamic nature of the Klamath River longitudinally, through seasons and under different hydrologic year types (and in particular under periods of multiple drought years) is not addressed in the TMDL. This speaks to the inadequate period of analysis (only year 2000) and the inherent limitations associated with such an approach in a complex and highly dynamic system such as the Klamath River. (p. 24) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:

Hemstreet – PacifiCorp

Response:

The Regional Water Board's use of trophic status is being misrepresented in this comment. As stated in the document, the intent is not to make a definitive determination of trophic status for all reaches for all seasons. Rather the purpose is to highlight the accelerated degradation of the system as demonstrated by evaluation of the parameters that a eutrophic classification index is composed. It is meant to clarify the changes over time due to factors such as nutrient loading, and changes in hydrologic conditions. Improving trophic status has meaning when the status of a waterbody has been dramatically altered through disturbance and pollutant inputs that threaten existing beneficial uses. Trophic states are a classification tool that summarizes the status of a system and is based on an index derived from assessment of several parameters. In the case of the Klamath River the trophic index includes (but is not limited to) nutrient levels, periphyton density (for free flowing portions), and chlorophyll a (for reservoirs) which are to be addressed through the TMDL. Therefore discussion about the trends in trophic status is meaningful. The dynamic nature of trophic conditions is addressed through the use of the TMDL model. This is accomplished through modeling different time periods and the development of alternate scenarios. The model and other lines of evidence used in the TMDL very clearly inform the management actions that must occur to improve the overall health of the system. These proposed management actions include restoring aquatic ecosystem functions and reducing the pollutant loads to the system.

C42. Comm ent(s):
The staff report provides no evidence to support the inference that the KSD and the LRDC are primarily responsible for a 9 degree Fahrenheit increase in temperature (See Staff Report at p. 4-11).

Comment(s) Made By:
Addington & Danosky – Klamath Water Users Association & Tulelake Irrigation District

Response:
The staff report does not state that the KSD and the LRDC are primarily responsible for a 9 degree Fahrenheit increase in temperature, but merely identifies them as upstream sources of heating.

C43. Comment(s): Ben and Bryan will address this comment
In the discussion regarding historically high ambient air temperatures, it would be good to add a note regarding the historical status of thermal refugia. Prior to widespread logging and agricultural development, which have increased sediment levels, reduced stream canopy, and depleted streamflow, there were likely a greater abundance of high-quality cool-water refugia due to more (and colder) water in tributaries and greater connection with hyporheic flow in the mainstem.

Comment(s) Made By:
Fetcho – Yurok Tribe
Crosby – Karuk Tribe
Bowman – Quartz Valley Indian Reservation

Response:
Regional Water Board staff doesn't have information that describes the historical extent of thermal refugia. Instead, the document describes the historical factors that have impacted thermal refugia and identifies the current extent of thermal refugia to the degree possible using existing information.

C44. Comm ent(s):
New information indicates that the effects of climate change are already *well underway* and need to be acknowledged by the Regional Water Board. This increased level of natural risk needs to be factored into the TMDL narrative and applied to land use limits (timber harvest, roads, etc.) in the rain-on-snow zone given well known global warming trends. NCRWQCB staff should, therefore, consider using forest age and stand variability indices for rain-on-snow risk as part of TMDL implementation or, at minimum, make it a requirement of USFS reporting under the MOA.

Comment(s) Made By:
Spain – Institute for Fisheries Resources & Pacific Coast Federation of Fishermen's Associations

Response:
While climate change is mentioned in the text, there is no explicit mechanism to alter TMDL targets in response to climate change. The science of climate change is rapidly developing, and Regional Water Board staff expects an evaluation of anticipated climate change effects on the Klamath River to be completed as part of the Secretarial Determination process. The Regional Water Board will continue to closely monitor emerging climate change analysis to determine if there are any additional measures that should be incorporated into the Klamath River TMDL action plan. However, current watershed wide allocations call for no increase in temperature above natural conditions. Translated into the implementation plan this calls for protection of cold water refugia, maintaining or achieving site-potential shade conditions, and eliminating all discharges (e.g., sediment debris flows, irrigation return flows) that negatively impact temperature conditions. The Regional Water Board is also working closely with the USFS to develop a waiver of waste discharge related to certain federal land management activities on U.S. Forest Service lands in the north coast region. A monitoring program will be included as part of this waiver.

C45. Comm ent(s):
Inferred quite strongly within the TMDL is the WQ position that creating pre-European impact will certainly improve water quality, since it must have been better prior to human intervention. (p.1)

Comment(s) Made By:
Cozzalio

Response:
The Regional Water Board is obliged to set TMDLs at levels that achieve water quality objectives. The water quality objective for temperature refers to natural receiving water temperature conditions, therefore it is necessary to evaluate natural conditions. The TMDL levels for nutrient and organic matter are also developed to ensure supporting conditions for beneficial uses and can be set above pre-European impact levels. However, in the Klamath basin because natural background levels are high the amount remaining for allocation is small.

C46. Comm ent(s):
Faulty assumptions of WQ include; worse Klamath quality conditions exist now than prior to dams; salmon existed in numbers above where dams are located; that salmon have the reserves to make it significantly past Copco even if the dams were removed; that the natural physical impediments that historically blocked salmon above Copco would

not re emerge on dams removals; that Klamath flows and quality would be higher if agriculture were removed from upper basin; that 'eco-structuring' will not harm all the other species that have adapted to upper conditions for thousands of years. (p. 3)

Comment(s) Made By:
Cozzalio

Response:
Regional Water Board staff relied on available analysis and research to characterize past water quality and beneficial use conditions. Regional Water Board's analysis of the Klamath hydropower project focuses on the water quality effects of the reservoirs in the reservoirs and downstream reaches. In regards to water quality prior to agricultural development, we relied on the results of the Upper Klamath TMDL analysis, which indicates that pollutant loads were much lower, and the water quality much better. Regional Water Board staff are unfamiliar with the term "eco-structuring".

C47. Comm ent(s):
Page 2-55, Figure 2.16. The natural conditions background values for phosphorus assumed in the Draft TMDL are unrealistically low (somewhere between oligotrophy and mesotrophy). These assumed values in no way correspond to the documented historical evidence of the Klamath system, which has been eutrophic or hypereutrophic throughout recorded history. The "natural conditions" shown on the graph also display unrealistically small variability. (p. 14) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
Regional Water Board staff does not agree with this comment. The natural conditions baseline scenario is not unrealistically low nor does it suggest oligotrophic conditions within the Klamath River. The mesotrophic status is far from unrealistic for several reaches within the Klamath system. Ward and Armstrong (2009) have recently released for peer review the results of a study conducted for the U.S. Fish and Wildlife Service (Arcata) to assess the community metabolism and associated parameters in the Klamath River below Iron Gate Dam. The study findings, which are consistent with the findings of Regional Water Board staff, are that under existing conditions the Klamath River below Iron Gate indicates a mesotrophic system. The Regional Water Board estimates are consistent with the most current science.

Responses Used In C47:
Ward, G.H., N.E. Armstrong. 2009. (In press) Assessment of Community Metabolism and Associated Kinetic Parameters in the Klamath River. Prepared for: U.S. Fish and Wildlife Service, Arcata Fish and Wildlife Office, 1655 Heindon Road, Arcata, CA 95521. Project Officer – Paul Zedonis.

C48. Comm ent(s):
Page 2-56, Figure 2.17. Same comment as for previous graph (Figure 2.16). (p. 14) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
See response to Comment C47.

C49. Comm ent(s):
The Draft TMDL does not provide any data to distinguish natural background loads from nonpoint source pollutant loads. Based on our review and discussion with Regional Board staff, it appears that the natural background estimates developed by the Klamath River Model for the TMDL prepared by Tetra Tech in June 2009 are based on the applicable water quality standards and assumed compliance with upstream TMDLs. These fictional natural background estimates do a disservice to the Regional Board's efforts to improve water quality in the Klamath River Basin as they from the basis for impossible load allocations. (p. 6)

Comment(s) Made By:
Addington & Danosky – Klamath Water Users Association & Tulelake Irrigation District

Response:
Regional Water Board staff relied on the results of the Upper Klamath TMDL analysis to define natural background conditions. We acknowledge that the load allocations will require a great amount of time and a lot of effort to achieve. However, we disagree that achieving the load allocations is impossible. The Regional Water Board staff also strongly disagrees that the natural conditions baseline estimates were derived from existing water quality standards or assumed compliance with the TMDLs. Natural conditions baseline modeling scenarios were developed prior to TMDL scenarios. The natural baseline conditions are not fictional but rather are based on several lines of evidence as explained in the Klamath River Model for TMDL Development (Appendix 6 of the TMDL staff report). Please also note that the dissolved oxygen site-specific objective was developed as a result of the modeling analysis which indicated that the existing Basin Plan objective for dissolved oxygen was not reflective of natural conditions in the Klamath River. So in fact, contrary to the suggestion in the comment, the modeling analysis has led to proposed changes in the objectives, not the other way around.

C50. Comm ent(s):
The model uses current flow data for Upper Klamath Lake, Lost River Diversion Channel, and KSD to maintain consistency with the existing conditions scenario. However, the model assumes that water quality and temperature levels for LRDC and KSD are equal to those of UKL under TMDL compliance conditions. These natural background assumptions are inappropriate and undermine the Draft TMDL. Basing the natural background conditions for these distinct engineered channels on assumed compliance with the UKL TMDL is unreasonable. There is no justification for using a fictional compliance level as the natural baseline. The Draft TMDL should also analyze and disclose the uncertainties associated with ever achieving the UKL TMDL. (p. 7)

Comment(s) Made By:
Addington & Danosky – Klamath Water Users Association & Tulelake Irrigation District

Response:
The decision to leave KSD and LRDC discharges in the natural conditions baseline scenario was made because the alternative, making assumptions about the operations of irrigation and hydropower facilities, would introduce a great amount of uncertainty, and would ultimately lead to results that couldn't be compared to other scenarios. The reason the water quality conditions of LRDC and KSD were set equal to the UKL boundary condition was so that the hydrodynamics of the model could be preserved without causing a change in water quality conditions in the river. The intent is to maintain the hydrodynamics in such a way that the water quality effects of the discharges are neutral in regards to Klamath River water quality. The levels were not set based on an assumed compliance level of these two discharges. The use of the Upper Klamath Lake TMDL compliance condition as the upper boundary condition for the compliance scenarios is the only legally consistent and logically compatible approach. Further comments on this topic should be submitted to Oregon DEQ.

C51. Comm ent(s):
Even if the assumed natural UKL water quality characteristics and temperature were accurate, the model should not apply those same levels to KSD and LRDC because water quality and temperature change as water flows in the Klamath River between the outlet of the Upper Klamath Lake and the point of discharge from the Lost River diversion Channel. In this regard, the background estimate should incorporate water quality loading data for the UKL diversion point to the Klamath Project (i.e., the "A" Canal) and one at the return point of that water to the Klamath River. The difference would inform the model by indicating what effect the return flows from irrigation practices have on the overall conditions were prior to the Klamath Project. (p. 7)

Comment(s) Made By:
Addington & Danosky – Klamath Water Users Association & Tulelake Irrigation District

Response:
The purpose of the natural conditions baseline scenario is to evaluate the water quality conditions that result from a natural state of the river, not to inform what effects irrigation practices are having on water quality.

C52. Comment(s):
The Basin Plan water quality objectives for the Klamath River are not achievable due to natural or historic conditions. The current quality of Upper Klamath Lake makes the downstream water quality objectives simply unattainable. (p. 9)

Comment(s) Made By:
Addington & Danosky – Klamath Water Users Association & Tulelake Irrigation District

Response:
Regional Water Board staff agree that the existing dissolved oxygen water quality objective for the Klamath River is inappropriate and have proposed revising the minimum to a lower value, reflecting the natural attainability of dissolved oxygen levels in the Klamath River, and the historically poor water quality. Regional Water Board staff also agree that the current Upper Klamath Lake water quality precludes achieving water quality standards downstream. The water quality objective for temperature refers to natural temperatures, thus natural temperatures are by definition compliant with the objective.

C53. Comment(s):
The Board has made little or no adjustment to their traditional approach for developing TMDL's, despite the fact that the Klamath River system is unique among those north coastal rivers the Board has been court ordered to regulate. There has been no accommodation for the fact that Klamath River water is heavily "loaded" when it enters California. (p.1)

Comment(s) Made By:
Cantrall – Modoc County Board of Supervisors

Response:
The Klamath River TMDL was developed consistent with state and federal guidance regarding development of TMDLs. The recognition of naturally high nutrient loading upstream of California is reflected in a variety of ways, including the decision to revise the water quality objective for dissolved oxygen, as well as through the nutrient data incorporated in the water quality model.

C54. Comm ent(s):
Standards are unachievable, given the poor quality of water that enters California. The Board's staff readily admits that it will take generations to make a difference in the water quality at the state line, yet the standards would go into effect quickly. (p.2)

Comment(s) Made By:
Cantrall – Modoc County Board of Supervisors

Response:
The fact that it may take decades to achieve water quality standards doesn't imply they are unachievable. The water quality standards have been in effect for over 30 years. The proposed action would not change those standards, with the exception of the water quality objective for dissolved oxygen, which is proposed to be decreased. The adoption of the Klamath TMDL will establish load allocations for various sources that must be achieved for water quality objectives to be met. However, it is not anticipated that compliance would be achieved instantaneously.

C55. Comm ent(s):
Regulatory Requirements- 6.1.4: The Report also makes no attempt to adjust the model or the proposed regulation to account for the poor water quality entering the state. (p.3)

Comment(s) Made By:
Cantrall – Modoc County Board of Supervisors

Response:
The model is based on actual water quality data, and explicitly accounts for the poor quality of water entering California. Regional Water Board staff agree that the existing dissolved oxygen water quality objective for the Klamath River is inappropriate and have proposed a revision to this objective, reflecting the natural attainability of dissolved oxygen levels in the Klamath River, and the historically poor water quality.

C56. Comm ent(s):
The Report indicates that the poor water quality upstream is the results of human activity, but provides no evidence to back up this claim. There is ample historical evidence to indicate that Upper Klamath Lake water quality was poor prior to the pioneer settlements. (p.4)

Comment(s) Made By:
Cantrall – Modoc County Board of Supervisors

Response:
The Klamath River TMDL analysis relies on the Upper Klamath Lake TMDL analysis of water quality effects from human activities. Please refer to the Upper Klamath Lake TMDL for such evidence. Regional Water Board staff acknowledge that Upper Klamath

Lake water quality was poor when European Americans arrived, however, it is worse now.

C57. Comment(s):
The Board's staff has continually ignored the upstream water quality problem in designing the proposed water quality standards. They have continually maintained that the upstream water quality problems are man caused without any evidence to back up this contention. In fact the current conditions, at least immediately downstream from the Project are greatly improved over what the natural conditions probably would have been. (p.5)

Comment(s) Made By:
Cantrall – Modoc County Board of Supervisors

Response:
The Klamath River TMDL analysis relies on the Upper Klamath Lake TMDL analysis of water quality effects from human activities. Please refer to the Upper Klamath Lake TMDL for such evidence. The recognition of naturally high nutrient loading upstream of California is reflected in the decision to revise the water quality objective for dissolved oxygen. The characterization of current conditions relative to historic conditions is speculative.

C58. Comment(s):
The TMDL has purposely ignored the poor quality of the water delivered to the state line. It has developed the TMDLs based on clean water being delivered even though they admit that it may be fifty years before this water will meet standards. Consequently, agricultural producers in the Project will be forced to clean dirty water to be in compliance. (p.7)

While the Board's staff has assured the County that Project irrigators will only be held responsible for their contribution to loading, the Report does not reflect that. (p.7)

Comment(s) Made By:
Cantrall – Modoc County Board of Supervisors

Response:
The Klamath TMDL development team has explicitly accounted for the poor quality of water that enters California. The recognition of naturally high nutrient loading upstream of California is reflected in the decision to revise the water quality objective for dissolved oxygen, among other things. The text of Chapter 6 has been modified to reflect that irrigators will only be responsible for their contributions to water quality impairments.

C59. Comm ent(s):
Statement: Chapter 4, Section 4.1.3, Page 4-5 states "These figures demonstrate that, unlike other river systems, the Klamath River pollutant loads are largest (~40%) in the upper half of the basin."
Comment: This statement implies that the nutrient and organic matter loads that originate in the Upper Klamath Basin are from pollutant sources. Upper Klamath Lake is overwhelmingly the largest source of nutrients relative to other nutrient sources, including agricultural, municipal, and industrial inputs in the Klamath Falls area. The use of the term "pollutant" in this instance is not consistent with the definition provided in Chapter 4, Section 4.1, Page 1.

Comment(s) Made By:
Hicks – U.S. Bureau of Reclamation (page 8 Specific comments)

Response:
The text doesn't identify the origin of the pollutants. Please note however that even natural sources of pollutants are pollutant sources. Regional Water Board staff are unable to find a definition of pollutants on the specified page, as described.

C60. Comm ent(s):
Statement: Chapter 4, Section 4.2.1.1, Page 4-11, Figure 4.4 – "Estimated temperature changes at Stateline due to reservoirs and irrigation return flows upstream. Positive values represent and increase above the natural baseline condition."
Comment: How much temperature increase is attributed to each source (reservoirs and irrigation return flows)? Also, this needs to be reevaluated with a revised "natural baseline conditions" scenario (see previous Statements above).

Comment(s) Made By:
Hicks – U.S. Bureau of Reclamation (page 8 Specific comments)

Response:
The contribution of individual stream heating factors occurring in Oregon will be presented in the Klamath TMDL promulgated by ODEQ. The intent of the quoted statement was simply to identify the human-caused stream heating factors upstream of the border. These results have been updated with the revised model data.

C61. Comm ent(s):
Statement: Chapter 6, Section 6.1.1, Page 6-2 states "Fundamental for the control of nutrient loads to the Klamath River is coordinating with the U.S. Bureau of Reclamation (USBR) to address discharges from the Klamath Irrigation Project."
Comment: The reader should be made aware that substantial nutrient load reduction occurs as the nutrients move through the Klamath Project and only a fraction of the diverted nutrients are being returned to the Klamath River, the water body from which they originated. Reduction of nutrients coming from the Lost River basin and the

Klamath Project cannot be expected until the overwhelming nutrient load originating from Upper Klamath Lake and the Klamath River are reduced. It's imperative that the details relating to the nutrient dynamics of the Klamath River system and the Klamath Project are accurately characterized and well understood by all stakeholders so that water quality improvement strategies can be developed and implemented to address the source of the problem, Upper Klamath Lake.

Comment(s) Made By:
Hicks – U.S. Bureau of Reclamation (page 10 Specific comments)

Response:
As owners and operators of the conveyance system that delivers water to and from the Klamath River, the USBR is clearly one of the parties responsible for ensuring water quality is not impacted by Klamath Project operations, including the discharge of concentrated agriculture return flows.

C62. Comment(s):
Jacob Kann, ecologist and scientist for Klamath Basin Rangeland Trust, insisted that timing and flows are related to the ph levels. Lewis responded that this water is always ph loaded, "the increase doesn't matter if it's always been saturated." (p. 1)

Comment(s) Made By:
Krizo

Response:
The statement above is not followed by a comment. No response required.

C63. Comment(s):
To date, 97,160 acres north of the Klamath Reclamation Project of agricultural land have been acquired by Government agencies and The Nature Conservancy. With evaporation of this shallow warm water, the water quantity available to the Klamath Lake has decreased, and phosphorus level has increased. (p. 2)

Comment(s) Made By:
Krizo

Response:
The comment is more relevant to the Upper Klamath Lake TMDL and the State of Oregon's implementation strategy for that TMDL.

C64. Comment(s):
There is a vast amount of science proving that the sources feeding into our lakes and tributaries are mineral laden. (p. 2)

Comment(s) Made By:
Krizo

Response:
Agreed, the high background loading of phosphorus from volcanic soils is acknowledged in the Staff Report.

C65. Comment(s):
We do not feel you should take our land and water and issue permits to force us to purify water that historically was not pure. (p. 2)

Comment(s) Made By:
Krizo

Response:
We agree. The Regional Water Board is not interested in taking land or water, nor do we expect any responsible party to purify water that historically was not pure. The implementation of the Klamath TMDL only requires that responsible parties be responsible for controlling their own loading of pollutants.

C66. Comment(s):
George Gibbs reported the Klamath River was of poor quality in 1851. In one entry, he said, "In camping on the Klamath, it is necessary to seek the neighborhood of the brooks, especially that this season; as the water, never pure, is now offensive from the number of dead salmon." (p. 2)

Comment(s) Made By:
Krizo

Response:
Comment noted. The naturally poor water quality of the Klamath River is noted and discussed in the Staff Report and incorporated into the water quality analysis.

C67. Comment(s):
High nutrient inputs to the KIP from Klamath Lake and Klamath River must be recognized as background sources beyond the control of agricultural interests. (p. 3-4)

Comment(s) Made By:
Krizo

Response:
The high natural load of nutrients and consequent water quality of Upper Klamath Lake is taken into account and incorporated into the Klamath TMDL analysis, as is the pollutant loading arising from human activities.

C68. Comm ent(s):
Page 4-11 and 4-12, Figures 4.4 and 4.5. These graphs show only the difference between two model runs, with no reference to the actual temperatures. Without knowing the actual temperatures, it is impossible to adequately address the statements in the text. Secondly, Figure 4.4 shows the results of temperature comparison with no indication of what time scale is present, is this a daily maximum, a daily mean, a daily minimum, a running mean of some number of days...? Thirdly, these are comparisons of the output of two model runs. If the expected accuracy of the models is +/- 2 ºC, then a difference of 4 ºC might be due to fluctuations in the model only. This error and associated uncertainty should be provided to the reader. (p. 27) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The statements in the text refer to differences in temperature, which is the information presented in the charts. Figure 4.4 represents the differences in daily maximum temperatures, which is now reflected in the caption. Also, please see the response to comment A2.

C69. Comm ent(s):
Page 4-23, Paragraph 2 and 3. What are the Klamath temperatures used in these calculations? From these two paragraphs, it seems as if there might be two different sets of Klamath temperatures (natural conditions and CA compliant conditions) used in evaluating the impact of the tributaries. Analysis would be clearer if only one set of Klamath River temperatures were used and the scenarios just reflected changes to tributary temperatures. Hopefully, that is what was done, but this is not clear. Adding to confusion are figure captions that describe tributary compliant or tributary natural conditions (e.g. "Figure 4-10 "Shasta TMDL compliant Shasta River conditions") implying that only the tributaries had these conditions applied. Please clearly identify the source of Klamath River temperatures (natural or compliance conditions) used in these calculations. It would be useful to add this information to the figures, as well. (p. 35) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
Figures 4.10 and 4.11 display data from a total of three modeling scenarios; the current conditions scenario, the natural conditions scenario, and the California compliant conditions scenario. The Klamath River temperatures are those associated with the specified scenarios. These comparisons are presented in order to evaluate the effects of the Shasta River on Klamath River temperatures in each of the three scenarios. Regional Water Board staff don't understand the confusion caused by the figure captions, as they accurately describe the data presented.

C70. Comm ent(s):
Page 4-23, Paragraph 4. The draft TMDL states that the California compliance scenario represents full compliance with the Shasta and Scott TMDLs and the Trinity ROD in the first sentence. The subsequent sentence states that for the "Shasta, Scott, and Trinity Rivers natural temperature estimates are meant to depict the absence of all anthropogenic impacts, representing full natural flows and site potential riparian conditions." These two sentences appear to be in conflict. For example, is the Regional Board staff defining the Shasta and Scott River TMDLs as implementing "natural" conditions for flow and temperature. The TMDL analyses for these tributaries should be used. For the Trinity River, ROD flows and associated temperatures should be used. There is no discussion of climate change, an important consideration in a TMDL that will take decades to implement. (p. 36) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
Thank you. The text has been modified for accuracy and clarity.

C71. Comm ent(s):
Page 4-23, Paragraph 5. The Shasta River TMDL has a flow recommendation, but this information is not provided. No flow information (unlike the Scott River presentation) is provided. Determining loads without flow information provided is not feasible. This comment applies to the Salmon, Trinity, and minor tributaries as well. (p. 36) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
Including this information would create an unwieldy document. Loads are reported in the document. Regional Water Board staff will make the flow data available upon request, as we have previously done for PacifiCorp.

C72. Comm ent(s):
Page 4-23, Paragraph 5. The draft TMDL identifies that "there is only a small difference" between the two scenarios in response that the Shasta River may warm the river in fall months. Throughout the TMDL, qualitative terms such as "slight difference," "negligible," "small," etc. are used to describe differences or results of analyses. These terms are vague and subject to different interpretation. Identifying a metric, most usefully based on model uncertainty, and examining results in a more rigorous manner (e.g., a basic exceedance plot), would provide considerably more information and form a more robust assessment. For example, if uncertainty analysis identified that the model was accurate to within 0.5°C, then an exceedance plot of the differences could be constructed and the probability of differences over 0.5°C could readily presented consistently throughout the entire document. Chapter 4 is filled with plots of differences that provide little analytical value (particularly because there are no tabular statistics on the differences, the scales are such that quantitative interpretation is difficult, and the data sets used to calculate the differences are not provided) and are left to subjective interpretation. This approach is insufficient to support a technical TMDL. (p. 36) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The terms identified are simply used to describe the results of analyses presented in charts. The reader is free to make their own interpretation of the data presented in the charts. The data sets used to calculate the differences have been provided to PacifiCorp, and will be provided to others that request it. However, including these data in tabular form would make an already large document much larger, without providing a great benefit to the public, while at the same time making the document overwhelmingly unwieldy. Regional Water Board staff disagree that this approach is insufficient.

C73. Comm ent(s):
Page 4-24, Figure 4.11. Because model uncertainty was not quantified, these results cannot be interpreted in a meaningful manner. Further, when notable discrepancies occur, such as in November, some discussion in the text should follow. Why would fall temperatures be so much warmer under a TMDL compliance condition than under existing conditions? Lack of interpretation and investigation of model output throughout the draft TMDL, i.e., why discrepancies occur, suggests that the models may have been used as "black boxes" with emphasis on the final model output and minimal regard to why the values are what they are. (p. 36) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
Please see the response to comment A2. Presumably, the commenter is referring to Figure 4.10, which shows a temperature increase during November in both the California Compliance Condition and Current Conditions scenarios. The greater temperature increase downstream of Shasta River in November depicted in the CA Compliance Condition scenario is a result of the decreased Shasta River temperature in the Natural Conditions Scenario (See Figure 4.12). Note that these figures are numbered 4.14 and 4.16, respectively, in the draft final staff report.

C74. Comm ent(s):
Page 4-24, Paragraph 1, Lines 1-3. The draft TMDL states that daily average temperatures regularly exceed 20 °C in the Klamath River. No figure is provided, no data presented. When does this occur? The river is not warm year-around. This begs the question of: what is the temperature of the Shasta River that makes it too warm to be a thermal refuge during summer months? Related to this point is the definition of a thermal refugia. What is the definition for the purposes of the TMDL? It appears that Regional Board staff have made a determination that 20°C defines a thermal refugia. This is based on the statement that "temperatures above 20°C (68°F) have been shown to inhibit adult Chinook migration." Referring to seminal work by Strange (2006), "[R]esults from 2005 supported the conclusion from previous study years that the thermal threshold for migration inhibition for KRB adult Chinook occurs at mean daily water temperatures (MDTs) of 23.5°C during falling water temperature trends, at MDTs of 21.0°C during rising water temperature trends, and at MDTs of 22.0°C during stable temperature trends." (page 5) Further, this definition of a refugia would thus be based on adult migration and not over-summering juveniles. This designation of thermal refugia is insufficient. Considerable thought has been given to the definition of thermal refugia and a single temperature is insufficient. Refugial areas in the Klamath River require several key attributes:

- persistence and stability (at a minimum these features must be continuously functional during the late spring through summer period).
- fish utilization (habitat, which may differ among species).
- appropriate temperatures for species present (each species may have a different thermal tolerance).
- appropriate flow (this may or may not include connectivity to the mainstem, but this is determined on a case-by-case basis. Protection of the watershed baseflow is critical).
- meteorological considerations (affects tributary stream temperatures as well as mainstem Klamath River) (p. 36-37) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
Temperatures are too high to support adult salmonids when the 7-day average of the daily maximum temperatures exceeds 20 °C (68 °F), and too high to support juvenile salmonids

when the 7-day average of the daily maximum temperatures exceeds 18 °C (64.4 °F), as described in Section 2.5.2. The text has been revised to make the basis of the 20 °C criteria clear and refer to Klamath River temperature graphs.

C75. Comm ent(s):
In sum, the thermal refugia representation is not defined in the draft TMDL, and thus a quantitative approach to assessing refugial areas cannot be completed. There is considerable literature specific to the Klamath River available to draw from, but these sources were not considered in the TMDL analysis. (p. 37) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
Regional Water Board staff drew from thermal refugia literature specific to the Klamath River, as indicated in section 6.5.4.1.

C76. Comm ent(s):
Page 4-25, Figure 4.12 Please provide year of the data (presumably 2000). Providing a range of years will also be useful for comparison. A more comprehensive presentation of the Shasta River analysis is required. This figure presents information, but there is no technical appendix outlining approach, assumptions, or presentation of data. There is no quantitative discussion of uncertainty (Chapter three states the Regional Board staff have "moderate confidence" in the results, which in a technical TMDL has no meaning). Further, recent work in the Upper Shasta River (Jeffres et al 2008, Jeffres et al 2009) should be considered in the TMDL for natural conditions baseline. Jeffres et al (2009) identifies that assumptions basic to the cold water determination on the Shasta River were overstated. More recent studies indicate that spring temperatures at Big Springs Creek are probably between 2 and 4°C warmer than assumptions in the Shasta River TMDL. Further, these studies have identified severe limitations to riparian shading for extended reaches of the Shasta River due to soils conditions. These important findings indicate the Shasta River TMDL temperature analysis should be revisited. Available data suggest that water temperatures under an implemented TMDL for the Shasta River are probably too cold in the Klamath River TMDL analysis. (p. 38) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
Regional Water Board staff agree that the Shasta TMDL should be updated as new understandings come to light. However, we feel it is premature to rely on the work by Jeffres and others. The Big Springs Creek system appears to be more complicated than

portrayed in their work, as indicated by the fact that after the first year of cattle exclusion, Big Springs Creek temperatures were reduced to levels that were not forecast by Jeffres and others (2009) to occur until after five years of passive restoration (Hoss, 2009).

The comment supports Regional Water Board staff's conclusion that a load allocation for Shasta River flow or revision of the Shasta TMDL flow recommendation is not warranted.   The year is 2000, as described in Appendix 7.

Hoss, Amy. 2009. Personal communication from Amy Hoss of The Nature Conservancy to Bryan McFadin (Regional Water Board staff) on September 9, 2009.

C77. Comm   ent(s):
Page 4-25, Paragraph 2.   A more comprehensive presentation of the Scott River analysis is required. There is no technical appendix outlining approach, assumptions, or presentation of data. There is no quantitative discussion of uncertainty (Chapter three states "there is uncertainty associated with those estimates," which in a technical TMDL has no meaning). Interannual variability is not discussed, but is considerable throughout the Klamath basin. (p. 38) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
A complete presentation of the Scott River analysis is presented in section 3.3.3.2. The development of the model is described in the Scott TMDL, cited in section 3.3.3.2, and available on the Regional Water Board's website. Section 3.3.3.2 presents a quantitative discussion of the uncertainty associated with the Scott River temperature model. Figure 4.15 presents the quantitative results of two of the flow conditions evaluated relative to current conditions, which allows the reader to evaluate the effects of uncertainty associated with the flow estimate.

C78. Comm   ent(s):
Page 4-27, Paragraph 1, Lines 1-4. See comment Page 4-24, Paragraph 1, Lines 1-3. (p. 38) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
See response to comment C74.

C79. Comm   ent(s):
Page 4-27, Paragraph 1, Lines 4-6 and Figures 4.16 and 4.17 (page 4-28). This

discussion of appropriate Scott River temperatures, boundary conditions and thermal refugia is unclear and confusing. Why are thermal refugia discussed herein and not under a separate section? Also, it is unclear what boundary conditions were finally used and why. There are limitations of the additional analysis conducted by Regional Board staff that indicate natural flows are overestimated and temperatures underestimated. Figure 4.17 provides a more likely estimate, but was this used in the TMDL analysis? Are Figures 4.13-4.15 ultimately used in any analysis? For Figure 4.16, why depict results that are in doubt? Or, is this the "revised" natural conditions. Are all these for year 2000, or is this analysis using other years of data? (p. 38) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The purpose of this analysis was to evaluate what thermal benefits the Scott River would be expected to provide under natural conditions so that changes in Scott River flow could be evaluated relative to the water quality objective for temperature. Both the ability of the Scott River to influence Klamath River temperatures downstream and provide thermal refugia at its mouth had to be evaluated. The text has been modified for clarity.

C80. Comm ent(s):
Page 4-28, Paragraph 3. The 0.5°C decrease in Trinity River temperatures for natural baseline is arbitrary. One could argue strongly that best available information would suggest that without Trinity Reservoir (natural condition) stream temperatures in summer under considerably lower flows would be notable higher. Without presentation of the actual data (versus just the differences), this discussion and Figures 4.18 and 4.19 have little meaning. Overall, there is little discussion of temperature conditions on the Trinity River (considerable temperature work has been completed on this tributary, but no citations are present) how ROD flows may or may not have an affect, and how they may or may not compare to natural conditions. (p. 38) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
Regional Water Board staff disagrees with the comment. Under the ROD flow schedule, reservoir releases are approximately equal to unimpaired reservoir inflows during the critical summer and fall months. Regional Water Board staff considered the reports prepared by the USFWS staff but found them to provide little predictive value, although some information was incorporated (see Appendix 7). Regional Water Board staff disagree that the information presented has little meaning, given the impact of Trinity River conditions on Klamath River temperatures, and feel the level of analysis is appropriate to support the decision to not assign flow allocations to the Trinity River.

C81. Comm ent(s):
Page 4-30, Paragraphs 2 and 3. None of the analyses completed for the selected tributaries are presented. There is no discussion of the approach, data, assumed meteorological conditions, what was considered in the sensitivity analyses, findings, or variability among the creeks. Several comments/limitations of this discussion:

- no discussion of the limitations of SSTEMP in such an application,
- no definition of what a "moderate" sized tributary is,
- no description of the range in tributary sizes and how such an application may differ for a "small" or "large" tributary,
- no presentation of conditions within these tributaries regarding riparian vegetation. The statement that solar radiation loads are important in stream temperature is widely accepted and the application of SSTEMP was not needed to arrive at that conclusion.
- no discussion if riparian shading was even used in the SSTEMP application.

The statement that the laws of thermodynamics are "universal" in nature has no real basis here because the discussion of shading is simply a modification of solar flux to a water surface, and has really nothing to do with thermodynamics of the heat budget formulation. (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
Amazing as it may seem, Regional Water Board staff regularly receive comments that the factors that determine stream temperatures (not the relative influence) change from location to location, including comments submitted as part of this process. Pointing out that all streams are subject to the same laws of thermodynamics is the basis for the statement. The use of the term "moderate" had no bearing on the outcome of the analysis, or how it was used. The SSTEMP analysis also is not the basis of any individual decision, and only provides another line of evidence that riparian shade controls are needed. Regional Water Board staff agree with the commenter's conclusion that solar radiation loads are important.

C82. Comm ent(s):
All creeks listed on page 4-30 are between approximately River Mile 108 and River Mile 50 – a region dominated by Douglas Fir forests. Yet the blanket assumption is that these analyses apply region-wide, without regard to aspect, soils, gradient, vegetation, geology, land use, and other factors that apply throughout the region. Subsequently, the draft TMDL concludes that riparian shade controls are needed in "many Klamath River tributaries" not subject to an existing TMDL. There is no basis for this statement. Each tributary has unique attributes and thermal regimes are not similar (as part of the four-year USBR study a FLIR flight from above Beaver Creek to approximately the Trinity River – over 100 miles – was flown and tributary temperatures defined). A tributary-by-

tributary assessment of the potential for such shade to exist should be completed to prioritize creeks that have the highest potential for temperature management, thus avoiding inefficient use of funds and resources on tributaries that have little potential for management. Further, an assessment of the disturbance regime within tributaries is required to identify the potential and frequency for debris flows in response to local geomorphology, hydrology events, fire, and other natural and anthropogenic conditions.

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
Yes, the blanket assumption is that solar radiation is an important factor in stream temperature dynamics throughout the basin, regardless of geology, soils, gradient, vegetation, etc. The basis of the statement comes from the fact that increases in solar radiation from human activities will lead to temperature increases. The Action Plan allows for alternatives that provide equal or better temperature protection, thus there is flexibility built into the approach. Regional Water Board staff would hope that any entity spending funds and resources to do active restoration of riparian vegetation for temperature management would do an analysis to ensure the locations made sense. Such an analysis could include assessment of factors noted by the commenter. However, such activities are not necessary to identify general actions that would lead to improved temperature conditions, and are not required by the Action Plan.

C83. Comm ent(s):
Page 4-30, Paragraph 4. There is no description of recovery of these streams. It is correct that the 1997 flood had a notable effect on the thermal regimes of many tributary streams in the Klamath Basin. However, Regional Board staff has failed to incorporate tributary temperature data from recent years to learn that many of these streams recovered stream side vegetation over subsequent years to a sufficient density to return water temperature regimes to pre-1997 conditions. Large floods will occur as part of the natural hydrologic variability and fire cycles in the basin. Streams will be impaired and streams will recover. An assessment of individual tributaries is required to effectively identify conditions within tributaries to priorities and manage these unique systems appropriately. (p. 39) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
Regional Water Board staff acknowledge that streams recover from disturbances. The fact that streams recover does not exempt land managers from the need to ensure their activities are not causing a condition that results in a stream having to go through a period of recovery during which water quality standards are not met. In regards to the final sentence of the comment, it is not clear what the commenter is suggesting, exactly, nor is it clear whether the commenter is suggesting that the Regional Water Board

should conduct such an analysis or require responsible parties to conduct the analysis. Regardless, the types of sediment discharges addressed in the Action Plan are already prohibited.

C84. Comm ent(s):
Page 4-30, Paragraph 5, Lines 1-8. There is no presentation of the stream width analysis. The assumptions, riparian shading (or lack thereof), stream width to depth ratio, presumed flows, assumed meteorological conditions, modified hypoerheic exchange (which can be important in these small streams, particularly when excess coarse sediments are present), etc. to support the conclusions of a 1-2°C increase are absent. Thus, to present that these conditions are conservative is meaningless. (p. 39) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
Regional Water board staff maintains that evaluating a doubling of the wetted width while keeping the riparian shade values constant results in conservative estimates of temperature increases associated with channel widening.

C85. Comm ent(s):
Page 4-30, Paragraph 5, Lines 8-12. The draft TMDL states that these streams at near equilibrium near the mouths (where the tributaries enter the Klamath River). This is incorrect for many tributaries, at least the summer periods where thermal conditions are of concern. If the tributaries were near equilibrium with meteorological conditions, they would probably be equal to or warmer than the Klamath River due to their smaller thermal mass. Under such conditions there would be no thermal refugial areas at creek mouths. The great value and benefit to the tributaries is that cool source waters, small channels, aspect, topographic and vegetation shading, hyporheic flow and groundwater interaction, and other factors keep them below equilibrium. This is why a tributary by tributary assessment is in order. (p. 40) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The text is contrasting the water temperatures of tributaries at their mouths versus farther upstream. Regional Water Board staff agrees that streams at equilibrium would not have temperatures necessary to provide refugia. However, it is generally true that tributaries are closer to temperature equilibrium at their mouths than farther upstream, thus Regional Water Board staff stand by the conclusion at the end of the sentence that states “it is likely that even larger temperature increases would occur in some reaches upstream

where the difference between the current temperature and the equilibrium temperature is greater."

C86. Comm ent(s):
Page 4-31, Paragraph 1, Lines 1-2. There is no citation for the Watershed Sciences work. Further, an infrared image (e.g., FLIR, TIR) is roughly a snapshot in time and identifying thermal response to channel form (e.g., width) is extremely challenging to parse out of an aerial infrared image unless multiple flights of the same reach at different times of day are completed. (p. 40) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The citation has been added to the document. The text simply states an observation about temperature patterns seen in the FLIR imagery.

C87. Comm ent(s):
Page 4-31, Paragraph 2. Excessive sediment loads create unique dynamics in the Klamath River thermal refugia. In the upper system – above the Scott River – where annual flow ranges are modest, most tributaries enter at elevations that match that of the river, which essentially provides access to the creek (e.g., Bogus, Cottonwood, Beaver, Horse Creeks…Humbug Creek is an exception). As one progresses downstream and the river flow range increases dramatically, tributary mouths are often located well above the river, with the tributary crossing alluvium to reach the main stem. In certain cases these creek mouths are several feet above the Klamath River summer flow stage and become disconnected. Longitudinal location and complex geomorphology conditions have direct implications on thermal refugia formation. For example, the timing of winter floods and subsequent snowmelt hydrographs in tributary streams plays an important role in the alluvial conditions at the mouth of tributaries because the flows (and thus sediment delivery) are often not coincident. These dynamics are discussed in USBR (2005). In sum, this is a complex issue and unique to each tributary. This paragraph is speculative and adds little to the technical TMDL regarding temperature impacts associated with sediments and approaches to managing these unique and valuable resources. (p. 40) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
Regional Water Board staff acknowledge that the dynamic interaction of hydrology and sediment is a complex issue. Regardless, the commenter points out that the alluvial conditions at the mouth of a stream is a function of sediment supply, in part. The

paragraph is only intended to point out the impacts of excess sediment conditions on thermal refugia at tributary mouths, as was done in the reference cited.

C88. Comm ent(s):
Page 4-32, Paragraph 4 (after all numbered bullets). No data are given, no analysis assumptions are provided, no uncertainty analysis was completed, and no documentation on methods is included. This is a systematic problem throughout this and other TMDL chapters. The draft identifies that flow data from 2000 was used, but nothing is presented. There is a note that the best quality assurance data from 2000-2007 was used, but no sources are cited making it difficult to interpret or provide direction on other data sources. Analysts familiar with the Klamath Basin know that that there are winter data gaps, there are tributaries that are poorly represented, yet none of this information is presented. How were these issues addressed in the analysis? Analysis of all tributaries is required, and where data are unavailable, a clear basis for using surrogates or estimates should be documented. Even a brief exercise yields immense insight, such as flows for the Shasta River near the mouth shown in the table below. A few minutes at the USGS website identifies the basic statistics for the period of record flows at the mouth, and the same for the 2000-07 flow period when water quality data was available. The 2000 flow of 180.8 cfs (from USGS) is similar to both the long-term mean and the 8 year mean (2000-2007). Even the simple statistics of maximum and mean annual flow provide insight valuable into system variability and potential loading conditions – flows can approximately range from 200 percent to 50 percent of the mean. This type of basic analysis was not completed at any systematic level in the TMDL. This results in load allocations that are not supportable or meaningful in implementing a long term TMDL. (p. 41) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The text has been modified to direct the reader to the description of how tributary loads were developed in Appendix 6. The approach for tributaries with no nutrient monitoring record and without a flow gauge station is also provided in Appendix 6.

C89. Comm ent(s):
Page 4-12, Paragraph 1, Lines 5-15. An exceedance curve of deviations would be a valuable addition to assess these data. Although positive differences as much as 1.5°C occur, this is only one day in 365. The remainder of the differences is less than 1°C. Further, an exceedance plot would also illustrate the number of days when deviations were positive (warmer) and negative (cooler). However, without a quantification of uncertainty, data interpretation is challenging. Using information from Watercourse (2006) for temperature model simulations on the Klamath River below Iron Gate Dam, model uncertainty is probably on the order of 1°C (a function of time of year and location). (p. 27) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
An exceedance curve would mask the temporal aspects of the data, whereas figure 4.5 displays the temporal nature of the deviations, as well as the magnitude and frequency. Figure 4.5 provides the necessary information to support the evaluation.

C90. Comment(s):
Page 4-14, Paragraph 2, Lines 5-6. The Draft TMDL states that "…the presence of Copco Reservoir can increase Klamath River water temperatures by more than 5.4 °F…." This is a misstatement of the facts. There is no "increase" in temperature; there is a change (of a week or two) in the time of year that a given temperature occurs in the river. The TMDL must be clear about this because the effect of an actual increase in temperature of 5.4 °F could have a substantially different effect than a change in timing of existing temperatures. The TMDL has presented no data or locally relevant citations to support the notion that a shift in time of certain temperatures has had a demonstrably adverse effect on beneficial uses. (p. 28) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
A change in the timing of existing temperatures involves an increase in temperature. The intrastate water quality objective for temperature clearly states "At no time or place shall the temperature of any COLD water be increased by more than 5 °F above natural receiving water temperature." There is no allowance for changes in timing of temperatures. The adverse effects on beneficial uses associated with the altered seasonal temperature pattern are discussed in sections 2.4.3.5 and 2.5.2.1.

C91. Comment(s):
Page 4-14, Paragraph 3, Lines 6-8. Same comment as previous. The maximum temperature does not increase. Instead, the timing of the maximum temperature shifts. (p. 29) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
See response to comment C90.

C92. Comm ent(s):
Page 4-14, Figure 4.7 and elsewhere. Presenting only differences and not actual model simulated temperature (or other constituents presented in this manner in Chapter 4) provides limited insight to the reader as to the relative impact of the difference given the actual temperature or concentrations in the aquatic system. Please include the actual temperature plots of the two scenarios in addition to the difference between scenarios. (p. 29) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
Regional Water Board staff disagree that this is necessary. A figure showing the differences in water quality that result from a human-caused alteration is appropriate for showing the effects of that impact. Also, it is instructive to show the resulting temperature increase associated with a human impact when the water quality objective limits increases in temperature.

C93. Comm ent(s):
Page 4-15, Paragraph 2, Lines 4-6. The Draft TMDL states "…Copco reservoir heats the water…." This statement is false. Copco reservoir does not heat the water, the sun and the air (through radiation and convection) heat the water. This distinction is important because it biases the discussion of possible alternatives. (p. 29) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The identified text has been removed from the staff report.

C94. Comm ent(s):
Page 4-15, Paragraph 2, Lines 1-9. On Page 4-14, the draft TMDL states that Copco Reservoir can increase water temperatures by more than 5.4°F. On page 4-15, the draft TMDL states that Copco can increase temperatures 6.3°F. Please clarify. The discussion of Copco Reservoir heating water "to a level close to equilibrium is erroneous" is vague and largely misleading. First, there is no analysis of equilibrium temperature conditions within the Klamath River upon which to base this discussion. Equilibrium temperature, by its very nature is highly dynamic in space and time, though monthly average estimates of equilibrium temperature could provide keen insight into system conditions. Second, review of available data would suggest that the springs below J.C. Boyle provide relatively cool waters in summer, relatively warm waters in winter, and have a more modest affect in the spring and fall when upstream river temperatures are similar to spring flow temperatures (PacifiCorp 2006). This influx of groundwater can thus impose

a deviation below local equilibrium temperature during summer periods, but the question remains: are inflow waters to Copco Reservoir at equilibrium. Modeling associated with the Project FERC relicensing (PacifiCorp 2008a) suggests that inflowing waters are approaching equilibrium temperature by the time they reach Copco Reservoir. The next question is that if they are not at equilibrium (in summer) what is their fate in Copco? To answer this we need to look at a third point: stratification. If the discussion is restricted to certain months of the year (e.g., late spring through early fall) when Copco reservoir is stratified (as noted on page 416 in the draft TMDL) there are a wide range of temperatures vertically distributed in Copco reservoir. Inflowing waters will seek similar densities and some will be lost to mixing imparted due to inflows and density driven flows (Fischer et al, 1979). Thus, notably colder waters will sink to greater depths while warmer waters will intrude into near surface layers of the reservoir. Therefore, defining equilibrium temperature for a stratified reservoir is not a valid approach. Defining equilibrium temperature for a river is straightforward because the assumption of vertical and lateral mixing can be applied. Further, the TMDL is based on natural conditions and thus any reference to equilibrium temperature should be based on the local river setting. Finally, the statement that "the "water is close to equilibrium when entering Iron Gate Reservoir" is misleading. Water entering Iron Gate reservoir is likely slightly cooler than equilibrium temperature of the river at this location until midsummer, then probably warmer than equilibrium temperature of the river until some time in the fall (PacifiCorp, 2006(a)). Otherwise there would be no fall thermal lag as identified in Figure 4.7 and 4.8. This is a lengthy comment, but it is necessary because the draft TMDL identifies that the "concept of equilibrium temperature is taken into account and addressed in the temperature load allocation and implementation recommendations for these facilities." However, it is apparent that the TMDL assessment of temperature is based on a simplistic and incorrect set of arguments. (p. 29) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The identified text has been removed from the staff report.

C95. Comm ent(s):
None of the species presented in Figures 5.4, 5.5, and 5.6 include typical riparian vegetation shading species useful in many of the tributaries. Ponderosa pines provide limited shade benefiting California in the Klamath basin. These are trees typical of drier climates and locations and although present in the basin are not typical riparian trees. Oak woodland, by definition is not a riparian ecosystem, although occasional oak trees can be located near rivers. Douglas fir and mixed hardwood conifer forests may be adjacent to streams in the lower basin where tributaries flow through large tracts of forests. However, there is no information provided for cottonwood, willow, birch, or alder – the typical riparian species used to thermal management in small streams. These are the species that would be functionally present in most tributaries to the Klamath basin, particularly in the interior reaches (approximately upstream of

Happy Camp) where large tracts of coniferous forests are less common and true woody riparian species are the dominant streamside trees. In the lower basin, the Douglas fir and mixed hardwood may grow adjacent to streams, but alder, birch, and willow, along with big leaf maple, can still dominate streamside vegetation (and in many system herbaceous species are of vital importance, particularly at small flow rates). Because the data provided in Figures 5.4-5.6 largely precludes these important species, the data are of little value and should not be broadly adopted as shade standards in the Klamath basin. (p. 47) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The curves presented in figures 5.4, 5.5, and 5.6 have been replaced and augmented with the results of a new analysis that represents a broader range of riparian species. The curves are presented as targets, not standards. They provide landowners a reasonable estimate of the amount of shade that should be expected for a range of potential conditions. The presentation of the curves does not preclude a landowner from presenting information or plans reflective of expected conditions on an ownership. In any case, the experience of Regional Water Board staff is that the species used in the curves are common riparian species, and are often the dominant species providing shade to watercourses.

C96. Comm ent(s):
Page 4-4, Paragraph 4, Line 2. Solar radiation, not air temperature, results in high heat load to the river. (p. 25) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The text has been modified to include solar exposure as a temperature factor.

C97. Comm ent(s):
The old Figures 4.21, 4.22, and 4.23 from the Agency Review Draft present some very important information regarding the consequences of Regional Water Board staff's decision not to require full restoration of flows in the Shasta and Scott Rivers as part of the Klamath TMDL. Because the CA Compliance scenario (used to set the pollutant allocations in Chapter 5) does not require restoration of full natural flows in the Shasta and Scott, maximum temperatures in the Klamath River will still be 1-2°C warmer than natural in mid-summer (Figure 1). The model results presented in old Figures 4.21, 4.22, and 4.23 show that natural flows in the Shasta and Scott are not necessary to result in near-natural (i.e. <1°C difference) temperature conditions during the fall chinook

spawning (i.e. September-October); the Klamath TMDL's required mitigation of thermal impacts from the reservoirs (e.g. by dam removal) will be sufficient in that regard.

The following point in the previous paragraph should be made clearer in the TMDL text:
-Dam removal will result in near-natural temperatures for fall chinook spawning. (p.10)

Comment(s) Made By:
Fetcho – Yurok Tribe
Crosby – Karuk Tribe
Bowman – Quartz Valley Indian Reservation

Response:
This section of the document has been re-analyzed with updated assumptions and re-written accordingly. However, the point that the Klamath River reservoirs are primarily responsible for the temperature impairment during the fall Chinook spawning season is now made in an expanded section 2.5.2.1.

C98. Comm ent(s):
The staff report provides no evidence to support the inference that the KSD and the LRDC are primarily responsible for a 9 degree Fahrenheit increase in temperature (See Staff Report at p. 4-11). (p. 5)

Comment(s) Made By:
Addington and Danosky – Klamath Water Users Association & Tulelake Irrigation District

Response:
The staff report attributes the temperature increases to the combination of all sources, and simply identifies the KSD and LRDC as two of those sources without quantifying their contribution to the 9 ^{o}F increase.

C99. Comment(s):
Please use research on livestock behavior and livestock waste per animal per day to calculate the percentage of nutrient and organic matter problems, which are directly related to livestock. (p. 3)

Comment(s) Made By:
Pace, Beck, Gillespie – North Group-Redwood Chapter-Sierra Club & Friends of Del Norte

Response:
The TMDL source analysis for nutrients associated with land use activities considered all land use activities together and assigned an allocation of no net loading above natural background conditions. The TMDL analysis did not quantify the loading from individual

land uses. The implementation plan addresses loading from livestock waste through the development of the conditional waiver for agriculture and the adoption of a prohibition on discharges that cause a violation of water quality standards. The type of analysis suggested by the commenter is not needed to require implementation of best management practices that control discharges of livestock waste.

C100. Comm ent(s):
The draft Klamath TMDL assigns nutrient and organic matter allocations for the Trinity River. The Trinity River is not listed as impaired for nutrients and organic matter and there has been no source analysis documenting problems relating to nutrients. What is the basis for these load allocations? Please clarify the regulatory mechanism by which this load allocation can be assigned.

Comment(s) Made By:
Kelley – U.S. Forest Service, Six Rivers National Forest

Response:
The Trinity River discharges nutrients and organic matter to the Klamath River. The Clean Water Act requires that TMDLs address all sources of the pollutant that a TMDL addresses. The Trinity River load allocations address the discharge of nutrients and organic matter from the Trinity River to the Klamath River. The allocations define the tributary loading that complies with water quality standards in the Klamath River. A tributary to a listed waterbody is assigned loads because it discharges to the listed waterbody. There is no requirement for listing of the tributary waterbody as a precondition for assigning a load allocation. Also see, section 6.4.1 in the staff report.

C101. Comm ent(s):
Historically the mainstem Klamath River has always had warm polluted water, largely as a result of the water flowing out of Upper Klamath Lake which is high in nutrients and temperature. The river is warm and polluted at its source and improves the further downstream you go.

Comment(s) Made By:
Briggs

Response:
See response to comments C53, C54, C55, C56, C57, C58, and C59.

TARGETS AND ALLOCATIONS

D1. Comment(s):
Taken as a whole, the Draft TMDL's dissolved oxygen (DO) and nutrient-related allocations and targets are based on management decisions that would require shifting the upper Klamath River system to an unnaturally lower trophic state. However, the Klamath River is naturally eutrophic, primarily because of the large, natural nutrient loadings to the river from Upper Klamath Lake. Upper Klamath Lake is hypereutrophic now, and is considered to have been historically eutrophic (Bortleson and Fretwell 1993, Wee and Herrick 2005). Studies of sediment cores from Upper Klamath Lake have shown that the lake has been highly productive for at least the past 1000 years (Eilers et al. 2001, Sanville et al. 1974). The Regional Board must address in a realistic manner how the drastic reductions of nutrient loads proposed in the Draft TMDL would be achieved. To our knowledge, there have been no documented cases in which nutrient load reductions on such a large scale have been achieved elsewhere, or even concluded as feasible and achievable for planning and implementation purposes. (cover letter p.3) (final comments p.2)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The comment above does not present the entire range of information regarding the historical trophic status of Upper Klamath Lake. Trophic classification is a tool to simply characterize the factors that define the productivity of a waterbody. In the case of Upper Klamath Lake the transition from a eutrophic waterbody to a hypereutrophic water body has had profound water quality implications and has resulted in impairment of beneficial uses. A more accurate summary of the trophic status and the prospects for shifting UKL trophic status from hypereutrophic can be provided through a more complete review the work by Eilers (2004) cited in the comment above. As described by Eilers (2004), there have been clear shifts in UKL productivity and species composition in the past 100 years, consistent with large scale land disturbance activities, which can be strongly implicated as the cause of the lake's current hypereutrophic character. In addition, this issue has been previously addressed in the technical report from the Upper Klamath Lake TMDL (ODEQ 2002):

The term eutrophic is often associated with adverse water quality condition (pollution), whereas in reality, a body of water may be both ecologically "healthy" and eutrophic. Historically UKL [Upper Klamath Lake] was a productive (eutrophic) and diverse ecosystem. It is presently a hypereutrophic system that frequently experiences such poor water quality as to be lethal to its native species (Saiki and Monda 1993). Thus statements such as UKL [Upper Klamath Lake] has always been a eutrophic system" should not be used as an excuse for inaction nor construed to mean that the system was polluted or unhealthy... The argument that it is useless to reduce nutrient loading because the lake will still be eutrophic indicates a misunderstanding of trophic level classifications. - Gearheart et al. 1995

The Klamath River historically has been a very productive ecosystem with variability by season and location. That is, productivity is not fixed but can change based on environmental conditions. Reducing pollutant loading in the upper basin is critical to restoring conditions in the upper Klamath River from eutrophic to hypereutrophic to one that supports beneficial uses. One of the key factors affecting the trophic balance in the Klamath River is the KHP and its dams. The California dams have created environmental conditions that have shifted the trophic status of these portions of the river from mesotrophic-eutrophic, to eutrophic-hypereutrophic. The TMDL allocations will restore the traditional trophic status (i.e., mesotrophic-eutrophic) to these reaches. A study recently completed by Ward and Armstrong (2009) concludes that under existing conditions the Klamath River below Iron Gate dam exhibits the characteristics of a mesotrophic system. Therefore the TMDL allocations cannot be characterized as suggesting a trophic status shift away from or beyond historical conditions, because the conditions consistent with TMDL targets are currently being marginally achieved with periodic exceedances.

Reducing nutrient and organic matter loads (current levels exceed background by several times) to UKL and the Klamath River presents a difficult and complex management challenge. This challenge is one that the Klamath TMDL project team (ODEQ, EPA Regions 9 & 10, and the Regional Water Board), working with other ongoing initiatives in the basin, can successfully address. The TMDL staff report and Action Plan proposes a strategy that includes an innovative mitigation / restoration option based on engineered treatment of pollutant loads combined with a traditional program of NPS Best Management Practices to work on pollutant reduction goals. The Regional Water Board is currently working with several other basin partners (including PacifiCorp) to develop a water quality accounting and tracking framework to facilitate nutrient offset projects. That is, basinwide collaboration on solutions is not only possible but is already occurring.

There have been several large scale (not as large as the Klamath basin) aquatic ecosystem restoration projects based on nutrient management programs (e.g., Lake Washington, Moses Lake - WA) that have provided us with many valuable lessons that have been incorporated into the proposed implementation plan. In addition there are other ongoing nutrient management programs of a similar or larger scale than the Klamath basin including: Gulf of Mexico hypoxia (Mississippi River – Gulf Hypoxia (USGS 2004); and the Chesapeake Bay (USGS 2000) among others. A comprehensive basin wide approach is consistent with emerging best practices and is the most effective way to restore water quality conditions in the Klamath basin.

References used in Response D1:
Eilers, J.M., J. Kann, J. Cornett, K. Moser, and A. St. Amand. 2004. Paleolimnological evidence of change in a shallow, hypereutrophic lake: Upper Klamath Lake, Oregon, USA. Hydrobiologia. 520:7-18.

Gearheart, R. A., J.K. Anderson, M.G. Forbes, M. Osburn, and D. Oros. 1995. Watershed strategies for improving water quality in Upper Klamath Lake, Oregon - Volumes I, II and III. Humboldt State University, August 1995.

Oregon Department of Environmental Quality. 2002. Upper Klamath Lake Drainage Total Maximum Daily Load (TMDL) and Water Quality Management Plan (WQMP). Portland, OR. Accessed November 2, 2009. Available at: <http://www.deq.state.or.us/wq/TMDLs/docs/klamathbasin/ukldrainage/tmdlwqmp.pdf>.

USGS. 2000. Factors Affecting Nutrient Trends in Major Rivers of the Chesapeake Bay Watershed. By Lori A. Sprague, Michael J. Langland, Steven E. Yochum, Robert E. Edwards, Joel D. Blomquist, Scott W. Phillips, Gary W. Shenk, and Stephen D. Preston. Water Resources Investigations Report 00-4218. Richmond, Virginia, 2000

USGS. 2004. Mississippi River/Gulf of Mexico Watershed Nutrient Task Force, 2004, A Science Strategy to Support Management Decisions Related to Hypoxia in the Northern Gulf of Mexico and Excess Nutrients in the Mississippi River Basin. Prepared by the Monitoring, Modeling, and Research Workgroup of the Mississippi River/Gulf of Mexico Watershed Nutrient Task Force, U.S. Geological Survey Circular 1270, 58 p.

Ward, G.H., N.E. Armstrong. 2009. (In press) Assessment of Community Metabolism and Associated Kinetic Parameters in the Klamath River. Prepared for: U.S. Fish and Wildlife Service, Arcata Fish and Wildlife Office, 1655 Heindon Road, Arcata, CA 95521. Project Officer – Paul Zedonis.

D2. Comment(s):
The Draft TMDL's nutrient allocations at Stateline (and other downstream locations by extension) are unachievable, as there are no realistic methods for the 90-98 percent reduction in total phosphorus and 65-75 percent reduction in total nitrogen in the upper Klamath River as required in the Draft TMDL at Stateline. As a result, the Draft TMDL fails to provide proposed nutrient load allocations that are achievable, practicable, or enforceable. (cover ltr p.3) (final comments p.2)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The first consideration in developing the nutrient allocations at Stateline is to identify nutrient concentrations and loads that establish conditions where water quality standards can be achieved and that beneficial uses can be supported. The second consideration is to

set allocations that are above estimated background conditions. These two objectives have clearly been met. The North Coast Regional Water Board believes with full implementation of the Oregon TMDL for Upper Klamath Lake, full implementation of the Lost River TMDL, and full implementation of the Klamath River TMDL that the nutrient targets can be met. The TMDL implementation plan envisions a combination of traditional BMPs, wetlands restoration, and innovative treatment technologies that will be employed to meet pollutant reduction goals. In addition, The Regional Water Board and their Klamath River TMDL team members are fully committed to participating in Interim Measures 10 and 11 described in the Klamath Hydropower Settlement Agreement (Draft – September 20, 2009) to implement pilot projects and evaluate various pollutant reduction measures to develop the optimal strategy for achieving pollutant reduction targets required by TMDL allocations. If during the course of the TMDL implementation or the Klamath Hydropower Settlement Agreement new science becomes available it will be considered as part of the adaptive management strategy for the TMDL and, if appropriate, nutrient allocations can be adjusted as part of the reassessment process.

D3. Comment(s):
The Draft TMDL's chlorophyll *a* targets of 10 ug/L for suspended algae chlorophyll *a* in the reservoirs and 150 mg/m2 for benthic algae chlorophyll *a* in the Klamath River downstream are unachievable, because the TMDL does not realistically consider the upper Klamath River as naturally eutrophic, with hypereutrophic Upper Klamath Lake as its source. (cover ltr p.3) (final comments p.2)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The Regional Water Board disagrees with this comment. As described in Chapter 2 of the Staff Report, several lines of evidence are used to establish the chlorophyll a and benthic algal biomass targets for the Klamath River reservoirs and the free flowing river reaches. In addition, Klamath River TMDL numeric targets were strongly supported by the independent TMDL peer reviewers with one exception. Dr. Desiree Tulos stated that the targets were too high and consideration should be given as to whether beneficial uses were adequately protected at the levels proposed by the Regional Water Board. Also please refer to comment response D1 above regarding the current classification of mesotrophic as stated in Ward and Armstrong (2009). Finally for a more complete discussion relevant to this comment refer to comment response D4 below.

D4. Comment(s):
Along with the reality of the naturally-enriched conditions in the Klamath River system, the chlorophyll *a* targets proposed in the Draft TMDL would require enormous nutrient reductions that are unrealistic and unachievable (as described above for TP allocations). The Draft TMDL's analyses show that the TP loads in the river would need to be reduced 90 percent and TN loads by 65 percent to achieve the 10 µg/L chlorophyll *a* target

(Appendix 2, page 11). The Draft TMDL's analyses show even larger reductions would be needed to achieve the 150 mg/m^2 target for benthic algae chlorophyll *a*; for that target, TP loads in the river would need to be reduced 98 percent and TN loads by 85 percent (Appendix 2, page 34). To our knowledge, there has been no documented case in which nutrient load reductions on such a large scale have been achieved elsewhere, or even concluded as feasible and achievable for planning and implementation purposes.

The Draft TMDL appears to acknowledge that the 150 mg/m^2 target for benthic algae chlorophyll *a* likely is not achievable. The Draft TMDL (in Appendix 2, page 37) states:

> "Table 19 shows that the 75th percentile summer TN concentrations under natural conditions appear to be greater than the concentrations estimated as needed to meet the 150 mg/m^2 maximum benthic chlorophyll *a* target in the analysis of existing conditions provided above in Table 15. This suggests that natural conditions may result in a tendency for elevated benthic algal densities in the Klamath River."

The Draft TMDL (in Appendix 2, page 37) states:

> "It is thus not clear from the benthic biomass spreadsheet analysis that the 150 mg/m^2 target could be met under natural conditions."

The Draft TMDL (in Appendix 2, page 38) states:

> "It is clear that significant reductions in summer nutrient concentrations would be needed to meet a target of 150 mg/m^2 maximum benthic chlorophyll a; however, the predicted magnitude of the needed reductions is highly uncertain."

The 10 µg/L target for suspended algae chlorophyll *a* in the reservoirs proposed in the Draft TMDL is inappropriate for application to the Klamath River, particularly in light of the naturally eutrophic nature of the upper Klamath River system, and the unrealistically large nutrient reductions that would be required for the target to be achieved. The 10 µg/L target was not selected with the naturally eutrophic Klamath River system in mind. Rather, it was selected for the Draft TMDL by the Regional Board staff as the most restrictive of several possible targets under the general, statewide Nutrient Numeric Endpoints (NNE) approach (Tetra Tech 2006).

As the Draft TMDL describes, the 10 µg/L target was chosen by Regional Board staff at a workshop, based on recommendations under the general NNE approach for the most restrictive of the 18 beneficial uses that have been designated for Copco and Iron Gate reservoirs – that is, Cold Freshwater Habitat (COLD) and Municipal Water Supply (MUN) beneficial uses. The Draft TMDL further acknowledges that the NNE-derived chlorophyll *a* target for the reservoirs is the most restrictive and is much lower than if based on other beneficial use categories, and states "10 µg/L summer average chlorophyll *a* provides one potential target for managing these reservoirs" (Appendix 2, page 6).

The 10 µg/L chlorophyll *a* target is not appropriate for the naturally eutrophic Klamath River system. Throughout the Draft TMDL, it is acknowledged that higher concentrations of nutrients result in higher levels of chlorophyll *a*, or that high levels of chlorophyll *a* are typical of nutrient-enriched water bodies (e.g., page 2-16). For example, as the Draft TMDL analyses show, achieving a chlorophyll *a* concentration of 10 µg/L would require TP load reduction to the reservoirs of 90 percent, resulting in an average growing-season phosphorus concentration of 0.03 mg/L (Appendix 2, page 17). As previously discussed above, such phosphorus loads reductions are infeasible and unachievable. That, in turn, means that 10 µg/L chlorophyll *a* is not a reasonable target in this naturally-enriched system.

As a key rationale for the 10 µg/L chlorophyll *a* target for the reservoirs, the Draft TMDL incorrectly states that the 10 µg/L chlorophyll *a* target is "achieved above the reservoirs but not within the reservoirs, thus the reservoirs themselves are the cause of these impairments" (page 4-20). But, in apparent contradiction, based on modeling analyses, the Draft TMDL concludes that the Klamath River entering Copco reservoir (at Shovel Creek) "exhibit high chlorophyll-a concentrations in the middle of the year"…"largely due to upstream conditions being carried downstream", and "in many of these situations, chlorophyll-a data are not available for comparison" The Draft TMDL makes an unsubstantiated assumption that "Nutrient impacts on phytoplankton are significant only in the reservoirs…[t]hus, the algae biomass in the riverine reaches is not related to the nutrient concentration"(Appendix 7, page 11).

The 10 µg/L chlorophyll *a* target for the reservoirs is inappropriate given that chlorophyll *a* levels in the river waters flowing into the reservoirs from upstream are frequently higher than 10 µg/L. Therefore, advected input of chlorophyll *a* alone could prevent achieving the target in the reservoirs. Data presented in the Draft TMDL clearly shows very high levels of chlorophyll *a* in the river from sampling sites above J.C. Boyle reservoir, at Keno dam, and at the Link River mouth (near the outlet of Upper Klamath Lake). The Draft TMDL states that "the high concentrations at these three stations are due in large part to residual algal biomass from Upper Klamath Lake" (page 2-60). Furthermore, the modeling analyses performed for the Draft TMDL to develop recommended TMDL allocations shows chlorophyll *a* levels in the river upstream of Copco reservoir ("Klamath River at Shovel Creek") that are much higher than 10 µg/L, particularly during summer, when the target is to be applied (as a "summer mean"). Figure 2 shows the Draft TMDL's model results for chlorophyll *a* levels in the river upstream of Copco reservoir (from Appendix 6, pages H-16 and H-19).

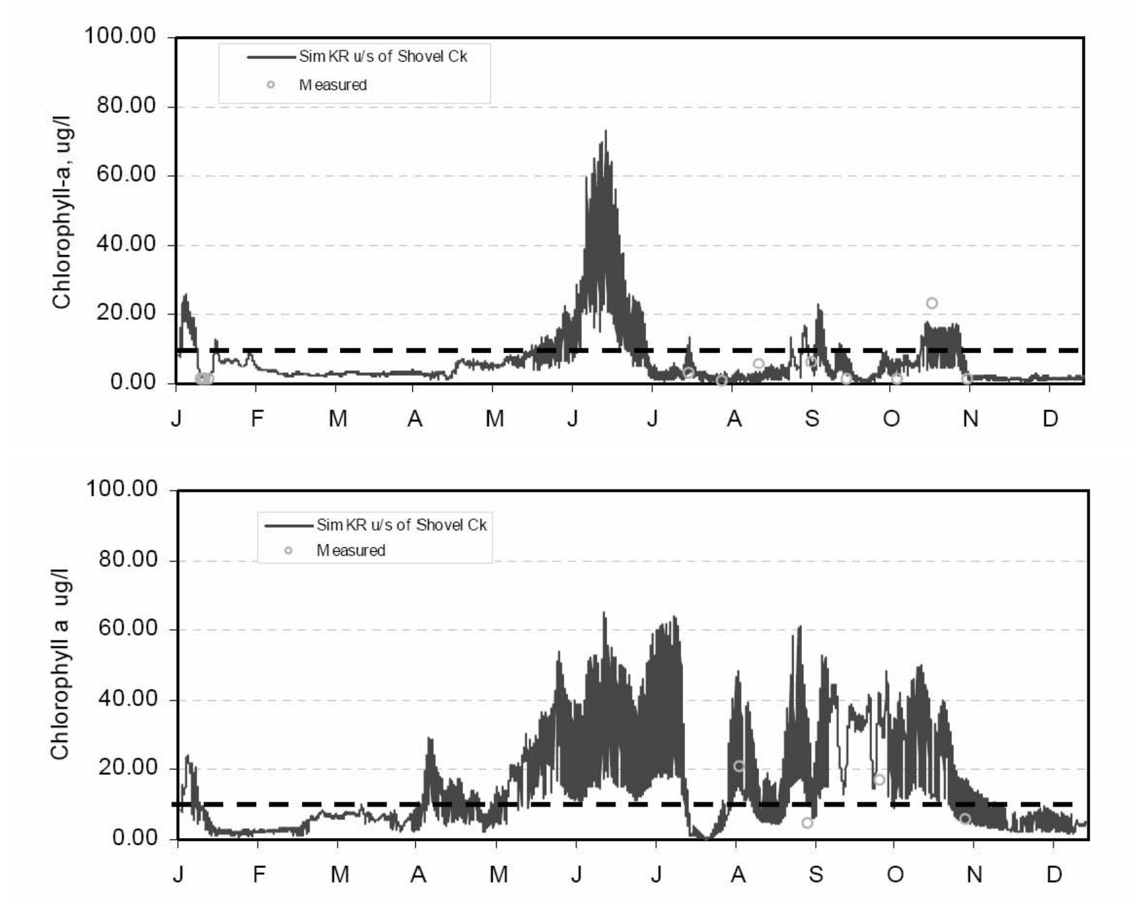


Figure 2. Draft TMDL's model results for chlorophyll a levels in the river upstream of Copco reservoir ("Klamath River at Shovel Creek") based on 2000 (upper plot) and 2002 (lower plot) simulation years (from Appendix 6, pages H-16 and H-19). For comparison purposes, a dark hatched line is added at the 10 µg/L chlorophyll *a* target level proposed in the Draft TMDL for the reservoirs just downstream of this location in the Klamath River.

(final comments p. 26-28)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The Regional Water Board does not agree with this comment which focuses on claims that the proposed TMDL targets for chlorophyll *a* are not achievable or are inappropriate. Two rather different targets are included here: A target reach-averaged maximum of 150 mg/m^2 chlorophyll *a* for periphyton in the Klamath River mainstem downstream of the Salmon River (Section 5.3.4) and an in-reservoir summer mean target of 10 µg/L for planktonic chlorophyll *a* (Section 5.1.1.2).

Regarding the periphyton target, it is important to realize that this target is NOT used as the basis for setting the nutrient allocations for the lower river. Instead, those allocations are derived from the model simulations of conditions necessary to meet the dissolved oxygen water quality standards. The 150 mg/m^2 periphyton density is an additional target for compliance that is believed to be consistent with the allocations, but is not a basis for the allocations.

The comment implies that the 150 mg/m^2 target for maximum periphyton concentration "likely is not achievable." The Regional Water Board agrees that it would be inappropriate to set a target that is not achievable, but believe that this is not the case, as explained further below.

In one respect, the argument about achievability of the periphyton target is moot in the context of the TMDL. The TMDL must establish loads that are less than or equal to the loading capacity, defined as "The greatest amount of loading that a water can receive without violating water quality standards" (40 CFR §130.2(f). In other words, the TMDL is required to achieve applicable standards. The Hoopa Valley Tribe Basin Plan includes a criterion of 150 mg chlorophyll *a*/m^2 for the reach of the Klamath River within the Hoopa Valley Indian Reservation, which is a water quality standard that must be met by the TMDL. If it were not possible to achieve this standard, potential responses would be either to revise the standard or to undertake a Use Attainability Analysis – both of which are outside the scope of the TMDL process. However, the Regional Water Board believes that this standard is both appropriate and achievable.

For the other portions of the river, there is not an established numeric water quality standard for periphyton. However, we believe that the 150 mg/m^2 target is both appropriate and achievable. In contending that it is not achievable, the comment cites three passages from Appendix 2. These are taken out of context and interpreted inappropriately in the comment:

- Table 19 does show that the 75^{th} percentile summer TN concentrations under natural conditions "***appear*** to be greater than the concentrations estimated as needed to meet the 150 mg/m^2 chlorophyll *a* target" (emphasis added). The comment, however, neglects the following paragraph, which points out that the natural (dams out) condition would result in more frequent scouring flows and less days of accrual time between scouring events. When the change in accrual time is included in the NNE analysis, it appears likely that the 150 mg/m^2 target can be met, with the possible exception of the most downstream location at Turwar and the station immediately below Iron Gate. The target is not proposed to apply immediately below Iron Gate, but would apply at Turwar. However, it should also be noted that the T1BS natural condition scenario analyzed here kept the concentrations in most of the downstream tributaries at estimated current levels, whereas a truly natural condition would result in some reduction in these loads, further reducing predicted maximum periphyton densities, particularly at the more downstream locations.
- Appendix 2 (p. 37) does state that it is "not clear from the benthic biomass spreadsheet analysis that the 150 mg/m^2 target could be met under natural conditions." This statement was made in the context of uncertainty about the days of

accrual and downstream tributary concentrations that would apply under natural conditions. It does NOT say that the target is likely to be unachievable, only that there is uncertainty as to whether it is achievable. Our best estimate remains that it is achievable.

- Appendix 2 (p. 38) states that "the predicted magnitude of the needed reductions is highly uncertain." This statement has no bearing on achievability; it only says that the exact magnitude of the needed reductions is uncertain. The analysis is fully consistent with the TMDL regulations for load allocations, which state (40 CFR §130.2(g)): "Load allocations are best estimates of the loading, which may range from reasonably accurate estimates to gross allotments, depending on the availability of data and appropriate techniques for predicting the loading."

Regarding the 10 µg/L target for planktonic chlorophyll *a*, the comment does not contend that this target is unachievable (indeed, model simulations show that it is achievable), but rather contends that it is "inappropriate" for the "naturally eutrophic" upper Klamath River system. The Basin Plan does not provide a numeric criterion for chlorophyll *a*, but does contain a narrative standard controlling biostimulatory substances to levels that do not "promote aquatic growths to the extent that such growths cause nuisance or adversely affect beneficial uses" and a narrative standard for toxics stating that "All waters shall be maintained free of toxic substances in concentrations that are toxic to, or that produce detrimental physiological responses in human, plant, animal, or aquatic life." In developing TMDLs to achieve narrative standards it is necessary to establish appropriate measurable indicators and target levels of those indicators sufficient to support beneficial uses. As outlined in Section 2, the chlorophyll *a* target of 10 µg/L is an appropriate target to ensure that aquatic life uses are supported and also to ensure that risk of toxic levels of microcystin are avoided. The lengthy comments regarding the development of the general California NNE target for COLD uses of 10 µg/L are not relevant once a site-specific target for the TMDL has been developed.

D5. <u>Comment(s):</u>
The Draft TMDL inappropriately assigns "zero nutrient loading from reservoir bottom" and negative nutrient allocations to Copco and Iron Gate reservoirs. The reservoirs are not a source of nutrients, but a net sink of nutrients, and load allocations less than zero are inconsistent with the Clean Water Act. (cover ltr p.3)

The Draft TMDL assigns "zero nutrient loading from reservoir bottom" and also assigns nutrient allocations to Copco and Iron Gate reservoirs of 74,569 pounds TP annually and 1,091,654 pounds TN annually despite the fact that the reservoirs are not a source of nutrients. These TP and TN allocations are to be achieved at a location upstream of Copco reservoir. These allocations are inappropriate, particularly given that the reservoirs are a net sink of nutrients. The Draft TMDL fails to accurately and realistically portray and account for the nutrient sources and dynamics in the Klamath River system. Even the Draft TMDL's model outputs clearly show that the reservoirs substantially reduce large nutrient pulses emanating from the Klamath River upstream (in response to bloom conditions in Upper Klamath Lake). (final comments p.2) (Also included in Source Analysis -

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The Regional Water Board disagrees with the statements made in this comment related to reservoir nutrient retention and nutrient dynamics and the impacts of nutrients generated from reservoir sediments. Regional Water Board responses to these statements have been included in responses to other comments: A6, A7, A33, A37, A38, C3, C10, and C13. The Regional Water Board continues to support the analysis and concept of zero discharge of nutrients from reservoir sediments. However, the updated TMDL staff report has adopted a more comprehensive approach to the reservoir allocations that does not require the designation of an allocation specific to reservoir sediments. The assignment of a single nutrient allocation (nutrient reduction goal) will provide PacifiCorp more flexibility in achieving desired conditions.

D6. Comment(s):
The compliance lens approach for assigning allocations to Copco and Iron Gate reservoirs is inappropriate for the nature of the reservoirs. The Draft TMDL assigns allocations to Copco and Iron Gate reservoirs in the form of a “temperature and dissolved oxygen compliance lens" for the period of May through October. This compliance lens approach is unprecedented, and would be unrealistic to actually apply in an advection-dominated, and stratified reservoir setting. (cover letter p.4) (final comments p.2)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The compliance lens is a necessary allocation to support existing COLD beneficial use and in anticipation of salmonid fish passage that would be required of PacifiCorp if the dams remain. It is true that the compliance lens approach has not often been used, primarily because sufficient sophisticated models and monitoring data are not often available. Refinement of the basic criterion requirements for DO and temperature to a compliance lens basis to support beneficial use is appropriate within the initial PacifiCorp compliance plan and as part of the TMDL adaptive management framework. The upstream reaches of the reservoirs dominated by advective conditions will reflect temperature and DO conditions within that reach and will likely be in compliance. In addition, if mixing rates sufficient to breakdown stratification do exist this should ensure good oxygenation throughout the water column. However, as additional thermal energy is added sufficient to change the influent temperature regime this will cause stratification to once again set up. Therefore a contingency capability must exist to ensure compliance lens conditions. The assertion that the compliance lens is unrealistic in the strongly stratified reservoirs (excluding Copco 2) is unsupported. The Regional Water Board will

review alternative strategies proposed by PacifiCorp in their TMDL implementation plan regarding feasibility and effectiveness.

D7. Comment(s):
The waste load allocation for Iron Gate Hatchery is arbitrary, and cannot be met. The allocation for the Hatchery is for zero net increase above "California compliant conditions (i.e. with no dams)" (page 5-26). As discussed elsewhere, the California compliant conditions are inappropriate and unattainable. Therefore, because the intake water from the Klamath River of Iron Gate reservoir will be in excess of the target value given in Table 5.15, the objective of zero net increase over the "compliant" condition cannot be met. In addition, because the target values for TP and CBOD are less than laboratory analytical reporting limits, compliance could not be demonstrated, even if it could be achieved.

In the alternative, supposing that zero net discharge could be achieved, there would be only a negligible, probably undetectable, effect of the loading to the Klamath River. Even under "compliant conditions" the existing load from the hatchery (page 4-22) would constitute only 0.02 percent of the proposed compliant load for TN (Draft TMDL Table 5.3) and only 0.05 percent of the compliant load for TP (Draft TMDL Table 5.2). Any benefit from eliminating this miniscule load could not conceivably justify the expense involved. (final comments p. 37)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
Iron Gate Hatchery is an NPDES permitted facility that discharges into an impaired waterbody (Klamath River). NPDES discharge policy requires that regardless the condition of the source water used by a facility it must meet water quality objectives upon discharge. The Regional Water Board agrees that the facility is a small source. The Regional Water Board has two areas of flexibility that can be applied to this situation: 1) nutrient and organic matter goals can be achieved through offsets upstream; and 2) the permit can include a compliance schedule for meeting new effluent limits such as those associated with TMDL waste load allocations. The TP targets are above detection limits and progress towards those targets can be evaluated through a standard monitoring program. Also in response to the comment stating that the targets are less than laboratory analytical reporting limits the Regional Water Board provides the following response:

Analytical labs commonly assess results against two precision thresholds. The Method Detection Limit (MDL) is defined as the minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero. The reporting limit (RL) is defined as the lowest concentration at which an analyte can be detected in a sample and its concentration can be reported with a reasonable degree of accuracy and precision. Analytical results between the MDL and RL are often reported as estimated values.

The MDL and RL for TP are based on procedural results and can vary between laboratories. There are several commercial laboratories that can achieve an RL below the TP concentration targets. For example, the Dept. of Fish and Game laboratory in Rancho Cordova used by the California State SWAMP Program achieves a RL of 0.01 mg/L and a MDL of 0.005 mg/L, well below target concentrations.

The MDL and RL for CBOD are equal at 3 mg/L. These levels are operationally defined and do not vary between laboratories.

Option 1) Analytical results of CBOD will be assessed using a 3-month running average for compliance evaluation against concentration targets. Analytical results reported as below the MDL will be assessed at one-half the MDL (i.e., 1.5 mg/L).

Option 2) Analytical results reported below the MDL for CBOD will be assumed to represent one-half the MDL (i.e., 1.5 mg/L). This assumption is a commonly used in water quality assessment (Helsel and Hirsch, 1992).

Alternatively, assessment of compliance with CBOD targets can be conducted using the concentration of Total Organic Carbon (TOC). The target concentrations were derived using a conversion factor applied to particulate and dissolved organic matter. Analytical results of TOC can be converted to an equivalent concentration of CBOD using these conversions.

D8. Comment(s):

The Draft TMDL assigns allocations to Copco and Iron Gate reservoirs in the form of a "temperature and dissolved oxygen compliance lens" for the period of May through October. The Draft TMDL further describes that "[t]he volume of each reservoir compliance lens is equal to the average hydraulic depth of the river in a free-flowing state for the width and length of the reservoir". This compliance lens approach is unprecedented – PacifiCorp is unaware of any actual implementation of a similar "compliance lens" approach elsewhere. This compliance lens approach is unrealistic to actually apply in an advection-dominated reservoir setting.

The concept of applying a fixed volume where temperature and DO are both acceptable based on the reach average depth of a free-flowing river
makes no physical sense: lentic and lotic systems are fundamentally different environments. The average reach depth (the Draft TMDL is unclear if this is average depth or average hydraulic depth) for a free-flowing river channel is not provided in the Draft TMDL, but based on modeling efforts is probably on the order of one meter. Even if the average depth were two meters, relying on this thickness of a compliance lens within the reservoir is tenuous given thermal stratification, wind mixing, and seasonal thermal loading. That is, such a thin lens would not actually persist in a biologically functional manner through the summer period.

Further, the definition states that the compliance lens applies to the width and length of the reservoir. This is an unattainable condition in reservoirs under stratified conditions. By definition, the thermocline within Copco and Iron Gate reservoirs does not extend the entire length of the reservoir. In shallower headwater areas, a hypolimnion is absent and there are no cold, deeper waters in the upper reaches of both reservoirs for considerable distances. Likewise, the thermocline also does not extend the full width of the reservoirs. Based on fundamental stratification dynamics and the morphology of reservoir systems, the compliance lens approach as defined in the draft TMDL cannot be realistically implemented. (final comments p. 36)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The comment highlights the point of the allocation exactly: the reservoirs have created an environment (stratified during critical summer period) where DO and temperature conditions are not satisfied together as they had been formerly under free flowing conditions. The text has been revised to make clear that the compliance lens applies to those portions of the reservoir that stratify. The requirements of the compliance lens ensure that there are supporting conditions within the reservoir for COLD during the summer period where currently these conditions do not exist. Also refer to comment response D6 above.

D9. Comment(s):
Taken as a whole, the Draft TMDL's DO and nutrient-related allocations and targets are based on management decisions that would require shifting the upper Klamath River system to an unnaturally lower trophic state. The Draft TMDL indicates that algal conditions driving TMDL nutrient-related allocations require "a general reduction in eutrophication potential" Appendix 2, page 14). The Draft TMDL states the general NNE chlorophyll-*a* value of 10 µg/L was obtained from Walker (1985), a research paper that concluded that for mean chlorophyll-*a* values of 10 µg/L or less, "expected bloom frequencies" (of algae) "are minimal for a system with average variability" (Walker 1985, page 61). Walker (1985) also indicates that a chlorophyll-*a* value of 10 µg/L agrees with "definitions of the mesoeutrophic boundary", which implies that the Draft TMDL's chlorophyll-*a* target value of 10 µg/L, based on a minimal bloom frequency, would require a shift to an unnaturally lower (mesotrophic) trophic state. As with the chlorophyll *a* target, the Draft TMDL targets in the reservoirs for *Microcystis* cell density, and concentrations of TP, TN, organic matter (as CBOD), and microcystin all likewise would require a shift to an unnaturally lower (mesotrophic) trophic state.

However, the Klamath River is naturally eutrophic, primarily because of the large, natural nutrient loadings to the river from Upper Klamath Lake. Upper Klamath Lake is hypereutrophic now, and is considered to have been historically eutrophic since the earliest-known statements regarding the lake's water quality were made in 1855 (Bortleson and Fretwell 1993, Wee and Herrick 2005). Evidence for the long-term highly productive status of Upper Klamath Lake is not limited to the historical record. Studies of sediment cores from Upper Klamath Lake have shown that the lake has been highly productive for at least the past 1000 years (Eilers et al. 2001, Sanville et al. 1974).

The very large nutrient reductions sought in the Draft TMDL allocations (e.g., a 90 percent or more reduction in TP in the river above Copco reservoir) are unrealistic and unachievable, especially in light of naturally eutrophic conditions in the Klamath River system. The Draft TMDL's own analyses show that Klamath River would be eutrophic under "natural conditions" (e.g., page 3-8; Appendix 2 pages 20, 32, 36, and 37). Even the Draft TMDL's numeric DO target of 85 percent saturation (under natural temperatures) is implicit recognition of high natural organic loading effects at Stateline upstream of Copco reservoir. As such, the Regional Board should revise the TMDLs to provide allocations and targets that are realistic and achievable. Otherwise, if the Regional Board considers the Draft TMDL targets to be necessary to protect designated beneficial uses and meet water quality objectives, the targets are unachievable and the designated uses cannot be fully attained.

The TMDL must more realistically address the challenges posed by the hypereutrophic conditions in Upper Klamath Lake, and the resulting large loads of nutrients from the lake to the Klamath River. The Regional Board must address in a realistic manner how the drastic reductions of nutrient loads proposed in the Draft TMDL would be achieved. (final comments p. 28, 29)

<u>Comment(s) Made By:</u>
Hemstreet – PacifiCorp

<u>Response:</u>
The Regional Water Board does not agree with this comment. Please refer to comment response D1 for further background and justification for the selected targets. It is clear that the TMDL targets are consistent with conditions that can be achieved; that are above natural background conditions; and provide supporting conditions for all beneficial uses. The Klamath River SSO for DO is in response primarily to DO conditions that can be achieved under natural background temperature conditions, not due to organic inputs from Upper Klamath Lake.

D10. <u>Comment(s):</u>
The Draft TMDL assigns nutrient allocations to Copco and Iron Gate reservoirs of 74,569 pounds TP annually and 1,091,654 pounds TN annually to be achieved at a location *upstream* of Copco reservoir (emphasis added) (page 5-22). The Draft TMDL provides limited explanation for the derivation of these additional nutrient allocations to Copco and Iron Gate reservoirs. The Draft TMDL suggests that the 10 µg/L chlorophyll *a* target for the reservoirs was not reached in model runs based on a scenario that assumes "natural conditions" or Oregon TMDL compliance conditions at Stateline upstream of the reservoirs. The Draft TMDL further suggests that additional nutrient allocations to Copco

and Iron Gate reservoirs equal the additional reduction in loads under “natural conditions” or Oregon TMDL compliance conditions that the model predicts would be necessary at Stateline to meet the 10 µg/L chlorophyll *a* target in the reservoirs. The Draft TMDL also assigns “zero nutrient loading from reservoir bottom sediments … to account for the flux of nutrients (e.g., ammonia and orthophosphate) from reservoir bottom sediments under anoxic conditions during the critical period May through October” (page 5-22).

These nutrient load allocations to the reservoirs are inappropriate for several reasons, including requiring less-than-natural nutrient concentrations to be achieved in the river. Also as discussed below, the rationale for this allocation is flawed and counterintuitive, given that the reservoirs are not a source of nutrients, but a net sink of nutrients. Therefore, under “natural conditions” or Oregon TMDL compliance conditions, the net nutrient loading in the Klamath River from Stateline to downstream of Iron Gate would be less with the reservoirs in place. (final comments p.22)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The TMDL allocations to Copco and Iron Gate reservoirs have been revised in the draft final to 67,048 pound of TP annually (a reduction of 22,367 pounds annually) and 1,025,314 pounds TN annually (reduction of 120,577 pounds annually), to be achieved upstream of Copco reservoir. The TMDL target of 10 µg/L chlorophyll *a* (summer mean) is consistently exceeded within the reservoirs. These exceedances lead to nuisance levels of algae and to toxic blue-green algal blooms. As explained in the TMDL staff report, the reservoirs create an environment which results in algal blooms that would not occur otherwise. Different lines of evidence were used to derive the TMDL target of 10 µg/L chlorophyll *a* (summer mean) including site-specific empirical analyses, the California Nutrient Numeric Endpoints framework (NNE), and the TMDL model. Analysis of monitoring data demonstrates that the TMDL target of 10 µg/L chlorophyll *a* (summer mean) is already achieved in free-flowing sections of the Klamath River both above and below the reservoirs. Therefore the target is realistic and achievable. The allocations to the reservoirs have been revised to reflect a single comprehensive requirement; the sediment flux allocation reduction requirement has been included in this overall allocation and the sediment allocation no longer exists as a discrete requirement. This provides PacifiCorp with greater flexibility in meeting the allocation reduction requirements. The conditions created by the reservoirs are controllable factors affecting water quality; therefore they must have an allocation assigned to them. There may be other mitigation measures to control the nuisance algal blooms that occur within the reservoirs that the Regional Water Board can consider that may decrease the size of the required nutrient reductions. This reconsideration is allowable within the adaptive management process. However, even though the below background conditions are unusual, the reductions are necessary to achieve water quality objectives within the reservoirs. The TMDL model reductions for TP and TN above Copco are consistent with the NNE estimate for reductions. The fact that the reservoirs serve as a net annual

nutrient sink is not relevant to this allocation. The allocation addresses water quality conditions within the reservoir. Also refer to comment response A6 for additional information.

D11. Comment(s):
The Draft TMDL assigns allocations to Copco and Iron Gate reservoirs in the form of a "temperature and dissolved oxygen compliance lens" that the Draft TMDL claims is equivalent to DO instantaneous mass in Copco reservoir of 32,398 pounds annually and in Iron Gate reservoir of 47,624 pounds annually. The Draft TMDL describes this allocation as for the period of May through October and "requires that DO concentrations consistent with 85% saturation or better overlap temperatures consistent with natural water temperatures (natural baseline summer mean is ~18.7 °C) at the point of entry to the reservoirs within a lens throughout the reservoir" (page 5-25). The Draft TMDL further describes that "[t]he volume of each reservoir compliance lens is equal to the average hydraulic depth of the river in a free-flowing state for the width and length of the reservoir" (page 5-25). This compliance lens approach is unprecedented, and is unrealistic to actually apply in an advection-dominated reservoir setting. (final comments p.22, 23)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
Refer to response to comments D6 and D8 above.

D12. Comment(s):
The Draft TMDL proposes numeric targets for total phosphorus (TP), total nitrogen (TN), and organic matter (CBOD) for the tailraces below, and mid-point locations within Copco 1 and Iron Gate reservoirs (as listed in Tables 5.12 and 5.13 on page 5-21). The Draft TMDL states that "[t]hese nutrient and organic matter targets are established at the monthly mean concentrations that coincide with meeting the in-reservoir chlorophyll-*a* summer mean target of 10 µg/L, *Microcystis aeruginosa* cell density target of 20,000 cells/mL, and microcystin target of 4 µg/L" (page 5-20). However, the derivation of the specific monthly target values presented in the Draft TMDL (i.e., as listed in Tables 5.10, 5.12, and 5.13) cannot be determined from the materials provided in the Draft TMDL.

Despite the above statement from the Draft TMDL, it appears that the nutrient target values for the reservoirs are based entirely on meeting the 10 µg/L chlorophyll-*a* target, since none of the models supposedly used in the Draft TMDL to estimate nutrient target values incorporate *Microcystis aeruginosa* cell density or microcystin variables. Rather, these variables are assessed through correlation back to chlorophyll-*a*. Therefore, it is evident that the TMDLs for nutrients and organic matter are fundamentally built on an assumed 10 µg/L chlorophyll *a* endpoint. However, for several reasons as discussed below, the 10 µg/L chlorophyll *a* target for the reservoirs is inappropriate for application to the Klamath River, particularly in light of the naturally eutrophic nature of the upper Klamath River system. The 10 µg/L target was not selected with the naturally eutrophic Klamath River system in mind. Instead, it was selected for the Draft TMDL as the most restrictive and stringent of several possible targets under the general, statewide Nutrient Numeric Endpoints (NNE) approach (Tetra Tech 2006).

The Draft TMDL also sets nutrient and organic matter targets for Copco and Iron Gate reservoirs and tailwaters at “natural conditions” values that assume full implementation and compliance with the Upper Klamath Lake TMDL (ODEQ 2002), plus the yet-to-be-issued TMDL for the upper Klamath River in Oregon (expected from ODEQ in fall 2009). The Draft TMDL states that “allocation and targets at stateline are presented in Sections 5.2.2 and 5.3.1, and reflect anticipated water quality at stateline once the Oregon TMDLs are fully implemented” (page 6-8). The Draft TMDL indicates that full implementation and compliance with both Oregon TMDLs “represent a critical part of the solution in meeting water quality objectives in California” (page 6-8).

Therefore, the TMDLs for nutrients and organic matter are built entirely on an assumed future state in which the upstream TMDLs are fully met. However, the very large reductions in nutrient loadings to Upper Klamath Lake necessary to achieve a compliant TMDL condition at Stateline cannot be feasibly attained. Yet, the Draft TMDL provides no discussion of any legal or practicable means of ensuring that the nutrient and organic matter loading reductions would occur at Stateline (and at other downstream locations by extension). (final comments p.21, 22)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The monthly mean nutrient and organic matter targets presented in tables 5.12 and 5.13 were developed using the TMDL model that reflect the monthly mass loads consistent with TMDL allocations. The TMDL allocations are presented as monthly mean concentrations because it is the concentrations during summer growth periods that are critical to controlling nuisance algal blooms. The commenter correctly identifies the linkage of water column concentration, chlorophyll *a* concentrations, and *Microcystis* / microcystin concentrations. The TMDL staff report explains these linkages within Chapter 2. The TMDL target of 10 µg/L chlorophyll *a* (summer mean) as asserted by the commenter is not assumed, arbitrary, or inappropriate. Comment responses B6, B9, B10, B11, B14, B15, A6, and C3 more than adequately demonstrate this target is based on clearly established risk to beneficial uses, broadly supported within the scientific literature, and is fully achievable. The TMDL target of 10 µg/L chlorophyll *a* (summer mean) also is not the most restrictive target, rather it is the target that provides supporting conditions within a reasonable level of protection from impairment to beneficial uses. The relationship of chlorophyll *a* to *Microcystis* and microcystin was established using site-specific data and received strong support from the independent peer review. The concept of using a dynamic model to provide monthly mean targets, that were developed using several lines of evidence, is standard practice, indeed it is one of the primary

benefits of using dynamic models. Consistent with TMDL policy, all allocations have independent applicability and must be achieved independent of the status of other allocations.

D13. <u>Comment(s):</u>
The Draft TMDL proposes DO targets at Stateline and the Copco 2 and Iron Gate tailraces that are expressed as monthly mean and monthly minimum DO concentrations. According to the Draft TMDL, these DO targets are calculated to achieve compliance with the California DO objective (page 5-20). It is clear from the analysis in the Draft TMDL that achieving these DO targets is dependent on meeting the Draft TMDL's nutrient and organic matter allocations at Stateline. For example, the Draft TMDL states "[n]utrient and organic matter allocations at stateline are set to control their biostimulatory and oxygen consuming effect on DO and to achieve the DO objective/targets…" (page 5-20). The Draft TMDL's numeric DO target of 85 percent saturation (under natural temperatures) is implicit recognition of high natural organic loading effects at Stateline upstream of Copco reservoir. (final comments p. 21)

<u>Comment(s) Made By:</u>
Hemstreet – PacifiCorp

<u>Response:</u>
The commenter is correct in saying that DO targets assigned at the Stateline, Copco and Iron Gate tailraces are calculated to achieve the proposed revised Site Specific Objectives for DO (as contained in Appendix 1 of the Klamath TMDL staff report). Meeting the DO targets is contingent on achieving all upstream nutrient and organic matter allocations. That is, progress must be made on all allocations as quickly as possible, not waiting for upstream compliance before working on downstream compliance.

The proposed revised SSOs for DO have been refined to require that ambient water quality in the mainstem Klamath be maintained at 90% DO saturation as calculated based on estimates of natural receiving water from October 1 through March 31 and 85% DO saturation during the rest of the year from Stateline to the Hoopa-California boundary. As observed by the commenter, the percent saturation criteria are an implicit recognition of the high natural organic loading effects; though, the effects subside during the winter when temperatures drop.

D14. <u>Comment(s):</u>
Is phosphorus limiting and the worst case condition? If so, then the TMDL should be explicit that the strategy in the Klamath River TMDL is phosphorus limitation. In fact, a nutrient limitation strategy for meeting chlorophyll *a* targets in both the reservoir and river (benthic) reaches is not presented in the draft TMDL. This leaves the entire analysis with no real management strategy or basis, just a hope that sufficiently low nutrients will somehow attain compliance. Without such a strategy explicitly stated, this leaves little direction for implementation actions because the regulated community does not know which nutrient – phosphorus or nitrogen –

should be targeted for management. In a system that has a history of eutrophication and has set specific targets for chlorophyll *a* for reservoirs and rivers a limiting nutrient strategy is pivotal – without a such a strategy resources will not be used in an efficient and effective manner and implementation goals will not be achieved. (p. 23) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
Nutrient limitation varies both temporally and spatially throughout the Klamath basin. Therefore an approach that targets both nutrients is required. The combined nutrient reduction strategy is widely recognized and accepted approach to controlling biostimulatory conditions and restoring beneficial uses (Welch 2009). In addition, the system is often oversaturated relative to both nutrients. The strategy presented in the TMDL staff report is abundantly clear, reductions in TN, TP, and organic matter are necessary to achieve supporting conditions throughout the Klamath River basin. The TMDL implementation and action plan clearly identifies actions that are tied to known sources and are designed to meet the TMDL allocations. The TMDL also benefits from an adaptive management approach that allows for refinement of management actions to those that experience indicates are more efficient and or effective.

D15. Comment(s):
Page 3-8, Paragraph 4, Lines 1-4. The Draft TMDL states that "…targets should not be set lower than the value expected under natural conditions." However, the natural conditions baseline used in the Draft TMDL appear to be substantially lower than any conditions that have been experienced in the Klamath system (Herrick and Wee 2005, Eilers et al. 2001). The TMDL provides no evidence to justify the choice of "natural conditions" that are so far removed from documented natural conditions. The proposed natural conditions must be supported with data or locally relevant citations. (p. 19) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The Klamath TMDL natural baseline conditions are not set below values expected under background conditions. The Upper Klamath Lake TMDL reviewed all available literature on this topic in deriving their TMDL background and compliant conditions. The median of this range was chosen for the Klamath River TMDL. The assumptions regarding the development of the natural baseline conditions are included in the staff report.

D16. Comment(s):
Page 5-5, Paragraph 2, Lines 7-10. Some set of nutrient allocations would have to be met above Copco even under "dams-out" conditions to prevent DO impairment and/or algae growth downstream. Are these load allocation for PacifiCorp upstream of Copco over and above the allocations that would be imposed in dams-out scenario? (p. 44) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The dams-in scenario requires additional allocations to the stateline allocation in order to meet the chlorophyll *a* targets within the reservoirs. The stateline allocations would allow the DO objective to be met in a dams-out scenario.

D17. Comment(s):
Page 5-6, Figure 5.1. Here and throughout these loading diagrams, "Benthic load" should clearly be identified as "Net Benthic Load" or otherwise re-labeled (e.g. ."Load only from sediments to water column. Load lost from water column to sediments not included."). (p. 44) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
References regarding the allocation loading from reservoir sediments are no longer included in Section 5.

D18. Comment(s):
Page 5-20, Table 5.10. The target values for total phosphorus are below the reporting limit for the analytical method. They therefore cannot be measured, and cannot be enforced. In addition, the targets are stated to a precision (3 decimal places) that is beyond the capabilities of the analytical method and, presumably, the model itself. In addition, the target values are extremely low relative to the actual conditions, and most likely too low relative to any reasonable historical condition. This comment applies to Table 5.12 and 5.13 as well. (p. 50) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
See response to comment D7.

D19. Comment(s):
Page 5-20, Tables 5.10, 5.12, and 5.13. The Draft TMDL allocations at Stateline, and for Copco and Iron Gate tailraces present a clear disconnect with the 2002 Upper Klamath Lake TMDL (ODEQ 2002). The Upper Klamath Lake TMDL seeks TP targets of 0.066 mg/L for inflows to the lake and 0.11 mg/L for the in-lake concentration, while the expectation in Tables 5.10, 5.12, and 5.13 is to achieve 0.030 to 0.039 mg/L TP. Even the allowable without-dams and natural conditions load capacities (as shown in Figure 5.9) would require about 84 percent TP reduction from existing loads (compared to 95 percent for the with-dams capacity). Given that Upper Klamath Lake is the primary source of water for the Klamath River, how does the Regional Board think it is possible for the much more restrictive river targets in the Draft TMDL to be achieved? One of the key aspects of TMDLs is that they must provide reasonable assurance that TMDL goals can be met. (p. 50) (PacificCorp – Appendix A and B.doc) – Also included in Legal and Policy Issues.doc

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
There is no disconnect with the UKL TMDL, the TMDL was used as the boundary conditions for the TMDL model. The nutrient and organic matter reductions are large but achieve able. The implementation plans provided by Oregon DEQ for their TMDLs (Lost River, UKL, and Klamath River, and the implementation plan provided in the Regional Water Board staff report provide the framework for reducing the pollutant levels to achieve supporting conditions. The TMDL analyses and implementation plans provide reasonable assurance that the TMDL goals can be met.

D20. Comment(s):
Page 5-22, Paragraph 2 (after 4th bullet). The Draft TMDL needs to explain the logic that recognizes that there will be a flux of nutrients from the reservoir sediments, and then establishes a loading from the sediments of zero. There is, in fact, little or no empirical evidence that any release of nutrients from the sediments has any effect on algal growth in the reservoirs, or on conditions downstream. The nutrients stay sequestered in the very small volume of water deep in the reservoir and are released only late in the fall when the reservoirs destratify, well after the growing season. The TMDL assumes, but presents no evidence, that the sediment release (if indeed that is what it is) has any effect on the reservoirs. (p. 50) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The PacifiCorp Facilities allocation has been consolidated and no longer includes specific reference to benthic flux from reservoir sediments. This change was made to simplify the

allocation and to provide greater flexibility in addressing the reductions that will be necessary to achieve compliance conditions.

The TMDL document does not contend that internal recycling of nutrients is the major factor driving water quality conditions in these reservoirs. Instead, the TMDL document clearly acknowledges that the majority of the nutrient load is derived from upstream. However, additional incremental contributions do occur from internal loading. Regulations require that the TMDL attempt to account for all sources, stating that the TMDL should include "LAs for any nonpoint sources of pollution and natural background sources, tributaries, or adjacent segments" (40 CFR §130.2(i)). Therefore, it is necessary to develop a load allocation for the flux of nutrients from reservoir sediments.

The comment states that there is "little or no empirical evidence that any release of nutrients from the sediments has any effect on algal growth in the reservoirs, or on conditions downstream." This assertion is unsupported. The incremental impact of nutrient releases from the sediments is likely to be small relative to upstream loads under current conditions, but that does not prove that it is non-existent. Indeed, simple logic will show that recycling of nutrients from the sediment, rather than burial and sequestration, can only increase the concentration of nutrients available to support algal growth.

The comment claims that any nutrients that are released will "stay sequestered in the very small volume of water deep in the reservoir." In fact, the hypolimnion of the reservoir tends to be mixed during stratification, so it is the entire volume below the thermocline that is directly influenced by sediment releases – by no means a "very small volume." Further, nutrients within this volume are not completely "sequestered" below the thermocline. In addition to occasional wind mixing events, two additional factors contribute to a lack of sequestration: First, both molecular and turbulent diffusion do occur across the thermocline, resulting in gradual mixing of hypolimnetic nutrients into surface waters even under stratified conditions. Second, it has long been recognized that many cyanophytes (blue-green algae) possess gas vacuoles that enable the organisms to regulate their position in the water column. As summarized by Wetzel (1975), "…blue-green algae are able to regulate buoyancy and undergo limited vertical migration to poise themselves within vertical gradients of physical chemical gradients favorable to growth… The population maximum, coupling population growth with movement downward, apparently often occurs as epilimnetic nutrient concentrations are depleted in summer. Movement to lower strata of low light and temperatures and increased nutrient availability occurs." Thus, cyanophytes under bloom conditions may actively "pump" nutrients from the thermocline, derived from bottom sediments, into surface waters. See response to Comment A33 for further details.

It is true that the majority of the releases of such nutrients are likely to occur in late fall when the reservoirs destratify. However, it is wrong to contend that the portion of releases that occur after the prime growing season have *no* effect downstream. Even in winter, some retention of nutrients occurs during transport in rivers, due to both microbial activity and physical export to the floodplain, reflecting the fundamental concept of "nutrient spiraling". Fall releases of hypolimnetic water with high nutrient concentrations will thus have an (albeit reduced) carryover effect on nutrient availability in the following growing season.

D20. References:
Wetzel, R.G. 1975. *Limnology*. W.B. Saunders Co., Philadelphia.

Allan, J.D. 1995. Stream Ecology: Structure and Function of Running Waters. London: Chapman and Hall.

D21. Comment(s):
Page 5-22, Last Paragraph. It is not clear that these figures (5.9-5.11) actually demonstrate the "difficulty of having dams on a naturally productive river." First, lower loads in "dams-in" scenario could result from a combination of factors, including the fact that reservoirs are a net sink of TP and TN. Also, the figures show that 40-80 percent of nutrient reduction applies to Oregon TMDL compliance. A California compliant river with dams only accounts for an additional 10-20% reduction, much of which may come from sedimentation losses. Recommend clearly identifying Oregon TMDL reductions. (p. 51) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The comment fails to acknowledge that the allocations are meant to address the water quality conditions within the reservoirs and have nothing to do with nutrient dynamics or any nutrient retention that the reservoirs may be responsible for. From Hudnell (2009): Cyanobacteria and other phytoplankton bloom most frequently when four stimulatory factors are present – excessive nutrients (primarily nitrogen and phosphorus), **warmth (>20 %C),** sunlight for photosynthesis and **quiescent or stagnant water** (Paerl et al., 2007; Paerl, 2008). (emphasis added) Because dams are a risk cofactor for two of the four stimulatory factors it is necessary to reduce nutrient concentrations to very low levels to compensate for the increased heat and quiescent waters created by the reservoirs. The quoted text in the comment refers to the fact that background (natural) nutrient concentrations in the Klamath River are naturally high (however not as high as current levels) and that there is very little assimilative capacity. The reservoirs cause quiescent waters and higher average summer temperatures. In combination with naturally high nutrient concentration "it is difficult to have dams on the Klamath River" and not have biostimulatory conditions resulting in nuisance levels of algae with poor water quality conditions.

References Used in Response D21:

Hudnell, H.K., The state of U.S. freshwater harmful algal blooms assessments, policy and legislation, Toxicon (2009), doi:10.1016/j.toxicon.2009.07.021

Paerl, H.W., 2008. Nutrient and other environmental controls of harmful cyanobacterial blooms along the freshwater-marine continuum. In: Hudnell, H.K. (Ed.), Cyanobacterial Harmful Algal Blooms: State of the Science and Research Needs, Adv. Exp. Med. Biol., 619, Chapter 10. Springer Press, New York, pp. 218–237. http://www.epa.gov/cyano/habs_symposium/ accessed November 12, 2009.

Paerl, H.W., Valdes-Weaver, L.M., Joyner, A.R., Winkelmann, V., 2007. Phytoplankton indicators of ecological change in the eutrophying Pamlico Sound system, North Carolina. Ecol. Appl. 17 (5 Suppl.), S88–S101.

D22. Comment(s):
Page 5-24, Paragraph 1, Figure 5.12, and Page 5-25, Paragraph 1. This presentation of a 'compliance lens' lacks rigor and presents an infeasible approach. The concept of applying a fixed volume where temperature and dissolved oxygen are both acceptable based on the reach average depth of a free-flowing river makes no physical sense: lentic and lotic systems are fundamentally different environments. The average reach depth (the draft TMDL is unclear if this is average depth or average hydraulic depth) for a free flowing river channel is not provided in the draft TMDL, but based on modeling efforts is probably on the order of 1.0 meter. Even if the average depth were 2.0 meters, relying on this thickness of a compliance lens within the reservoir is tenuous given thermal stratification, wind mixing, and seasonal thermal loading. That it, the chances that such a thin lens would persist in a biologically functional manner through the critical summer period would be quite small. Thus the volumes identified are probably too small. (p. 51) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
Please refer to comment responses D6 and D8 above.

D23. Comment(s):
Further, the definition states that the compliance lens applies to the width and length of the reservoir. This is an unattainable condition in reservoirs under stratified conditions. By definition, the thermocline within Copco and Iron Gate reservoirs does not extend the entire length of the reservoir. In shallower headwater areas the hypolimnion pinches out and there are no cold, deeper waters in the upper reaches of both reservoirs for considerable distances. Similarly, as the thermocline does not extend the full width of the reservoirs. Based on fundamental stratification dynamics

and the morphology of reservoir systems, the compliance lens approach as defined in the draft TMDL cannot be achieved. (p. 51) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
Please refer to comment D6 and D8 above.

D24. Comment(s):
Page 5-27, Table 5.17. These targets will be a function of assumptions throughout upstream river reaches, including tributaries. Previous comments regarding Link Dam boundary conditions and Shasta River boundary conditions (phosphorus), as well as other comments addressing the TMDL analysis will have to be reassessed in a subsequent draft of the TMDL. (p. 51) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The Regional Water Board includes the TMDL targets in Table 5.17 with the understanding that they will be achieved as a result of a long-term compliance schedule. As more information becomes available through monitoring and other scientific studies within the basin, the Regional Water Board will reassess both the compliance schedule and individual targets. The current targets are the result of the best available science, and other than minor changes due to model updates, these targets will be included in the draft final TMDL staff report.

D25. Comment(s):
Page 5-27, Table 5.18. No data are provided to support the values for these major tributaries. A comprehensive analysis of assumptions, approach, limitations, and uncertainty should be presented in the draft TMDL. (p. 51) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
A description of the calculation of tributary source loads and allocations (excluding the Shasta River) has been included in Appendix 6.

D26. Comment(s):
Page 5-28, Table 5.19. CBOD values included in this table are below both the

method detection limit and method reporting limit for standard production laboratories. A minimum value of 2.0 mg/L would be appropriate. (p. 52) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The text has been revised to provide other options for evaluating targets. Analytical labs commonly assess results against two precision thresholds. The Method Detection Limit (MDL) is defined as the minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero. The reporting limit (RL) is defined as the lowest concentration at which an analyte can be detected in a sample and its concentration can be reported with a reasonable degree of accuracy and precision. Analytical results between the MDL and RL are often reported as estimated values.

The MDL and RL for CBOD are equal at 3 mg/L. These levels are operationally defined and do not vary between laboratories.

Option 1) Analytical results of CBOD will be assessed using a 3-month running average for compliance evaluation against concentration targets. Analytical results reported as below the MDL will be assessed at one-half the MDL (i.e., 1.5 mg/L).

Option 2) Analytical results reported below the MDL for CBOD will be assumed to represent one-half the MDL (i.e., 1.5 mg/L). This assumption is a commonly used in water quality assessment (Helsel and Hirsch, 1992).

Alternatively, assessment of compliance with CBOD targets can be conducted using the concentration of Total Organic Carbon (TOC). The target concentrations were derived using a conversion factor applied to particulate and dissolved organic matter. Analytical results of TOC can be converted to an equivalent concentration of CBOD using these conversions.

D27. Comment(s):
Page 4-5, Paragraph 2, Line 7-8. Why is the "total annual mass" used to quantify the pollutants? A large total annual mass may not significantly impact the water quality of the river if it is adequately diluted. Further, the main concern in the Klamath River is the problematic summer months, so a seasonal distribution of these pollutant loadings would be more useful, i.e., not just May through October, but monthly June through September. (p. 25) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The purpose of the source analysis is to identify source areas and categories that would benefit from additional pollutant loading controls. Pollutant loading allocations and targets are provided in both mass and concentration. TMDL targets include monthly average concentrations for TN, TP, and CBOD thus addressing the seasonal issues.

D28. Comment(s):
(page 9 Specific comments):
Statement: Chapter 5, Section 5.1.2.2, last paragraph, page 5-5, states "For most Klamath River compliance locations, allocations have been set as monthly mean concentrations for nutrients (TP and TN) and organic matter (CBOD)."
Comment: Monthly mean concentrations need to be defined. What are a minimum number of measurements before a representative mean can be determined? What should the time sequence of measurements be, etc.?

Comment(s) Made By:
Hicks – U.S. Bureau of Reclamation

Response:
The definition of monthly mean and sampling sequence for the Klamath TMDL are included in the TMDL staff report Chapter 7 Monitoring, the AIP 2009 Klamath River Monitoring Plan (Klamath AIP Work Group 2009), and in the Klamath Basin Water Quality Monitoring Plan (Royer and Stubblefield 2009).

D29. Comment(s):
We recommend that all TMDLs and associated load allocations and wasteload allocations be expressed in terms of daily time increments. (p. 2)

Comment(s) Made By:
Hashimoto Zeigler-EPA

Response:
A table summarizing mass loading on a daily time increment has been included in Chapter 5.

D30. Comment(s):
The water temperature allocations in the Draft TMDL are unachievable. (cover ltr p.3)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
Please see the response to comment Z3.

D31. Comment(s):
Regarding Iron Gate Hatchery, the Draft TMDL states that “there is no allowable temperature increase that can be allocated” and that “the temperature load allocation for the Hatchery equals zero temperature increase above natural temperatures” (page 5-18). The Draft TMDL does not interpret or provide an analysis of “natural temperatures” for the Hatchery temperature allocation. The Draft TMDL only states that “no temperature data are available to evaluate the effects of the hatchery effluent on the Klamath River” (page 4-21), but that “[r]egardless, because the discharge of elevated temperature waste is not allowed per the interstate water quality objective for temperature, any effluent discharged to the river at a higher temperature than the river exceeds the objective” (page 4-21 to 4-22). (final comments p.6)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The temperature numeric targets for the hatchery are presented in Table 5.6.

D32. Comment D32 was a duplicate of another comment. This is a placeholder to maintain the numbering of comments.

D33. Comment(s):
Page 3-11, Paragraph 2, Lines 8-10. Site potential shade conditions are not clearly explained in the TMDL. (p. 20) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
Site potential shade is discussed in section 6.5.1.1.

D34. Comment(s):
Page 5-2, Table 5.1. This table has several flaws. First, a target of zero increase above the estimated "natural" temperatures is not possible to meet – it is not measurable, it takes no account of interannual variability, or of seasonality. Second, instantaneous mass seems a very odd target because what the fish “see” is concentration. Mass is dependent not only on concentration, but on volume. By making the volume larger, the target could be met even at inadequate concentration. Third, the chlorophyll *a* target is unreasonably low, appropriate to a mesotrophic system, not the eutrophic to hypereutrophic system that exists, and has existed historically, in the Klamath River. Fourth, the *Microcystis* target seems too low since the WHO guideline is 20 µg/L, and

the biomass target is tied to the biomass of all blue-green species – the TMDL provides no explanation for the logic of this target. Fifth, the nutrient target for the hatchery is tied to taking the dams out. The nutrient load for the hatchery should be set without regard to the presence or absence of the dams. (p. 43) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
1) The targets are the monthly average temperatures; zero increase is the load allocation. Zero increase is a numeric representation of the condition that meets the water quality objectives for temperature. The measurability of "zero" can be addressed in any regulatory action that implements the TMDL. However, defining zero based on what is measurable today is inappropriate, as technologies to measure water temperatures change. Ultimately, the allocation cannot be anything but zero, given the water quality standards and the absence of BIP support. In addition, please see response to comment K53. 2) The instantaneous mass is not the target or allocation. Rather it is an example of the type of calculation that will need to be made on continuous basis. The allocation is to provide supporting conditions that meet the DO and temperature targets within the volume of water described as the compliance lens. 3) The rationale for the chrolophyll a target is adequately described in the staff report and was strongly supported by the peer review team and is appropriate for the reservoirs. 4) The WHO guideline of 20 µg/L of microcystin is for moderate health effects, the TMDL targets need to be protective not indicative of when the reservoirs are posted for potential health effects. 5) The comment is incorrect. The nutrient target for the hatchery is consistent with upstream compliance conditions – whether the dams are in or out. Facilities with NPDES permits are required to meet water quality objectives of the water body into which they discharge.

D35. Comment(s):
Watershed wide, Temperature. Allocations for shade are inappropriate, incorrect, and probably infeasible in most sub-basins. The draft TMDL is unclear if these apply to the mainstem: if so this is inappropriate. Sediment as a controllable factor is a weak surrogate for temperature control regarding stream width and hyporheic flow. Strongly encourage the Regional Board staff to identify site potential analysis on a tributary-by-tributary basis, versus an overly general blanket approach that will be difficult to implement, let alone manage. (p. 43) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
Regional Water Board staff find that allowing riparian trees to provide riparian shade is utterly feasible, and disagree that sediment is a weak surrogate since it is the cause of the

effect being addressed. Regional Water Board staff disagree that riparian shade allocations will be difficult to implement given the USFS Aquatic Conservation Strategy, Board of Forestry Anadromous Salmonid Protection Rules, general waste discharge requirements for timber activities, and 401 certification process. Nearly all of the 'actions' that will need to be taken to comply with this allocation are actually inaction: allowing trees to remain in place in order to provide shade to the stream. The site potential analyses suggested are unnecessary for implementation of the riparian shade allocation.

D36. Comment(s):
Stateline, Temperature. Zero increase above natural baseline is not measurable and thus unenforceable. Further, lack of interannual variability in the draft TMDL assessment provides no means to account for a naturally warmer or cooler year. No sensitivity analysis was completed to determine the range of potential "natural" temperatures. How will this be assessed by Regional Board staff: how will natural temperatures be defined for 2010 or any future year? This approach is unenforceable except after the fact, which does little to protect the resources.

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The reservoir allocations are tied to the temperature of the water entering the reservoir, which eliminates the need to estimate natural temperatures to assess compliance.

D37. Comment(s):
Page 5-4, Paragraph 1, Lines 1. It might be more clear to say that the intrastate temperature objective's intention is that any increase in temperature "doesn't increase adverse impact on beneficial uses." An increase in temperature may be acceptable, it would seem, if it didn't increase adverse impacts on the system. Perhaps temperature increases are an issue during "critical time periods," but they are probably not an issue year-round. An allocation of no temperature load is unmeasurable and inapplicable. (p. 44) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The language and intent of the intrastate water quality objective for temperature is clear and accurate as written. An increase of 5 ^{o}F or more is always an exceedance of the intrastate water quality objective. Also, please see responses to comments Z3 and D34.

D38. Comment(s):
Page 5-11 to 5-13 (including Figures 5.4, 5.5, and 5.6): Riparian Shade. The thermal benefits derived from riparian shade to a stream or other waterbody cannot simply be based on a single "effective shade" parameter. How these would be managed is unclear. Overall, these graphs are inappropriate for temperature load allocations for shade as applied globally in the Klamath River basin and may be infeasible and ineffective in certain watersheds. (p. 47) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
Effective shade is an appropriate surrogate measure of solar loading. The graphs present the riparian shade targets, not load allocations. In addition, please see the responses to comments D 35 and D40

D39. Comment(s):
There is no definition of riparian shade for the purposes of the TMDL. Riparian shade generally includes herbaceous and woody riparian shade. The occurrence and persistence of each type of vegetation varies from system-to-system and year-to-year. A combination of both usually provides the ultimate shade benefit to a river. Further, smaller streams benefit remarkably from herbaceous vegetation shading as well as woody riparian vegetation shading, while larger streams generally benefit more widely from the latter. (p. 47) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The potential for riparian vegetation to provide shade is generally dependent on the tallest species present. Regional Water Board staff acknowledge the site-specific nature of riparian shade analyses. These charts provide reasonable depictions of the potential effective shade levels for a range of site-specific factors. See also response to comment D38.

D40. Comment(s):
There is no description of the analysis, assumptions, citation, limitations, and how this is applied not only to the tributaries, but also the mainstem. The draft TMDL does not state whether this is applicable to only tributaries, or to the mainstem as well. Application of riparian shade as a prescription to temperature management in the mainstem is not applicable as a temperature control strategy and these figures, not similar assessment should be applied to the mainstem Klamath River in California. Even within tributaries such as the Scott, Shasta, Salmon (and certainly Trinity) Rivers, simple shading curves may not be applicable. Such shade curves may be most

applicable in small streams regions such as the Navarro or Mattole Rivers where rivers flow through continuous forested tracts. This approach was not applied in the Shasta River (the draft TMDL has mis-stated this). (p. 47) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The allocation applies watershed-wide. The Action Plan provides an option for a discharger to propose alternatives that provide equal or better protection of stream temperatures. The Shasta temperature TMDL assigns load allocations based on potential shade conditions, consistent with the approach described in section 5.2.1.1 for the Klamath basin.

D41. Comment(s):
Topographic shading is mentioned in this section, but little is said about how this is included into the "effective shade" graphs. Topographic shading is due to local terrain and can include mountains, hills, stream banks, boulders, and other land features that cast shade. In fact, there is no real way to include topographic shading in the manner presented in the TMDL because topographic shading is a function of stream aspect, local topography and time of year. Small topographic shade elements (e.g., banks, in stream rocks and boulders) can have profound effects on small streams and should be defined on a stream-by-stream basis. (p. 48) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
Defining the topographic shade of each stream subject to the temperature TMDL is unnecessary. Topographic shade never reduces effective shade, thus the effective shade curves present a depiction of the minimum shade that would be expected for the specified conditions, and any topographic shade augments the effective shade provided by vegetation.

D42. Comment(s):
Time of year is not addressed in Figures 5.4, 5.5, and 5.6. However, day length and solar altitude are critical elements in assessing solar radiation reductions for aquatic systems and how they impact local temperatures. Summer solstice provides the longest day length and highest solar altitude in the Klamath Basin, but maximum temperatures do not occur until approximately August 1. What is the date that these figures apply, or are they seasonally averaged? If they are a seasonal average, what period is used for the average? Finally, there is no description of this analysis, source

of data, assumptions (setback from bank, density, solar transmittance), or documentation. (p. 48) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The text describing the riparian shade analysis has been augmented to address the comment.

D43. Comment(s):
Page 5-14, Paragraph 1 and elsewhere. The temperature load allocation for human-caused discharges is "zero temperature increase" is unachievable and unmeasurable. (p. 48) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
Please see the responses to comments Z3 and D34.

D44. Comment(s):
Page 5-14, Paragraph 2. Definition of substantial human-caused sediment related channel alteration. It is unclear how an action that "increases channel width, decreased depth, or removes riparian vegetation to a degree that alters stream temperature dynamics and is caused by an increased sediment loading" can be measured against natural processes in the system. What is the baseline? What is the metric for sediment loading? How and where is this measured? How are legacy activities incorporated? Who is responsible for monitoring and assessing potential changes, let alone defining what fraction of the impact is due to natural processes or human-caused actions? To be applicable, a complete TMDL appendix outlining these and many other questions is required. Without such guidance from Regional Board staff, regulatory oversight will be vague and implementation of actions ineffective. (p. 48) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
Regional Water Board staff don't anticipate the need to define the fraction of impacts that are due to human activities. The implementation of the sediment-related channel alteration allocation will occur as compliance with applicable waste discharge requirements or waivers thereof. The terms of the WDRs/waivers will not be vague. The necessary actions to achieve the allocation are well understood. Management practices

required for compliance with applicable WDRs/waivers will include inventory, prioritization, and mitigation of sediment-delivery hazards. Those hazards include unstable road fills, unstable landings, stream crossings, and unstable hillslopes with potential to deliver sediment to a stream channel.

D45. Comment(s):
Page 5-15, Table 5.5. Presenting a range for the temperature numeric targets would be more beneficial. Does the table take climate change into account and upon what are the chosen values based? Monthly average temperatures have only limited biological value. Monthly averages represented in Table 5.6 are likewise of limited biological value. (p. 49) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The monthly average temperatures are depictions of compliant conditions, and aren't intended to provide "biological value".

D46. Comment(s):
Page 5-15, Last sentence. Instead of "increase above natural," should this read "increase above Oregon TMDL values"? (p. 49) (PacificCorp – Appendix A and B.doc)
Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The text is correct as originally written.

D47. Comment (s):
Page 5-16, Paragraph 2. Please define the "Thermal Plan." (p. 49) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The *Water Quality Control Plan for Control of Temperature in the Coastal and Interstate Waters and Enclosed Bays and Estuaries of California* is also known as the Thermal Plan. The document has been modified to indicate this.

D48. Comment(s):
Page 5-16, Paragraph 2, Lines 3-4. 'Temperature alterations caused by the reservoirs

adversely effect beneficial uses.' See comments Temperature: Page 5-4, Paragraph 4 and Page 4-13, Paragraph 2. (p. 49) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
See response to comments E4 and A31.

D49. Comment(s):
Page 5-17, Paragraph 1, Lines 5-10. Discussion states that "maximum temperatures periodically increase by approximately 0.5°." But this analysis and accompanying Figure 5.7 have little relevance because 0.5° is more resolution than temperature model warrants. Also, the statement implies a pattern of periodic increases, where no pattern is apparent. Overall, maximum temperatures are decreased by Copco year-round and only a few times are maximum temperatures increased. Without actual data to assess conditions within this reach, little can be said about daily range of temperatures. Further, Copco reservoir occupies a broad, open terrain, while upstream reaches are often referred to as the canyon, thus a reduced daily range due to more topographic shading than in upstream reaches makes little sense. Simplistic statements without supporting evidence reduce confidence in the TMDL findings. (p. 49) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The Copco reservoir allocation was developed using the best available information. The word "periodically" has been replaced with the word "occasionally". Bathymetry data indicates that Copco reservoir does not occupy a "broad, open terrain". Rather, the bathymetry information indicates that the river flowed at the foot of a steep canyon wall to the south of the river for substantial portions of the Copco reach.

D50. Comment(s):
Page 5-16, Paragraph 4, Lines 7-8. The appropriate scenario for determining allowable temperature increases (i.e. "natural increases") in California is: Oregon TMDL compliant at Stateline and "natural conditions" downstream. Please clarify that this is the scenario referred to. Again, without the Oregon TMDL, it is difficult to confirm where temperatures at Stateline would come from. (p. 49) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The Oregon TMDLs (and their anticipated load allocations and wasteload allocations) are being developed by Oregon as part of a comprehensive multistate analysis of pollutant loadings to the Klamath River. The Oregon TMDL load allocations are also being designed to meet California water quality standards at the Oregon/California border.

D51. Comment(s):
The watershed target associated with "Road-Related Landslides" is also problematic. The target is "a decreasing trend." Landslide occurrence depends strongly on the occurrence of rare, catastrophic storms. These storms may only occur once a decade or less. In order to monitor the trends in road related landslides, many landslide-inducing storms must occur before trends in landslides can be assessed. This requires many decades (i.e., 50-100 years) before this target can be realistically assessed. A more appropriate target would be a decreasing trend in the number (or volume) of potential road-related source areas for landslides.

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The road-related landslide target has been modified, as suggested.

D52. Comment(s):
I would hate to see funding and effort focused on riparian planting, when an equivalent effort at reducing the potential for debris flows by restoring roads could have a much more important effect on stream temperatures. I would suggest that the TMDL process should evaluate the relative effectiveness of riparian plantings versus road restoration in reducing future temperature loading to the system.

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The TMDL addresses the removal of vegetation that provides shade to streams in the Klamath Basin while at the same time addressing roads and the potential for debris flows. The TMDL implementation plan requires that responsible parties maintain and/or restore natural riparian shade. Responsible parties are not required to actively plant riparian vegetation unless they have removed it. However, they are prohibited from preventing natural shade from becoming re-established.

D53. Comment(s):
The ranges of widths presented in Figures 5.4, 5.5, and 5.6 do not correspond to the appropriate stream sizes for such an approach. As noted above, this method may be

useful for small streams coursing through continuous tracts of forest where trees are of sufficient size, density, and provide a continuous source of shade. The widths included in these figures extend up to 100 meters – well over 300 feet. The rule of thumb in temperature monitoring is that for riparian vegetation to be effective in temperature management (without topographic shading) woody vegetation height should be similar to stream width. Douglas fir and Ponderosa pines illustrating 30 percent effective shade for stream widths at 100 meters. For streams widths on the order of 100 meters there is little relief from riparian shading during the warmer summer months (Deas et al. 1997). Further, there is no definition of tree density and solar transmittance. It appears Regional Board staff have assumed 100 percent blockage by trees and continuous woody vegetation – akin to a wall being placed by the river edge. However, this is unrealistic. Actual riparian systems are complex and inconsistent in density, continuity, distance from river edge, species present etc. The important element of riparian shade strategies for temperature control is that without continuous, low transmittance vegetation over large river reaches temperature management is not feasible. Riparian vegetation shade presents meteorological conditions that may result in water temperatures several degrees below un-shaded conditions equilibrium water temperatures. Thus, if vegetation shading is not continuous, but rather intermittent, the river simply heats towards unshaded equilibrium in unshaded reaches. Deas et al (2006) illustrated this topographic shading in the Klamath River.

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The range of widths covers the vast majority of the watercourses in the basin. The values are calculated based on geometric relationships, and quantify the relationship of effective shade to stream channel width and tree height, as well as reach orientation. Quantified relationships are superior to a rule of thumb. Regional Water Board staff acknowledge that wider channels have less effective shade. These figures allow for that general statement to be put into a meaningful context.

D54. Comment(s):
Klamath National Forest has many watersheds with high-elevation headwaters and potentially increased peak flow risk. Firm targets for limiting road densities, and dates for their attainment are needed to prevent still more flood damage to refugia.

Comment(s) Made By:
Fetcho – Yurok Tribe
Crosby – Karuk Tribe
Bowman – Quartz Valley Indian Reservation

Response:
Proposed targets for roads are intended to address road factors that result in decreased sediment delivery over time, and thus don't rely on specific road density as a surrogate for road design and maintenance practices that minimize sediment delivery.

D55. Comment(s):
The Klamath TMDL implementation language regarding road density reduction and road decommissioning on USFS lands does not have a hard target and notes that USFS budget constraints may limit their ability to comply. The final Klamath TMDL needs to clearly state, nonetheless, that the hydrologic and sediment risk of not actively dealing with the KNF road network is unacceptable.

Comment(s) Made By:
Spain – Institute for Fisheries Resources & Pacific Coast Federation of Fishermen's Associations

Response:
The TMDL sets targets for reducing the number of road-related landslides and a target for zero increase in temperature caused by substantial human-caused sediment-related channel alteration. Regional Board staff believe that these targets are sufficient to require measures to address road maintenance and reduce road densities on a time schedule. Parties responsible for maintaining roads in the Klamath Basin are required to inventory sediment sources, prioritize sites and schedule implementation projects to address road maintenance issues and sediment sites. The Regional Board TMDL analysis did not assess the relationship between road density and water temperature as part of this TMDL. Road management measures are described in the implementation plan for each responsible party and will be incorporated into the appropriate permitting mechanisms to address this issue.

D56. Comment(s):
Section 6.5.4 states that "The road networks in the Klamath River basin contribute to elevated temperatures in tributary watersheds through the discharge of excess sediment". Where are the data substantiating this claim?

Furthermore, if in fact that data exists, and if in fact it is of any significance at all, I take objection with the notion that all roads contribute to the problem". Many of our roads in Butte Valley, and to some extent Shasta Valley, are flatter than a tabletop with no physical chance of contributing any sediment to the Klamath River system even if this claim can be substantiated.

Comment(s) Made By:
Sumner – Siskiyou County Public Works

Response:
The TMDL staff report provides evidence that roads discharge sediment in the Klamath Basin that contributes to the temperature impairment through debris flows and channel alteration (see 4-30 of the TMDL staff report). Regional Board staff recognize that not all roads are discharging sediment in the Klamath Basin. This is why the implementation plan requires parties responsible for road maintenance in the Klamath Basin to assess their existing sediment discharges and road maintenance needs and develop a schedule that prioritizes sediment source control projects on roads. Roads in flat land areas would fall very low on the priority list due to their relatively low potential for significant discharge.

D57. Comment(s):
While setting limits for road density would be new for private lands, Klamath National Forest (KNF) and Six Rivers National Forest have already adopted targets of 2.5 miles per square mile of watershed (mi./mi.) maximums in their own road maintenance and planning. The need for such standards should be recognized. If these targets are not, for any reason, added to the final TMDL, they need to be a part of the USFS MOA. Doing so will also greatly improve the prospects for increased federal funding.

Comment(s) Made By:
Spain – Institute for Fisheries Resources & Pacific Coast Federation of Fishermen's Associations

Response:
Proposed targets for roads are intended to address road-related factors that result in decreased sediment delivery over time, and thus don't rely on a specific road density as a surrogate for road design and maintenance practices that minimize sediment delivery. This approach more directly addresses sediment sources.

D58. Comment(s):
The road crossing failure target is less than one percent is just untenable – it would cost millions of dollars to achieve so we're looking for something more reasonable like 90% of the crossings addressed in ten years – 80% will pass 100 year flood over the next 20 years. (p. 6)

Comment(s) Made By:
Schuyler – Klamath National Forest

Response:
Please submit the USFS cost estimates to the Regional Board for meeting this target. The TMDL does not require immediate compliance but does require an estimate of funding needs and a time schedule for implementation. Meeting the 90% crossing target stated would most likely be an acceptable target over the next ten-years. The ability to reach the 'less than one percent' target could be assessed at the ten-year mark. The Regional Board understands that time is needed to come fully into compliance with TMDL targets

and expects that it will take a considerable amount of time. This is why the TMDL requires the USFS to document their progress so the Board can make a decision about the need for further action when the TMDL is periodically reviewed.

D59. Comment(s):
There is an emerging body of science regarding setting prudent risk limits on land use disturbance, and the Regional Water Board staff should recognize this. These levels of risk also need to be reflected in WDR, waiver and MOA language. Suitable guidelines for limits, together with their scientific literature references, were provided (see original comment letter). (p. 5)

Comment(s) Made By:
Spain – Institute for Fisheries Resources & Pacific Coast Federation of Fishermen's Associations

Response:
Proposed targets for roads are intended to directly address road factors that result in decreased sediment delivery over time, and thus don't rely on surrogates for practices that minimize sediment delivery.

D60. Comment(s):
Page 5-16, Paragraph 3, Lines 6-8. The Draft TMDL states "Because the upstream heat loads are outside of the control of the dam operators…, the allocations apply to the condition of the water as it enters the reservoirs." This is inconsistent with the treatment of nutrients. If the upstream heat loads are outside of the control of dam operators, it would seem to follow that upstream nutrient loads would likewise be outside the control of the dam operators. (p. 49) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
Temperature and nutrient loads manifest very differently downstream. Nutrient allocations requiring upstream reductions are to address water quality conditions within the reservoirs (e.g., chlorophyll-a and microcystin targets) caused by the biostimulatory conditions created by the impoundments. This requires upstream actions on the part of the reservoir operators to address controllable factors. Upstream temperature loads have additional water quality impacts due to being trapped in impoundments (thermal lag), but those effects are addressed by the tailrace allocation.

D61. Comment(s):
Page 5-22, Paragraph 1, Line 1. PacifiCorp is assigned an allocation that requires reduction of nutrients upstream of its facility. This is contrary to the allocation for

temperature where PacifiCorp was considered not responsible for the excess temperature coming from upstream – it is inconsistent. Additionally, it is illogical and unsupportable to assign an allocation upstream of a source. (p. 50) (PacificCorp – Appendix A and B.doc)

<u>Comment(s) Made By:</u>
Hemstreet - PacifiCorp

<u>Response:</u>
The nutrient reductions are not inconsistent with the temperature allocation. The nutrient reductions are required to meet controllable water quality conditions within the reservoir. PacifiCorp is responsible for water quality conditions within their facilities. The draft final version (March 2010) of the TMDL staff report (Chapter 5) makes clear PacifiCorp must meet its in reservoir targets, but can do so through a combination of nutrient reductions, in reservoir treatments, or trades and offsets upstream as credits towards the necessary nutrient reductions.

D62. <u>Comment(s):</u>
EPA recommend that the TMDL clearly state, if any source currently assigned load allocations are later determined to be point sources, those load allocations are to be treated as wasteload allocations for the purposes of determining appropriate water quality based effluent limitations. (p. 2)

<u>Comment(s) Made By:</u>
Hashimoto and Ziegler – USEPA

<u>Response:</u>
Regional Water Board staff agree that acknowledging flexibility to allow new discharges without necessarily needing to re-open the TMDL is advisable. However, it would not be appropriate to attempt to convert a load allocation to a waste load allocation unless specifically quantified as such in the initial allocation. Moreover, the Basin Plan prohibits point source discharges to which any waste load allocation would apply. Nevertheless, it is difficult to foresee every contingency and the TMDL implementation plan is already designed to allow this type of flexibility through the accounting and tracking program if a new discharge proposed is otherwise appropriate. Staff has added the text to the Staff Report to clarify that new discharges may be allowed through the accounting and tracking program if offsets equal to or greater than the proposed discharge are implemented that would not otherwise be required by law.

Chapter 6, section 6.7.2 Program Objectives

Add the following bullet:

- Provides a mechanism to allow new discharges if sufficient offsets are implemented that would not otherwise be required by law.

D63. Comment(s):
Clarification of language associated with the diversion potential is needed. For example, it is rare that a stream diversion results in a debris torrent that scours channel and stream banks. Watershed specialists understand that this is a high risk in some areas but they do not happen on a regular basis associated with culvert failures and diversions. The statement that "less than one percent of stream crossings have conditions where modification is inappropriate because it would endanger travelers or where modifications are impractical because of physical constraints" should be deleted unless there exists a peer reviewed document to support this claim. When examining Forest Service roads, this statement is not true. We have many miles of operation maintenance level 3, 4, and 5 roads where installing diversion dips would prove a safety concern thereby exceeding the 1% claim.

Comment(s) Made By:
Kelley – U.S. Forest Service, Six Rivers National Forest

Response:
Numeric targets are expressions of conditions that are expected to result in attainment of water quality standards. These targets can be revised if data indicate it is warranted. Likewise, if the USFS can make a case that a particular stream crossing can't be modified to eliminate diversion potential Regional Water Board staff will consider it.

D64. Comment(s):
Pg. 5-28. Table 5.19 lists the nutrient and organic matter annual monthly mean concentration allocations for tributaries to the Klamath River. Table 4.2 on pg 4-10 indicates that current and baseline conditions are the same. Based on this table for small tributaries to the Klamath, it appears as if current levels of TP, TN, and CBOD are all within natural conditions and that no load reductions are expected. If this is the case, it would be helpful to state somewhere after Table 5.19 or in section 6.4.1 pgs 6-16 and 6-17 that the tributaries are currently meeting TMDL requirements for TP, TN, and CBOD and that no load reductions are required.

Comment(s) Made By:
Kelley – U.S. Forest Service, Six Rivers National Forest

Response:
Please see the response to comment L10

D65. Comment(s):
This section provides a good overview of the issues and multi agency efforts currently underway with respect to water quality monitoring within the Klamath Basin. Of special interest to the Forest Service is the statement on Draft TMDL pg. 7-27 that ... "based on modeling to date, it has been found that water quality from the minor tributaries do not have a significant impact on conditions in the Klamath River. Therefore, monitoring these tributaries is not a high priority". If monitoring to date has shown that the minor

tributaries are not negatively influencing water quality on the mainstem Klamath and are not a high priority for monitoring, it would be helpful to the Forest Service for the Klamath TMDL to state or summarize these findings in Chapters 2 through 6. Examination of data in Chapter 4 table 4.2 indicates that current TP, TN, and CBOD are at baseline levels for the minor tributaries and Chapter 6 indicates that many of these same tributaries are thermal refugia as well. Review of the data presented in the draft Klamath TMDL appears to indicate that all tributaries on the Six Rivers National Forest are currently meeting the TMDL for temperature and nutrients. It therefore appears that reductions in waste loads (temp and nutrients) are not warranted on the minor tributaries and the lack of need to monitoring these stream reflects these conditions. If this is indeed the case, clearly articulating which sections of the Klamath Basin meet TMDL load allocations is helpful to the public and land management agencies. EPA acknowledged in the North Fork Eel Sediment TMDL that the Forest Service was meeting sediment load allocations and that further reductions were not warranted. Based on the info presented in this draft Klamath TMDL, comparable statements for temperature and nutrients for tributaries within the Six Rivers National Forest would be helpful and appropriate.

<u>Comment(s) Made By:</u>
Kelley – U.S. Forest Service, Six Rivers National Forest

<u>Response:</u>
The language in section 7.8.1 has been modified to state that monitoring these tributaries is not a high priority for understanding mainstem conditions and water quality drivers. A tributary that provides a refuge from warmer mainstem water does not necessarily satisfy the water quality objective for temperature. Also, please see the response comment L10 and L13.

TMDL MARGIN OF SAFETY

E1. Comment(s):
Page 5-9 Paragraph 2, Lines 11-12. (Conservative Assumption). It is astonishing that the basis of the an implicit margin of safety for dissolve oxygen, nutrients, and organic matter TMDL allocations analysis consists of these four bullet points, plus a statement that uncertainty was reduced by applying a "comprehensive, dynamic numerical model." Klamath River water quality dynamics are complex, varying considerably in space and time. Even though the numerical model applied has a wide range of parameters, constants, coefficients, not all processes are modeled. There is only a single algae group on the mainstem reservoirs, there is a simple sediment model in both the river and reservoirs, the partitioning of organic matter at Link Dam is incorrect in the TMDL model, the two group algae model for low dissolved oxygen conditions in Keno Reservoir is completely untested and parameter values have no basis, representation of Iron Gate outlet works has been specified instead of simulated, there is undocumented code that has direct implications on model results, available data are limited in winter throughout the system, and only a single year is modeled for the California TMDL - just to mention a few model and data limitations. An implicit MOS approach in a basin such as the Klamath is inaccurate, inappropriate, and unacceptable.

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
Regional Water Board staff disagree with the comment. Additional text has been added describing more conservative assumptions, as well as clarifying that uncertainty was reduced by incorporating conservative assumptions into the model, allowing the conservative assumptions to be expressed in the predicted dissolved oxygen and chlorophyll-a levels. See also responses to USGS comments, and responses to comments on modeling issues in section A.

E2. Comment(s):
Bullet point 1. Without a presentation of the current sediment oxygen demand (SOD) and its impact on oxygen levels in the river, this bullet point cannot be interpreted. Further, SOD is a small player in the overall dissolved oxygen conditions in the river reaches because of the limited deposition of organic matter (high shear environment) and the near continual mechanical reaeration in the Klamath River due to the high gradient (and once the river gradient diminishes below Orleans, dissolved oxygen is much less of an issue). SOD is a bit-player and although this is a conservative assumption, it is also negligible.

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The comment characterizes the river gradient and reaeration rates with a broad brush. There are certainly many low gradient reaches of the Klamath River downstream of Iron Gate reservoir. Regional Water Board disagree with the statement that SOD is negligible, but agree that it is not a major oxygen sink and that the assumption that SOD will remain constant is a conservative one. In that regard, it contributes to the implicit margin of safety.

E3. Comment(s):
Bullet point 2. Please expand and explain this bullet point. "Timing of allocations" is based on the scenario with greatest loads from UKL has no basis, explanation, or citation. "Magnitudes of allocations are based on median loading conditions from UKL," would mean that 50 percent of the time loads are greater than those upon which allocations are based. This is incorrect. Loads are based on the 1995 conditions – one of seven years of data (1992-98) used in formulating the UKL TMDL load allocation. Further, 1995 is the second lowest year of the seven years, and less than 50 percent of the 7-year mean conditions. Thus, if the UKL is accepted as "representative" of a range of conditions from 1992-98, the majority of years (5 out of 7, or 71.4 percent of the time), TMDL compliant conditions as defined in the California TMDL will not be met. The representation of this in the California TMDL is erroneous, misleading, and presented with such brevity that without considerable data and information requests from Regional Board staff, ODEQ, and EPA, such a condition would never have been identified. This is another example of the critical nature of uncertainty analysis and a clear limitation of modeling only a single year for TMDL load allocations in a complex basin such as the Klamath River. Multiple years must be simulated to represent the appropriate range of potential conditions such that reasonable load allocations can be determined. Further, selecting unrealistically low load allocations at the upstream boundary (Link Dam) is not conservative and will lead to unattainable TMDL allocations. Finally, the misleading presentation of information in the TMDL due to an inadequate description of the analysis approach and fundamental assumptions severely hampers the credibility of the Draft TMDL.

UKL TMDL model output for 40% reduction case. Highlighted row (1995) is the information used in the California TMDL (ODEQ, 2002).

Year	Outflow (kg/yr)	Percent of 7-yr Average
1992	13,854	21.6%
1993	114,637	178.5%
1994	50,860	79.2%
1995	30,237	47.1%
1996	103,839	161.7%
1997	83,970	130.8%
1998	52,057	81.1%
Mean	64,208	100.0%

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
Please see the response to comments A2, A3, and A4.

E4. Comment(s):
Bullet point 3. This bullet point essentially translated to a simplistic approach that reduces all nutrients to low levels. There is no nutrient reduction strategy that targets one (N or P) – an approach that is fundamental to water quality management. In retrospect, this is not a surprise because no assessment of trophic status or nutrient limitation was completed for the Klamath River under existing or a TMDL compliant condition. Without a clear nutrient limiting strategy (even if that strategy is co-limitation), implementation actions will be severely hampered and valuable resources will be wasted. It is important to reduce both nutrients, but it is also important to identify a limiting nutrient so effective water quality improvement actions can be identified, prioritized, and implemented at an appropriate time. This may also be a conservative assumption, but it is also too simplistic and could ultimately hamper the effective implementation of the TMDL.

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
Please see the response to comment D14.

E5. Comment(s):
Bullet point 4. Basing analyses on low flow conditions does not necessarily provide a MOS. Higher flow doesn't mean less WQ impact as higher flows can result in higher loadings for similar in-stream concentrations. In short, this is not conservative, particularly if dam removal occurs prior to effective implementation of nutrient and organic matter reductions in Oregon. (p. 45-46) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
This approach is conservative because basing analyses on low flow conditions results in more stringent load allocations due to the assimilative capacity being reduced (i.e., the same load into a lesser amount of water results in a higher concentration) under low flow conditions.

E6. Comment(s):
Page 5-9, Paragraph 2, Line 2-4. Using a numerical model does not, in itself, provide a MOS. How was uncertainty reduced by the model and by how much? The model can actually magnify uncertainty and error. (As we say in modeling, "Garbage in, garbage out.") Models may increase precision of results (even to a ridiculous level, e.g. "load = 2,253,542 kg), but accuracy is not necessarily increased (Deas and Lowney 2000). We believe that not enough data were incorporated in model calibration and validation and there was not enough evaluation of uncertainty to make the statement that "uncertainty was reduced … by applying (this) model." There is no inherent implied MOS in this application of the model. (p. 44) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
Please see the responses to comments A2, A3, and A174.

E7. Comment(s):
Page 5-3, Paragraph 4, Lines 5-9 and associated TMDL sections. The draft TMDL identifies that there are explicit and implicit margins of safety. The TMDL load allocations equations are:

- Temperature TMDL = Loading Capacity = ΣWLAs + ΣLAs + Natural Background + MOS (pg 5-4)
- Total Phosphorous TMLD = Loading Capacity = ΣWLAs + ΣLAs (pg 5-9)
- Total Nitrogen TMDL = Loading Capacity = ΣWLAs + ΣLAs (pg 5-10)
- Organic Matter TMDL = Loading Capacity = ΣWLAs + ΣLAs (pg 5-11)

In all cases the draft TMDL relies on an implicit margin of safety, wherein conservative assumptions are employed. No quantification of uncertainty was completed, no sensitivity analysis was presented, and no interannual variability was assessed to provide any idea of the magnitude of an implicit margin of safety for each parameter (Temperature, TP, TN, CBOD, dissolved oxygen). Such a margin of safety would assuredly be different for each parameter. Translating uncertainty (or conservative assumptions) in TP, TN, and CBOD to dissolved oxygen is not discussed. The approach presented in the draft TMDL provides little confidence that the load allocations are appropriate or achievable. Additional comments are included below for individual parameters. (p. 43) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
Please see the responses to comments A2, A3, A174, E8.

E8. <u>Comment(s):</u>
Temperature: Page 5-4, Paragraph 4. Taking credit, as a margin of safety (MOS), for periods of time during which beneficial uses (BUs) are not impaired does not appear to be consistent with the intention of MOS. An MOS is meant to ensure protection of beneficial uses in consideration of uncertainty and errors. This credit does not help to address the uncertainty of temperature values (or any other parameter in the draft TMDL) and application of the targets during times when beneficial uses are threatened. This seems like an incorrect use of MOS and creates an overly restrictive TMDL allocation. Specifically, how do these periods coincide with identified heating loads versus periods when BUs are not an issue? There is a brief note regarding periods when beneficial uses are not impaired and that the "timing of those periods changes from year to year and is difficult to predict but there is no analysis to support this statement. Further, the river is already impaired by temperature during certain "critical time periods." Is it unfair to make this the condition for MOS (margin of safety)? Overall, this seems like a simplistic approach given that you have a "comprehensive, dynamic numerical model" (page 5-9), which may be conservative, but may also be grossly over restrictive. (p. 44) (PacificCorp – Appendix A and B.doc)

<u>Comment(s) Made By:</u>
Hemstreet – PacifiCorp

<u>Response:</u>
The requirement to incorporate a margin of safety in TMDLs is intended to take into account any lack of knowledge concerning the relationship between pollutant loading and water quality. In this case, Regional Water Board staff determined that the Klamath River is too hot to accommodate more heat during summer and fall without beneficial uses of water being adversely affected. Thus, the allowable heat load during those time periods must be zero in order for the intrastate water quality objective to be met. The remainder of the year is when Regional Water Board staff have discretion to allocate any heat loads, given the intrastate water quality objective for temperature. However, because temperature affects salmonids and other cold water species at all stages of their life cycle, limiting temperature increases in winter and spring addresses uncertainty concerning the relationship between pollutant loading and water quality at the only time of year there is discretion to do so.

LINKAGE BETWEEN TECHNICAL ANALYSIS AND IMPLEMENTATION PLAN

F1. Comment:
A number of commenters (Addington and Danosky, Cantrall, Hicks, Kobseff) commented that the draft TMDL staff report does not adequately link the technical analysis to the requirements in the implementation plan.

Response:
The following response provides an overview of the approach to developing the technical TMDL and the linkage to the proposed implementation plan. There are overlaps between this narrative response and others, including some in sections A, H, K, O and Q.

The Klamath River Hydrologic Unit in California, Middle Hydrologic Area (HA) (Oregon to Trinity River) and Lower HA, Klamath Glen Hydrologic Sub Area (HSA) (Trinity River to Pacific Ocean) is listed on the federal Clean Water Act 303(d) List of Impaired Water Bodies for temperature, nutrients, and low dissolved oxygen/organic enrichment. In addition, Copco 1 and 2 and Iron Gate Reservoirs are listed as impaired for microcystin, and the Klamath Glen HSA is listed as impaired for sedimentation/siltation. (See Figure 1.2 and Table 1.1) The TMDLs for the Klamath River in California reported here address temperature, dissolved oxygen/organic enrichment, nutrient, and microcystin water quality impairments for the Klamath River in California.

As described in Chapter 1, TMDL development involves two general steps. The first step involves the development of the technical TMDL, and is the technical/ analytic/ scientific step in which the TMDL allocations and targets are quantified (this step constitutes the content of Chapters 2, 3, 4, and 5). The second step is the policy component and involves the development of the strategy to attain and maintain water quality standards. The elements of this strategy for meeting water quality standards in the Klamath River are detailed in the Implementation Plan (Chapter 6), and are incorporated into the Basin Plan as the Action Plan for the Klamath River Total Maximum Daily Loads Addressing Temperature, Dissolved Oxygen, Nutrient, and Microcystin Impairments in the Klamath River in California and the Lost River Implementation Plan. Both steps are described here, with particular emphasis on the linkage between the technical TMDL and the Implementation Plan.

Technical TMDL Development

The analytic approach for completing the technical TMDL is described in Chapter 3 of the Staff Report, and involved several lines of evidence, including: 1) review of published reports and consultation with experts; 2) empirical analysis of water quality monitoring data; and 3) application of several water quality models. Assessment of tributary stream temperatures involved the application of the USGS-supported stream temperature model (SSTEMP), as well as the Tennessee Valley Authority's River Modeling System model for the Shasta River, and Heat Source temperature model for the Scott River (See Chapter 3 for details). Assessment of nutrients and biostimulatory response in the reservoirs and riverine reaches in California included a spreadsheet application of the U.S. Army Corp of Engineers BATHTUB model and a spreadsheet tool using the Revised QUAL2K Model, respectively (see Chapter 3 and Appendix 2). Finally, the water quality models RMA, CE-QUAL-W2, and EFCD, were the primary analytic tools used for developing the Klamath River TMDLs, and in combination these models are referred to here as the Klamath River TMDL model (see Chapter 3 and Appendix 6).

The Klamath River TMDL model is a mathematical model that simulates water quality conditions of the mainstem Klamath River, based on representations of the physical, chemical, and biological conditions of the river system. The application of any water quality model, including the Klamath River TMDL model, involves characterizing: 1) the physical environment (e.g. the width, depth, and slope of the river channel; the location of tributaries that flow into the river; and the weather conditions over time); 2) the quality and quantity of water entering the river (e.g. temperature, dissolved oxygen and nutrient concentrations, and flow rates); and 3) the physical, chemical, and biological processes that cause the water quality and quantity to change in space and time (e.g. the evaporation of water from a reservoir, as affected by air temperature and wind speed; the decomposition of an algae cell as it is transported from Upper Klamath Lake to the Pacific Ocean, and the associated release of nutrients to the water column; and the release of dissolved oxygen to the water from algae growing on the bottom of the river, to name a few). The model simulates water quality conditions by applying mathematical equations to represent these physical, chemical, and biological processes, and based on the characterization of the initial water quality conditions.

The process of model calibration involves getting the model to predict water quality and quantity conditions as close as possible to measured conditions (e.g. getting the predicted dissolved oxygen concentrations over time to match as best as possible the measured dissolved oxygen concentrations over time at a given location). This process is achieved by altering the depiction of the physical, chemical, and biological processes. Model calibration is limited by the available data/information or assumptions used to characterize the incoming water quality and quantity conditions (referred to as the "boundary conditions"), and the data/information/assumptions used to describe the physical, chemical, and biological processes that affect water quality conditions. The process of model calibration must be grounded in reality by characterizing the boundary conditions and the physical, chemical, and biological processes in a reasonable manner. Following model calibration, it is standard practice to validate (also known as corroborate) the model to a separate data set for a separate year. Appendix 6 presents the model calibration and validation for the Klamath River TMDL model.

The utility of water quality models is that they are tools that can be used to predict water quality under varying conditions. In other words, once a water quality model is calibrated (and validated), different scenarios can be applied that represent alternative boundary conditions and/or alternative physical, chemical, and biological conditions, and predict the resulting water quality conditions. For the purposes of Klamath River TMDL development, a number of scenarios were applied using the Klamath River TMDL model to: 1) assess the impacts of physical conditions, such as the presence of dams, on water quality conditions; and 2) determine the boundary conditions that result in attainment of water quality standards in the Klamath River. The difference between 1) the water quality boundary conditions that result in attainment of water quality standards in the Klamath River and 2) the water quality boundary conditions represented under current conditions that contribute to not meeting water quality standards in the Klamath River, reflects the change that is needed pursuant to the TMDL. The Klamath River TMDL allocations and targets represent the water quality conditions needed to meet water quality standards, and were determined based on the application of the Klamath River TMDL model scenarios. The different model scenarios applied for developing the Klamath River TMDLs are identified in Chapter 3 and detailed in Appendix 7 of the Staff Report.

The TMDL assigns allocations to all sources of pollution, including waste load allocations (WLA) for point sources[1] and load allocations (LA) to nonpoint sources[2] (40 CFR § 130 .2(i)). A wasteload allocation (WLA) is defined as "[t]he portion of a receiving water's loading capacity[3] that is allocated to one of its existing or future point sources of pollution". WLAs constitute a type of water quality-based effluent limitation (40 CFR § 130.2(h)). A load allocation is defined as "[t]he portion of a receiving water's loading capacity that is attributed either to one of its existing or future nonpoint sources of pollution or to natural background sources" (40 CFR § 130.2(g)).

As detailed in Chapter 6, the Klamath River TMDLs in California assign wasteload allocations to the Iron Gate Hatchery, and assign load allocations at Stateline, to the Klamath Hydroelectric Project facilities, and at the mouths of the tributaries to the Klamath River. In addition, temperature-related load allocations for shade and human-caused discharges of sediment are assigned to the watershed areas of the Middle and Lower Hydrologic Areas of the Klamath River (see Figure 1.2 of the Staff Report). These temperature-related load allocations are set to meet the temperature water quality objective, and apply to any anthropogenic activity that alters the natural riparian shade condition or causes substantial sediment-related channel alteration. The nutrient and organic matter load allocations assigned at the tributary mouths are set to the levels necessary to meet the biostimulatory substances and dissolved oxygen water quality objectives. These nutrient and organic matter load allocations apply to any

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1 A point source is any discernible, confined, and discrete conveyance, including any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, landfill leachate collection system, vessel or other floating craft from which pollutants are or may be discharged. This term does not include return flows from irrigation agriculture or agricultural stormwater runoff. (40 CFR 122.2)

2 Nonpoint sources are pollution sources that are diffuse and do not have a single point of origin or are not introduced into a receiving stream from a specific outlet. Nonpoint source pollutants are generally carried off the land by uncontrolled stormwater runoff. The commonly used categories of nonpoint sources are agricultural return flow, forestry, urban runoff, mining, construction, land disposal, and saltwater intrusion. The term also includes certain sources that may have a single point of origin but are excluded from the definition of "point source" by the Clean Water Act (such as agricultural return flows).

3 Loading capacity is the amount of total pollutant load that a water body can receive and meet applicable water quality standards.

anthropogenic activity that discharges nutrients and/or organic matter within these tributary watersheds.

Implementation Plan
The Klamath River technical TMDL must be accompanied by an implementation plan pursuant to Water Code section 13242. The implementation plan translates the information in the technical TMDL into discrete and identifiable actions that will bring the waterbody into compliance. In other words, the Implementation Plan is the strategy for achieving the technical TMDL (i.e. the allocations and targets), and attaining and maintaining water quality standards. It identifies the parties responsible for controlling pollutant discharges to meet the TMDL and recommends implementation measures for adoption into the Regional Water Board Basin Plan as the Klamath River TMDL Action Plan. The measures include regulatory actions for the Regional Water Board to take to implement and enforce the TMDL, and measures required of the responsible parties.

All point source discharges of pollutants to surface waters require a National Pollutant Discharge Elimination System (NPDES) permit under section 402 of the Clean Water Act. Therefore waste load allocations (WLA) are implemented through an NPDES permit. An NPDES permit contains effluent limitations based on applicable technology and water quality standards. WLAs constitute a type of water quality-based effluent limitation (40 CFR § 130.2(h)). For the Klamath River TMDLs, the WLAs for Iron Gate Hatchery will be implemented through a revised NPDES permit (No. CA0006688) and WDR permit (No. R1-2000-17).

In California, discharges of waste that are not NPDES "discharges of pollutants" require the issuance of waste discharge requirements (WDRs) unless otherwise waived.
In the Klamath River watershed in California, discharges of waste that are not subject to NPDES permits include runoff from nonpoint sources, including irrigated agriculture, grazing, or forestry activities, runoff from roads, and discharges from the Klamath Hydroelectric Project facilities. As described above, nutrient and organic matter load allocations are assigned at the mouths of the tributaries to the Klamath River, and temperature-related load allocations for shade and human-caused discharges of sediment are assigned to the watershed areas of the Middle and Lower Hydrologic Areas of the Klamath River.

The Implementation Plan must identify the regulatory mechanisms that will be developed and implemented to achieve the load allocations. The implementation actions taken to achieve load allocations must be consistent with the *Policy for Implementation and Enforcement of the Nonpoint Source Pollution Control Program* (State NPS Policy). This policy requires that "all current and proposed nonpoint source discharges must be regulated under waste discharge requirements (WDRs), waivers of WDRs, a Basin Plan prohibition, or some combination of these tools" (Regional Water Board 2007, p.4-33.00). For further discussion of these tools see Section 6.1.4 of the Staff Report.

The State NPS Policy was adopted in 2004, and for the Klamath River watershed in California, the development of the Implementation Plan serves as the opportunity to identify the regulatory tools that will bring the watershed into compliance with the policy. For some pollutant sources in the Klamath River watershed in California, the method of compliance with this policy is already in place (e.g. timber harvest activities on federal and non-federal lands). However, if the source is currently unregulated, or the current permits, waivers and/or prohibitions are not sufficient to attain the TMDL, a means to comply with the NPS Policy must be proposed as part of the Implementation Plan. In the Klamath River watershed in California, discharges from the following nonpoint sources are not currently covered by a WDR, waiver, or prohibition: grazing and irrigated agricultural activities[4], runoff from county roads, and nonpoint source activities, not including timber harvest activities, on USFS lands. Therefore, the Implementation Plan proposes the development of new regulatory tools for discharges from these nonpoint sources in the Klamath River watershed in California.

[4] Discharges from grazing and irrigated agriculture in the Scott and Shasta River watershed are currently covered by the conditional waivers developed as part of the Scott and Shasta River TMDL Action Plans, which will remain in effect until August 2011 and January 2010, respectively.

LOAD ALLOCATION AND STATELINE

G1. Comment(s):

The Regional Board simply does not have authority to assign a load to the Stateline since the Board's authority is limited to the stretch of the river downstream of the California-Oregon border. ODEQ has not yet adopted a TMDL for the Klamath River, and the Draft TMDL cannot rely on estimates of ODEQ's intended load allocations to impose a "load allocation" to the Klamath River at Stateline. The Stateline is not a discharge. (p. 3)

Comment(s) Made By:

Addington & Danosky – Klamath Water Users Association & Tulelake Irrigation District

Response:

A load allocation is defined as "[t]he portion of a receiving water's loading capacity that is attributed either to one of its existing or future nonpoint sources of pollution or to natural background sources." (40 CFR § 130.2(g).) Wherever possible, natural and nonpoint source loads should be distinguished. The assignment of a load allocation to a water body segment alone has no force and effect under the law except to the extent that it may narrow the loading capacity of the stream available to point sources. A load allocation does not create new bases for enforcement absent a subsequent and separate action by the implementing agency that identifies a responsible party contributing pollution above the assigned load allocation, and an accompanying permitting or other enforcement mechanism to implement measures to meet an assigned load allocation. If a load allocation is assigned and identified as a nonpoint source load, it is entirely up to the regulatory body, in this case, the State of Oregon, and the tools available to it, to implement that load allocation in the way it deems appropriate. The Klamath TMDL does not propose regulating the Klamath River at Stateline as a discharge, not would it have authority to do so.

G2. Comment(s):

KWUA requests that the Regional Board remove the load allocation to the Stateline and clarify that the Draft TMDL, including its load allocations and wasteload allocations, does not apply to the Klamath Project in any way. (p. 4)

Comment(s) Made By:

Addington & Danosky – Klamath Water Users Association & Tulelake Irrigation District

Response:

The Regional Water Board intends to work closely with ODEQ and ODA in implementing the Klamath and Lost River TMDLs. One of the purposes of coordination with Oregon is to align each state's approach to controlling nonpoint sources of pollution. The Klamath TMDL does not propose regulating discharges in Oregon. In California, the Regional Water Board is required by the State NPS Policy to regulate all sources of waste, including agricultural activities, directly through permits, waivers and/or prohibitions, as discussed in section 6.1.4. For the USBR, USFWS, and TID, the implementation plan measures include an evaluation and implementation of methods to reduce the water quality impacts of the operation of the Klamath Project and Wildlife Refuges and implementation of an effective pollutant reduction strategy.

G3. Comment(s):
KWUA disagrees with the implementation plan's assignment of specific implementation measures for TMDL compliance in Oregon. KWUA cautions the Regional Board not to predetermine ODEQ's regulatory efforts with respect to the mainstem of the Klamath River in Oregon, including irrigation return flows from the Klamath Project in Oregon. (p. 11-12)

Comment(s) Made By:
Addington & Danosky – Klamath Water Users Association & Tulelake Irrigation District

Response:
The Klamath TMDL does not attempt to "predetermine" ODEQ's regulatory efforts in Oregon. The text is explanatory in nature as to how Oregon typically implements TMDLs. It is important information for California to understand and communicate how it expects Oregon to implement its TMDLs.

G4. Comment(s):
Allocations and Targets-6.2.1
The Report states "It is appropriate for the Regional Water Board to account for these anticipated upstream load reductions in Oregon when developing the TMDLs for the segments of the Klamath River that are downstream in California". The County strongly disagrees with that statement. It is not appropriate to account for these anticipated reductions when the Board staff readily admit it will be generations, if at all, before water quality standards will be met at the state line. (p.4)

While the discussion of the source of upstream pollutants may be subject to some additional research, it is absolutely unacceptable to create water quality standards downstream predicated on clean water at the state line. (p.4)

Comment(s) Made By:
Cantrall – Modoc County Board of Supervisors

Response:
The Clean Water Act is a comprehensive federal water quality law designed to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters." (33 U.S.C. § 1251(a).) The Clean Water Act requires states to establish water quality standards that specify both the beneficial uses of water bodies and the levels of quality that must be met and maintained in order to protect the designated uses. (*Id.* § 1313.) In California, beneficial uses of water bodies and objectives necessary to protect the beneficial uses are prescribed in the Basin Plan. Water quality standards are not based on

the existing water quality from Oregon. Moreover, the Klamath TMDL is not "creating" water quality standards. TMDLs require a quantitative numeric pollutant target established at a level necessary to achieve water quality standards in an impaired waterbody. (33 USC §1313(d)(1)(C).)

G5. Comment(s):
Table 5.5, page 5-15 of the draft TMDL presents temperature numeric targets at Stateline expressed as monthly averages. Further, the draft defines (page 5-15) the temperature allocation at Stateline is "zero increase above natural". Oregon's corresponding temperature TMDL target is the numeric biologically based criteria of 20 deg C or natural thermal potential plus 0.3 degrees C whichever is greater. The targets presented in Table 5.5 would be considerably lower than targets based solely on Oregon's water quality standard. DEQ looks forward to more discussions regarding temperature targets below biologically based criteria and targets that apply in months when no impairment is likely to occur. Additionally, the Department's metric for temperature is the 7-day average of the daily maximum temperatures while Regional Board's metric is a monthly average. (p.1)

Comment(s) Made By:
Foster – Oregon Department of Environmental Quality

Response:
Regional Water Board staff worked closely with ODEQ staff throughout the development of the Klamath River TMDLs, in accordance with the Memorandum of Agreement on the development of the Klamath River TMDLs signed by Regional Water Board, ODEQ, and USEPA Regions 9 and 10. The temperature targets at Stateline are based on the Oregon allocation scenario and are consistent with ODEQ's TMDL and water quality standard for temperature. The Oregon temperature standard contains a human use allowance of 0.3 oC (0.54 oF) temperature increase when natural temperature conditions are above the numeric temperature criteria, which is 20 oC (68 oF) in this situation. The human use allowance is distributed among the point and non-point sources of Klamath River temperature increases in Oregon. Because of the small magnitude and locations of thermal sources in Oregon, the Klamath River temperatures at Stateline that result from implementation of Oregon's temperature standard are consistent with California's water quality objective for temperature (i.e. the small magnitude of the allocated temperature increases and their distance from California results in temperatures that cannot be distinguished from natural temperatures by the time the water reaches Stateline). Although the metrics chosen by ODEQ and Regional Water Board differ, they are equivalent in that they are expressing the same loading condition.

G6. Comment(s):
The DO metrics presented in Table 5.9 differ from Oregon's water quality standard metrics and DEQ is concerned about the representation of nutrient concentrations as allocations. DEQ is drafting load and waste load allocations to sources in Oregon to

achieve DO, pH and temperature objectives in Oregon and California and the nutrient concentrations presented as load allocations in Table 5.10 are of concern to DEQ and need to be discussed. (p.1, 2)

Comment(s) Made By:
Foster – Oregon Department of Environmental Quality

Response:
Regional Water Board staff worked closely with ODEQ staff throughout the development of the Klamath River TMDLs, in accordance with the Memorandum of Agreement on the development of the Klamath River TMDLs signed by Regional Water Board, ODEQ, and USEPA Regions 9 and 10. The DO targets and the nutrient (TP and TN) and organic matter (CBOD) allocations at Stateline are based on the Oregon allocation scenario and are consistent with ODEQ's TMDL allocations and water quality standards for DO and pH. The TP, TN, and CBOD load allocations at Stateline are expressed both as monthly mean concentrations (see Table 5.8) and daily loads (see Table 5.2), consistent with USEPA guidance.

G7. Comment(s):
For Temperature and Dissolved oxygen, DEQ looks forward to discussions regarding the anticipated variability expected, given that the targets are based on natural conditions and natural conditions are expected to vary year to year. For example, there will be years when the targets cannot be achieved regardless of controls on anthropogenic loading due to natural hydrologic and weather variability. It may not be appropriate to call the tables presented 'targets' and 'allocations' given this natural variability. (p.2)

Comment(s) Made By:
Foster – Oregon Department of Environmental Quality

Response:
Regional Water Board staff worked closely with ODEQ staff throughout the development of the Klamath River TMDLs, in accordance with the Memorandum of Agreement on the development of the Klamath River TMDLs signed by Regional Water Board, ODEQ, and USEPA Regions 9 and 10. The temperature and DO targets at Stateline are based on the Oregon allocation scenario and are consistent with ODEQ's TMDL and water quality standard for temperature. The temperature and DO targets at Stateline reflect the "human use allowance" that is part of ODEQ's water quality standards for temperature and DO,

Regional Water Board staff agree that water quality conditions at Stateline will vary from year to year due to natural variability in hydrology and weather conditions. Numeric targets are the numeric water quality conditions that represent attainment of the applicable water quality objectives for a TMDL. In some cases numeric targets can equal a numeric water quality objective. In other cases, such as temperature and DO numeric targets are a numeric interpretation of the conditions that meet a narrative water quality objective. TMDLs are established to meet water quality standards, considering seasonal variability, and including a margin of safety. TMDL targets are not independently enforceable, but rather reflect a "goal post" for conditions that are compliant with water quality standards.

G8. Comment(s):
Finally, the Department recommends that load allocations at Stateline reflect Oregon's draft allocations. Regional Board's draft allocations at Stateline (Tables 5.1, 5.5 and 5.5) reflect upstream existing and future TMDLs and in no way imply jurisdictional authority on the part of California. The document states that these are Load Allocations at Stateline but does not explicitly state that these allocations are Oregon's draft allocations. The document should be revised to refer the reader to Oregon's draft TMDL allocations at Stateline

Comment(s) Made By:
Foster – Oregon Department of Environmental Quality

Response:
Regional Water Board staff worked closely with ODEQ staff throughout the development of the Klamath River TMDLs, in accordance with the Memorandum of Agreement on the development of the Klamath River TMDLs signed by Regional Water Board, ODEQ, and USEPA Regions 9 and 10. The targets and load allocations at Stateline are based on the Oregon allocation scenario and are consistent with ODEQ's TMDL and water quality standards.

A load allocation is not directly enforceable and must be viewed in context with the accompanying implementation plan. California's implementation plan makes it clear that load allocations measured at the California/Oregon Border are assigned to sources within the State of Oregon, and will be allocated pursuant to the TMDLs being developed by the State of Oregon. Oregon is the implementing authority for Oregon sources. The only implementation action specified is for Regional Water Board, ODEQ and USEPA to work together as specified in the Klamath River/Lost River TMDL Implementation Memorandum of Agreement developed to implement and monitor measures that will achieve compliance with the Klamath and Lost River TMDLs in Oregon and California.

G9. Comment(s):
Pollutant reductions in Oregon are key to the successful reduction of nutrient concentrations in California downstream, yet Oregon's authority to regulate non-point source discharges is weak. More details need to be known about agreements and MOUs between agencies.

Comment(s) Made By:
Grunbaum

Response:
The TMDL Staff Report provides all of the details currently available on the Memorandum of Agreement with USEPA and ODEQ and the proposed MAA with USBR, USFWS, and TID. The Klamath TMDL Staff Report makes clear that achieving compliance with the Klamath River TMDLs in California and Oregon will require a coordinated approach that involves state and federal agencies as well as responsible parties in both states, and the Regional Water Board remains committed to that process. The Regional Water Board is encouraging the implementation of large scale, engineered projects designed to reduce nutrient loads to the Klamath River in Oregon and California, through a Klamath basin water quality improvement tracking and accounting program. This program will provide a mechanism that would allow for collaboration among basin stakeholders and the commenter is encouraged to participate in that process.

G10. Comment(s):
Statement: Chapter 6, Section 6.2. Page 6-8. Section discusses Klamath Straits Drain and Stateline load allocations.
Comment: Loading from KSD is questionable as it appears to actually reduce loads to the Klamath River as compared to the loads diverted from Klamath Lake. This section should also discuss what the options are if the Stateline allocations are not met. (page 10 Specific comments)

Comment(s) Made By:
Hicks – U.S. Bureau of Reclamation

Response:
Regarding KSD loading to the Klamath River, please see response to comment C21.

Under Clean Water Act section 402(d), a downstream state has certain procedural remedies against an upstream state's issuance of NPDES permits that may adversely impact that state's water quality standards. An NPDES permit shall not be issued "[w]hen the imposition of conditions cannot ensure compliance with the applicable water quality requirements of all affected States." (40 CFR § 122.4(d).) For nonpoint source pollution, under section319(g) of the Clean Water Act, a state may petition USEPA to convene a management conference if a bordering state is not meeting applicable water quality standards in another state. Fortunately, these legal remedies are not likely necessary or applicable due to the coordinated approach and good working relationship already establish between the states and USEPA.

G11. Comment(s):
The State of California (and Region IX EPA) should insist that waters delivered to the boarder of the State of California from Oregon should meet Water Quality Standards. This requires cooperation and actions from the State of Oregon and regional management by the EPA. (p.4)

Comment(s) Made By:
Levine – Coast Action Group

Response:
Comment noted.

G12. Comment(s):
California lives downstream of Keno dam, and the regional board has not only the ability, but the obligation, to create tough standards and require that Oregon meet them before fish go extinct. (p. 4)

Comment(s) Made By:
Terence – Klamath Riverkeeper

Response:
Comment noted.

G13. Comment(s):
Regional Board has no authority in Oregon. (p. 1)

Comment(s) Made By:
Solem – Klamath Irrigation District

Response:
Comment noted. Please see response G1.

G14. Comment(s):
Our particular concern is that the failure of Oregon to achieve the water quality standards they agreed to would result in greater restrictions on the contributions allowed by agriculture. However, after discussions with Regional Water Board staff, it is our understanding that the allowable contributions of pollutants will not in any way be affected by water quality at the state line. We appreciate this position and request that it be retained and clarified in any final action taken by the Regional Water Board. (p. 4)

Comment(s) Made By:
Rice and Oldfield – California Farm Bureau Federation and California Cattlemen's Association

Response:
In general, individual dischargers of waste from nonpoint source land use activity such as irrigated agriculture and grazing are only responsible for their own discharges.

LOST RIVER IMPLEMENTATION

H1. <u>Comment(s):</u>
Since no land within the Klamath Irrigation Project discharges to the Klamath River in California, KWUA believes that the Draft TMDL does not apply to the Klamath Irrigation Project.

<u>Comment(s) Made By:</u>
Addington & Danosky – Klamath Water Users Association & Tulelake Irrigation District

<u>Response:</u>
The US Bureau of Reclamation's Klamath Project (Klamath Project) is located in the Lost River basin, which is a tributary to the Klamath River. Part of the Klamath Project is located in California and there are pollutant loadings identified in the Lost River TMDL, promulgated by the USEPA in 2008, that contribute to the Klamath River water quality impairments. Since the Oregon and California TMDLs shared an analysis, the implementation plan in California must address all pollutant loads in California that contribute to water quality impairments in the Klamath and Lost River basins.

H2. <u>Comment(s):</u>
Why should the watershed-wide temperature allocations apply to the Lost River when the Lost River was delisted for temperature in 2006.

<u>Comment(s) Made By:</u>
Addington & Danosky – Klamath Water Users Association & Tulelake Irrigation District

<u>Response:</u>
The geographic scope of the watershed-wide allocations has been clarified in the technical analysis of the revised staff report and do not apply to the Lost River basin. However, the Basin Plan water temperature objective applies regionwide and still must be met.

H3. <u>Comment(s):</u>
The Draft TMDL refers to the Klamath Straits Drain (KSD) as a nonpoint source of pollution. However, in the Lost River TMDL, EPA analyzes the KSD as an impaired segment (i.e. receiving water). KWUA does not believe it is possible for a waterbody to be both a receiving water and a nonpoint source of pollution. KWUA further questions the extent to which a TMDL may identify a reservoir as a source of discharge subject to load allocations. The identification of the KSD or a segment of the mainstem of the Klamath River as a pollutant source is inappropriate, if these waters are themselves receiving waters.

Comment(s) Made By:
Addington & Danosky – Klamath Water Users Association & Tulelake Irrigation District

Response:
The commenter provides no basis for these assertions. The Klamath Straits Drain discharges to the Klamath River and the Klamath TMDL assigns an allocation at the point of discharge in Oregon at a level necessary to meet water quality standards in the mainstem Klamath River. A waterbody may indeed be receiving water and at the same time have an allocation assigned to it - as all other major tributaries do; i.e. the Trinity, Salmon, Scott and Shasta Rivers. These tributary allocations serve as boundary conditions in the shared model analysis.

H4. Comment(s):
Despite the continued reference to the development of a TMDL for the California segment of the mainstem of the Klamath River in public notices provided in the development for the TMDL, the implementation plan appears to establish measures for the Klamath Irrigation Project tin Oregon and in the Lost River Basin of California.

Comment(s) Made By:
Addington & Danosky – Klamath Water Users Association & Tulelake Irrigation District

Response:
California does not have jurisdiction in Oregon and the California TMDL implementation plan does not establish measures there. The Oregon Department of Environmental Quality (ODEQ) is scheduled to adopt an implementation plan to address water quality impacts in Oregon. The Regional Board will work with ODEQ and USEPA Region 9 and 10 under the terms of an MOA to address TMDL pollution sources cooperatively throughout the Klamath basin. The geographic scope of the Klamath implementation plan includes the Lost River basin and the plan also serves as the implementation plan for the Lost River basin TMDLs promulgated by the USEPA in December 2008. This has been explicitly noticed in conjunction with the release of the most recent draft of the Klamath TMDL on December 23, 2009.

H5. Comment(s):
The implementation plan is at best vague as to its application to the watersheds outside of the Klamath River in California. In fact, the proposed implementation plan states that there is currently no implementation plan for the Lost River TMDL in California. The proposed implementation plan does not even describe the water quality standards applicable to the Lost River in California. The Regional Board staff's attempt to sweep the EPA Lost River TMDL implementation into the implementation plan for the Klamath River without any substantive analysis of its ability to ensure compliance with the EPA Lost River TMDL is wholly inappropriate.

Comment(s) Made By:
Addington & Danosky – Klamath Water Users Association & Tulelake Irrigation District

Response:
The Lost River basin is part of the Klamath River basin. The implementation plan includes a table that was excerpted from the Lost River TMDL that gives all the load allocations for the Lost River basin. The water quality standards applicable to the Lost River basin in California are described in the USEPA Nitrogen and CBOD TMDLs for the Lost River basin in California. The nutrient and water temperature standards are the same in the Lost River basin as in the Klamath River basin and are provided in section 2.2 of the Klamath TMDL staff report. The Klamath TMDL includes measures for water quality improvement in the Lost River basin and serves as the implementation plan for the Lost River basin. The agricultural waiver scheduled for adoption as part of the Klamath implementation plan will be the mechanism to implement the Klamath and Lost River TMDLs with respect to agricultural discharges. Monitoring of the Lost River basin to assess compliance with the EPA's TMDL is included as part of the Klamath TMDL monitoring plan.

H6. Comment(s):
Regional Board cannot assign responsibility to any party conducting activities associated with irrigated agriculture in the Klamath River basin. Under Porter-Cologne, the Regional Board has authority over the actual "dischargers" responsible for discharges to water of the state. The Regional Board cannot assign responsibility for certain discharges unless the assignee is actually responsible for the subject discharge.

Comment(s) Made By:
Addington & Danosky – Klamath Water Users Association & Tulelake Irrigation District

Response:
This has been corrected in the revised staff report and the Basin Plan language. If a party conducting activities associated with irrigated agriculture is not discharging, there is no requirement to file a Report of Waste Discharge or obtain coverage under a permit or agricultural waiver.

H7. Comment(s):
Irrigation districts do not have authority to enforce water quality standards and cannot be called upon to ensure that their constituent irrigator comply with a TMDL.

Comment(s) Made By:
Addington & Danosky – Klamath Water Users Association & Tulelake Irrigation District

Response:
The Tulelake Irrigation District is responsible for discharges of waste associated with their drainage network. They are not responsible for pollutants originating on the fields

or in drains they do not own. The Tulelake Irrigation District is also not responsible for organizing group compliance with the TMDL or future agricultural waiver; group compliance with the waiver is optional. However, the Regional Board encourages group compliance because it has proven an effective way to organize compliance on a large scale in other Regional Water Board waiver programs around the state.

H8. Comment(s):

- The County insists that the Klamath Irrigation Project irrigators be held responsible only for their contribution to the loading of the river and furthermore be given credit for their contributions for enhancing the water quality as it flows through the Project.
- Parties who are potentially affected by implementation measures would likely participate more willingly if the end point of implementation were reasonable.

Comment(s) Made By:
Addington & Danosky – Klamath Water Users Association & Tulelake Irrigation District
Cantrall – Modoc County Board of Supervisors

Response:
Klamath Project irrigators are only responsible for their contribution to pollutant loading as stated in the current draft of the Klamath TMDL (section 6.5.6.1). Individuals are not directly responsible for meeting TMDL targets that apply to the mainstem Klamath River. The ‘end point’ of implementation for individual dischargers is to implement management practices that effectively control discharges and other controllable water quality factors from *their* activities. They are not responsible for discharges outside of their control. This is a reasonable endpoint for individuals. However, just as individuals are not responsible for pollution from operation of the Klamath Project, they will also not be given credit for reductions in pollution that are a consequence of the operation of the Klamath Project. See comment C21 for more discussion of the impact of the Klamath Project on water quality in the Lost River and Klamath River basins.

H9. Comment(s):

The County would have no problem with imposing a "permit waiver" process for irrigated agriculture in the Klamath Project if one could point to science based data indicating a direct cause and effect relationship between the farming in the project and a contribution to pollutant loading into the river system. No such evidence exists, in fact just the opposite. The County believes that no regulatory action should be taken that affects the Klamath Project until it has been shown that the Project contributes to the loading of the river. Until then, the voluntary incentive based approach that has proven successful in the Project for years should continue to be the vehicle of choice for maintaining and improving water quality.

Comment(s) Made By:
Cantrall – Modoc County Board of Supervisors

Response:
The Lost River TMDL shows the contribution of irrigated agriculture and the Klamath Project to pollutant loading in the Lost River basin and the Klamath River TMDL shows the impact of project loading on water quality in the Klamath River. Project irrigators that are discharging pollutants to the Lost River basin in California will be required to address their discharges as part of the proposed agricultural waiver program regardless of the net effect of the Klamath Project. The agricultural waiver program is being developed through a process separate from the TMDL process and is required by the State NPS Policy. For more discussion of the waiver see general response Q1. For more discussion on the nutrient and water temperature impacts of the project see response to comment C21.

H10. Comment(s):
Given the enormous investment the Project irrigators have made to water quality and quantity over the past years, it seems reasonable that until there is solid documentation to show load contribution, the successful voluntary incentive-based programs that are currently in place should suffice for "regulations".

Comment(s) Made By:
Cantrall – Modoc County Board of Supervisors

Response:
The Regional Water Board recognizes the water quality improvement projects implemented by project irrigators over the past years. Klamath implementation will incorporate existing efforts to improve water quality. Irrigators are encouraged to document their water quality improvement measures and develop a water quality plan to address pollution that results from their operations, and water quality monitoring plans to demonstrate water quality improvements. Irrigators will be given credit for past efforts shown to be effective in improving water quality; however, the Regional Water Board is still required by State law to adopt a regulatory mechanism to control all nonpoint source discharges including agricultural discharges.

H11. Comment(s):
Given the information that shows the Project activities contributing to improving water quality, the County believes there is no justification for either a permit or a permit waiver process. However, if a permit waiver program was to be developed, it should be structured so that the holder of the waiver would be the Tulelake Irrigation District (TID), rather than the individual landowners. This waiver should also include the "lease lands" on the Tulelake National Wildlife Refuge. TID delivers the irrigation water for this farmland and provides for its removal through the pumping stations. The County would strongly oppose the Refuge controlling the mechanism for water quality responsibility on the lease lands.

Comment(s) Made By:
Cantrall – Modoc County Board of Supervisors

Response:
The Regional Water Board is required to adopt a permit, conditional waiver, prohibition, or some combination of these measures to control discharges from agricultural activities in the Klamath River basin. To address discharges associated with agricultural activities, the Klamath implementation plan recommends the development of a conditional waiver. The specific requirement of the agricultural waiver will be decided during a separate stakeholder process that will begin after adoption of the Klamath TMDL. Dischargers are individually responsible for addressing their impact to water quality, but are encouraged in the implementation plan to organize a group compliance program that could be led by the Tulelake Irrigation District or another local group. Lessees are responsible for discharges associated with their activities on lease lands. While the US Fish and Wildlife Service and the US Bureau of Reclamation are not responsible for these discharges, they are responsible for discharges associated with the conveyance and delivery of water on the lease lands. In addition, the implementation plan includes an MAA with USBR, USFWS, and Tulelake Irrigation District to address the impact of the operation of the Klamath Project, the wildlife refuges, and the lease lands.

H12. Comment(s):
There is no evidence to show that grazing within the Project contributes to loading in the downstream river system. The County believes it would be irresponsible and unworkable to have individual grazers within the Project be responsible for complying with proposed standards. Any loading, if it were to occur, would be carried by the Project's tailwater return system and it would be impossible to determine the source. If the Board were to make the decision to require a waiver, the waiver held by Tulelake Irrigation District (TID) should encompass any grazing activities within TID's boundaries.

Comment(s) Made By:
Cantrall – Modoc County Board of Supervisors

Response:
TID is not responsible for an individual’s contribution to water quality impacts. They are responsible for pollution sources associated with the conveyance and delivery of water through their drainage network. Individuals are responsible for addressing discharges that are the result of their operations. If a grazing operation is discharging waste, it must participate in the agricultural waiver program after it is adopted, or submit a Report of Waste Discharge to the Regional Water Board. Dischargers may also choose to participate in the waiver as part of a group. Compliance with waiver and any enforcement actions will be determined by the extent to which the enrollee is meeting the conditions of the waiver. Determination of the particular impacts downstream of a single discharge source on a ranch is not a precondition for enrollment in the waiver. There only has to be a discharge of waste to waters of the State. Data on water quality in the tailwater system will be used to evaluate the waiver program and TMDL implementation

as a whole and not to enforce on individuals. Finally, as noted above, individual dischargers would be expected to implement management practices that effectively control discharges and other controllable water quality factors from *their* activities. They are not responsible for discharges outside of their control.

H13. Comment(s):
The Report states that "ranch water quality management plans may be required as part of the conditional waiver of WDRs and/or general WDRs for grazing and may be required at any time by the Board's Executive Officer". The County believes that this requirement is arbitrary and places too much authority without redress in the hands of the Executive Officer. As stated above, this should not be handled at the individual operator's level within the Project.

Comment(s) Made By:
Cantrall – Modoc County Board of Supervisors

Response:
The staff report has been amended and the requirement to develop a ranch water quality management plan has been removed. However, the Executive Officer of the Regional Water Board may require a water quality plan from any discharger at any time. Porter-Cologne Water Quality Control Act (Section 13267) grants the Executive Officer the authority to request technical reports to address any discharge to waters of the State as necessary to protect beneficial uses. At the discretion of the Executive Officer, individuals may be required to submit a Report of Waste Discharge and a plan if they are discharging. Whether the submittal of a water quality plan will be required as a condition of the future agricultural waiver has not been decided. That decision will be made as part of the public development of the agricultural waiver scheduled to begin after adoption of the Klamath TMDL.

H14. Comment(s):
The County urges the Board to take a long look at the weaknesses in the Report and find a balance between complying with the court requirements and creating an unnecessary and costly regulatory morass that will cause great harm to our citizens and in the short and long term both, contribute nothing to improving water quality. .

Comment(s) Made By:
Cantrall – Modoc County Board of Supervisors

Response:
Reducing pollutant loading has been demonstrated repeatedly to lead to improvements in water quality. The Klamath implementation plan requires measures that will improve water quality by reducing pollutant loading. Experience in other regions of California with agricultural waiver programs provides many examples from which the North Coast

Regional Water Board can draw in designing a program that leads to water quality protection while minimizing the regulatory burden on dischargers.

H15. Comment(s):
We question, however, the necessity for the MAA to include an action item to "Complete a water quality study to characterize the seasonal and annual nutrient and organic matter loading through the KIP and refuges."(p. 6-21). The technical analyses conducted in the development of the Lost River TMDL have already provided this. What is needed, in fact, are detailed work plans for the types of project that would be most effective in cleaning up water quality pollution in the Lost River basin, the prioritization of projects, and implementation of the highest priority projects.

Comment(s) Made By:
Fetcho – Yurok Tribe
Crosby – Karuk Tribe
Bowman – Quartz Valley Indian Reservation

Response:
The MAA proposed for development in the Klamath implementation plan includes the prioritization of water quality projects and implementation. If the Lost River TMDL analysis is sufficient to make decisions about the best use of resources and the most effective water quality improvement projects, then that part of the MAA will have already been fulfilled. Regional Water Board staff will work with USBR and USFWS to determine what data is needed to move forward as part of the MAA development process.

H16. This is a Placeholder. No comment represented by this number

H17. Comment(s):
Some of our members have been individually assured by your staff that the Project will be held responsible only for that loading that can be documented to come from activities within the Project. However we are aware that this proposed document does not adequately reflect this new position stated by your staff.

Comment(s) Made By:
DePaul – Modoc County Farm Bureau

Response:
This is true; the load allocations to the Klamath Straits Drain in the Klamath TMDL and to the Lost River in the Lost River TMDL are not the direct responsibility of individual landowners. Individuals are responsible for discharges that originate from their operations. Monitoring will show any progress towards meeting water quality allocations and targets assigned to the Klamath Project as a whole. Individual dischargers will be

expected to implement management practices that effectively control discharges and other controllable water quality factors from their own activities.

H18. Comment(s):
Add language clarifying that this TMDL implements the Lost River TMDL and include Tulelake WWTP as a responsible party.

Comment(s) Made By:
Hashimoto and Ziegler – USEPA

Response:
This language has been added and the City of Tulelake is now a responsible party in the Klamath implementation plan. The Lost River TMDL load allocations will be incorporated into their NPDES permit as part of implementation in the Lost River basin.

H19. Comment(s):
KRK encourages the Regional Water Board to pay special attention to what nutrient loading comes from farm operations along the Lost River in both California and Oregon at what times of year and where tailwater from those farms goes. (p. 5)

Comment(s) Made By:
Terence – Klamath Riverkeeper

Response:
The TMDL implementation plan addresses these issues through the proposed MAA and through the proposed development of an agricultural waiver in the Klamath basin. The TMDL also supports the implementation of engineered treatment projects to address nutrient loadings in the Upper Basin through the tracking and accounting program.

H20. Comment(s):
The final Klamath TMDL and Lost River TMDL should be joined going forward because Klamath River water quality problems cannot otherwise be resolved. The Klamath TMDL must address restoring normative ecosystem processes as a solution to the current water quality and ecological crisis. If winter flows from the Lost River were captured in restored Lower Klamath Lake wetlands and summer drain water from the Tule Sump had more residence time there, there could be a substantial reduction in the nutrients now delivered to Keno Reservoir. The long-standing problems with summer pollution from the Straits Drain would be resolved and Lost River winter overflow water could be captured instead of being discharged to the river during winter.

Comment(s) Made By:
Spain – Institute for Fisheries Resources & Pacific Coast Federation of Fishermen's Associations

Response:
The Klamath River implementation plan is the implementation plan for the Lost River TMDL. The implementation plan includes the development of an MAA with the USBR, USFWS, and Tulelake Irrigation District to address the impact of the operation of the Klamath Project on water quality in the Lost River basin and the Klamath River mainstem. The purpose of the MAA is to prompt the implementation of measures to reduce pollutant loading and meet TMDL load allocations. While the Regional Water Board cannot require the manner of compliance with the TMDL load allocations, it can have input into which projects would be most effective at addressing the TMDL impairments. Managing water flow in and out of Lower Klamath Lake is a potential candidate project to help achieve the load allocations.

H21. Comment(s):
The draft TMDL sets a goal of reducing nutrients by 50 percent in the Lost River but it does not demonstrate that that amount will be a sufficient to allow recovery of water quality in Keno Reservoir, an element of the current, parallel Klamath TMDL development process.

Comment(s) Made By:
Spain – Institute for Fisheries Resources & Pacific Coast Federation of Fishermen's Associations

Response:
The nutrient allocations in the Lost River TMDL are set to address the impairments in the Lost River basin and were set before the development of the Klamath TMDLs. The Regional Water Board supports the Lost River TMDL load allocations as sufficient to begin implementation and work towards water quality improvement in Keno Reservoir. The allocation to the Klamath Straits Drain at its discharge point to the Klamath River is assigned as part of Oregon's Klamath River TMDL, which shared an analysis with California. This allocation may require greater load reductions in the Lost River basin, however, it is important to bear in mind that the 50% reductions in the Lost River TMDL were not for the Klamath Straits Drain but for various locations in the Lost River basin in California. In this respect, the load allocations from the two TMDLs are not comparable. If monitoring shows that the Lost River basin TMDLs have been achieved and the Klamath TMDL load allocations are not being achieved, one or both of the TMDLs and/or implementation plans may be revised as part of TMDL reassessment.

H22. Comment(s):
The most galling flaw of the Lost River TMDL is that it assigns a lead role in implementation to the Klamath Basin Water Users. Placing a special interest

group in charge of a government water pollution control program is absurd.

Comment(s) Made By:
Spain – Institute for Fisheries Resources & Pacific Coast Federation of Fishermen's Associations

Response:
The Klamath TMDL implementation plan serves as the implementation plan for the Lost River TMDL in California. The USEPA provided implementation recommendations as part of the Lost River TMDL. While their recommendations were considered in development of the Klamath implementation plan, they are not enforceable. The Klamath Water Users Association (KWUA) is a non-profit corporation representing Klamath Project farmers and ranchers on both sides of the California-Oregon border. They will not be "in charge" of Klamath implementation in California, but may be considered as a third party group for purposes of complying with the future agricultural waiver proposed for development as part of the Klamath implementation plan. If the enrollees in the waiver decide to form a group to track compliance with the waiver, the KWUA may be a suitable agency to organize implementation efforts and report to the Regional Water Board. The Regional Water Board sees the benefit in group compliance with the waiver in that it streamlines administration of the waiver and promotes proactive efforts to improve water quality. However, individuals would still be responsible for complying with the waiver and addressing discharges from their lands. The regulatory requirements of the proposed waiver program will be developed through a public process and are not specified in the Klamath TMDL.

H23. Comment(s):
If this course (abandoning the Lost River technical TMDL) is for some reason impractical then implementation of the Lost River TMDL must be joined to that for the Klamath TMDL because the water quality problems of the two are inextricably linked.

Comment(s) Made By:
Spain – Institute for Fisheries Resources & Pacific Coast Federation of Fishermen's Associations

Response:
The Klamath River TMDL implementation plan incorporates implementation of the Lost River TMDL. One of the goals of the agricultural waiver program is to make TMDL implementation requirements consistent in the Klamath River basin, including the Lost River basin.

H24. Comment(s):
Until sucker populations in the Lost River expand, the beneficial uses of water in the sub-basin shall not have been restored. The U.S. EPA's failure to address sucker recovery is a profound failing in the TMDL. The draft TMDL clearly does not meet the

standards of the Clean Water Act that requires that this critical beneficial use be restored.

<u>Comment(s) Made By:</u>
Spain – Institute for Fisheries Resources & Pacific Coast Federation of Fishermen's Associations

<u>Response:</u>
The USEPA developed the Lost River TMDL and responded to comments in writing concerning the issues brought to their attention by the public. The Lost River TMDL public comment period was the appropriate forum for voicing concerns about that technical TMDL analysis. It is the Regional Water Board's expectation that suckers in the Lost River basin will benefit from water quality improvements that result from measures implemented as part of the Lost River implementation plan.

H25. <u>Comment(s):</u>
The Klamtrack program and a future management agency agreement with Reclamation cannot be relied upon to ensure implementation of the TMDL. The staff report should summarize those efforts for informational purposes and provide for an amendment to the Basin Plan in the event any of the anticipated measures come to fruition.

<u>Comment(s) Made By:</u>
Addington & Danosky – Klamath Water Users Association & Tulelake Irrigation District

<u>Response:</u>
The Regional Water Board chiefly relies upon its regulatory tools to implement the Klamath TMDLs, however, the MAA and the tracking and accounting program are important elements of Klamath TMDL implementation because they promote projects to reduce nutrient loading in the Upper Basin on a faster timeline than would be achieved through traditional regulatory means.

H26. <u>Comment(s):</u>
- We need to know more about the proposed development of a Management Agency Agreement (MAA) between USBR, USFWS and the Regional Water Board to implement the Lost River and Klamath River TMDLs, as well as the MOU between U.S. EPA, Oregon Department of Environmental Water Quality (ODEQ) and the Regional Water Board.
- We are supportive of cooperative efforts and would be willing to further engage with both states as well as federal agencies on the subject of the proposed Management Agency Agreement on page 6-20 of the TMDL.

<u>Comment(s) Made By:</u>
Addington & Danosky – Klamath Water Users Association & Tulelake Irrigation District
Fetcho – Yurok Tribe

Crosby – Karuk Tribe
Bowman – Quartz Valley Indian Reservation

Response:
The Regional Water Board staff welcome the participation of TID, KWUA, the Karuk Tribe and any other interested parties in the development of the MAA. In fact, the December 2009 public review draft proposes that TID be a party to such an MAA. The MOU among Oregon DEQ, Regional Water Board, and EPA is posted on the Regional Water Board website at: http://www.waterboards.ca.gov/northcoast/water_issues/programs/tmdls/klamath_river/.

H27. Comment(s):
The author inappropriately identifies the U.S. Bureau of Reclamation as one of "The parties responsible for implementing water quality control measures that meet the Lost River and Klamath River TMDL allocations in California."

Comment(s) Made By:
Hicks – U.S. Bureau of Reclamation

Response:
The implementation plan proposes a Management Agency Agreement between the USBR, USFWS, and Tulelake Irrigation District to improve water quality in the Lost River basin and the Klamath River mainstem. Staff named these three entities together as responsible parties in developing the MAA because all have an influence on hydrology and water quality within the Klamath Project in California. Even if it is true that USBR is not be responsible legally for discharges from the wildlife refuges and agricultural activities within the Tulelake area in California, USBR is responsible for meeting any load allocations that are assigned to it in the Oregon Klamath TMDL at the Klamath Straits Drain and the Lost River Diversion Canal. Meeting these allocations is essential to improving water quality in the Klamath River mainstem at the Stateline and downstream into California. The Klamath Straits Drain discharge requires a significant reduction in nutrients and organic matter to meet the Klamath TMDL. This discharge can comprise a significant portion of the flow in the Klamath River downstream of the discharge during certain times of the year and contributes to water quality problems downstream.

We believe there is an opportunity for USBR to work with dischargers responsible for meeting the Lost River TMDL allocations in California and jointly managing water quality. There is precedent for this approach in the Central Valley where the Regional Water Board (Region 5) and the USBR developed an MAA that describes the cooperative actions USBR will take under the Salt and Boron TMDL for the lower San Joaquin River. Pursuant to this MAA, USBR agreed to implement a plan entitled "Actions to Address the Salinity and Boron TMDL Issues for the Lower San Joaquin River" and has also submitted a "Draft Compliance and Monitoring Evaluation Plan". The MAA also includes quarterly reporting to the Regional Water Board on the implementation of the water quality improvement actions pursuant to the submitted plan.

To implement the Klamath TMDLs, the Regional Water Board and the Oregon Department of Environmental Quality and USEPA Region 9 and 10 signed a MOA that included a commitment to work with the Klamath Water Users Association, USBR and USFWS to meet the Klamath TMDL allocations. In the Lost River TMDL, EPA included the following implementation recommendations:

1. An MOU among USEPA, USBR, and USFWS to outline appropriate roles and responsibilities and identify joint funding for monitoring to achieve TMDLs.

2. USBR should evaluate the Klamath Project operation for possible water quality improvements, such as through water reuse in the Lost Rive together with other water management actions, to achieve TMDL allocations for the Oregon Lost River and Klamath River TMDLs.

3. USBR should establish a Lost River basin water quality monitoring program with trend monitoring stations.

ACCOUNTING, TRACKING, and LANDSCAPE ENGINEERING

Note:
The "KlamTrack Program" referenced in the June 2009 draft of the Klamath TMDL is referred to in the December 2009 draft as the "tracking and accounting program" and will be referred to as such in these responses.

I1. Comment(s):
Tribes need to be specifically included in the KlamTrack Program, the process needs to be transparent, and the program needs to be led by the Regional Water Board.

Comment(s) Made By:
Fetcho – Yurok Tribe
Crosby – Karuk Tribe
Bowman – Quartz Valley Indian Reservation

Response:
Text in section 6.7 has been revised to state that "Regional Water Board staff plan to coordinate with stakeholders and tribal governments interested in the program in 2010." The tribes will be included in the development of the program that will be led by Regional Water Board, ODEQ and USEPA.

I2. Comment(s):
There must be strong evidence and a high likelihood that any pollution trading allowed will have at least as positive an effect on water quality, at the site of the discharge, as pollution control done in a "normal" way – that is, pollution reduced at the source, rather than at an alternate site.

Comment(s) Made By:
Fetcho – Yurok Tribe
Crosby – Karuk Tribe
Bowman – Quartz Valley Indian Reservation

Response:
Regional Water Board staff agree with this approach. Part of the development of the tracking and accounting program will be to devise trading ratios to account for what the commenter describes. For example, any "credit" received for reducing nutrient loading in the upper basin to address a load allocation downstream would consider the actual reduction in pollutant loads realized at the location downstream; not in the upper basin where the project is implemented. The TMDL model may be used to determine the appropriate ratios.

I3. Comment(s):
Because pollution trading could be much cheaper than on-site compliance, the burden of proof should be on such entities to demonstrate that pollution trading would be effective.

Comment(s) Made By:
Fetcho – Yurok Tribe
Crosby – Karuk Tribe
Bowman – Quartz Valley Indian Reservation

Response:
Regional Water Board staff agree and polluters will account for the effectiveness of their pollution trading projects/measures through monitoring of pollutant load reductions.

I4. Comment(s):
Due to the uncertainties surrounding effectiveness the predicted outcomes of pollution trading should contain some safety factor (i.e. >200% of the effectiveness of on-site compliance, perhaps larger if the uncertainties were very large) to assure that goals are met.

Comment(s) Made By:
Fetcho – Yurok Tribe
Crosby – Karuk Tribe
Bowman – Quartz Valley Indian Reservation

Response:
Regional Water Board staff agree. There will be a provision for this in the tracking and accounting program. Other mitigation requirements, such as those required through 401 permit, utilize this type of safety factor in calculating mitigations.

I5. Comment(s):
Page 6-55 to 6-57. The discussion about watershed trading/offsets is good to have, but vague regarding program components and responsibilities, other than mention of the KlamTrack program.

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
As PacifiCorp is aware, the tracking and accounting program is still under development, and this is why discussion of the program in the implementation plan lacks specificity.

I6. Comment(s):
The commenters cited stressed the importance of restoring Lower Klamath Lake and other natural wetlands in the Upper Klamath basin to improve water quality in the Klamath River and made several suggestion of how to do so.

Comment(s) Made By:
Fetcho – Yurok Tribe
Crosby – Karuk Tribe
Bowman – Quartz Valley Indian Reservation
Pace, Beck, Gillespie – North Group-Redwood Chapter-Sierra Club & Friends of Del Norte
Spain – Institute for Fisheries Resources & Pacific Coast Federation of Fishermen's Associations
Terence – Klamath Riverkeeper

Response:
Staff are aware of the important role Lower Klamath Lake and other wetlands could play in reducing nutrient loading to the Klamath River. The Klamath implementation plan proposes the development of an MAA with the US Bureau of Reclamation, the US Fish and Wildlife Service, and Tulelake Irrigation District that would lead to the development of a water quality management plan for the Klamath Irrigation Project and National Wildlife Refuges. The study proposed as part of the MAA would inform the development of a water quality management plan that would set out a schedule for meeting the Klamath and Lost River TMDL allocations. Restoration of wetlands in and around the Lower Klamath River may be included in the plan if it is found to be feasible and effective at reducing nutrient loading from the Klamath Straits Drain to the Klamath River.

I7. Comment(s):
The NRC (2004) report recommended expanding wetlands surrounding the Tule Sump by flooding public lands and reconnecting marshes and wetlands. Such measures would not only expand sucker habitat, but would assist significantly with nutrient absorption and create a more natural pH balance. The U.S. EPA provides no such direction in the Lost River TMDL and fails to even mention expanding Tule Lake, ignoring all opportunity for sucker recovery.

Comment(s) Made By:
Spain – Institute for Fisheries Resources & Pacific Coast Federation of Fishermen's Associations

Response:
The Lost River TMDL has already been adopted by the USEPA. As described in the above response, the Klamath TMDL recognizes the potential for restoration of wetlands in and around the Federal Wildlife Refuges to reduce nutrient loading.

I8. Comment(s):

- The TMDL should analyze and display feasible options for big treatment and compare these options based on positive impact to water quality impairments and other associated benefits (e.g. wildlife habitat, flood control, etc.).
- I think there should be aerators on the river. Also I have included an article on a "robot fish" that they use in Europe to monitor oxygen and pollution levels. They might be useful.

Comment(s) Made By:
Pace, Beck, Gillespie – North Group-Redwood Chapter-Sierra Club & Friends of Del Norte
Schmidt

Response:
There are several potential centralized or alternative treatment options to improve water quality in the Klamath Basin; however, the TMDL implementation plan is not the appropriate forum to evaluate all possible options. The central purpose of the TMDL is to lay out a plan for regulation of discharges that affect water quality in the Klamath Basin. The TMDL includes provisions to consider these types of treatments; institutional mechanisms for implementing them, such as the MAA with the US Bureau of Reclamation, US Fish and Wildlife Service, and Tulelake Irrigation District; and the tracking and accounting program. Concerning 'robot fish': thank you for that suggestion.

BLUE GREEN ALGAE

J1. Comment(s):

We could not find any mention in the Public Draft TMDL of the sampling that has been conducted on Klamath River aquatic fauna to assess the concentrations of microcystin in their tissues. (p. 5)

Comment(s) Made By:

Fetcho – Yurok Tribe
Crosby – Karuk Tribe
Bowman – Quartz Valley Indian Reservation

Response:

A summary of tissue concentration information is included in Table 2.10 as part of the impairment assessment.

J2. Comment(s):

In discussing how best to collect samples to assess the potential public health threats posed by blue-green algae, it is noted that "Few samples have been taken in near shore backwater areas where scums have been frequently reported and photographed." (p. 2-62) Due to a recently-released report, this statement is now outdated and should be replaced with the following language: "Prior to 2008, few samples had been taken in near shore backwater areas where scums have been frequently reported and photographed. In 2008, however, the Karuk Tribe began collecting samples in these areas. These samples frequently show high levels of Microcystis even when mid-channel samples did not (Kann and Corum 2009)." (p. 5)

Comment(s) Made By:

Fetcho – Yurok Tribe
Crosby – Karuk Tribe
Bowman – Quartz Valley Indian Reservation

Response:

The text has been revised to reflect the updated information.

J3. Comment(s):

We agree that the Microcystis aeruginosa cell density < 20,000 cells/L is an excellent target, but the Microcystis aeruginosa cell density <50% of the blue-green algae biomass it is unnecessary and not supported. For example, if the total blue-green algae biomass is very low, then it should not matter if Microcystis aeruginosa is 50% of the total -- because the total amount of Microcystis aeruginosa would still be very low. Public health risks are driven by the concentration of Microcystis aeruginosa cells and microcystin toxin, not the relative percent of the blue-green algae biomass that is Microcystis aeruginosa. We suggest a revised target of simply "Microcystis aeruginosa cell density <

20,000 cells/L". This is the only place in the entire TMDL that we can find any mention of a 50% target, so we suspect that its inclusion in Table 5.1 may have been unintended. (p. 11)

Comment(s) Made By:
Fetcho – Yurok Tribe
Crosby – Karuk Tribe
Bowman – Quartz Valley Indian Reservation

Response:
The cell density target was confirmed through a site-specific analysis. The percent biomass target was not. Therefore the text has been revised to be consistent with the comment above.

J4. Comment(s):
Blue-Green algae, a source of *microcystins* in the Klamath Basin, are a point of controversy. A recent study done on *microcystins* in Siskiyou County was unable to detect any adverse health effects from exposure. It seems prudent that actual health-related issues would need to be demonstrated before an action plan aimed at human health regarding Blue-Green algae could be developed. (p.4)

Comment(s) Made By:
Kobseff – Siskiyou County Board of Supervisors - District 3

Response:
Human health effects associated with exposures to microcystin (the toxin) and microcystis (the cyanobacteria) are well documented. Both the World Health Organization's *Toxic Cyanobacteria in Water: A guide to their public health consequences, monitoring and management* (WHO 1999) (http://www.who.int/water_sanitation_health/resourcesquality/toxicyanbact/en/index.html) and EPA's draft *Toxicological Reviews of Cyanobacterial Toxins: Microcystins LR, RR, YR and LA* (available at http://cfpub2.epa.gov/ncea/cfm/recordisplay.cfm?deid=160548) describe numerous studies linking microcystis spp. with illness in people. WHO 1999 states "In the various reported incidents of poisoning in humans and livestock caused by cyanobacteria or their toxins, *Microcystis* is the most frequently cited organism." A significant example of human illness and death resulting from microcystin exposure was the use of microcystin-contaminated water in blood dialysis in a Brazilian clinic, resulting in the fatal exposure of 50 dialysis patients. Additionally, toxicological studies using laboratory animals documented significant health effects analogous to those effects seen in humans. Human and animal toxicity data were used in developing both WHO's *Toxic Cyanobacteria in Water: A guide to their public health consequences, monitoring and management* (WHO 1999), and EPA's draft *Toxicological Reviews of Cyanobacterial Toxins: Microcystins LR, RR, YR and LA*, as well as in developing recommendations for limiting exposures to microcystins in the Klamath River basin, prepared by OEHHA (2008).

The Regional Water Board believes that this comment is referring to a Centers for Disease Control/CA DPH study conducted in 2008 at Copco and Iron Gate reservoirs (Backer et al. 2009). The CDC study supports inhalation as a possible pathway of exposure for health risks associated with microcystins. The study confirms that inhalation is a route of exposure to cyanotoxins during recreation at water bodies with cyanobacterial blooms, and such exposure may pose a public health concern. The issue of actual exposure and effects was not addressed by this study, and remains an area for future investigation. Regional Water Board has documented impairment due to blue-green algae (*Microcystis* and microcystin) in Chapter 2 of the TMDL staff report.

References:

Lorraine C., Sandra V. McNeel, Terry Barber, Barbara Kirkpatrick, Christopher Williams, Mitch Irvin, Yue Zhou, Trisha B. Johnson, Kate Nierenberg, Mark Aubel, Rebecca LePrell, Andrew Chapman, Amanda Foss, Susan Corum, Vincent R. Hill, Stephanie M. Kieszak and Yung-Sung Cheng. 2009. Recreational exposure to microcystins during algal blooms in two California lakes. National Center for Environmental Health, Centers for Disease Control and Prevention. Toxicon. http://dx.doi:10.1016/j.toxicon.2009.07.006

J5. Comment(s):
I swim in Lake Copco and the Klamath River with my dogs and family and we have never had any health issues due to algae.

Comment(s) Made By:
Bodnar

Response:
Please see response to Comment J4.

KLAMATH HYDROELECTRIC PROJECT

K1. Comment(s):
Page 2-36, Paragraph 36, First Bullet under "Impoundments". The Draft TMDL states that the Project reservoirs "have a small net retention of nutrients". This is consistent with similar statements elsewhere in the Draft TMDL (e.g., page 4-20 and 4-21) that downplay any value or benefits from nutrient retention by the reservoirs. However, even the Draft TMDL's own analysis indicates that nutrient retention by the reservoirs is significant. On page 4-19, the Draft TMDL states "[t}he TMDL model estimates are reasonably consistent with the estimates developed by Asarian and Kann (2009) through statistical analysis of empirical monitoring data" in which Kann and Asarian (2009) estimated that the reservoirs retain 8.3 percent of the inflowing load of total phosphorus and 13 percent of the inflowing load of total nitrogen on an annual basis. Further, Table 4.5 (page 4-20) in the Draft TMDL shows that annual nutrient retention in the reservoirs could be as much as 29 percent for total phosphorus and 33 percent for total nitrogen.

Using the Draft TMDL's annual load estimates (Table 4.2 on page 4-9), retention of the inflowing load of total phosphorus at a rate of 8.3 percent annually equates to a reduction of about 60,000 pounds of total phosphorus, and retention of the inflowing load of total nitrogen at a rate of 13 percent annually equates to a reduction of about 400,000 pounds of total nitrogen. Such levels of nutrient retention by the reservoirs are not "small" or "limited" as characterized by the Draft TMDL.

As described in PacifiCorp (2006), the total annual net retention of nutrients by Copco and Iron Gate reservoirs is substantial, particularly when both reservoirs are considered in combination. The observed concentrations of total inorganic nitrogen (TIN) and total nitrogen (TN) in particular are consistently lower in water released from Iron Gate reservoir than in the water entering Copco reservoir. These observations support the conclusion that Iron Gate and Copco reservoirs act as a net sink for both total nitrogen and total phosphorus over the long term (i.e., on a seasonal or annual basis).

Overall, the monthly nitrogen retention values summarized in PacifiCorp (2006) indicate that the reservoirs acted to retain a significant percentage of inflowing TN (21 percent) and TIN (42 percent) over the entire evaluation period of March-November 2002. Given the large inflowing nitrogen load of nearly 600 metric tons to Copco reservoir over the entire evaluation period of March-November 2002, the substantial net retention provided by Copco and Iron Gate reservoir is an important process for reducing downstream loads to the Klamath River below Iron Gate dam. Retention of these loads results in water quality improvements downstream in the Klamath River due to reduced incidence of attached algae and *Cladophora* growth. In addition to downplaying reservoir retention of nutrients, the Draft TMDL also does not recognize the beneficial role of the reservoirs in shifting the timing of inflowing summertime nutrient "peaks" from upstream sources, notable Upper Klamath Lake. The travel times of flows in the river are important to understanding and explaining nutrient dynamics in the Klamath River. It is apparent that the very large loads of nutrients and organic matter in the Klamath River from Upper Klamath Lake and other upstream sources are often "event-driven" – that is, characterized by large "spikes" of organic matter delivered to the river following the collapse of large algae blooms that are typical in Upper Klamath Lake during the algae growing season. Therefore, it follows that such substantial nutrient "events" would have a downstream influence on nutrient concentrations at a particular point in space and time along the river. This influence would manifest itself in the form of a downriver "lag" in the event, the extent to which would depend on river travel times.

To assess potential "lag", Watercourse Engineering simulated the downstream movement of nutrient events using the RMA-2 dynamic hydraulic model and the RMA-11 water quality model (as described in PacifiCorp 2004). These simulations clearly illustrate the occurrence of a lag associated with travel time through the reservoirs. Figure A4 below shows notable decreases in the magnitude of the peak of the event in Copco reservoir, and the lag of the peak due to travel time through Copco reservoir. Similar decreases and lag times occur through Iron Gate Reservoir. The reservoir lag times are considerable, allowing for processes such as decay and settling to occur. These simulated results also support empirical data findings of nutrient reductions in reservoirs and "lag" of peak nutrient concentration (see Figure A5 below).

These lag times are important to recognize and consider when assessing the roles of nutrient retention in the system. If the reservoirs are assumed as static, isolated systems, and inflow and outflow nutrient conditions are compared on a given day, as done by Kann and Asarian (2005) and Asarian and Kann (2006), it is easy to mistakenly identify that the reservoirs are sources of nutrients. For example, as identified in Figure 4-18 in late October, Copco reservoir inflows may indicate higher levels of total nitrogen than Iron Gate reservoir outflows. However, Iron Gate is actually further reducing the input from Copco reservoir because of the considerable lag. That is, TN in Copco reservoir inflows has been reduced as the "peak" passes through the reservoirs.

The lag effect from the reservoirs displaces the peak influx of nutrients further into the future. In the cases shown in Figures A5 and A6 below, the peak TN leaves Link dam in late July in the middle of the algae growth season. This peak does not manifest itself at Copco dam until some weeks later, and does not appear at Iron Gate dam until well into October, and then is considerably attenuated. This displacement of TN influx further into the future suggests the reservoirs have a beneficial effect on reducing downstream attached benthic algae (periphyton) in the river during the peak algae growing season. Without the reservoirs, the simulations indicate that peak TN conditions would occur coincident with maximum standing crop of benthic algae in late July or early August. With the reservoirs, the simulations indicate that peak TN conditions are lagged by several weeks into late summer and early fall when the benthic algae community is in overall senescence due to lower solar altitude and decreased day length. Conversely, in the absence of the Copco and Iron Gate reservoirs, it is likely that attached benthic algae (periphyton) would increase in the river downstream of Iron Gate during the peak algae growing season. Nutrients released to the river system below Iron Gate dam in mid-summer rather than in late summer and early fall would have a considerably greater potential for being sequestered in algal biomass.

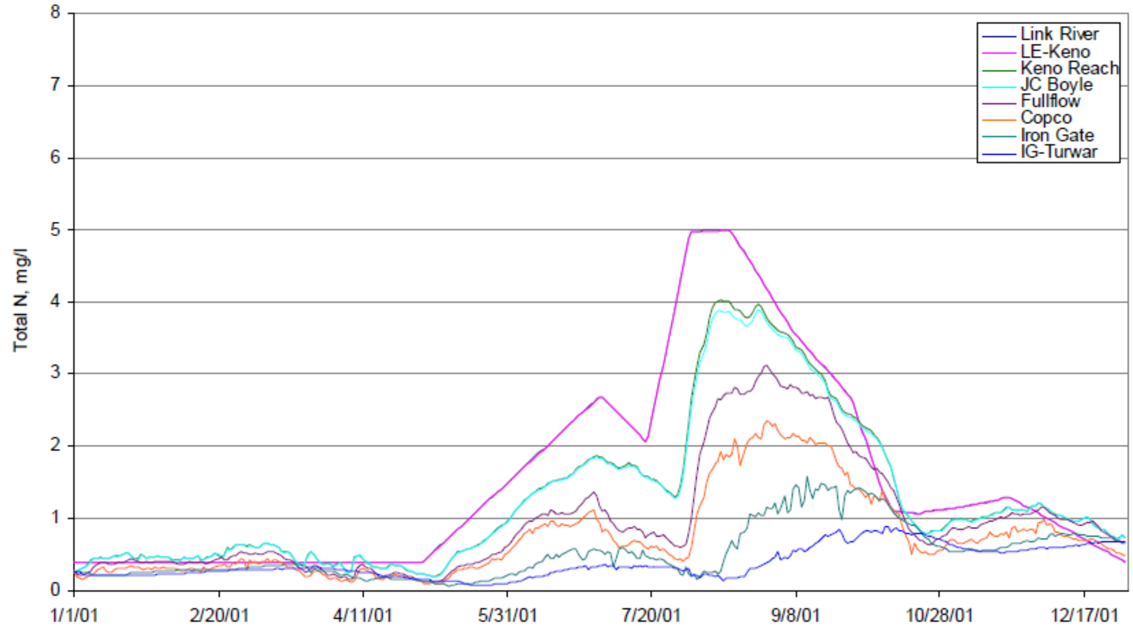

Figure A5. Model simulations of total nitrogen in the downstream direction for the Klamath River from Link dam to Iron Gate dam for existing condition (graphic labels correspond to the head of each reach).

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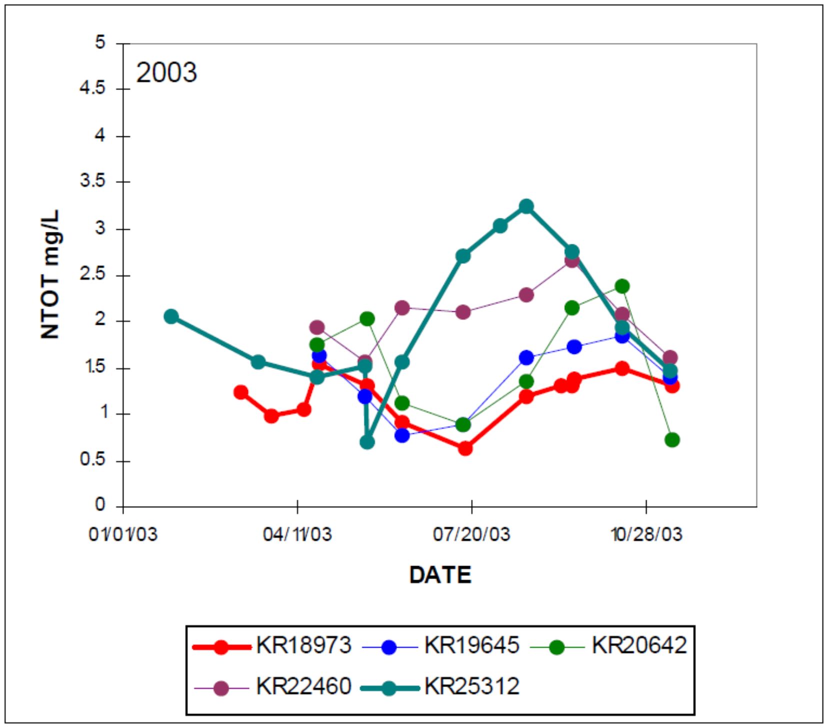

Figure A6. Observed total nitrogen values (NTOT; in mg/L) during 2003 in the Klamath River below Iron Gate dam (KR18973), above Iron Gate reservoir (KR19645), above Copco reservoir (KR20642), below J.C. Boyle dam (KR22460), and below Link dam (KR25312).

(p. 9 - 11) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
Regional Water Board staff disagrees with many of the assertions made in this lengthy comment. In our assessment of the role of reservoirs on water quality Regional Water Board staff has taken a balanced approach to evaluate both the positive and negative water quality impacts associated with the reservoirs.

1. Regional Water Board staff agrees and have stated that the reservoirs do retain nutrient loads. The comment seems to accept the rates given in Asarian et al.'s (2009) latest work, which is used in the TMDL staff report as one of the lines of evidence evaluating reservoir nutrient retention. For further discussion on this topic refer to comment B 21: Hemstreet – PacifiCorp – Impairment Assessment - Nutrients). The comment reference to the 29% retention for TP we consider to be an over-estimate and inconsistent with most lines of evidence.

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2. Regarding the assertion that the reservoirs benefit downstream reaches by reducing the growth of *Cladophora*, please refer to comment B 20 (Hemstreet – PacifiCorp – Impairment Assessment - Nutrients), which discusses other ways that the dams/reservoirs

affect periphyton besides nutrients (i.e. temperature, substrate, flow regime, light availability). The factors discussed in B20 suggest that dams can also can contribute to increased periphyton densities.

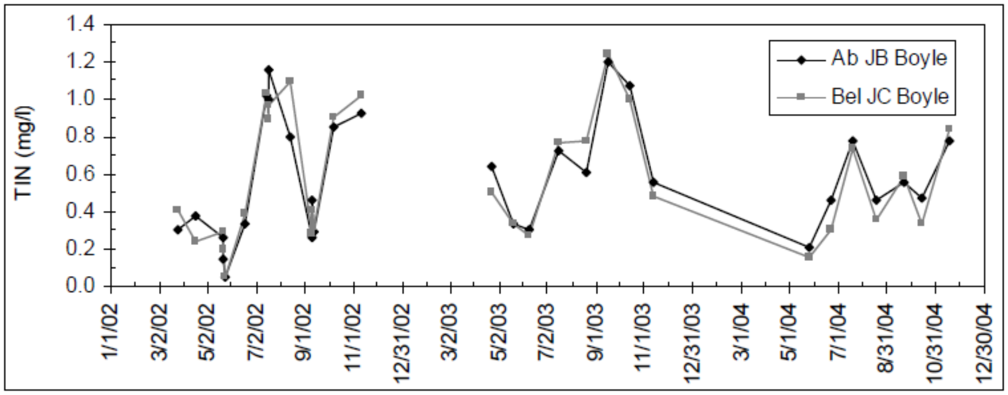
3. The mass amounts retained are large on an absolute basis. When Regional Water board staff state that the retention is "small" and "limited" we are referring to the percent retained, which is a small fraction of the total and is limited relative to other reservoirs of similar size.

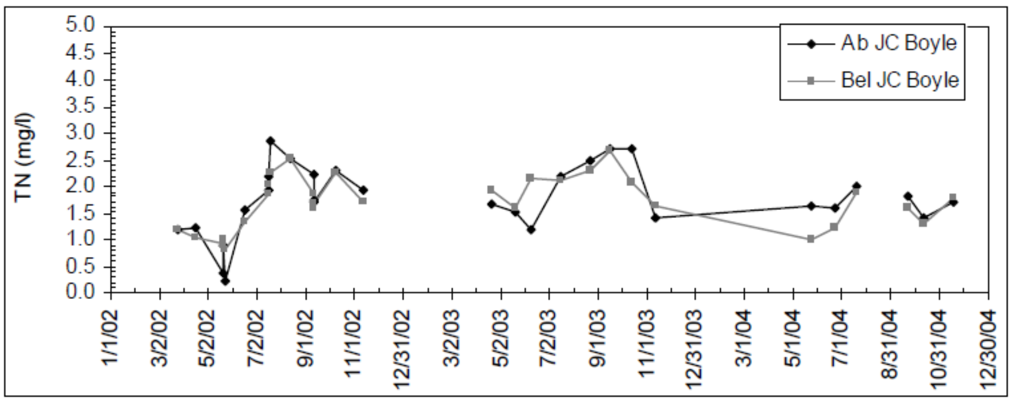
4. For phosphorus, it can be misleading to look only at annual retention, as the majority of the retention occurs in Winter-Spring, when more of the phosphorus is in particulate form. Nitrogen retention occurs throughout the year. The long-term annual retention of phosphorous is small enough that reservoir retention is not an effective control option for limiting periphyton density.

5. Reservoirs spread out event-driven spikes of nutrient loads; however, this is not necessarily beneficial in regard to algal response in the lower river. Without the dams, much of the nutrient load would move in event-driven pulses (as stated by the commenter) and a good portion of such load would flush through the system without elevating concentrations for long enough to allow full periphyton response. With the dams in, the influent load pulses are smoothed out, resulting in lower peaks, but longer periods of elevated concentrations in the river. Refer to comment response C12 for additional discussion on whether it is beneficial to capture large slugs of organic matter and meter it out slowly, and how the reservoirs can create their own internally-driven organic matter events.

6. The model simulations of "lag" by Watercourse have not been fully documented. It is clear that across all reservoirs a lag would be accumulated in the transmission of peak concentrations from Upper Klamath Lake. There does appear to be evidence to support the existence of a temporal lag in nutrient concentrations through the reservoirs (i.e., see longitudinal figures in Asarian et al. (2009). This is expected due to factors such as hydraulic residence time. However, the example that is presented in Asarian (2009) is not representative of the concept put forward in the comment model simulation. This example shows peak concentrations leaving Upper Klamath Lake in mid August, with low concentrations through the winter and spring. The 2005-2007 monitoring above Copco reported by Asarian et al. (2009) suggests that concentrations entering Copco often increase in the fall and remain elevated through about April – contrary to the pattern shown in the simulated example. In such cases the lag and associated spreading of peak concentrations caused by the reservoirs may actually serve to increase nutrient concentrations at the start of the simulation. The concentration pattern used in the simulation appears partially based on the last figure provided in the comment, for 2003. This shows an August peak in TN concentration leaving Link, with concentrations declining at the end of the year. This is based on a single measurement in early November. Further, the monitored concentrations in 2003 show winter concentrations of TN leaving Link in the range of 2 mg/L, whereas the model simulation used in the example has TN of only about 0.25 mg/L for the winter period.

The PacifiCorp model over-predicts the reduction in peak nutrient concentrations through the reservoirs, especially J.C. Boyle Reservoir (for example, compare model outputs in Figure 4-18 [same as Figure A5 in PacifiCorp's TMDL comments] in PacifiCorp [2006] *Appendix B Causes and Effects of Nutrient Conditions in the Upper Klamath River* with field data shown in Figure 4.4 of that same report), but also Iron Gate and Copco. The J.C. Boyle issue has been corrected in the TMDL model.





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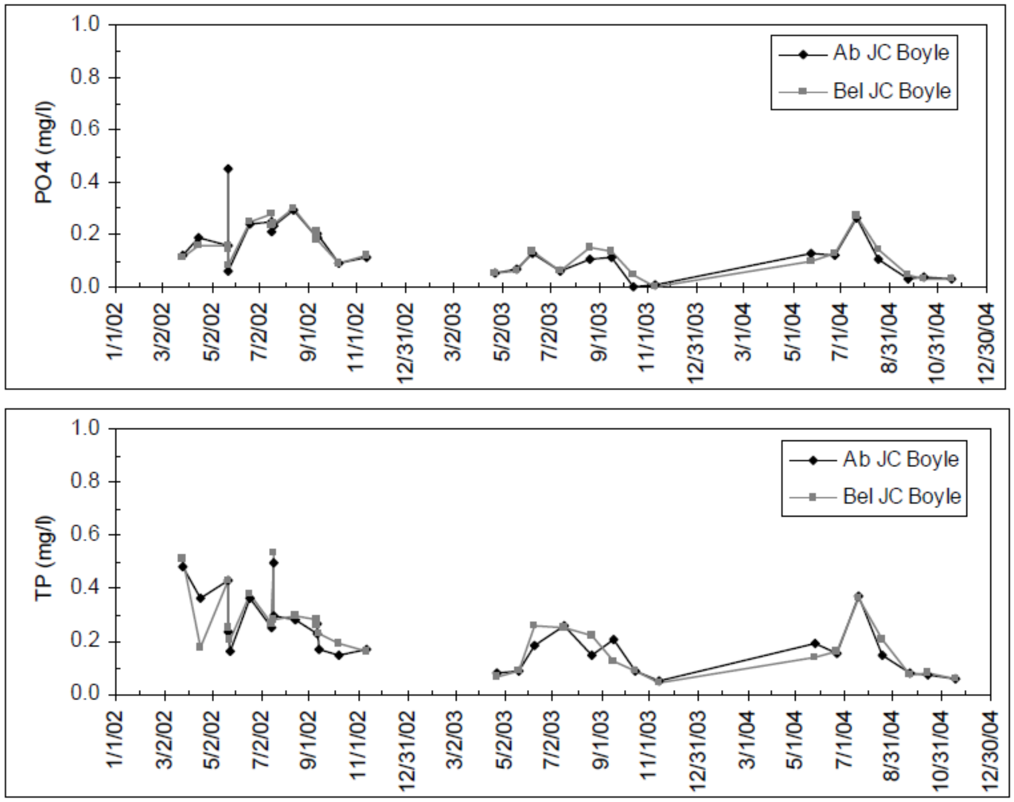

[Figure 4-4 from PacifiCorp 2006]. Observed total inorganic nitrogen (TIN), total nitrogen (TN), orthophosphate (PO4), and total phosphorus (TP) in the Klamath River above and below J.C. Boyle reservoir, 2002-2004.

7. Earlier work of Asarian and Kann is criticized for its day-by-day comparison of inflows and outflows. These criticisms have now been addressed by the refined analysis provided in Asarian et al. (2009).

8. The statement that "in the absence of the Copco and Iron Gate reservoirs, it is likely that attached benthic algae (periphyton) would increase in the river downstream of Iron Gate…" is not supported. As noted above, loads downstream might increase, but not necessarily median concentrations. Further, the argument made here neglects the fact that absence of the dams would result in more frequent scouring flows which would suppress periphyton growth. In addition, it is generally not true that periphyton standing crop begins to decline in late July or early August. There are several field data reports (Yurok 2006 and 2007, Stocking 2006) that indicate that mainstem periphyton biomass often did not reach peak levels until September (or sometimes August).

K2. <u>Comment(s):</u>

In our opinion, the only way that PacifiCorp can meet TMDL requirements, water quality objectives, and water quality targets is to remove the lower four dams. (page 2)

<u>Comment(s) Made By:</u>

Fetcho – Yurok Tribe
Crosby – Karuk Tribe
Bowman – Quartz Valley Indian Reservation

Response:
Comment noted. The Klamath River TMDL does not specify or require that KHP facilities be removed for TMDL compliance. For additional information on the proposed Regional Water Board approach to Implementation for PacifiCorp facilities refer to comment response K39.

K3. Comment(s):
I understand that under the federal Environmental Protection Agency there are no documented standards for microcystin in water quality requirements at this time and find that to utilize levels of microcystin as the prime factor in considering dam removal is unscientific and ridiculous.

Comment(s) Made By:
Gierak

Response:
The relevant standards for the inclusion of microcystin as part of the Klamath River TMDL come from the "*Water Quality Control Plan for the North Coast Region*" narrative objectives for Biostimulatory Substances ((page3-3.00) and Toxicity (3-4.00). The Regional Water Board lacks implementation authority to require dam removal to address microcystin levels. Moreover, it is premature to determine what, if any, facility modification are necessary to meet water quality standards and other applicable laws, in light of the additional studies being conducted on the Project. For more details about that process, please refer to comment K39. The development of site-specific chlorophyll *a*, *Microcystis*, and microcystin numeric targets was rigorously scientific and received very favorable review by the independent peer review panel.

K4. Comment(s):
Disagrees with the assertion that J.C. Boyle, Copco 1, Copco 2, and Iron Gate Dams are the causative factor of algae (*Microcystis*) in the Klamath River.

Comment(s) Made By:
Gierak

Response:
See response to comment K3 above.

K5. Comment(s):
Disagrees with the finding that Klamath River beneficial uses have been impacted by the presence of the dams which impede fish passage. Largest recorded run of Salmon on the Klamath River occurred in 1928 long after the dams were in place.

Comment(s) Made By:
Gierak

Response:
Regional Water Board staff does not agree with this comment. For example, both Iron Gate and J.C. Boyle dams were installed after 1928. Moreover, the Klamath River TMDL does not specifically address the presence of the dams as a fish barrier. Rather the TMDL addresses water quality conditions within the reservoirs based on existing COLD beneficial use and provisional fish passage required by the federal Endangered Species Act.

K6. Comment(s):
Lastly, while dam removal negotiations may affect how PacifiCorp complies with the TMDL, timely enforcement of the Clean Water Act is still critical in ensuring that pre-dam removal water quality conditions are adequate for fish, and that the dams are in fact removed by 2020. You are legally obligated to do everything in your power to ensure the terms of the agreement meet or exceed your strong TMDL pollution limits.

Comment(s) Made By:
Klamath Riverkeeper - Various

Response:
The Regional Water Board lacks implementing authority over the KHP. For more information on the jurisdiction and two possible regulatory pathways for the KHP, please see comment K39. Notwithstanding this lack of permitting authority, PacifiCorp has committed to implementing certain interim water quality measures in order to make reasonable progress toward TMDL compliance while further studies are conducted regarding the possibility of dam removal. The conditions of the Klamath Hydrological Settlement Agreement (KHSA) requires that PacifiCorp comply with the Klamath River TMDL. PacifiCorp is required to submit a plan following TMDL adoption to describe how they will comply with the TMDL. This plan will include a timeline that requires the approval of the Regional Water Board. The Regional Water Board is hopeful and committed to working within that process to produce water quality improvements in the interim time period while KHP infrastructure is studied. PacifiCorp and the Regional Water Board have ongoing discussions regarding interim measures that have been described in PacifiCorp's Reservoir Management Plans. In addition, PacifiCorp is participating in the development of the Klamath Basin Water Quality Accounting and Tracking Program that is anticipated to provide a central role in coordinating efforts to reduce pollutant loading in the Klamath basin. And finally, the interim measures direct the Regional Water Board, PacifiCorp, and others to work together to organize a conference on pollutant reduction strategies for the Klamath basin.

K7. Comment(s):
This TMDL is designed to further dam removal. (p. 4)

Comment(s) Made By:
Fowle

Response
Regional Water Board staff does not agree with this comment. The TMDL was designed to address water quality impairments associated with nutrients, temperature, dissolved oxygen, and *Microcystis* / microcystin. For additional information on the proposed Regional Water Board approach to Implementation for PacifiCorp facilities and two possible pathways to water quality compliance for these facilities, refer to comment response K39.

K8. Comment(s):
The Regional Board places unattainable conditions on dams forcing removals due to characteristics of a reservoir. (p. 4)

Comment(s) Made By:
Cozzalio

Response
The TMDL identifies load allocations to the reservoirs required to achieve water quality conditions that support beneficial uses. Load allocations can only require that dischargers implement water quality measures through a permitting mechanism such as waste discharge requirements or waivers of waste discharge requirements. In some instances, pollution sources may be identified and assigned a load allocation that results in a recommendation to another agency or entity if the Regional Water Board lacks authority over that pollution source. The Regional Water Board lacks permitting authority over the KHP and therefore has no enforceable mechanism to implement load allocations. Clean Water Act compliance will likely be one of several factors considered in ongoing studies on KHP infrastructure. Meanwhile, staff is recommending that PacifiCorp implement its interim water quality measures that the Klamath Hydroelectric Project Settlement Parties agreed to in the KHSA as an effective way to move toward TMDL compliance. The TMDL implementation plan allows PacifiCorp flexibility in developing an appropriate plan that accommodates various contingencies. The Regional Water Board will track progress and will not decide what, if any, long-term infrastructure modifications may be necessary for TMDL compliance until additional studies and analyses are presented. For additional information on the proposed Regional Water Board approach to Implementation for PacifiCorp facilities refer to comment response K39.

K9. Comment(s):
It has long been 'our' theory and observation that this extreme reach naturally non conducive salmon habitat is supported by factors opposite those currently considered. Those conditions for the salmon to migrate to the few historically known and marginal habitats ending at Spencer Creek are dependent upon the periphyton/algae shading/food production habitat and DO cycles/supersaturation interaction to allow migration of end run salmon in pulses. That consistency of post dams balance has aided the conditions, not degraded them. If true, then virtually every mandated implementation and outcome will be to the detriment of this upper reach 'habitat'. (p. 5)

Comment(s) Made By:
Cozzalio

Response
Regional Water board staff does not agree with this comment. Based on the best available science Regional Water Board staff has determined that these reaches are impaired for use by salmonids.

K10. Comment(s):
The Draft TMDL must be carefully tailored to ensure that it does not inappropriately attempt to encourage dam removal by threatening to impose particularly onerous obligations upon the PacifiCorp should the dams not be removed. (p. 4)

Comment(s) Made By:
Rice and Oldfield – California Farm Bureau Federation and California Cattlemen's Association

Response:
See response to comment K8. The TMDL applies allocations to the reservoirs required to achieve water quality conditions that support beneficial uses. For additional information on the proposed Regional Water Board approach to Implementation for PacifiCorp facilities, refer to comment response K39.

K11. Comment(s):
The TMDL does not project the effect of dam removal. (p. 2)

Comment(s) Made By:
Morris- Siskiyou County Farm Bureau

Response:
This comment is correct. A modeling scenario using existing conditions with dams out was not needed to develop the allocations needed for the TMDL scenario and therefore this scenario was not included in the model runs.

K12. Comment(s):
While the discussions on page 2-60 note that the chlorophyll-a target of 10 ug/L is exceeded at reservoir stations in California and Oregon, the text should also note that while the target is not exceeded in the Klamath River between Boyle and Copco Reservoirs, it is exceeded at the below Iron Gate Dam station and at I-5, indicating that Iron Gate Reservoir is releasing algae into the river below it. (p. 5)

Comment(s) Made By:
Fetcho – Yurok Tribe
Crosby – Karuk Tribe
Bowman – Quartz Valley Indian Reservation

Response:
Figure 2.22 of the TMDL staff report illustrates this point; the elevated levels of chlorophyll *a* below Iron Gate reservoir are noted on page 2-61.

K13. Comment(s):
In discussing internal nutrient loading, it is stated on page 4-17 that "High pH at the sediment surface may cause release of adsorbed phosphorus from sediments, with or without agitation of sediments." This sentence should be a candidate for deletion since it may not be relevant to Copco and Iron Gate Reservoirs. (p. 9)

Comment(s) Made By:
Fetcho – Yurok Tribe
Crosby – Karuk Tribe
Bowman – Quartz Valley Indian Reservation

Response:
This section has been largely revised and the sentence referenced in the comment is no longer included in the text. However pH conditions at the sediment water interface do reach levels that allow desorption of phosphorus from the sediments.

K14. Comment(s):
Thus, an argument could be made that PacifiCorp's allocation is not sufficiently restrictive and that if PacifiCorp wants to keep its reservoirs in place, then the TMDL should require PacifiCorp to reduce nutrients down to levels where blue-green algal blooms would not occur in its reservoirs -- regardless of the actions of other upstream entities. This is probably a moot point, however, because, in our opinion, there is no way for PacifiCorp to meet its temperature allocations other than through dam removal. Thus, the magnitude of PacifiCorp's required nutrient reductions is only of minor importance, and the amount currently proposed in the TMDL would appear reasonable. (p. 12)

Comment(s) Made By:
Fetcho – Yurok Tribe
Crosby – Karuk Tribe
Bowman – Quartz Valley Indian Reservation

Response:
Comment noted. For additional information on the proposed Regional Water Board approach to Implementation for PacifiCorp facilities refer to comment response K39.

K15. Comment(s):
The only way to ensure safe passage through the reservoir is to meet the water quality objectives of the Basin Plan throughout the reservoirs. (p. 12)

Comment(s) Made By:
Fetcho – Yurok Tribe
Crosby – Karuk Tribe
Bowman – Quartz Valley Indian Reservation

Response:
Regional Water Board staff consulted with fisheries biologists and the literature in developing the guideline for the compliance lens load allocation. We believe the existing proposal meets the objectives of protecting the beneficial use.

K16. Comment(s):
In the discussion of the compliance lens we suggest that more emphasis be placed on the requirement to meet the DO and temperature allocations simultaneously, both spatially and temporally. (p. 3)

Comment(s) Made By:
Hashimoto and Ziegler – USEPA

Response:
Section 5.3.2.2 has been revised to clarify the requirements related to the compliance lens.

K17. Comment(s):
Without dam removal in the bag, PacifiCorp has a large and costly cleanup responsibility, and should not be allowed to make it disappear by investing in techno-fixes, writing its own cleanup plans or monitoring its own progress. (p. 3)

Comment(s) Made By:
Terrence – Klamath Riverkeeper

Response:
The Klamath River TMDL Implementation and Action Plan will be developed in conjunction with PacifiCorp to ensure that mitigation and monitoring addresses TMDL compliance and that monitoring and reporting is transparent to the public. For additional information on the proposed Regional Water Board approach to Implementation for PacifiCorp facilities refer to comment response K39. In addition, the Regional Water Board and other stakeholders are working with PacifiCorp to develop each year a mainstem monitoring plan for the Klamath mainstem from Link River to the mouth for baseline, trend, and public health objectives. PacifiCorp provides $500,000 a year for this monitoring program which will continue until dam removal in 2020. And finally the Klamath Basin Monitoring Program, composed of a large number of entities throughout the basin have developed a basinwide comprehensive monitoring program that hopefully will continue to provide critical information on progress towards Klamath River recovery.

K18. Comment(s):
Section 6.3 Implementation of Allocations and Targets- Klamath Hydroelectric Project and Iron Gate Hatchery: On November 13, 2008, the California Natural Resources Agency, along with the United States Department of Interior, the State of Oregon, and PacifiCorp executed an Agreement in Principle (AIP) describing a framework for removing four of the Klamath River dams owned and operated by PacifiCorp. Since that time, parties in support of the AIP have been developing the Final Hydropower Agreement, expected to be signed by the end of September 2009. DFG considers this progress along the path toward removal of four mainstem dams the most effective, long term approach to address load allocations ultimately assigned to PacifiCorp's KHP. (p. 7)

Comment(s) Made By:
Stacey – California Department of Fish and Game

Response:
Regional Board staff agrees that if the dams are removed, subject to additional studies, load allocations would either be met, or no longer applicable in the absence of the facility. Section 7.6 of the KHSA identifies dam removal as the final compliance measure for Oregon and California TMDLs. The Klamath TMDL implementation plan specifies that if Parties move forward with dam removal, the Regional Water Board will review the issue in light of additional studies before approving this action. For additional information on the proposed Regional Water Board approach to Implementation for PacifiCorp facilities refer to comment response K39.

K19. Comment(s):
Section 6.3.1 Allocations and Targets: Some of the proposed approaches to implement allocations concern DFG.

The description of a proposed in-reservoir compliance lens does not include calculations of the actual volumes of water necessary to achieve the DO and temperature load allocation. Based on DFG's understanding of the concept, this approach could require large volumes of water to implement and maintain the compliance lens continuously within the reservoir. In turn, maintaining a given DO and temperature allocation could compromise the ability of the next downstream party to meet their respective load allocation. In the case of Iron Gate Reservoir, the IGH is immediately downstream, and as discussed in detail earlier in this memo, the hatchery cannot be responsible for the quality of water received from the KHP, DFG recommends consideration of other alternatives for setting in-reservoir allocations for DO and temperature that do not rely on prolonged management of large quantities of water. (p. 7, 8)

Comment(s) Made By:
Stacey – California Department of Fish and Game

Response:
The Regional Water Board provided an instantaneous DO mass calculation for the compliance lens based on year 2000 meteorological conditions. The compliance lens is required during the TMDL critical period, which coincides with the period of reservoir stratification, May through

September. The oxygen mass is required for supporting DO conditions within the compliance lens at a depth where the supporting temperature occurs. However, the compliance lens allocation did not account for years and periods when there is insufficient cold water within the hypolimnion to support compliance lens volume. Under normal conditions it is anticipated that the compliance lens would not require any additional water inputs external to the reservoir (other than normal upstream flows). Any contingency requiring additional cool water would need to be balanced against downstream uses. Since meteorological and in-reservoir water quality conditions are dynamic and change on a daily basis the instantaneous DO mass necessary to maintain the lens at the temperature boundary depth will cause the required DO input to fluctuate. PacifiCorp will need to monitor compliance lens conditions and ensure adequate oxygenation of the lens. This approach is not likely to negatively impact the ability of downstream users to meet allocations. Nevertheless, NPDES discharges are often required to remove constituents present in upstream water before discharging in order to meet water quality standards.

K20. Comment(s):
Section 6.3.1.3 Implementation
As stated previously, DFG is committed to developing a Final Hydropower Agreement providing for the removal of all KHP facilities discharging pollutants into the mainstem Klamath River in California. This effort will require consideration of a broad array of regulations, legislation, policies, and scientific investigations. Given this scope, the AIP targets actual removal beginning in 2020. In the near term, the AIP provides for interim measures to be implemented prior to dam removal to protect water quality in the Klamath River. These measures include:

- Annual water quality monitoring including Blue-Green Algae (BGA) and BGA toxin monitoring;
- Investigation of nutrient reduction measures such as wetlands, aeration-oxygenation systems and reservoir circulation;
- A 2009 water quality technical conference focused on nutrient enrichment and nutrient reduction strategies; and
- Turbine venting at Iron Gate Dam.

DFG recommends the Regional Board include these proposed interim actions in the suite of short term measures under consideration. It is anticipated that reaching a Final Hydropower Agreement by September 2009 would trigger implementation of these measures, while also providing support for a long term and comprehensive approach to addressing water quality issues in the Klamath basin. (p. 8)

Comment(s) Made By:
Stacey – California Department of Fish and Game

Response:
The Regional Water Board is not a party to the Final Hydropower Agreement but has reviewed the proposed interim measures and the original PacifiCorp Reservoir Management Plans where the measures were originally described. The Regional Water Board has provided to the AIP

parties an evaluation of these interim measures relative to their ability to achieve TMDL compliance. The form of the evaluation was to assess RMP measures including upstream nutrient offsets (e.g., constructed wetlands treatment) against each TMDL allocation and target. Each RMP measure was assigned a feasibility ranking by Regional Water Board staff. The following feasibility ranking scale was used in this process: 1) Viable – recommended; 2) Uncertain – further study needed; and 3) Not viable – not recommended. In-reservoir measures such as epilimnion circulation were assigned ratings of 2 or 3, upstream offsets were assigned a rating of 1. The full evaluation summary table (Recommended Implementation Measures for PacifiCorp Compliance with the Klamath TMDL) has been included as Attachment 3. Regional Water board staff believes that this summary continues to accurately reflect their evaluation regarding the viability of RMP and interim measures to meet TMDL compliance goals and to improve water quality in any interim period prior to potential dam removal activities. For more detail on KHP implementation, please see K39.

K21. Comment(s):

There appears to be an error in the flow data presented on page 4-21 for various locations associated with Iron Gate Hatchery operations. The calculations used to convert units from millions of gallons per day (mgd) to cubic feet per second (cfs) appear to be erroneous, and the cfs numbers require correction. For example, it is erroneously stated that "Average flows through the hatchery system are 16.1 million gallons per day (mgd) (1494.6 cubic feet per second [cfs])", where the correct number should be 25 cfs (calculation: 16.1 mgd * 1.55 cfs/mgd = 25 cfs). (p. 9)

Comment(s) Made By:

Fetcho – Yurok Tribe
Crosby – Karuk Tribe
Bowman – Quartz Valley Indian Reservation

Response:

The cited text is in error and is due to a transcription error from the original EXCEL spreadsheet calculation. In addition, the Regional Water Board after consulting further with CDFG have determined that the average flow through the system is 12 million gallons per day (see comment K22). The text has been revised in the updated staff report.

K22. Comment(s):

Section 4.2.3 Iron Gate Hatchery: DFG believes there may be a math error in the discharges from the hatchery. On average, IGH discharges 12 million gallons per day (mgd) which equals 18.6 cubic feet per second (cfs). The TMDL states the hatchery discharges 1494.6 cfs. This is often more than the flow of the Klamath River below Irongate Dam. The hatchery loads are minimal compared to inputs from the reservoirs above them. For this reason, the model does not include them in the TMDL. (p.3, 4)

Comment(s) Made By:

Stacey – California Department of Fish and Game

Response:
The cited text is in error and is due to a transcription error from the original EXCEL spreadsheet calculation. In addition, the Regional Water Board after consulting further with CDFG have determined that the average flow through the system is 12 million gallons per day (see comment K22). The text has been revised in the updated staff report.

K23. Comment(s):
4.2.3.1 Temperature: The Regional Board does not require temperature monitoring of the IGH effluent and states, "Thus, no temperature data are available to evaluate the effects of the hatchery effluent on the Klamath River. Regardless, because the discharge of the elevated temperature waste is not allowed per the interstate water quality objective for temperature, any effluent discharged to the river at a higher temperature than the river exceeds the objective."

DFG disagrees with this statement based on the following:

1. Water temperatures at the hatchery are measured in accordance with the IGH Monitoring and Reporting Program.

2. The Water Quality Control Plan North Coast Region 1 (Basin Plan) discusses controllable water quality factors. Controllable water quality factors are those actions, conditions, or circumstances resulting from man's activities that may influence the quality of the waters of the State and that may be reasonably controlled. The Basin Plan water quality objectives for Temperature in COLD interstate waters states, "At no time or place shall the temperature of any COLD water be increased by more than 5^{o} F above natural receiving water temperature."

Based on the quality of water which is supplied to IGH from the Iron Gate Reservoir, the hatchery effluent temperatures are not controllable factors. Additionally, based on the proportions of the water discharged from the hatchery compared to the flow in the Klamath River, the IGH discharges could not physically raise the temperature of the Klamath River by more than 5^{o} F, as allowed in the Basin Plan. It is not consistent with the Basin Plan to state that any effluent discharged to the river at a higher temperature than the river exceeds the interstate objective. Based on hatchery measurements, water discharged from IGH is generally lower than temperatures of the Klamath River. Cold water discharged from IGH has the ability to create cold-water refugia downstream of the hatchery. (p.4)

Comment(s) Made By:
Stacey – California Department of Fish and Game

Response
1. The text has been modified to state the following:

Iron Gate Hatchery effluent temperatures were not measured prior to 2008. Effluent temperatures are currently measured as quarterly grab samples. Thus, adequate temperature data are not available to evaluate the effects of the hatchery effluent on the Klamath River.

Regardless, because the discharge of elevated temperature waste is not allowed per the interstate water quality objective for temperature, any effluent discharged to the river at a higher temperature than the river exceeds the interstate objective.

2. There are two water quality objectives for temperature that apply to the Klamath River, as explained in section 2.2.1.2. The first is the interstate temperature objective, which prohibits the discharge of elevated temperature waste. The interstate water quality objective is found in the *Water Quality Control Plan for Control of Temperature in the Coastal and Interstate Waters and Enclosed Bays and Estuaries of California*, which is incorporated into the Basin Plan as an appendix.

The second water quality objective for temperature is the intrastate temperature objective found in the Basin Plan. CDFG's characterization of the intrastate objective is incomplete. The full text of the objective states:

"The natural receiving water temperature of intrastate waters shall not be altered unless it can be demonstrated to the satisfaction of the Regional Water Board that such alteration in temperature does not adversely affect beneficial uses.

At no time or place shall the temperature of any COLD water be increased by more than 5°F above natural receiving water temperature.

At no time or place shall the temperature of WARM intrastate waters be increased more than 5°F above natural receiving water temperatures."

The 5°F temperature criteria only applies after a demonstration that a temperature increase can be accommodated without adversely affecting beneficial uses. Regardless, the interstate objective prohibits the discharge of thermal waste.

Regional Water Board staff disagree that the hatchery discharge is not a controllable factor. The hatchery and the hydropower project that it is intended to mitigate are all controllable water quality factors, as evidenced by the KHSA.

As a practical matter, if the hatchery is discharging water colder than the river, then the discharge meets the waste load allocation and is compliant with water quality standards.

TMDL compliance will be addressed during the process of revising and updating the hatchery's NPDES permit.

K24. <u>Comment(s):</u>
Section 5.1.1.1 Temperature Numeric Targets: Chapter 5, Allocations and Numeric Targets specifies a temperature load allocation to IGH of: "zero temperature increase above natural temperatures". Subsequently, Chapter 5 defines the monthly average temperatures, equal to the temperatures associated with the Klamath River just downstream of Iron Gate Dam, and are calculated from the California compliance scenario as the target for IGH. This approach does not

acknowledge the actual routing of water through the IGH facilities. The water received by the hatchery is from two locations within Iron Gate Reservoir. This hatchery supply water is not always comparable in quality to water in the Klamath River below Iron Gate Dam which generally flows from PacifiCorp's penstock.

Specifically, there are two intakes for IGH, a deep intake located approximately 70 feet below the reservoir surface and a shallow intake about 13 feet from the surface. These hatchery water sources are distinct from the mid-range intake for the powerhouse penstock. It is the temperature of the water the hatchery receives from Iron Gate Reservoir that should constitute the benchmark for determining the hatchery contribution to water quality parameters.

Additionally, instead of setting a "no allowable temperature increase," DFG proposes a temperature load allocation comparable to what is proposed for the Klamath hydroelectric Project (KHP) Iron Gate Reservoir. Such an approach would limit the IGH allocation to a 0.1 Celsius increase (daily average and daily maximum). Compliance with the proposed temperature allocation should be determined at a point after the intake water has had a chance to mix and prior to entering the hatchery. This will allow for an accurate determination of potential temperature loading from IGH operations. (p.5)

Comment(s) Made By:
Stacey – California Department of Fish and Game

Response:
The comparison of hatchery effluent water quality to Klamath River water quality at or near the point of discharge is appropriate for evaluating compliance with the water quality objectives for temperature. The compliance criteria, including the issues noted in the comment, will be addressed during revision and update of the hatchery's NPDES permit.

K25. Comment(s):
Section 5.1.1.2 and Table 5.1 Dissolved Oxygen and Nutrient-Related Numeric Targets: DFG disagrees with how this target was calculated, IGH water imported from the 70-foot valve is nutrient enriched and oxygen depleted. The water is aerated prior to use at the hatchery by means of an aeration tower below the dam. All numeric targets should be a net contribution for IGH with the net value based on the quality of the water received by the hatchery compared to the quality discharged Additionally TMDL targets are based on the "dams out" scenario and are not controllable or practicable factors which the IGH can change. (p.5)

Comment(s) Made By:
Stacey – California Department of Fish and Game

Response:
TMDL waste load allocations must be incorporated into relevant NPDES permits. In this case, the hatchery waste load allocations are based on water quality compliant conditions in the receiving water, the Klamath River. However, because the waste load allocations will constitute new effluent limits for the hatchery, the revised permit can also incorporate schedules that allow

time for the discharger to come into compliance. The Regional Water Board anticipates that such a compliance schedule would be developed for this permit.

K26. Comment(s):
Section 5.1.2.2 Dissolved Oxygen, Nutrient and Organic Matter Loading Capacity, Allocations, and Margin of Safety: Additional temperature and dissolved oxygen and nutrient load allocations are assigned to the reservoirs to keep the reservoir results within compliance, yet there are no site-specific allocations specified to keep the IGH in compliance. All allocations are zero for the IGH. There must be an allowance made for the poor quality water which the hatchery is receiving from the Iron Gate Reservoir. The intake water is not a controllable factor for the IGH. It is not practicable for the hatchery to release water which is cleaner than the water it receives. These concentration targets are listed in Table 5.14 and Table 5.15. These targets reflect California compliance conditions with no dams. Allowances must be made for the period of time it will take to get the dams out as well as the water quality at the hatchery intake. Additionally the numeric targets shown in Table 5.15 are lower than Basic Labs reporting limits in the case of carbonaceous oxygen demand (CBOD) and total phosphorous (TP). (p.6)

Comment(s) Made By:
Stacey – California Department of Fish and Game

Response:
See response to comment K25.

K27. Comment(s):
Section 5.2.3 Temperature Numeric Targets and Load Allocations to Copco 2 and Iron Gate: The reservoir compliance targets and allocations are expected to be achieved gradually over time and the TMDL acknowledges that, "Because upstream heat loads are outside of the control of the dam operators (PacifiCorp), the allocations apply to the condition of the water as it enters the reservoirs." IGH should have the same benefit of all allocations applying to the condition of the water as it enters the hatchery intake. (p.6)

Comment(s) Made By:
Stacey – California Department of Fish and Game

Response:.
See response to comment K25.

K28. Comment(s):
Section 5.2.4 Temperature Numeric Targets and Waste Load Allocations to Iron Gate Hatchery: The temperature allocated for IGH equals zero increase above natural temperatures. Net values are needed for the hatchery with allocated temperature increases that also correspond to the natural temperature increases. (p.6)

Comment(s) Made By:
Stacey – California Department of Fish and Game

Response:
Comment noted. The compliance criteria will be defined during revision and update of the hatchery's NPDES permit.

K29. Comment(s):
Section 5.3.3. Dissolved Oxygen and Nutrient-Related Numeric Targets and Waste Load Allocation to Iron Gate Hatchery: The DO targets for IGH were established at a point just above Bogus Creek. The sampling point needs to be one of the regular monitoring points consistent with the NPDES permit. The sample point in the Klamath River is contaminated by back-flow from Bogus Creek.

The zero net increase of nutrient and organic matter loads are based upon the compliance condition of no dams just downstream of where Iron Gate Reservoir is currently located. IGH cannot meet these Nutrient and Organic Matter Monthly Mean Concentrations Targets *(mg/L)* without an allowance which incorporates the quality of the intake water. IGH receives poor quality water, and this is not a controllable factor for the hatchery.

The DO numeric targets in Table 5.14 are significantly higher than the specific water quality objectives listed in the Basin Plan for the Klamath River below Iron Gate Dam. It is not practicable for the IGH to meet these higher targets. (p.6)

Comment(s) Made By:
Stacey – California Department of Fish and Game

Response:
This compliance point sampling location issue will be addressed as part of revising and updating the hatchery NPDES permit.

The DO numeric targets are based on the CA compliance run of the Klamath TMDL model. The compliance scenario models the water quality conditions that will be achieved as a result of implementation of the TMDL both in Oregon and California. Further, the compliance scenario is modeled as if the dams are removed. According to the model, the result in California is water quality that exceeds the water quality objectives in some months. For this reason, the DO targets at the Iron Gate Hatchery also exceed the water quality objectives in some months. (Please note that the Appendix 1 of the Klamath TMDL staff report describes a proposal to the Regional Water Board to amend the basin plan by removing the existing Site Specific Objectives (SSOs) for DO in the mainstem Klamath and replacing them with recalculated SSOs).

As a practical matter, while the dams are still in, the Iron Gate Hatchery occasionally receives from the tailrace water which is low in DO and must be aerated. The Iron Gate Hatchery may not be able to consistently meet high DO targets during those times when inflow is of poor quality. The Regional Water Board staff have discussed this issue with the Department of Fish and Game and are considering mechanisms for addressing this as part of revising and updating the hatchery NPDES permit.

K30. Comment(s):
Section 6.3.2.3 Implementation: It is encouraging to note the TMDL acknowledges the new NPDES permit may allow additional time needed for DFG to make infrastructure improvements to IGH. It also discusses intermediate milestones for pollutant reductions in the hatchery discharges which may include:

1. Improving effluent water quality to the level of the intake water to the hatchery; and
2. Meeting current receiving water quality in the Klamath River at the point of discharge. IGH may have the option of achieving some or all of its load reductions through offset mitigation if the potential changes to hatchery operations are limited in their ability to effectively reduce pollutant loads. Any offset mitigation would be coordinated through the Klamath River water quality improvement accounting and tracking program.

As stated previously, DFG has documented temperatures in Bogus Creek higher than the Klamath River below the dam, and it is not clear where the proposed target temperatures would be measured. Further, IGH is a *mitigation facility* for the KHP and has no influence over the operation of the KHP or the resulting temperature of the water in Iron Gate Reservoir at the hatchery intakes. Accordingly, the only meaningful numeric temperature targets would be those assigned to the KHP.

As discussed in our comments on Chapter 5, Allocations and Numeric Targets, the TMDL specifies zero net nutrient and organic matter loading. IGH nutrient and organic matter discharge quality must equal the quality of intake water to the facility. Currently, CBOD is sampled at IGH Influent Monitoring site 004 and then compared to the Effluent Discharge sites of 005 and 006. The raceway effluent site 005 samples are taken downstream of the raceway discharge, while the settling pond effluent site 006 is just downstream of Bogus Creek. As described previously, Bogus Creek is a major influence on water quality that impacts the downstream water quality sampling sites.

To address this challenge, DFG recommends initiating monthly mean average standards for total phosphorus, total nitrogen, and CBOD with a net difference from sampling site 008 (at the Lake View Road Bridge) or Bogus Creek, whichever is higher, from the downstream sampling site of 009. Downstream sampling site 009 may be the preferred effluent sampling site because all IGH water has mixed at this point; however this would necessitate subtracting Bogus Creek effluent values. DFG also recommends including CBOD sampling for sites 008, 009 and Bogus Creek. (p. 9)

Comment(s) Made By:
Stacey – California Department of Fish and Game

Response:
Regional Water Board staff agree with points 1 and 2 above.

The numeric temperature targets for the Iron Gate Hatchery are equal to the numeric temperature targets for the Iron Gate tailrace.

The monitoring and compliance program developed by the Regional Water Board for the TMDL and the NPDES permit will account for inputs from Bogus Creek. DFG recommendations and observations with respect to compliance monitoring will be considered during permit revision and update.

K31. Comment(s):

Section 4.2.3 Iron Gate Hatchery: Bogus Creek often experiences temperature and turbidity much higher than that in the mainstem of the Klamath River. However, Bogus Creek is not mentioned in the TMDL as a contributing factor to the Klamath River water quality impairment or the hatchery effluent water quality as measured at the gage downstream from both sources. (p.3)

Only by factoring in the parameters of Bogus Creek and accounting for these influences can an accurate reading be obtained of the potential contribution the IGH effluent has on the Klamath River. Alternatively, hatchery effluent samples could be obtained and compliance determined within the discharge piping of the settling ponds instead of within the Klamath River, isolating the Bogus Creek influence. (p.3)

Monitoring stations below the IGH also include inputs of nutrients from Bogus Creek and these inputs must be subtracted out to determine the true loading from hatchery inputs. Settling ponds are used when IGH cleans the ponds or treats the fish with any chemical to remove organic inputs, suspended and settleable solids as well as fish feed from the discharge. (p.4)

Comment(s) Made By:

Stacey – California Department of Fish and Game

Response:

The inputs from Bogus Creek will be reconsidered once additional monitoring data becomes available. Through the TMDL adaptive management and reassessment process allocations and targets can be reconsidered as new information or studies become available. See also response to comment K30.

K32. Comment(s):

Page 4-21, Paragraph 3, Line 7. There is a serious error in calculation of flow through the hatchery reported here. Actually, 16.1 mgd really equals 24.9 cfs, not “1,494.6 cfs”. (p. 35) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:

Hemstreet – PacifiCorp

Response:
The error is a result of a transcription error from the spreadsheet calculations. The text has been revised to reflect the correct calculations. However, the Regional Water Board staff have reviewed the most current information on hatchery discharges and are currently using the daily flows through the rearing facility (12.1 million gallons per day - see CFG comment K22 above).

K33. Comment(s):
Page 4-21. Paragraph 4, Lines 6-9. Average flows through the hatchery are less than 50 cfs with maximums up to approximately 50 cfs. The draft TMDL states that average flow through the hatchery are 1,494.6 cfs and maximum flows are 2,961.4 cfs. (p. 35) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The text has been revised to provide the correct calculations.

K34. Comment(s):
Page 4-21. Paragraph 6, Lines 2-3. Please contact California Department of Fish and Game staff at the Iron Gate Hatchery. They have twice daily temperature readings which they use to manage water supply and temperature for the hatchery. (p. 35) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
Regional Water Board staff has the daily intake temperatures, it is the discharge temperature data that is unavailable. Regional Water Board staff will be working with CDFG to establish a monitoring and reporting program as part of the updated NPDES permit.

K35. Comment(s):
Page 4-22, Paragraph 1, Line 6. The Draft TMDL states here that the average flow in the hatchery is 7.5 mgd, but on page 4-21 it says the average flow through the hatchery is 16.1 mgd. (p. 35) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
There are various flows through the hatchery operation. Not all of the flows are included in the TMDL. The TMDL includes flows through the raceways and incubation building (12.1 million

gallons a day). The text has been revised to reflect the 12.1 million value. See comment K22 above.

K36. Comment(s):
Page 4-22, Paragraph 2, Line 4. On page 4-22 the average flow through the hatchery was stated as 16.1 mgd, yet here it is stated at 7.5 mgd, considerably smaller. (p. 35) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
There are various flows through the hatchery operation. Not all of the flows are included in the TMDL. The TMDL includes flows through the raceways and incubation building (12.1 million gallons a day). The text has been revised to reflect the 12.1 million value. See comment K22 above.

K37. Comment(s):
Page 4-22, Paragraph 3, Lines 1-5. No data are presented for the hatchery discharges, not even the difference. The only information provided is the p-statistic for the statistical test applied. Further the Mann Whitney U Test is to assess if two populations are different and not to assess the differences between two populations. (p. 35) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The data used in the hatchery analysis is from 2004, the samples were taken by Regional Water Board staff as part of a preliminary evaluation of hatchery operations. The data is available upon request. The analysis will be updated using additional data collected since the 2004 as part of the process to update the IGH NPDES permit. The Mann Whitney U test was applied appropriately to determine if the two populations were different – the text has been revised to accurately reflect this analysis.

K38. Comment(s):
On page 6-15, the Draft TMDL discusses implementation for allocations associated with the Iron Gate Hatchery. On September 14, 2007 PacifiCorp submitted a revised Monitoring and Reporting Plan (MRP) per Water Code Section 13267(b) Order issued by the Regional Board. PacifiCorp has been following the requirements of this proposed MRP since January 2008 per the terms of the Settlement Agreement with the Klamath River Keeper. In addition, PacifiCorp submitted the results of the 2007 chemical pollutant scan to the Regional Board per the 13267(b) Order referenced above. PacifiCorp considers these submittals to the Regional Board as necessary steps towards working towards the issuance of a renewed NPDES permit for the

hatchery. PacifiCorp will continue working with the Department of Fish and Game and the Regional Board to assess discharge from the Iron Gate Hatchery through the NPDES renewal process addressing the need for additional measures, if necessary. (PacificCorp – Appendix A and B.doc) (This comment was also inserted into the Legal and Policy Issues.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
Regional Water Board staff agrees with this comment.

K39. Comment(s):

- Pacific Corp submitted comments on the schedule and timing of the Implementation Plan as it relates to the KHP. PacifiCorp states that the implementation language is vague, objects to the 60-day time period for it to submit its plan for Regional Water Board approval, questions the timing as it relates to the Oregon TMDLs, and indicates its intent to work with Regional Board staff to better refine the implementation timeline to account for differing Project outcomes.

- Also, because the Draft TMDL fundamentally links its success to the Oregon TMDLs, it is premature for the Regional Board to seek comments on their TMDLs for California, and proceed further with development of these TMDLs without the Upper Klamath River TMDL in Oregon also being completed and available for review.

- Page 6-11 to 6-14. The implementation discussion is vague with respect to the Klamath Hydroelectric Project. The 60 day period listed on page 6-14 for PacifiCorp to submit its implementation plan is way too short, and unprecedented. Eighteen (18) months is more common, consistent with EPA TMDL guidance.

- Even as the TMDL is still under development, PacifiCorp is already proactively implementing important water quality measures and activities designed to bring about substantial water quality improvements in the Klamath River basin. PacifiCorp has and will continue to implement these measures and activities under a number of separate but related commitments, including elements of the Agreement in Principle (AIP), the Interim Conservation Plan (ICP), Reservoir Management Plans (RMP), as well as other planned activities. PacifiCorp acknowledges that the measures proposed in the AIP and ICP are premised on a dam removal outcome as described in the AIP, and that a different Project outcome may require different Project-related measures under the TMDL and subsequent Implementation Plan. PacifiCorp intends to work with Regional Board staff to ensure that the final Implementation Plan adequately considers and accommodates different Project outcomes.

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
KHP implementation will occur under one of two possible regulatory paths and in both cases under the decision making authority of agencies other than the Regional Water Board. The two possible tracks are the hydropower relicensing proceeding and the settlement agreement approach. It is important to understand that both of these tracks involve decisions made in larger contexts that include consideration of other issues such as endangered species needs, and power, in addition to Clean Water Act and TMDL compliance. While the Regional Water Board will decide whether a proposed implementation plan submitted by PacifiCorp is satisfactory for TMDL compliance, Regional Board approval must occur in the context of these other processes. Because the regulatory process and outcome of the settlement negotiations is largely outside of the Regional Water Board's control, the Klamath River TMDL Implementation Plan attempts to accommodate various alternatives, which may explain why the language is vague. The two regulatory paths are described below, followed by suggestions for the incorporation of certain elements into PacifiCorp's proposed implementation plan.

The KHP is licensed by the Federal Energy Regulatory Commission (FERC) with a license that expired on March 1, 2006. The KHP continues to operate under an annual license until renewal. FERC is authorized and empowered to issue licenses for hydroelectric projects to promote the development, transmission, and utilization of power with equal consideration to the purposes of energy conservation, the protection, mitigation of damage to, and enhancement of, fish and wildlife, recreational opportunities, and the preservation of other environmental qualities. (16 U.S.C.§ 797(e).) All licenses are issued on the condition that the project, as adopted, shall be, in the judgment of the Commission, best adapted to a comprehensive plan for improving or developing a waterway for the benefit of interstate commerce, power-development, protection, mitigation, and enhancement of fish and wildlife, and for other beneficial public uses. (16 C.F.R. § 803(a).)

In 2004, FERC prepared a Final Environmental Impact Statement (FEIS) that describes the positive and negative environmental effects of the proposed action to relicense the continued operation of the KHP, and alternative actions, including decommissioning all or part of the project. Clean Water Act compliance for FERC-regulated hydropower facilities is implemented through Clean Water Act section 401 water quality certification process by the State Water Board. (See Resolution No. 2007-0028 and Supplemental Analysis [declining petition requesting Regional Board to issue waste discharge requirements for the KHP].) As part of the 401 certification proceeding, the State Water Board is preparing an Environmental Impact Report (EIR) since the FEIS does not fully comply with CEQA (State Water Board 2008). The FEIS will form the basis of the EIR, and the State Water Board has initiated the process of soliciting information from stakeholders regarding the adequacy of the FEIS and the scope of the EIR. The EIR will evaluate four alternatives for operating the KHP, two of which include removal of two and four of the KHP dams, respectively. As authorized by section 401, the State Water Board will apply appropriate state water quality requirements through the FERC licensing proceeding as part of its decision to issue or deny water quality certification. Regional Water Board staff participates in the FERC relicensing and 401 process to provide information and consultation to ensure that the KHP meets water quality standards and other Basin Plan requirements. While the Regional Water Board may participate and comment in this proceeding, we cannot predict or determine the ultimate decision that these jurisdictional agencies will make, and therefore, the TMDL Implementation Plan must provide flexibility to accommodate these processes that govern the relicencing. Under the FERC/401 track, TMDL implementation should defer to this process.

At the same time, certain parties have been engaged in settlement negotiations that contemplate the voluntary removal of the KHP. This Agreement stemmed from a larger negotiation of the Klamath Basin Restoration Agreement (KBRA) that addresses water rights issues in Oregon. Completion of the KBRA was contingent on completion of the Hydroelectric Settlement Agreement. On November 13, 2008, an Agreement in Principle (AIP) to remove four of the Klamath River dams (JC Boyle, Copco 1 and 2, and Iron Gate) was announced after negotiations between the representatives of the federal government, the state of California, the state of Oregon, and PacifiCorp. The Regional Water Board was not a party to the negotiations. On September 30, 2009 a draft Klamath Hydroelectric Settlement Agreement was released. (Documents are available at http://www.edsheets.com/Klamathdocs.html.) Under section 3.3 of the draft Settlement Agreement, the Secretary of the Department of the Interior will conduct very detailed studies and assessments to determine, *inter alia*, whether dam removal (i) will advance restoration of the salmonid fisheries of the Klamath Basin, and (ii) is in the public interest. The Secretary is to make a determination by March, 2012, subject to various contingencies, on whether to move forward with the project. As part of this process, a detailed plan for facility removal will be developed that describes the " physical methods to be undertaken to effect Facilities Removal, including but not limited to a timetable for Decommissioning and Facilities Removal, which is removal of all or part of each Facility as necessary to effect a free-flow condition and volitional fish passage." (Agreement, section 3.3.2.)

Because the Regional Water Board is preempted from directly issuing waste discharge requirements to the KHP so long as the project is operated under a federal license issued by FERC, absent a FERC/water quality certification process, the TMDL load allocations (and existing water quality objectives) as they apply to the KHP cannot be directly implemented and enforced. Settlement Parties contemplate federal legislation that would indefinitely delay the relicensing process before the FERC and accompanying Clean Water Act section 401 permitting process before the SWRCB. (See section 6.5 of the draft Agreement [Abeyance of Relicensing Proceeding].) In contemplation of the absence of the FERC/401 process, it was necessary for Regional Water Board staff to participate in discussions about how the Parties view the regulatory pathways envisioned in the Hydropower Agreement and their relationship to Oregon and California's TMDLs. This is reflected in section 6.3 of the draft Klamath Hydroelectric Settlement Agreement released on September 30, 2009. Section 6.3.2 provides:

6.3.2 TMDL Implementation Plans

A. No later than 60 days after ODEQ's and the North Coast Regional Water Quality Control Board (NCRWQCB)'s approval, respectively, of a TMDL for the Klamath River, PacifiCorp shall submit to ODEQ and NCRWQCB, as applicable, proposed TMDL implementation plans for agency approval. The TMDL implementation plans shall be developed in consultation with ODEQ and NCRWQCB.

B. To the extent consistent with this Settlement, PacifiCorp shall prepare the TMDL implementation plans in accordance with OAR 340-042-0080(3) and California Water Code section 13242, respectively. The plans shall include a timeline for implementing management strategies and shall incorporate water quality-related measures in the Non-ICP Interim Measures set forth in Appendix D. Facilities Removal by the DRE shall be the final measure in the timeline. At PacifiCorp's discretion, the proposed plans may further include other planned activities and management strategies developed individually or cooperatively with other sources or designated management agencies. ODEQ and NCRWQCB may authorize PacifiCorp's use of offsite pollutant reduction measures, subject to an iterative evaluation and approval process; provided, any ODEQ authorization of such offsite measures conducted in Oregon solely to facilitate attainment of load allocations in California waters shall not create an ODEQ obligation to administer or enforce the measures.

The draft TMDL requires PacifiCorp to submit a proposed implementation plan for approval by the Regional Water Board within 60 days from the date of TMDL adoption that includes implementation measures, a timeline for implementation, measurable milestones, and a provision to periodically update the plan. The 60-day time period was based directly from language in the draft Settlement Agreement (see Settlement Agreement, section 6.3.2). While the timing for submittal to ODEQ and the Regional Water Board may differ, it is preferable that PacifiCorp follow one consistent TMDL implementation plan that meets both states' requirements to the extent consistent with their statutory and regulatory authorities. Regional Board staff do not object to revisiting the time frame for submittal, and in fact hope to align it with Oregon's TMDL requirements to the extent possible for efficiency. (Note: OR is responsible for water quality certification of J.C. Boyle, one of four hydroelectric facilities in the KHP.) However, the suggestion to allow eighteen months does not seem appropriate here, particularly because the bulk of PacifiCorp's implementation has already been defined in various interim measures agreed to by Settlement Parties.

Since PacifiCorp is a Party to this Agreement and understands its intricacies, it may propose timelines in its implementation plan that best align with the timelines contained in the Settlement. The implementation plan should identify appropriate intervals whereby PacifiCorp will provide the Regional Water Board updates on the status and progress of the plan. At a minimum, the Regional Water Board will want to review the plan in 2012 in light of the Secretary's Determination. Based on the evidence and analyses conducted pursuant to the Secretarial Determination, and the substantive conclusions by the Department of Interior, the Regional Water Board will revisit the content of the KHP implementation plan. In addition, the proposed implementation plan must include a mechanism for Regional Board approval of offset projects described in more detail below. Regional Board staff are flexible about how this may occur, but the plan must be formulated with the goal of having approved projects ready for implementation in the event of an Affirmative Determination.

Section 6.3.2 of the Hydropower Agreement describes generally the content of the implementation plan to include a timeline for implementing management strategies, water quality-related measures in Appendix D and Facilities Removal as the final measure. The proposed plan may further include other planned activities and management strategies developed individually or cooperatively with other sources or designated management agencies. Appendix D contains water-quality measures that could potentially serve to meet TMDL needs if implemented effectively. As described in more detail below, Interim Measures 10 and 11 have significant potential to contribute towards meeting the Klamath River TMDL load allocations and targets in California. PacifiCorp may propose the use of offsite pollutant reduction measures (i.e. offsets or “trades”) to meet the allocations and targets, including those for Iron Gate Hatchery (see Staff Report Section 6.3.1.3). Candidate offsite pollutant reduction measures should be informed by Interim Measures 10 and 11 (discussed below) and credits determined through the water quality improvement accounting and tracking program (KlamTrack; see Section 6.7 of the Staff Report).

Interim Measure 10 provides funding for a water quality conference that focuses on the design and implementation of nutrient and organic matter reduction projects. The conference should assess the appropriateness and feasibility of various centralized pollutant removal technologies, including wetland treatment systems, wastewater treatment systems with energy recovery capabilities, aquatic plant harvesting, as well as agricultural best management practices. The conference serves as an opportunity to bring together water quality restoration experts, with the objective of developing recommendations and preliminary conceptual design for projects to achieve large-scale nutrient and organic matter reductions in the basin.

Interim Measure 11 provides funding for interim water quality improvements and is critical for achieving large-scale nutrient reductions in the basin. Under this Interim Measure, PacifiCorp spends $250K/yr until date of Secretarial Determination to be used for studies or pilot projects. By the date of the Secretarial Determination, a priority list of projects will be developed, informed by the water quality conference and Secretarial Determination studies. In the event of an Affirmative Determination by the Secretary, PacifiCorp provides funding of up to $5.4 million for implementation of projects and $560K/year for operation and maintenance of such projects. As stated in the Settlement Agreement, the “purpose of this measure is to improve water quality in the Klamath River during the Interim Period leading up to dam removal. The emphasis of this measure shall be nutrient reduction projects in the watershed to provide water quality improvements in the Mainstem Klamath River, while also addressing water quality, algal and public health issues in Project reservoirs…."

Regional Water Board staff agree that Interim Measure 11 should focus on the development and implementation of nutrient reduction projects, building upon ideas generated from the Interim Measure 10 water quality conference. PacifiCorp should focus on offsets in its proposed implementation plan, and commit to the goal of having viable projects ready for implementation by the date of the Secretarial Determination. Further, a list of priority projects should be completed by PacifiCorp and the Implementation Committee and select project(s) should be ready for construction by the date of the Secretarial Determination. That means that projects must be presented to the Regional Water Board prior to the Secretarial Determination date with adequate time for review.

The Klamath Hydroelectric Settlement Agreement includes the formation of an Interim Measures Implementation Committee (IMIC - Interim Measure 1) for the purpose of collaborating with PacifiCorp on "ecological and other issues related to the implementation of the Interim Measures set forth in Appendix D" (Hydropower Agreement, Appendix B). The IMIC will meet, discuss, and seek to reach consensus on implementation of various Interim Measures, including Interim Measure 11. Though not a Party, Section 3.2 of Appendix B states that the North Coast Regional Water Board may be a member of the IMIC, and the Regional Water Board intends to have a staff representative participate on the IMIC with to purpose of providing guidance on a project's potential to meet TMDL requirements. As previously stated, the TMDL implementation plan must provide for separate updates and presentations to the Regional Water Board for approval. The IMIC is not involved in Interim Measure 10: Water Quality Conference. This measure states that PacifiCorp, the North Coast Regional Water Quality Control Board, and the Oregon Department of Environmental Quality, will convene a steering committee to develop the agenda and panels for the water quality conference. The Regional Water Board intends to work closely with ODEQ and PacifiCorp on Interim Measure 10.

Interim Measure 11 also identifies the development of a water quality accounting framework. Regional Water Board staff support PacifiCorp's involvement in developing a water quality improvement accounting and tracking program for the Klamath River basin (i.e. KlamTrack). The purpose of KlamTrak is to provide a structure that facilitates the efficient application of offset programs by consolidating contributions and distributions. Consistent with the stated purpose of Interim Measure 11 and the goal of TMDL compliance, the majority of PacifiCorp's funding should be focused on the development and implementation of on-the-ground projects that, once implemented, will provide water quality improvements in the mainstem Klamath River.

The Interims contain valuable monitoring provisions and also a Coho Enhancement fund and turbine venting that could positively influence water quality. Water quality monitoring performed under Interim Measure 15 will be valuable in tracking baseline water quality conditions and compliance with the TMDLs.

The TMDL accommodates a variety of implementation options to address reservoir-related water quality impairments depending on whether the settlement moves forward or the State Water Board and FERC process continues. Regardless of the process, PacifiCorp must implement measures designed to move toward compliance with TMDL allocations and protection of beneficial uses. This is true for any process that proposes continued operation of the KHP, as well as for any alternative that considers dam removal. In addition, PacifiCorp must implement adequate water quality control measures to offset on-going reservoir impacts while the reservoirs are modified to meet the load allocations or, alternatively, up to the time they are decommissioned. PacifiCorp may propose the use of offsite pollutant reduction measures in the interim period consistent with the Klamath River water quality improvement accounting and tracking program, subject to an iterative evaluation and approval process. The implementation plan submitted by PacifiCorp should provide certain time periods after which a reassessment process may occur to avoid having to develop an alternative plan in the event that the settlement is discontinued. For now, we think that the acknowledgement that the FERC/401 process resumes if the settlement terminates will suffice. If that occurs, the Regional Water Board will revisit PacifiCorp implementation plan to discuss possible revisions. The implementation plan must also provide for Regional Board review more site specific environmental assessments of dam removal in the event that the Settlement moves forward before approval of that approach as a final TMDL compliance measure. The proposed BPA has been amended to reflect these contingencies.

K40. Comment(s):
PacifiCorp argues that the temperature TMDLs are inconsistent with the Clean Water Act because they do not determine, and would not establish, the thermal load limits necessary to ensure the protection and propagation of a balanced, indigenous population of shellfish, fish, and wildlife. PacifiCorp submitted numerous comments to show that the Klamath River has a balanced indigenous population of shellfish, fish, and wildlife, and concludes that because this standard is met, its obligation for temperature can be satisfied.

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
In order to achieve the Clean Water Act's objective to restore and maintain the chemical, physical, and biological integrity of the Nation's waters, "it is the national goal that wherever attainable, an interim goal of water quality which provides for the protection and propagation of fish, shellfish, and wildlife and provides for recreation in and on the water be achieved by July 1, 1983." (33 USC §1251(a)(2).) Stated in this broad context, all of the Regional Water Board's water quality planning efforts in part, are designed to meet this goal, including water quality objectives, existing and potential beneficial uses that the objectives are designed to protect, and the antidegradation policy.

The phrase “protection and propagation of balanced, indigenous population of shellfish, fish, and wildlife” (BIP) appears again under section 316 of the Clean Water Act. (33 USC §1326.) This provision articulates how the Clean Water Act approaches thermal discharges, which are point source discharges and predominately cooling water intake structures that discharge to the ocean. Under section 402 of the Clean Water Act, a National Pollutant Discharge Elimination System (NPDES) permit is required for all point source discharges of pollutants to surface waters of the United States. NPDES permits typically regulate the discharge of treated sewage, stormwater, and other pollutants discharged through a discrete conveyance such as a pipe, ditch or channel. Subdivision (a) of Clean Water Act section 316 allows for a variance from applicable thermal limitations to surface water if the permittee can demonstrate that the balanced indigenous community of aquatic organisms is protected and maintained. Subdivision (b) requires the determination of whether the withdrawal of cooling water causes or has the potential to cause adverse environmental impacts on aquatic populations and communities. This section suggests that the BIP could be a lower standard that other water quality standards.

Clean Water Act section 303(d)(1)(B) provides: Each State shall identify those waters or parts thereof within its boundaries for which controls on thermal discharges *under section 1311* of this title are not stringent enough to assure protection and propagation of a balanced indigenous population of shellfish, fish, and wildlife. (33 USC §1313(d)(1)(B)[emphasis added].) For waters identified under(1)(B), section 303(d)(1)(D) requires each State to estimate the total maximum thermal load required to assure the protection and propagation of a balanced , indigenous population of shellfish, fish, and wildlife. (33 USC §1313(d)(1)(D).) Section 1311 prescribes strict timetables for point source discharges to apply best practicable control technology and any more stringent limitations necessary to meet water quality standards. (33 USC § 1311(b).) No NPDES permit may be issued authorizing the discharge into saline estuarine waters which at the time of application do not support a balanced indigenous population of shellfish, fish, and wildlife. (33 USC §1311(h)(9).)

Title 40, Code of Federal Regulations section 130.7(c)(2) specifies that the thermal TMDL applies to waters for which controls on thermal discharges under section 301 are not stringent enough to assure BIP. (40 CFR 130.7(b)(2).) We must acknowledge that 40 CFR section 130.7(c)(1) provides that the State establish TMDLs at levels necessary to attain applicable narrative and numeric water quality standards for “pollutants other than heat.” Nonetheless, 40 CFR section 130.7(c)(1) must be interpreted in context, and does not limit the State from establishing heat loads to comply with water quality standards other than BIP. Nothing in section 303 or the Code of Federal Regulations allow the relaxation of water quality standards as applied to the KHP. Moreover, we do not agree that the Klamath River water quality is protective of BIP, as explained in more detail below.

The Klamath River was not listed as impaired because controls on point source thermal discharges are not stringent enough. The Klamath River has only one point source discharge subject to section 301 of the Clean Water Act, which is the fish hatchery. In fact, the North Coast Basin Plan prohibits most point source discharges on the Klamath River. (Basin Plan, 4-1.00.) The Klamath River was listed as impaired pursuant to Clean Water Act section 303(d)(1) for waters which effluent limitations on all point source discharges are not stringent enough to implement water quality standards. Heat is a defined pollutant under section 502(6) of the Clean

Water Act. The Basin Plan contains temperature standards that are not being met in the Klamath River. There is little authority to support the notion that the BIP standard relating to cooling plants waives our obligations to address temperature under section 303(d)(1)(A) and 303(d)(1)(C). This inquiry might be different if PacifiCorp had previously applied for a variance under the Clean Water Act and received approval from the appropriate water quality agency for a different or less stringent temperature standard, but we are not aware of any such procedure available for facilities other than cooling plants. Discharges from the tailrace of a dam, absent the addition of a pollutant, are not considered discharges of pollutants and therefore are not subject to federal NPDES permitting. (See *National Wildlife Federation v. Consumers Power Co*. (6th Cir. 1988) 862 F.2d 580; *National Wildlife Federation v. Gorsuch,* (D.C.Cir.1982) 693 F.2d 156.) Even if such a process existed, a variance procedure similar to one provided for cooling plants may not be appropriate. The KHP is a much different type of facility because it is located on and within the water body itself rather than an offsite facility that discharges heated water from a pipe to the surface water. Instream hydroelectric facilities have additional implications for temperature, including the heating of impounded water and the need for fish to pass through the dam and reservoir itself. The Regional Water Board is obligated by law under Water Code section 13242 to ensure compliance with water quality objectives and PacifiCorp points to no authority that would allow the Regional Board any discretion in this regard.

Even if section 303 (d)(1)(D) and accompanying federal regulations can be read to support PacifiCorp argument that temperature TMDLs should meet a lower standard, we cannot agree that BIP is met on the Klamath River for reasons described below.

The USEPA guidance on establishing thermal effluent limitations on power plants (EPA, 1977) provides a good proxy for the test of whether a balanced indigenous population (BIP) of fish, shellfish, and mollusks has been supported by past thermal discharges of existing facilities. The guidance suggests that one or more representative important species (RIS) be identified to simplify the evaluation process, and gives criteria for use in identifying appropriate RIS. EPA suggests species that are threatened or endangered, thermally sensitive, or commercially recreationally valuable species be considered in RIS assessments.

EPA recommends that a number of factors be considered in evaluating thermal effects of a discharge on a RIS, including high temperature survival, optimum temperature for performance and growth, normal spawning dates and temperatures, and special temperature requirements for reproduction, among others.

Finally, EPA provides guidance for the ultimate test of protection and propagation of the BIP. The following conditions must be met to make a finding that the effluent discharge is consistent with the support of a BIP:

1. There is no convincing evidence that there will be damage to the balanced, indigenous community, or community components, resulting in such phenomenon as those identified in the definition of appreciable harm.
2. Receiving water temperatures outside any (State established) mixing zone will not be in excess of the upper temperature limits for survival, growth, and reproduction, as applicable, of any RIS occurring in the receiving water.

3. The receiving waters are not of such quality that in the absence of the proposed thermal discharge excessive growth of nuisance organisms would take place.
4. A zone of passage will not be impaired to the extent that it will not provide for the normal movement of populations of RIS, dominant species of fish, and economically (commercial or recreational) species of fish, shellfish, and wildlife.
5. There will be no adverse impact on threatened or endangered species.
6. There will be no destruction of unique or rare habitat without a detailed and convincing justification of why the destruction should not constitute a basis for denial.
7. The applicant's rationales present convincing summaries explaining why the planned use of biocides such as chlorine will not result in appreciable harm to the balanced indigenous population.

If we identify coho salmon as a RIS, as suggested by the EPA guidance, and treat the Klamath Hydropower Project as a point source, the only conclusion that can be reached is that the BIP has not been supported. Five of the seven decision criteria identified by EPA are not met, whereas all of the criteria must be met in order to conclude that a BIP has been maintained.

The beneficial use impairment section of the Problem Statement (Chapter 2, section 2.6.1) clearly describes how the COLD, RARE, MIGR, and SPWN beneficial uses are currently not fully supported. Furthermore, the Klamath River does not support a balanced indigenous population, as evidenced by :

- the designation of coho salmon as a threatened species by state and federal agencies;
- the endangered nature of eulachon, spring-run Chinook (historically the most prolific salmon run in the Klamath River), and summer steelhead,
- declining numbers of winter steelhead, fall chinook salmon, chum salmon, and Pacific lamprey;
- the restricted range of cutthroat trout;
- unusually high juvenile salmonid mortality rates in spring months;
- the high incidence of fish diseases;
- the annual threat of fish kills, such as occurred in 2002; and
- the recent closure and restrictions of ocean fisheries due to reduced Klamath River salmon populations.

The Klamath TMDL temperature goal of natural water temperature complies with the temperature water quality objective and ensures the full protection of all beneficial uses to the degree that the natural system is able to provide. The fact that temperatures in the Klamath Hydroelectric Project and Iron Gate Hatchery are not representative of natural receiving water temperatures means that they are not in compliance with Water Quality Objectives and are contributing to the impairment of beneficial uses and the imbalance in indigenous populations.

K41. Comment(s):

The Draft TMDL's water temperature allocations and targets are inconsistent with the Clean Water Act because they are not based on ensuring the protection and propagation of a balanced, indigenous population of shellfish, fish, and wildlife (BIP). The Draft TMDL's temperature allocations and targets are based on "ideal" or near-ideal temperatures for salmonids in the generally colder waters of the Pacific Northwest, not the “thermal load which cannot be exceeded in order to assure protection and propagation of a balanced, indigenous population of shellfish, fish and wildlife” in the Klamath River per 40 C.F.R. § 130.7(c)(2). Based on agency testimony, the Administrative Law Judge's findings in the Energy Policy Act of 2005 trial-type hearing for Project support the conclusion that the temperature effects of the Project are consistent with the protection and propagation of a BIP.

<u>Comment(s) Made By:</u>
Hemstreet - PacifiCorp

<u>Response:</u>
The Klamath TMDL temperature allocations and targets are based on natural temperature conditions, not temperatures that are ideal for salmonids. “The primary temperature numeric targets for the Klamath River temperature TMDL are monthly average temperatures calculated from the estimated natural temperature regime of the Klamath River, and are presented in Section 5.2 (Chapter 5, p.5-1).” Natural receiving water temperatures would comply with the temperature Water Quality Objective (temperature objective) contained in the Basin Plan as follows. The temperature objective for *interstate* waters prohibits the discharge of elevated temperature waste, whereas the *intrastate* temperature objective states that temperatures must be maintained as natural, unless a proposed increase is less than 5 ^{o}F and doesn’t adversely impact beneficial uses. Because even natural water temperatures in Klamath basin streams would adversely affect the beneficial uses during critical time periods, no additional heat load can be accommodated, and the natural receiving water condition becomes the temperature objective. The ability of the Klamath River to support a balanced and indigenous population is tenuous, even under natural conditions. The temperature load allocations are set to natural, as opposed to ideal temperatures for support of salmonids, because; 1) the Regional water Board has no authority to set allocations that result in better than natural conditions, 2) load allocations that are better than natural are unreasonable, and 3) load allocations that are better than natural are infeasible. Compliance with the temperature objective (meeting natural receiving water temperatures) ensures the protection of all beneficial uses in the Klamath River, including COLD, WARM, SHELL and WILD, to the degree that the natural system is able to provide. The full support of all beneficial uses is not possible under natural conditions, thus temperature increases above natural are incompatible with a balanced indigenous population of shellfish, fish, and wildlife. Establishing load allocations based on natural conditions is the best possible means of achieving a balanced indigenous population and fully complies with both state water quality standards and the Clean Water Act’s requirement for thermal TMDLs.

The ALJ makes two findings that specifically refer to water temperatures and migration and two general findings about migration past Iron Gate dam:

- Although water temperature in the summer above IGD is an issue, they will not preclude coho salmon from utilizing the habitat within the Project area (ALJ, 7-12, P.36);
- Summer water temperatures are likely to block the migration of adult spring-run Chinook salmon before they reach suitable holding or natal areas (ALJ, P.19, 2A-39);
- If access was provided, anadromous fish would migrate past Iron Gate Dam (ALJ, p. 14, 2A-12);

- Coho salmon below IGD would migrate above the dam if access was provided through fishways (ALJ, 7-15, P.36).

The ALJ does not conclude "that the record clearly establishes that existing water temperatures will not preclude anadromous salmonid migration". The ALJ makes no findings that water temperatures above Iron Gate dam are suitable for salmonids, and on the contrary states that summer water temperatures in the summer are an issue for both spring-run chinook and coho. The statement that fish will migrate above the dam if access provided is not equivalent to a statement that water temperatures above the dam are suitable and fully protective of salmonid migration, spawning and rearing

K42. Comment(s):
The ALJ cited agency testimony that the temperature conditions are faced by anadromous fish to an equal degree both above and below Iron Gate dam.

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
This statement by the ALJ does not make any statement about the suitability of conditions above and below Iron Gate dam. As discussed in response K40 temperatures throughout the Klamath River do not meet water quality objectives and therefore are not fully supportive of beneficial uses. The NRC report clearly identifies the deleterious impacts of increased daily minimum temperatures on salmonids below the dams, and the record is clear that the dams increase minimum temperatures downstream.

K43. Comment(s):
The ALJ cited agency testimony that coho salmon in other parts of the Klamath system occupy water with temperatures in excess of 26°C (the data relied upon by the draft TMDL cites 25°C as "lethal" for coho adults), and juvenile coho salmon observations in the main stem Klamath River where temperatures exceed 20°C (the data relied upon by the draft TMDL considers chronic effects to be observed in core juvenile rearing habitat at temperatures above 16°C). The ALJ also concluded that the evidence also demonstrates that juvenile fish most likely would not outmigrate during periods of sub-optimal water temperatures. See Findings of Fact on USFWS/NMFS Issue 2(A) in McKenna (2007).

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
Regional Water Board staff have performed an exhaustive analysis of the temperature requirements of the various lifestages of salmonids, including information from indepth reviews on this issue conducted by ODEQ and USEPA (see Appendix 4). The document has been reviewed by numerous agencies, tribes, and individuals in the Klamath River basin (including

NMFS and NOAA) and has also gone through a peer review process. At no time during those reviews were any concerns raised about the lifestage MWMT temperature thresholds, which are directly from those recommended by the USEPA (2003), or the lethal temperature thresholds, which are well documented in the literature and in PacifiCorp own assessment of temperatures that are lethal to salmonids (PacifiCorp 2005).

Although anadromous salmonids may "occupy" or be "observed" in areas of the Klamath basin with temperatures in excess of the juvenile rearing thresholds (MWMT of 16°C core and 18°C non-core rearing) and lethal temperature thresholds (25°C for coho adults), it does not mean that these temperatures are optimal, preferred, supportive, or even survivable for salmonids, nor that they are fully protective of the COLD beneficial use. Temperature influences growth and feeding rates, metabolism, development of embryos and alevins, timing of life history events such as upstream migration, spawning, freshwater rearing, and seaward migration, susceptibility to disease, and the availability of food. Temperatures at sublethal levels can effectively block migration, lead to reduced growth, stress fish, affect reproduction, inhibit smoltification, create disease problems, and alter competitive dominance (Elliott 1981, USEPA 1999a). Further, the stressful impacts of water temperatures on salmonids are cumulative and positively correlated to the duration and severity of exposure. The longer the salmonid is exposed to thermal stress, the less chance it has for long-term survival (Ligon et al. 1999). All of the aforementioned effects of elevated water temperatures result in an impairment of the COLD, MIGR, RARE, and SPWN beneficial uses (see Chapter 2, section 2.6.1 for further discussion) and precludes a balanced indigenous population of fish and shellfish.

Regional Water Board staff found the following facts in the ALJ, which document the temperature requirements of salmonids and mirror those findings made in Appendix 4 of the Klamath River TMDL. It is important to note that the tolerance of temperatures "for short periods of time" or "providing there is abundant food, thermal refugia, and other conditions" does not indicate that these temperatures are fully protective or supportive of beneficial uses:

- Adult fall Chinook optimal temperature is 14C, though they can withstand temps exceeding 20C for short periods of time (ALJ, 2A-27, P.17);
- Juvenile fall Chinook can withstand temps >20C providing there is abundant food, thermal refugia, and other conditions are not stressful (ALJ, 2A-28, P.17);
- Temperatures below 16C are optimal for adult spring-Chinook, however they can be found in pools with temperatures >20C (ALJ, 2A-36, P.18);
- Juvenile steelhead prefer temperatures of 15-19C, but can withstand temperatures >22C providing food is abundant by finding thermal refuge or living in areas where the nocturnal temperatures drop below the thermal threshold (ALJ, 2A-44, P.19);
- Adult coho migration is keyed to water temperature (below 16C) and river flow, however adult coho migration has been observed where these stimuli are reduced (ALJ, 7-10, P.35);
- Coho salmon prefer cold water ranging from 12-14C but can tolerate higher water temperatures >20C where food is abundant, there is thermal refugia, and other conditions are not stressful (ALJ, 7-11, P.36).

<u>References:</u>
Administrative Law Judge Findings of Fact (ALJ) September 27, 2006.

Elliott, J. 1981. Some aspects of thermal stress on freshwater teleosts. In Pickering, A.D. ed., Stress and Fish: Academic Press, London, p. 209-245.

Ligon, F., A. Rich, G. Rynearson, D. Thornburgh, and W. Trush. 1999. Report of the Scientific Review Panel on California Forest Practice Rules and Salmonid Habitat: Prepared for the Resource Agency of California and the National Marine Fisheries Sacramento, Calif. 92pp. + appendices.

National Research Council of the National Academies (NRC). 2004. Endangered and Threatened Fishes in the Klamath River Basin. Washington, D.C. National Academies Press.

PacifiCorp. 2005. Water Temperature and Dissolved Oxygen Thresholds for Use in AR-1 (Anadromous Fish Protection). Klamath Revised AIR AR-1 Temperature Criteria. May 31, 2005.

U.S. Environmental Protection Agency (USEPA). 1999a. A review and synthesis of effects of alternation to the water temperature regime on freshwater life stages of salmonids, with special reference to Chinook salmon. Region 10, Seattle, WA. EPA 910-R-99-010. 279pp. Available at: <http://www.critfc.org/tech/EPA/ report.htm>. Website accessed on June 11, 2004.

U.S. Environmental Protection Agency (USEPA). 2003. EPA Region 10 Guidance for Pacific Northwest State and Tribal Water Quality Standards. Region 10, Seattle, WA. EPA 910-B-03-002. 49pp. Available at: <http://www.epa.gov/r10earth/ temperature.htm>. Website accessed on June 23, 2004.

K44. Comment(s):
Compared to a hypothetical without-Project scenario, the thermal phase shift created by the presence of the reservoirs has a cooling effect on Iron Gate and Copco tailrace water temperatures during spring and summer. As such, current temperature conditions are more frequently within (i.e., cooler than) chronic effects thresholds to salmonids (as used in the Draft TMDL based on maximum weekly maximum water temperature [MWMT] values) than modeled without-Project or "natural" conditions during spring and summer. The Draft TMDL provides a definition of MWMT values as the daily maximum temperatures over running seven-day consecutive periods, and states that MWMT is also known as the seven-day average of the daily maximum temperature, or "7-DAD Max" (Appendix 4, page 2).

The modeling results indicate that the maximum MWMT reached during the mid-August through December period is less under Current than Without-Project conditions (about 23 versus 25°C, respectively, in Figure 1). In addition, the MWMTs reached under Current conditions are within the temperature effects thresholds for Adult Migration the same percentage of time than under Without-Project conditions. The MWMTs reached under Current conditions are within the temperature effects thresholds for Core Juvenile Rearing and Spawning, Egg Incubation, and Fry Emergence a slightly lesser percentage of time than under Without-Project conditions. The MWMTs are within the temperature effects thresholds for Core Juvenile Rearing about 50 percent of the time under Current conditions and about 57 percent of time under Natural conditions, or a difference of about 7 days. The MWMTs are within the temperature effects thresholds for Spawning, Egg Incubation, and Fry Emergence about 43 percent of the time under Current conditions and about 53 percent of time than under Natural conditions, or a difference of about 10 days.

In addition, the Draft TMDL indicates that “the optimal temperature range for juvenile salmonids is 10-15°C, with a lower limit of 4°C“ (page 2-51). Figure 1 indicates that MWMTs are within this optimal 10-15°C range for a longer duration (about 10 percent longer) under Current conditions than Natural conditions, and are less frequently below the 4°C “lower limit’ than under Natural conditions. Collectively, these results indicate that MWMTs under Current conditions are as supportive, if not more so, for salmonids than under Without-Project conditions based on the thresholds, optimal ranges, and limits assumed in the Draft TMDL.

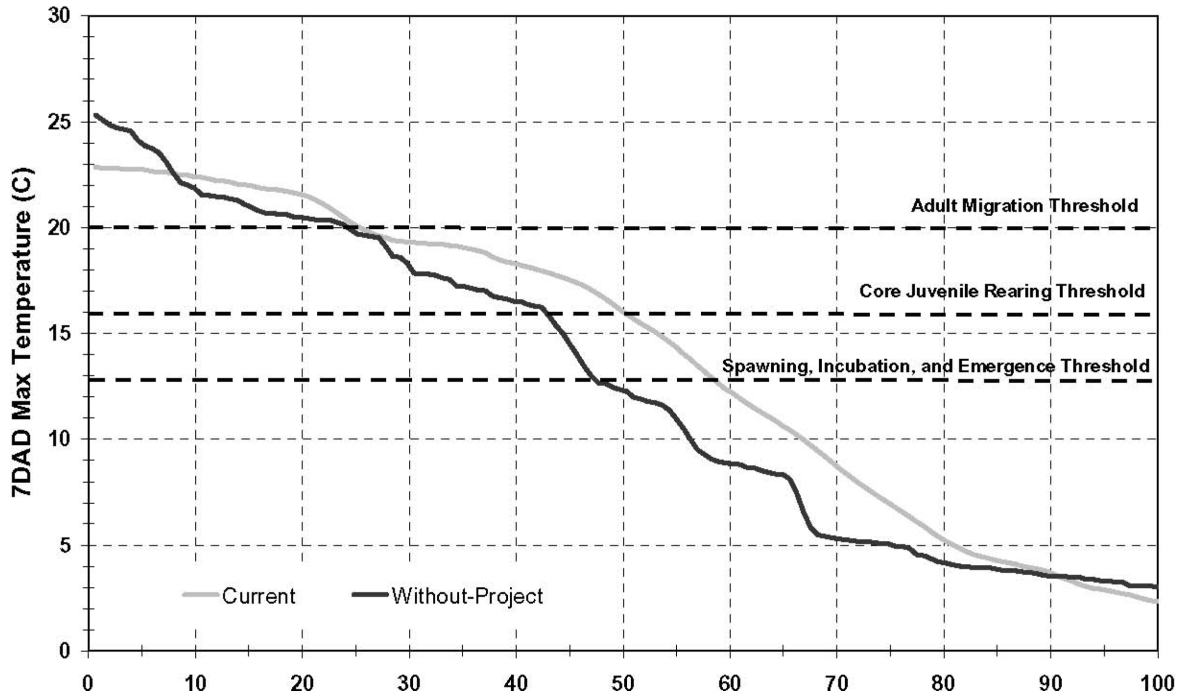

Figure 1. Comparison of duration of existing maximum weekly maximum water temperatures (7DAD Max) at Iron Gate tailrace under Current and Without-Project modeling scenarios during August through December (based on Watercourse modeling results performed during FERC relicensing studies).

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
For clarification, the Draft TMDL defines the MWMT as the “maximum seasonal or yearly value of the daily maximum temperatures over a running seven-day consecutive period (Appendix 4, P.2)”. The comment only acknowledges a portion of the definition.

The analysis presented above is flawed and misleading. The commenter presents data as maximum weekly maximum temperature (MWMT) values when they are actually weekly maximum temperature WMT values. There is an important distinction between these values, which is that the MWMT is the maximum value of the WMTs in a given season of concern. It is a single value. A single value is appropriate because physiological temperature effects on fish are cumulative. The mixing of these metrics indicates a lack of understanding of the evaluation of chronic effects of high temperatures on fish.

The analysis above presents findings in a probability distribution curve that eliminates any temporal context. Combining data from August to December to evaluate the spawning season that occurs from September to November obfuscates the true impact of temperature during the spawning season. The use of data from December, when temperatures are the coldest, has the effect of shifting the curves to the left, but adds no value to the analysis of the effects of the dams on juvenile rearing, adult migration, or spawning. The conclusion that "MWMTs are within the temperature effects thresholds for Spawning, Egg Incubation, and Fry Emergence about 43 percent of the time under Current conditions and about 53 percent of time than under Natural conditions, or a difference of about 10 days" is at odds with the Klamath TMDL model results that indicate that under existing conditions the WMT of 13 ^{o}C (the spawning, incubation, and emergence threshold) isn't achieved until 20 days after it would be under natural conditions.

Although Regional Water Board staff reject the notion that the Klamath TMDL water quality model is flawed, we can point to other analyses based on the Pacificorp's model that support our conclusions, as we have done in the Draft TMDL. Dunsmoor and Huntington (2006) evaluated the temperature effects of the Klamath Hydropower Project using Pacificorp's model data for the years 2000-2004. Their analysis results are summarized in the table below.

	Pacificorp Model, 2000-2004 (Dunsmoor Huntington, 2006)		Klamath TMDL Model, 2000	
Time Period	Existing Condition	Without Project	Existing Condition, MWMT (C)	Without Project, MWMT (C)
Sept. 10-23	Stressful or worse 90% days	Stressful 9% of day	19.2	18.7
Sept. 24 – Oct. 7	Suboptimal or worse of days	Suboptimal 37 % c	18.1	15.5
Oct. 8 – Oct. 21	Suboptimal 70% of da	Suboptimal 1% of	16.1	11.4
Oct. 22 – Nov. 4	Optimal 100% of days	Optimal 100% of d	12.9	8.2

The results of Dunsmoor and Huntington's analysis are consistent with and support the conclusion of the Klamath TMDL Staff Report.

Regarding colder than natural temperatures, the information presented in figure 1 (in the comment above) does not address this issue, since it is based on temperatures from August to December, which is not when the colder than natural temperatures occur.

K45. Comment(s):
The Draft TMDL discussion on Figure 2.11, and the MWMT thresholds for four life stages, lacks accuracy and balance by not providing important context and not extending the analysis to other periods of the year. For example, because the Draft TMDL focuses so much attention on Copco and Iron Gate reservoir temperature effects, it is a fundamental omission that the Draft TMDL's discussion on Figure 2.11 does not point out that the "measured" annual maximum MWMT are lower immediately downstream of Iron Gate dam than at any other location throughout the river system. Also, the Draft TMDL conclusions based on Figure 2.11 mislead the reader by failing to acknowledge that certain of the four life stages for key salmonid species are not present in the mainstem river downstream of Iron Gate dam when the annual maximum (or warmest) MWMT values occur in late July (e.g., spawning, incubation, and emergence). The Draft TMDL is deficient by not displaying and analyzing the modeled (or other "measured") data in comparison with the MWMT thresholds for other periods of the year when the life stages are present.

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
The purpose of assessing these data is to evaluate whether the river has capacity to assimilate increased heat loads during the hottest critical periods without adversely affecting the beneficial uses. The SPWN beneficial use has been deleted from the text.

K46. Comment(s):
The Draft TMDL erroneously implies that the cooler temperature releases at Iron Gate dam during late winter than modeled "natural" temperature conditions "may reduce the growth rates of salmonids rearing in the Klamath River, and may ultimately reduce the survival rate of salmonids in the ocean" (page 2-51). The Draft TMDL provides no substantive evidence for this assertion, but only implies that the cooler temperature releases at Iron Gate dam during late winter are adverse because "the optimal temperature range for juvenile salmonids is 10-15°C, with a lower limit of 4°C" (page 2-51). However, the Draft TMDL fails to provide the context that both current and "natural" temperature conditions are below the optimal range for juvenile salmonids during the winter, and modeled Without-Project temperature conditions are below 4°C (and therefore below the optimal range) more frequently than current conditions during the winter (see Figure 1 above).

Rather, exposure of juvenile salmonids to seasonally reduced water temperatures during spring and early summer under existing Project operations, primarily within the Iron Gate dam reach, would be expected to benefit the overall health and condition of juvenile rearing salmon. Exposure to reduced water temperatures within the Iron Gate dam reach during the spring and early summer juvenile rearing period would contribute to reduced vulnerability of juveniles to disease and infection. The Draft TMDL itself acknowledges this by stating that "juvenile fish migrating down the Klamath River in the spring suffer high mortality rates due to C. Shasta, which is more virulent at temperatures that typically occur that time of year" (page 2-50).

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
Regional Water Board based the statement on the body of literature reviewed and summarized in Appendix 4. However, no action to increase late winter temperature is proposed.

In regards to Figure 1, please see the response to comment K44.

K47. Comment(s):
Exposure to lower water temperatures under current Iron Gate releases does not result in reduced juvenile growth rates (PacifiCorp 2008b). Results of studies by Marine and Cech (2004) show that juvenile Chinook salmon growth rates are virtually identical over a temperature range from 13-16°C and 17-20°C reflecting the general range of seasonal temperatures expected to occur during the juvenile rearing period under existing conditions in the reach downstream of Iron Gate dam. Results of these growth studies show no evidence that lower spring and early summer water temperatures under existing Project operations would adversely impact juvenile salmon growth rates.

PacifiCorp's conclusions with regard to beneficial Project-related water temperature effects on salmonids during spring and early summer are supported by other recent independent analyses. In an analysis of the effects on fall Chinook of hypothetical temperature conditions with and without Project dams and reservoirs, Bartholow et al. (2005) concluded that water temperature conditions for juvenile rearing life stages are better with Project dams and reservoirs than without, especially immediately below Iron Gate dam. In a subsequent analysis of factors limiting fall Chinook production potential, Bartholow and Henriksen (2006) concluded that water temperature during spawning and egg incubation is not a significant factor affecting fall Chinook production in the Klamath River.

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
Regional Water Board staff stand by the original statement, which refers to temperatures in the 3-4 °C range during late winter, not in the range of 13-20 °C during spring and early summer. The work of Bartholow et al (2005) is discussed in section 2.5.2. The comment grossly mischaracterizes Bartholow and Henriksen's (2006) conclusion. In evaluating graphs presenting annual fish production versus maximum weekly water temperature, Bartholow and Henriksen state: "In neither case would one conclude that water temperature is the decisive factor limiting freshwater production. Instead, one would surmise that many limitations are involved, both habitat and water quality." The statement that temperature is not the decisive factor is not equivalent to saying that temperature is not a significant factor.

K48. Comment(s):
The Draft TMDL further incorrectly concludes that the warmer temperatures in the releases at Iron Gate dam during fall (compared to modeled "natural" temperature conditions) adversely affect the reproductive success of adult salmonids because "the seasonal decline in temperatures during the fall months is delayed in comparison to estimated natural temperatures" (page 2-50). Within the Klamath River, adult fall-run Chinook salmon migrate upstream to spawn from approximately mid-August through October, and adult coho salmon migrate upstream to spawn from approximately mid-September through December. Water temperatures are undergoing a typical seasonal pattern of decline during mid-August through December. The seasonally declining temperature conditions are generally suitable for migration, spawning, and egg incubation throughout the river under both existing conditions and modeled "natural" temperature conditions. As the Draft TMDL itself points out, Strange (2006) found that fall Chinook salmon will migrate at temperatures as high as 23°C if temperatures are rapidly falling.

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
Please the response to comment K44.

K49. Comment(s):
In the 2007 FPA trial-type proceeding on Project FERC relicensing requirements, the presiding administrative law judge (ALJ) ruled, based on the testimony of fisheries experts from NMFS and USFWS, that existing temperatures conditions will not preclude successful fall Chinook spawning and egg incubation. The ALJ concluded that the fall Chinook spawning period (early September through late October) coincides with declining river temperatures in the suitable range, which by early November are within the optimal range for the developing embryos (i.e., 4-12°C) (see Findings of Fact 2A-27 and 2A.6 in McKenna 2007).

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
Please see the responses to comments K41, K43, and K44.

K50. Comment(s):
In a similar situation to the Klamath River, Geist et al. (2006) conducted research on water temperature effects on fall Chinook salmon spawning in the Snake River downstream of Hells Canyon dam. The key objective of the research by Geist et al. (2006) was to determine whether various temperature exposures from 13°C to 17°C during the first 40 days of spawning egg incubation followed by declining temperature of approximately 0.28°C per day (to mimic the thermal regime of the Snake River) affected survival, development, and growth of fall Chinook salmon embryos, alevins, and fry. Geist et al. (2006) determined that there were no significant differences in embryo survival at initial temperature exposures up to 16.5°C. Geist et al. (2006) further determined that there were no significant differences in alevin and fry size at hatch and emergence across the range of initial temperature exposures. On the basis of their research, Geist

et al. (2006) concluded that an exemption to the state water quality standards for temperature was warranted for the portions of the Snake River where fall Chinook salmon spawning occurs.

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
The study by Geist et al. (2006) was conducted in a laboratory using Chinook salmon eggs that were taken from adult Chinook held at 12 ^{o}C. Geist et al. (2006) noted that this factor likely influenced the results. Furthermore Geist et al. notes that "Exposure of female fish to elevated water temperatures can adversely affect egg viability", and they note that eggs taken from adult salmon held in hatcheries at water temperatures greater than 15.5 ^{o}C had poor viability. The state of Oregon has not granted an exemption to water quality standards for temperature based on this work (Turner, 2010).

Geist, D., C. Abernathy, K. Hand, V. Cullinan, J. Chandler, and P. Groves. Survival, Development, and Growth of Fall Chinoook Salmon Embryos, Alevins, and Fry Exposed to Variable Thermal and Dissolved Oxygen Regimes. Transactions of the American Fisheries Society 135:1462-1477.

Turner, Dan. 2010. Personal communication from Dan Turner of Oregon Department of Environmental Quality via phone conversation to Bryan McFadin (Regional Water Board Staff) on March 4, 2010.

K51. Comment(s):
Section 4.2.2.1 of the Draft TMDL discusses the effects of the Project reservoirs on water temperature based on calculated changes in modeled river temperatures upstream and downstream of the reservoirs for both current and modeled "natural" conditions (pages 4-13 to 4-15). The Draft TMDL concludes that these calculated changes demonstrate that the presence of the reservoirs "significantly influences temperature of the Klamath River" (page 4-14). However, this section does not provide any specific analysis of biological effects, except for the single sentence that "[t]he timing of the increases coincides with the time when Chinook salmon currently spawn in the Klamath River mainstem directly downstream of the reservoir" (page 4-14). However, again the Draft TMDL fails to provide accurate context that, irrespective of calculated changes in modeled temperature, the MWMT values under Current conditions are within (i.e., cooler than) the thresholds developed in the Draft TMDL for migration and spawning as often, if not more so, than under modeled "natural" conditions.

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
The purpose of this analysis is to define the change in temperatures caused by the reservoirs, not evaluate the biological effects of those temperature changes. The biological effects of increased

temperatures are discussed in chapter 2 and Appendix 4. Additionally, please see the response to comment K44.

K52. Comment(s):
Temperature modeling also shows that differences in Iron Gate tailrace water temperatures between existing and without Project conditions diminish as a function of distance downstream from Iron Gate dam as water temperatures reach thermal equilibrium within the river. Temperature conditions may vary considerably due to local meteorological conditions and tributary contributions, but water releases from Iron Gate dam generally reduce mainstem average temperatures slightly in spring and summer, and increase mainstem average temperatures slightly in fall with diminishing effect down to the Scott River (Basdekas and Deas 2007). In general, there is very little difference in the suitability of river temperature conditions for salmonids under existing and modeled "natural" temperature conditions, and temperature conditions affecting attraction and entry of migratory salmonids into the river during upstream migration are independent of Project operations. (final comments p.8-16)
Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
Regional Water Board staff disagree with the statement that there is little difference in the suitability of river temperature conditions for salmonids under existing and modeled "natural" temperature conditions. The biological implications of the temperature changes caused by the Klamath Hydropower Project are discussed in Sections 2.4, and 2.5.2 of the Staff Report.

K53. Comment(s):

- Because the temperature load allocations at Stateline are unachievable, the Draft TMDL is unachievable. That, in turn, means that the relevant water quality objectives cannot be achieved. In addition, the Regional Water Board has not shown that all beneficial uses can be attained even under "natural" conditions, nor why an increase in temperature above "natural" would adversely impact beneficial uses. Yet the Draft TMDL requires compliance with the modeled "natural" temperature conditions. Accordingly, the Draft TMDL is inconsistent with the Clean Water Act and EPA's implementing regulations because it is unachievable and not certain to protect beneficial uses even if compliance is attained. Therefore, the appropriate course before completing the TMDL would be to either revise the relevant water quality objectives (if the revisions would protect beneficial uses) or conduct a use attainability analysis to remove uses or subcategories of uses that cannot be attained, or to establish new, more refined and site-specific subcategories that are more reflective of this system.

- Numeric TMDL targets are unachievable. In particular, the load allocations to natural and nonpoint sources that are necessary to achieve the targets are unachievable. Unachievable load allocations to natural and nonpoint sources are inconsistent with EPA's TMDL regulations.

A TMDL is "[t]he sum of the individual WLAs [wasteload allocations] for point sources and LAs [load allocations] for nonpoint sources and natural background." 40 C.F.R. § 130.2(i). That is, WLAs + LAs = TMDL. But whereas WLAs may be "allocated" (or not) to individual point sources, LAs must be "attributed" to natural and nonpoint sources based on a reasonable prediction of the actual pollutant loading from those sources. EPA's regulations provide:

(g) *Load allocation (LA)*. The portion of a receiving water's loading capacity that is attributed either to one of its existing or future nonpoint sources of pollution or to natural background sources. Load allocations are *best estimates of the loading*, which may range from reasonably accurate estimates to gross allotments, depending on the availability of *data and appropriate techniques for predicting the loading*. Wherever possible, natural and nonpoint source loads should be distinguished.

(h) *Wasteload allocation (WLA)*. The portion of a receiving water's loading capacity that is *allocated* to one of its existing or future point sources of pollution. WLAs constitute a type of water quality-based effluent limitation.

(i) . . . If Best Management Practices (BMPs) or other nonpoint source pollution controls make more stringent load allocations *practicable, then* wasteload allocations can be made less stringent. Thus the TMDL process provides for nonpoint source control tradeoffs.

40 C.F.R. §130.2 (emphasis added)

As shown by the emphasized language, LAs are an attribution of the actual or expected loadings from natural and nonpoint sources based on "best estimates," "data," and "appropriate techniques for predicting the loading." An LA, then, may not simply be allocated to a natural or nonpoint source but must be a reasonable prediction of the actual loading from the source. For nonpoint sources in particular, any LA that would require a reduction in existing loadings must consider the enforceability and practicability of the reductions.

An LA, then, may not simply be allocated to a natural or nonpoint source but must be a reasonable prediction of the actual loading from the source. For nonpoint sources in particular, any **LA that would require a reduction in existing loadings must consider the enforceability and practicability of the reductions. (final comments p.23, 24**)

In contrast, the Draft TMDL does not reasonably predict the actual loading from the source based on enforceable regulations, data, or other information because the actual loading depends on the attainment of the upstream temperature load allocations, which are not enforceable.

Because the temperature load allocations at Stateline are unachievable, the Draft TMDL is unachievable. That, in turn, means that the relevant water quality objectives cannot be achieved. In addition, the Regional Water Board has not shown that all beneficial uses can be attained even under "natural" conditions, nor why an increase in temperature above "natural" would adversely impact beneficial uses. Yet the Draft TMDL requires compliance with the modeled "natural" temperature conditions. Accordingly, the Draft TMDL is inconsistent with the Clean Water Act and EPA's implementing regulations because it is unachievable and not certain to protect beneficial uses even if compliance is attained. Therefore, the appropriate course before completing the TMDL would be to either revise the relevant water quality objectives (if the revisions would protect beneficial uses) or conduct a use attainability analysis to remove uses or subcategories of uses that cannot be attained, or to establish new, more refined and site-specific subcategories that are more reflective of this system. (final comments p.16-18)

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
PacifiCorp objects to assigning a load allocation to a natural or nonpoint source, and insists that it must be a "reasonable prediction of the actual loading from the source" taking into consideration the enforceability and practicability of the reductions. PacifiCorp goes on to conclude that the draft TMDL load allocations are improper and not based on actual loading from the source because the actual loading depends on the attainment of the upstream temperature allocations which are not enforceable. PacifiCorp then submits that temperature and numeric load allocations are unachievable and, as such, are inconsistent with federal regulations and therefore the Regional Water Board should conduct a Use Attainability Analysis before undertaking the TMDL.
This argument fails for a number of reasons.

First, PacifiCorp submits no evidence to support its claim that the load allocations are unachievable except a bald conclusion that Oregon will not be able to achieve compliance at Stateline. We disagree. As described previously, the load allocations at Stateline are aligned with Oregon's own TMDL, which is designed to attain its water quality standards. We have acknowledged the difficulty that Oregon faces as evidenced by efforts to establish a mechanism for large centralized restoration projects, but do not take such a dim view of our potential for problem solving. We are more optimistic about the States' ability, when working together with the help of other federal, state and local agencies and other organizations, to make significant measurable improvements in the water quality of the Klamath River. We are certainly not prepared at this juncture to simply give up because the task appears difficult. The very nature of a water body going through a TMDL process suggests difficulty as the TMDL process was designed to address water quality problems where traditional controls have not worked.

Water quality agencies, including those in Oregon and California and USEPA, have the responsibility establish TMDLs designed to attain water quality standards regardless of the difficulty in enforcement. (See e.g. United States v. State Water Resources Control Board, l82 Cal.App.3d 82, 122 [finding Board's approach under its water quality obligations was flawed because standards were based on what the Board thought it could implement and achieve rather than protection of beneficial use].)

"Water quality objectives, we realize, may not always be readily enforceable. The statutory factors enumerated in section 13242, particularly the provisions for recommended action and time schedule, reflect the Legislature's recognition that an implementing program may be a lengthy and complex process requiring action by entities over which the Board has little or no control and also requiring significant time intervals. Thus, we do not believe that difficulty in enforcement justifies a bypass of the legislative imperative to establish water quality objectives which in the judgment of the Board will ensure reasonable protection of beneficial uses." (Id.)

In our case, the Regional Board must develop an implementation plan designed to meet the standards and ensure the reasonable protection of beneficial uses. The implementation program takes into account the difficulty of enforcing objectives and, in particular, considers the options reasonably available to dischargers to comply with the objectives. The TMDL contains reopeners and the ability to adaptively manage as we learn more and measures are implemented.

LOAD ALLOCATIONS APPLIED TO KHP ARE APPROPRIATE FOR A FERC-REGULATED HYDROELECTRIC FACILITY

Second, PacifiCorp arguments regarding federal regulations as applied to load allocations take too a narrow view without considering the blend of federal and state law and variety of implementation options as it applies to the process before us. We agree that a load allocation, as described in the federal regulations are best estimates of the loading, which may range from reasonably accurate estimates to gross allotments, depending on the availability of data and appropriate techniques for predicting the loading. Wherever possible, natural and nonpoint source loads should be distinguished. (40 C.F.R. § 130.2(g).) PacifiCorp's argument, however, fails to acknowledge the discrete nature of the KHP notwithstanding its characterization as a "nonpoint source" and the regulatory mechanisms available to the State to ensure its compliance.

For the purpose of this discussion, it is useful to explore nonpoint source pollution in the context of the Clean Water Act. Most common nonpoint source pollution comes from diffuse sources and land use activities that is difficult to predict and quantify with precision. Often the approach in a TMDL is to estimate loads and implement nonpoint source requirements for land uses, consisting of the implementation of Best Management Practices that are designed to limit discharges. Because of the difficulties associated with these nonpoint source discharges, it would be wise for an agency to consider the enforceability and practicality of such a control measure before relying on a load reduction from that source. The Regional Water Board does not have many options for assigning loads to source categories and the implementation of programs for agricultural and other land uses is challenging. Often a TMDL assigns loads to every responsible party to the maximum extent, with joint and several obligations to implement, and no load left over to allocate to future uses. (See e.g. Shasta TMDL, 50 years for attainment because of the length of time to establish and grow riparian vegetation.)

But not all nonpoint sources are associated with land use activities that are dispersed and difficult to control. Nonpoint source pollution also includes other pollution exempted from the NPDES permitting program for point source discharges. This "category is defined by exclusion and includes all water quality problems not subject to § 402 [of the Clean Water Act]." (National Wildlife Federation v. Gorsuch (1982) 693 F.2d 156, 166.)

Dams and reservoirs fall in this category. Courts have upheld EPA's statutory construction that since there is no "addition" of a pollutant, discharge from dams are not a point source and therefore generally do not require NPDES permits.

Under section 402 of the Clean Water Act, point source discharges to waters of the US are prohibited unless covered by a NPDES permit issued by EPA or state government if lawfully delegated. Control of all other sources is reserved for the states and local government through the area wide waste management plans under section 208 of the Clean Water Act. (See Gorsuch at 176 [describing legislative history of 1977 amendments, section 208 was a devise for separating out pollution sources amenable to NPDES technological controls and partly an "experiment" in the effectiveness of state regulation (citations omitted)].) Reasons cited for why dams are not appropriately regulated under point source control are several. First, water quality problems associated with dams involve effects attributable to the dam itself, not just effects resulting from the discharge. "[D]ams may not be amenable to the nationally uniform controls contemplated by § 402 because pollution problems are highly site-specific." (Gorsuch at 177, FN61 (citing EPA Brief)].) Also, Congress wanted to avoid interference with state management over water quantity and state allocation plans, thus dams were better left to regulation by the state, particularly in state agencies that have explicitly combined the two functions of regulating water quantity and quality. (Gorsuch at 179.) In exempting dams from NPDES requirements, courts point to other authorities better equipped to apply to such facilities. (National Wildlife Federation v. Gorsuch (1982) 693 F.2d 156, 183 [discussing state efforts to remedy dam-caused pollution and citing Clean Water Act section 401(a)(2)]; National Wildlife Federation v. Consumers Power Co. (1988) 862 F.2d 580, 590 [citing FERC authority to address hydroelectric facility's impact on fisheries].) The fact that dams and reservoirs are exempted from NPDES requirements does not mean that these facilities are immune from Clean Water Act requirements.

EPA does not have direct authority to regulate nonpoint sources under the Clean Water Act, and has historically relied on grants and the state to administer an effective nonpoint source programs. EPA will not approve a TMDL for example, unless the State shows reasonable assurances that the water quality standards will be obtained. For states that lack state authority over nonpoint source discharges, often grants and encouragement is all that is available for TMDL implementation of nonpoint source pollution. Fortunately, we do not encounter these difficulties with the KHP. While the KHP is technically a nonpoint source because it is exempt from NPDES permitting requirements, the facility actually functions more discretely and therefore is more easily analyzed for its impacts on water quality. The Code of Federal Regulations does not limit the available controls a State has for TMDL implementation just because its text is written in the context of nonpoint source pollution from land use activity. (See 40 CFR §130.2(i) ["If [BMPs] *or other nonpoint source pollution controls* make more stringent load allocations practicable, then wasteload allocations can be made more stringent" (emphasis added)].) For these reasons, the KHP is more of a controllable factor than other nonpoint sources and therefore load allocations assigned to it are entirely appropriate, enforceable and practical.

STATE AUTHORITY OVER THE KHP AND THE FLEXIBILITY PROVIDED TO IMPLEMENTING AGENCY IN TMDL IMPLEMENTATION PLAN

The State has authority to condition the project under section 401 of the Clean Water Act, and it is much easier to predict the resultant water quality improvements from such requirements. In California, the State Water Board issues water quality certification for FERC licensed projects, not the Regional Water Board. (Cal. Code Regs., tit. 23, § 3855.) Section 401 of the Clean Water Act establishes the legal authority by which the state may deny or condition certification based on federal or state water quality requirements. State water quality certification authority over FERC licensed hydroelectric projects is broad and includes substantive state law requirements. (See generally *PUD No. 1 of Jefferson County v. Washington Department of Ecology* (1994) 511 U.S. 700.) In processing water quality certification, the State Board may utilize all of its authority under water quality and water rights law, which includes the state law prohibitions on waste and unreasonable use and obligations under the public trust doctrine. (See US v. SWRCB at183-184 [discussing water quality enforcement authority generally]; Id. at 200-202 [discussing the Board's authority to enforce water quality standards in a water rights context].) Regardless of how the State Board may choose to implement the Basin Plan in the 401 process, the TMDL load allocations are sufficiently stringent to help guide the State Board's decision-making to determine KHP compliance with water quality standards but flexible enough to allow opportunities to explore various options for achieving compliance, including time schedules to accommodate various contingencies. A brief discussion of a recent court decision will help illustrate this concept.

The State Water Resources Control Board Cases (2006) 136 Cal.App.4th 674, involved a challenge to the manner in which the State Water Board had been implementing the Bay-Delta Water Quality Control Plan, a state policy for water quality control. The Bay-Delta Plan included instream flow objectives and implementing language that directed the State Water Board to conduct a water right proceeding to reallocate water rights in accordance with the flow objectives in the Plan. After a subsequent water right proceeding, the State Water Board adopted a water right decision that did not strictly implement several of these objectives. The court held that the State Water Board could not implement alternate flow objectives in lieu of flow objectives actually provided for in Water Quality Plan. (*Id.* at 77-78 ["[W]hen a water quality control plan calls for a particular flow objective to be achieved by allocating responsibility to meet that objective in a water rights proceeding, and the plan does not provide for any alternate, experimental flow objective to be met on an interim basis, the decision in a water rights proceeding must fully implement the flow objectives provided for in the plan"].) The State Water Board must fully implement the water quality plan or duly amend it. Had the water quality plan allowed more flexibility in its objectives and its implementing language, the State Water Board's decision would likely have been upheld in its entirety. But the plan had clearly specified the water right decision "will allocate responsibility for meeting objectives." Thus, the exact language in the plan becomes extremely important.

Our case is similar in that there will eventually be a decision applied to the KHP that implements the Basin Plan, but different because the implementing agency will not be the agency that promulgates the plan. Thus, the lesson from the State Water Resources Control Board Cases to allow sufficient flexibility for implementation becomes even more important. It is not the Regional Board's intent to unduly bind the implementing agency on the range of options for KHP Clean Water Act compliance. If the Regional Water Board was the implementing agency, it would want latitude to study various aspects of infrastructure modifications and other methods of compliance, and the ability to allow time schedules before making an ultimate decision. It is the Regional Board's intent to allow the same options for the agency charged with implementation authority here. The implementation plan has been amended to make this point patently clear.

KHP'S LOAD ALLOCATIONS ARE APPROPRIATE IN THE CONTEXT OF OTHER SOURCES REQUIRED TO REDUCE GRADUALLY OVER TIME

PacifiCorp objects to temperature load allocations attributed to the KHP as inequitable and inconsistent with State law for treating the KHP differently than compliance for other sources, which is expected "gradually over time" without justification or discussion of relevant factors. But the differences in load allocations demonstrate precisely the relevant factors that PacifiCorp asks to be considered. Viewing the KHP load allocations in context with the other source categories in California, there is only one point source discharge that exists and its contribution to impairment and conversely, its ability to effectuate improvements in water quality, is minimal. Impaired water bodies in the North Coast region are largely made up from nonpoint sources of pollution from land uses, which have been historically difficult to regulate. The Regional Board is making progress in this area with the establishment of its timber program and early development of an agricultural waiver, but it remains a challenge to control many diffuse sources that cumulatively contribute to water quality impairments. Other TMDLs may address nonpoint source control tradeoffs, thereby allowing a waste load allocation to become less stringent. In the North Coast, we have the difficult task of assigning loads to every identifiable nonpoint source, developing effective programs in cooperation with the communities that must implement the programs, and hoping that the application of management measures will eventually lead to water quality improvements over time. Consideration of the timing for how nonpoint source contributions can be reduced must necessarily accommodate the difficulties in implementation. Moreover, while the nonpoint source land use activities are important influences on the water quality of tributaries, these activities are not the primary drivers influencing poor water quality in the mainstem of the Klamath River in California.

In contrast, the KHP's ability to influence and improve water quality of the Klamath River is enormous. The KHP alters the temperature regime in the Klamath River and creates low dissolved oxygen and high temperature conditions within the reservoirs and at the tailraces. It alters the nutrient dynamics of the river by creating physical conditions that promote nuisance blooms of suspended algae, including toxin-forming blue-green algae species. While perhaps more specific and tailored than TMDL description regarding nonpoint sources from land use activities, the load allocations to PacifiCorp are no less stringent than would be applied to other controllable water quality factors. Notwithstanding the acknowledgement of implementation flexibility, it is entirely appropriate and necessary for the Regional Board to assign specific and stringent allocations to the KHP. Load allocations to the KHP are justified and necessary because of the discrete nature of the source which makes implementation of water quality control measures practical and enforceable. Moreover, much of the allocation is designed to mitigate the KHP's own contribution to the impairments.

KHP LOAD ALLOCATIONS AND TARGETS RELATE TO THE KHP'S CONTRIBUTION TO WATER QUALITY IMPAIRMENT AND ARE REASONABLY NECESSARY TO PROTECT BENEFICIAL USES

Compliance Lens DO/Temp

The compliance lens allocation requires overlapping temperature and DO conditions that meet water quality objectives and support COLD and MIGR beneficial uses. Currently, Copco 1 and 2 and Iron Gate Reservoirs stratify during summer months, resulting in warmer water with higher dissolved oxygen (DO) concentrations in the upper layers and colder water with lower DO conditions in the lower layers. These conditions do not meet temperature and DO water quality objectives and are stressful, if not lethal, to cold water fish. Cold-water fish (rainbow trout) are currently present within the reservoirs. If the KHP facilities are relicensed by FERC, PacifiCorp will provide fish passage for anadromous salmonids, at which time the compliance lens will become even more critical to support COLD and MIGR beneficial uses. If the temperature, DO and biostimulatory substances objectives were achieved at stateline (i.e. if stateline allocations and targets were met), but there were no change to the operation of Copco 1 and 2 and Iron Gate Dams, then these reservoirs would still stratify during summer months, resulting in temperature and DO conditions that do not meet objectives, and do not support COLD and MIGR beneficial uses. Therefore, the compliance lens allocation is necessary and required in addition to upstream load reductions.

Nutrients/Organic Matter

Current conditions in Copco 2 and Iron Gate Reservoirs promote algae blooms during the summer months, resulting in violations to the biostimulatory substances, toxicity, suspended material, and floating material narrative objectives; these water quality conditions do not support the REC1, REC2, and MUN beneficial uses in the reservoirs, and periodic and potential non-support of these same uses plus FISH and CUL in riverine reaches below Iron Gate.

The nutrient load allocations to the KHP facilities in California are set to the levels necessary to meet the chlorophyll-a, *Microcystis aeruginosa*, and microcystin TMDL targets for Copco 1 and 2 and Iron Gate Reservoirs. These TMDL targets serve as quantitative surrogates for the toxicity, suspended material, and floating material narrative objectives. In addition, numeric nutrient targets are established to track compliance with the nutrient allocation.

If the DO and biostimulatory substances objectives were achieved at stateline (i.e. if stateline allocations and targets were met), but there were no change to the operation of Copco 1 and 2 and Iron Gate Dams, then these reservoirs would still create conditions that promote algal blooms during summer months, and would still not meet the chlorophyll-a, *Microcystis aeruginosa*, and microcystin TMDL targets. Therefore, the nutrient load allocations to the KHP facilities in California are set to levels that are below those at stateline (i.e. require additional nutrient reductions to those represented in the allocations at stateline) to remedy conditions created by the existence of the reservoirs themselves.

DO/Temp tailrace targets and allocations
The DO targets at the reservoir tailraces are set to track compliance with the nutrient and compliance lens allocations to the KHP facilities in California. The DO targets at the tailrace were established using the stateline compliance scenario (i.e., compliance with DO objective at stateline) not with the additional KHP allocations.

The temperature allocations for the KHP facilities in California limit the change in water temperature to that which would occur under a run-of-river condition (i.e. a natural temperature increase). The temperature allocations apply to the condition of the water as it enters the reservoirs, and are not dependent on compliance with upstream temperature allocations. The temperature targets are set at set to monthly average temperature conditions consistent with the estimate natural temperature regime of the river. The temperature targets are set to track compliance with the temperature allocations.

KHP allocations and targets are reasonably necessary to support beneficial uses and are designed in part to mitigate the impact of the KHP's own contributions to impairment. In cases where allocations and targets are more difficult to meet without requisite reductions upstream, the targets and allocations are still appropriate in order to support beneficial uses in the KHP area and to prevent nuisance conditions that would not occur in the absence of the project itself. Moreover, the TMDL implementation plan provides a mechanism for offsets which will help effectuate the required reductions upstream, and flexibility in time schedules for final compliance that allows for detailed studies on infrastructure modifications and other compliance scenarios.

EVIDENCE DOES NOT SUPPORT A USE ATTAINABILITY ANALYSIS
Finally, the evidence does not support a Use Attainability Analysis (UAA) at this time. Under Code of Federal Regulations, title 40, section 131.10(g)(4), a state "may remove a designated use" that is not existing if attaining the use is not feasible because "dams, diversions or other types of hydrologic modifications preclude the attainment of the use, and it is not feasible to restore the water body to its original condition or to operate such modification in a way that would result in the attainment of the use." A "use attainability analysis" is "a structured scientific assessment of the factors affecting the attainment of the use which may include physical, chemical, biological, and economic factors...." (40 CFR §131.3(g).) A UAA cannot be used to remove an existing use.

The Clean Water Act was intended to clean up the nation's waters, not simply to perpetuate the status quo. (33 U.S.C. 1251(a) ["The objective of this Act is to *restore* and maintain the chemical, physical, and biological integrity of the Nation's waters."] [emphasis added].). It aims as an interim objective to eliminating all water pollution, to achieve water quality levels to allow waters to be fishable and swimmable. (33 U.S.C.

1251 (a)(2); 40 CFR 131.2.) While the Act recognizes that reaching these goals may not be possible for all waters, it requires rigorous analysis when a state wishes to designate a water body as unable to achieve these uses. (40 CFR 131.5(a)(4), 131.6(a), 131.10(j); compare 40 CFR 131.10(k) [specifying that no UAA is required for waters designates as fishable and swimmable].) This stands in contrast to the permission granted to states to impose *more* stringent standards than those developed under the Clean Water Act. (40 CFR 131.4(a).) States must designate a use if can be obtained through the Clean Water Act's point source control program and using cost-effective and reasonable best management practices for non-point sources: however these establish a "minimum" standard for use designation, leaving states free to designate uses that would require additional actions to achieve. (40 CFR 131.10(d).)

The Clean Water Act provides no mandate for states to initiate a procedure to remove a designated use, and such a mandate would run counter to the purpose and language of the act, as discussed above. (40 CFR 131.10(g)(4) [indicating that a state "may" remove uses after a UAA.].)

As discussed above, the TMDL allocations and targets are required to support existing beneficial uses of FISH, CUL, COLD, MIGR, REC1, REC2, and MUN. In addition, the Basin Plan identifies the following beneficial uses relevant to fish passage for the Iron Gate and Copco Lake Hydrologic Subareas: COLD (Cold Freshwater Habitat), RARE (Rare, Threatened or Endangered Species), MIGR (Migration of Aquatic Organisms), and SPWN (Spawning, Reproduction, and/or Early Development).[1] These designations are also identified for reaches below the KHP on the Klamath River. For uses that could be characterized as "potential" rather than existing,[2] a UAA is appropriate when it is shown that even under natural conditions, the use or water quality objective could not be attained. This problem arose in model runs for DO and led to the development of a site-specific DO objective. But, a use designation that would be unachievable under natural conditions is quite different from a designation that would be achieved under natural conditions but will be challenging to meet given the waterbody's current state of development.

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1 PacifiCorp is not specific about what beneficial use cannot be met, and what re-designation it would propose, unless it means to suggest that Clean Water Act should not apply on the Klamath River or to the KHP generally. The Regional Board would reject such a notion out of hand in light of the beneficial uses that the river currently supports.

2 Water quality objectives are established to be sufficiently stringent to protect the most sensitive use. In the Basin Plan, designated uses are listed and identified as either an existing use ("E") or a potential use ("P). The beneficial uses designated for the Klamath River that protect fish are identified as existing, even though the blockage to fish passage had already occurred before the Basin Plan was adopted. There is some question about why these uses were not designated as "potential" instead of "existing." It is likely that other species were and are present in these upper reaches that rely on the beneficial use designation. The potential beneficial use for anadromous species can be implied by the more stringent designation. In addition, actions taken upstream may be appropriate in order to protect the existing beneficial uses downstream where anadromous fish are present. (*See* 40 C.F.R. § 131.10(b) [in designating uses, ensure water quality standards provide for attainment and maintenance of downstream water quality standards].)

Here, ample historic evidence indicates that the Klamath River under natural conditions supported a robust anadramous fishery – the most sensitive use affected by the water quality constituents addressed in this TMDL.

It may be appropriate to consider changing a use if man-made changes are so indispensable and/or irreversible to be considered natural background. That is not the case here. The Klamath Hydroelectric Settlement Agreement (KHSA) was recently signed by state, federal, tribal and local governments, PacifiCorp, and other stakeholders including irrigators and environmentalists, to establish a path to evaluate dam removal. Given the broad coalition of governmental and private interests that have agreed to undertake a nuts-and-bolts evaluation of dam removal and its economics, the alterations the dams have established are not irreversible or indispensable.

As described above in K40, the Klamath River is not meeting the minimum standard under Clean Water Act section 101(a)(2) for water quality which provides for the protection and propagation of fish, shellfish, wildlife. (40 CFR §131.10(j) & (k).) As Federal Code of Regulations title 40, section 131.10(g)(4) suggests, a state may wish to conduct a UAA where existing dams or other facilities preclude attainment of certain use designations, and restoration to the original condition is not feasible. However here, evidence indicates that the beneficial uses can be improved with existing facilities in place. Additionally, the KHSA and a host of studies suggest that it is not infeasible to remove the dams, restoring the river to a more natural condition.

In the FERC proceeding, National Marine Fisheries Service (NMFS) issued modified prescriptions for Fishways and Alternatives Analysis pursuant sections 18 and 33 of the Federal Power Act, including the requirement to provide both upstream and downstream passage at each of the dams. An administrative hearing challenging the condition resulted in a finding that substantial evidence supported NMFS's finding that voluntary fish passage would improve the fishery. Removing the designations that would support an anadramous fishery from waters in the area of PacifiCorp's facilities would be in direct conflict with this condition.

Regional Water Board staff has evaluated the use of KHP Reservoir Management Plan (RMP) measures and AIP interim water quality measures for potential TMDL compliance, which included some proposals for in-reservoir modifications. The following feasibility ranking scale was used in this process: 1) Viable – recommended; 2) Uncertain – further study needed; and 3) Not viable – not recommended. In reservoir measures such as epilimnion circulation were assigned ratings of 2 or 3, upstream offsets were assigned a rating of 1. While the initial evaluation was not promising, Regional Board staff will continue to work with PacifiCorp to evaluate the feasibility of infrastructure improvements and offset projects as identified in more detail in K39 to achieve Clean Water Act compliance.

In addition, PacifiCorp cites no evidence to support its contention that it cannot attain the proposed load allocations in light of the flexible TMDL implementation structure designed to allow offsets for an interim time period while restoration options are explored and pursued. The Klamath TMDL provides some latitude to explore options to operate the KHP in a way that would result in the attainment of the use. Accordingly, the Regional Board staff cannot agree that a UAA is appropriate at this time, and any more specific response would be too speculative in the absence of a specific proposal.

Even if ultimately PacifiCorp cannot develop an approach to operating the KHP in a manner that complies with the Basin Plan, evidence exists to show that restoration is feasible. Fisheries experts have stated that the key to stopping the decline of salmon is the removal of dams and/or the protection and/or restoration of their spawning streams (Moyle, 2002). The National Research Council recommended that "…serious evaluation should be made of the benefits to coho salmon from the elimination of Dwinnell Dam and Iron Gate Dam on the grounds that these structures block substantial amounts of coho habitat…." (National Research Council, 2004). During the FERC relicensing process studies were conducted on the feasibility of dam removal and the impact of lost generation. PacifiCorp estimated the costs of ladders and screens for NMFS fisheries prescriptions at about $200 million. FERC estimated the cost of removal of the four mainstem dams at just under $80 million (but said costs would be much greater if sediments were contaminated and had to be removed). (Federal Energy Regulatory Commission, 2007.) The California Energy Commission (CEC) prepared a model to evaluate the economic risks or benefits to ratepayers. In a letter to FERC in 2007, the CEC stated that "it would generally be more cost effective to decommission rather than relicense the Klamath Hydro Project. [model] results affirm that decommissioning the [KHP] and procuring replacement power for 30 years would be less costly to PacifiCorp and its ratepayers than relicensing the project and mitigating its impacts." (California Energy Commission, 2007.)

The California Coastal Conservancy (CCC) conducted several studies on dam removal, particularly focused on sediments. Preliminary studies determined that the quantity of sediments eroded during drawdown of the reservoirs would be quickly transported downstream. (Stillwater Sciences, 2004.) This conclusion was further evaluated and confirmed in a later report. (Stillwater Sciences, 2008) Core samples collected in Iron Gate and Copco Reservoirs and the evaluation concluded that no contaminants at levels of concern were found and that "sediment chemistry would permit downstream erosion of river reservoir sediments." (Gathard Engineering Consulting (2006).) Stillwater Sciences (2009) conducted an analysis of the impacts of the high turbidity levels that will occur during reservoir drawdown on fish species that occur in the Klamath River. The study indicated that drawdown of the reservoirs prior to removal will result in high levels of turbidity that may result in short term impacts to fish in the Klamath River, but that the impacts to certain species can be reduced through the timing of speed of the reservoir drawdown. All fish species were predicted to recover from the high levels of turbidity. (Stillwater Sciences, 2009.) While additional studies may be helpful (Stillwater Sciences, 2009a), a great deal of the analysis conducted to date demonstrates that dam removal is feasible and provides economic benefits to ratepayers when compared to relicensing with mandatory conditions.

Additionally, further analysis of the economic and environmental impacts of dam removal is ongoing. It would be an inefficient use of resources to initiate a UAA at this point in time, without getting the benefit of this additional research. We expect more detailed evaluations will be conducted as the FERC proceedings and/or for the environmental analysis developed to support the Secretarial Determination. As part of the FERC/401 certification proceeding, the State Water Board is preparing an Environmental Impact Report (EIR) that will evaluate four alternatives for operating the KHP, two of which include removal of two and four of the KHP dams, respectively. Under the KHSA, the Secretary of the Department of the Interior will conduct very detailed studies and assessments to determine, *inter alia*, whether dam removal (i) will advance restoration of the salmonid fisheries of the Klamath Basin, and (ii) is in the public interest.

It would be inappropriate at this time for the Regional Water Board to conduct an analysis to determine whether the existence of the KHP precludes the attainment of a potential beneficial uses, and whether it is feasible to restore the water body to its original condition. The decision by the State on whether to conduct a UAA is up to the discretion of the State and the Regional Water Board staff cannot recommend pursuing this option. The TMDL Implementation Plan is flexible enough to allow the Secretarial Determination to move forward and that process will help inform this question, which could perhaps be revisited in 2012 after the Secretary makes findings.

References:
Moyle, Peter B. 2002. Inland fishes of California. University of California Press, Berkeley, CA.

National Research Council of the National Academies. 2004. Endangered and Threatened Fishes in the Klamath River Basin. The National Academies Press, Washington, DC.

Federal Energy Regulatory Commission. 2007. Final Environmental Impact Statement for Hydropower License, Klamath Hydroelectric Project, FERC Project No. 2082-027. Federal Energy Regulatory Commission Office of Energy Projects Division of Hydropower Licensing. November 2007.

California Energy Commission. 2007. Letter from B.B. Blevins, Executive Director, California Energy Commission to Philis Posey, Acting Secretary, Federal Energy Regulatory Commission. April 19, 2007.

Stillwater Sciences. 2004. A Preliminary Evaluation of the Potential Downstream Sediment Deposition Following the Removal of Iron Gate, Copco, and J.C. Boyle Dams, Klamath River, CA, Final Report Prepared for American Rivers, California Trout, Friends of the River and Trout Unlimited. May 2004.

Gathard Engineering Consulting. 2006. Klamath River Dam and Sediment Investigation, Final Report. November 2006.

Stillwater Sciences. 2008. Klamath River dam removal study: sediment transport DREAM-1 simulation. Technical Report, Prepared for California Coastal Conservancy, 1330 Broadway, 13th Floor, Oakland, CA 94612, 73 pages. October 2008.

Stillwater Sciences. 2009. Effects of Sediment Release Following Dam Removal on the Aquatic Biota of the Klamath River, Final Technical Report. Prepared for State Coastal Conservancy Oakland, California. January 2009.

Stillwater Sciences. 2009a. Dam Removal and Klamath River Water Quality: A Synthesis of the Current Conceptual Understanding and an Assessment of Data Gaps. Technical report. Prepared for State Coastal Conservancy, 1330 Broadway, 13th Floor, Oakland, CA 94612, 86 pages. January 2009.

K54. <u>Comment(s):</u>

- The Regional Board did not consider relevant factors in determining the thermal load allocations nor establish the criteria used to make these determinations. The development of a load allocation plan "requires the consideration of numerous factors, including cost, technical achievability and equity." SWRCB "Impaired Waters Guidance," at p. 5-18. An allocation plan should achieve an acceptable balance between these factors. *Id.* Furthermore, "[l]oading scenarios may be adjusted… taking political, social, and economic factors into consideration," such as deciding to apply reductions only to a few targeted sources. *Id.* at p. 5-19. Most importantly, however, "[t]he criteria for making these decisions (e.g., magnitude of impact, degree of management controls in place, feasibility, probability of success, cost) must also be established." *Id.*

  The load allocation plan is inequitable and inconsistent with State law for treating PacifiCorp's expected compliance differently than compliance by other sources, which is expected "gradually over time" without any justification or discussion of the relevant factors considered. As discussed above, the thermal load allocations assigned to the Project should have been attributed based on the actual or expected loadings. Finally, the cost of compliance methods was not considered for the Project, specifically the cost of dam removal, which the Draft TMDL indicates is the only means for compliance. This issue is further discussed below.

- The Regional Board did not consider relevant factors in determining the thermal load allocations nor establish the criteria used to make these determinations. The development of a load allocation plan "requires the consideration of numerous factors, including cost, technical achievability and equity." SWRCB, "Impaired Waters Guidance," at p. 5-18. An allocation plan should achieve an acceptable balance between these factors. *Id.* Furthermore, "[l]oading scenarios may be adjusted… taking political, social, and economic factors into consideration," such as deciding to apply reductions only to a few targeted sources. *Id.* at p. 5-19. Most importantly, however, "[t]he criteria for making these decisions (e.g., magnitude of impact, degree of management controls in place, feasibility, probability of success, cost) must also be established." *Id.*

The nutrient allocations specified in the Draft TMDL for the Project and Iron Gate Hatchery would require huge reductions in nitrogen and phosphorus that are not related to the actual loadings from either source. A source is only responsible for the loadings it controls. It is inequitable to require a source to reduce its loadings by more than it contributes. Other TMDLs have recognized the difficulty of changing the trophic state of a naturally eutrophic system. For example, Crowley Lake in California was considered impaired by nutrients based on observations of blue-green algae blooms, but the TMDL resulted in the recognition that the reservoir was naturally eutrophic because even with maximum reductions of anthropogenic influent TN and TP, the trophic state index would remain essentially unchanged. Therefore, in the Crowley Lake case, rather than assigning unachievable negative load allocations, the Regional Board staff concluded that a site specific objective for DO should be prepared to account for naturally eutrophic conditions. Unlike the Crowley Lake TMDL, the nutrient allocations assigned in the Draft TMDL to the Project and Iron Gate Hatchery do not consider feasibility given similar circumstances or equity.

Moreover, the TMDL concludes that the water quality objectives are difficult to meet with the PacifiCorp facilities in place, yet it also states that with or without the dams, the nutrient loads would be in excess of acceptable loads (p. 4-21, 5-22). Other recent TMDLs involving hydropower projects, such as those for Hells Canyon and the Spokane River, for example, did not set the baseline to conditions that would exist without the dams in place. Here, the TMDL is inconsistent with State law for failing to consider the feasibility of the nutrient reductions assigned to the Project and the equity of assigning such reductions below the amount of loading the reservoirs actually contribute.

Although the TMDL states that off-site mitigation may be used to meet allocations for Iron Gate Hatchery and the Project in the interim, it fails to discuss any quantification of the expected reductions (p. 6-14, 6-15, 6-55-6-56). Several peer review comments questioned how the nutrient targets would be met. *See* Appendix 7, p. 1, 12, 26. As discussed above, the Regional Board staff's response that it need not consider feasibility is incorrect. *See* Appendix 7, p. 2. The load allocations were improperly set to require reductions below natural conditions. As such, it is not a matter of debating various implementation methods. Rather, it is a failure to accurately characterize natural conditions and identify feasible solutions.

Finally, despite highlighting the conclusion that the water quality objectives will be difficult to meet with the Project facilities in place, the Draft TMDL did not consider the cost of dam removal, which it indicates is the only viable means of compliance with TMDL load allocations (p. 5-22). This issue is discussed further below.

The Draft TMDL does not discuss how the relevant factors were considered in developing the DO and nutrient load allocation plan. If these factors were in fact considered, this fact should be explicitly stated and a discussion of factors considered and results reached should be included in the Draft TMDL. The criteria for determining that the Project and Iron Gate Hatchery should be required to achieve such large reductions should be established and included in the Draft TMDL.

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
Citing a guidance document from the State Water Resources Control Board, PacifiCorp claims that the Regional Board did not consider relevant factors in determining TMDL load allocations or establish the criteria used to make load allocation decisions. Factors to consider and balance include 1) cost, technical achievability and equity; 2) political, social, and economic factors; and 3) magnitude of impact, degree of management controls in place, feasibility, and probability of success.

The SWRCB document titled "A Process for Addressing Impaired Waters" is a guidance document that does not carry the force and effect of a regulation. In its introduction, the goal of the document is stated "to assist" Regional Water Boards. It details certain phases of the TMDL process that do not precisely follow the Regional Board's TMDL chapters but generally tracks our approach. "The process for addressing impaired waters is presented as a science-based methodology, beginning with the formulation of a conceptual model that serves as the technical plan for projects and as the baseline from which the technical approach can be adapted as scientific investigations provide new data and information. Throughout this process the focus is on identifying actions that can result in the successful restoration of impaired waters." (Guidance at 1-2.) "[T]he information in this document is presented as discrete prescriptive steps. In reality, each of the RWQCBs will have wide latitude and numerous options, as well as some legal constraints, when determining how to address impaired waters." (Id.)

Moreover, these factors were most certainly taken into consideration when developing the TMDL implementation plan. In February of 2009, the Regional Water Board circulated a draft scoping document for TMDL implementation. (Water Quality Restoration Plan for the Klamath River Basin in California: Draft Scoping for TMDL Implementation (February 19, 2009).) Regional Water Board staff held five public workshops where an overview of the impairments and potential implementation measures was provided. The document provided an overview of draft load allocations, identified potential responsible parties, and potential permitting and other applicable implementation mechanisms. The document discussed implementation challenges of controlling sources where traditional controls may not apply or where the Regional Water Board lacks implementing jurisdiction. (Id., at 1.) It invited feedback and input on a variety of information related to implementation, including the benefits and burdens of different implementation approaches. Regional Water Board received numerous submittals that helped inform the development of the proposed implementation plan. At that time, PacifiCorp submitted comments outlining its proposed interim measures, including monitoring, and was supportive of proposed implementation elements that are consistent with those in the most current draft.

This Staff Report and draft final Implementation Plan reflects the consideration of relevant factors cited above. For example, the document acknowledges that the allocation at the stateline will require an unprecedented level of cooperation between the states and federal government to achieve pollutant loading reductions necessary to meet water quality objectives and support beneficial uses in both states. That topic alone indicates relevant factors under consideration which led to the formation of a Management Agreement with Oregon and EPA to help coordinate implementation, and early implementation specified on the Lost River tributary. In addition, the Regional Board has structured a pollutant trading and tracking program to encourage the implementation of centralized treatment options. This approach reflects consideration of engineering, costs, political and social factors, magnitude of impact, degree of success, and feasibility. This program is even more defined in the proposed Implementation Plan and supported in part by PacifiCorp's commitment in Interim Measures 10 and 11 as part of the Hydroelectric Settlement Agreement. This trading approach in the context of the interim time period where structural options for the KHP are explored in depth is consistent with an approach recommended in the SWRCB Guidance document. (Guidance at 5-19 ["Another consideration is the use of pollutant trading concepts to help optimize costs while fulfilling load reductions"].)

Regarding the load allocations in absence of their context in the implementation plan, the justification for KHP is supported in K53 above. The KHP is one of the few controllable water quality factors available to California. Moreover, the facility itself contributes greatly to the impairments. PacifiCorp repeatedly complains that it is inequitable to require "huge reductions in nutrients" not related to the actual loadings from the source. This argument takes too narrow a view of the TMDL exercise. The TMDL demonstrates that the load allocations are necessary to meet water quality objectives and ensure the protection of beneficial uses in the reservoirs. By altering the assimilative capacity of nutrients in the system, the reservoirs are the source, and the impairment that the allocations address would not exist in the absence of that source. Although it is often implied, Regional Water Board staff have clarified in the TMDL that the load allocations could be met by alternative management measures or offsets. Regardless, PacifiCorp is responsible for the water quality conditions in its reservoirs.

PacifiCorp's comments also over emphasize the issue of "achievability," perhaps confusing a load allocation with a technology-based effluent limitation (TBEL). TBELs prescribe national standards that apply to a specific industrial category after an in-depth assessment of available pollution control technologies and practices. A model technology is selected as the basis for the required level of control. While that specific technology is not mandated, USEPA must demonstrate that the control is "achievable." The Clean Water Act also contains water quality-based requirements (WQBELs), which are developed when TBELs are not adequate to meet water quality standards in the receiving water. TBELs and WQBELs are applied to point source discharges through NPDES permits.

TMDLs are established at levels necessary to attain and maintain the applicable narrative and numerical water quality standards. A water quality standard defines the water quality goals of a water body by designating uses to be made by the water and by setting criteria (or objectives in California) necessary to protect the designated uses. (40 CFR §131.2.) Criteria may be numeric (chemical or biological parameters with influence on aquatic life and human health), or narrative, often expressed as waters "free from" a given poor water quality condition, such as floating material in amounts that cause nuisance or adversely affect designated uses. (40 CFR § 131.11.) Because load allocations apply to nonpoint sources of pollution, neither TBELs nor WQBELs are necessarily relevant; however, the discussion is informative. If a load allocation were to be applied in a permit, as a wasteload allocation is applied in an NPDES permit, it would be considered a WQBEL, not a TBEL, because it is based on meeting the water quality standards of the receiving water. There is no specific legal requirement to show that a load allocation is "achievable" given the current state of technology or control practices like a TBEL. PacfiCorp also argues that standards are not "attainable" discussed above in response to comment K53. Attainability and achievability are different concepts.

Whether or not a load allocation is achievable is not a legal standard; however, various factors can and should be considered. But again, load allocations must be viewed in context with the implementation plan. Recognizing the Regional Water Board's lack of implementing jurisdiction over the KHP, the implementation plan allows PacifiCorp to submit a proposed plan that accommodates the various regulatory processes that could occur. The implementation plan adds enough flexibility, through the allowance of offsets and time schedules, for implementing agencies to develop more specific conditions of approval that adequately meet the load allocations.

PacifiCorp's reference to how other TMDLs have addressed impoundments demonstrates that reservoir treatment depends on the circumstance in the particular waterbody. Eutrophic status can reflect a condition of use impairment (man-made) or reflect naturally occurring conditions. In the first instance, a TMDL should be prepared. In the Crowley Lake TMDL, the Lahontan Regional Water Board found that Crowley Lake was naturally eutrophic. North Coast Regional Water Board staff do not necessarily agree with that Board's determination to not consider the reservoir a controllable water quality factor, but these decisions are better left to each Regional Board based on the facts of a given situation. The beneficial uses were not impaired in Crowley Lake. Also, although a Use Attainability Analyses was proposed for Crowley Lake, it appears that that process was not successful. Like most TMDLs, the Board will have the opportunity to assess the success of management measures and adjust or perhaps revise its management approach in the future. The Hells Canyon TMDL assigned load allocations to impoundments, assigning responsibility for water quality problems related exclusively to the impoundment effects. Like the Klamath TMDL, it acknowledges the complexity and provides flexibility to accommodate the regulatory processes and adaptively manage as more information becomes available. Similarly, the Spokane TMDL assigned responsibility to impoundments that would be implemented in the FERC relicensing process. There is not one uniform approach to addressing impairment contributions from impoundments, nor should there be. Each situation will present unique circumstances and will require some flexibility in the proposed implementation, if at all, depending on the severity of impacts, other sources available for reduction, and implementation ability.

The structure of the implementation plan for KHP obviously considers relevant factors regarding legal feasibility, and management controls in effect. The Regional Water Board recognizes that the KHP will undergo one of two possible processes, either the FERC/401 or the Settlement route. In each, a process is in place to review technical and economic feasibility, among other things, before deciding what modifications or removal of the project is necessary. Those two processes are driven by other concerns in addition to water quality and will necessarily be decided by a different agency after thorough analyses.

K55. Comment(s):

- The temperature targets, wasteload and load allocations for the Project and Iron Gate Hatchery are more stringent than necessary and result in *de facto* water quality objectives. As discussed above, the temperature effects of the Project and Iron Gate Hatchery are consistent with a BIP and the application of a zero thermal load as a year round margin of safety is inappropriate in this instance. In effectively establishing a new thermal water quality objective, the Regional Board should have complied with the procedure for adopting revised objectives and considered the relevant factors. Water Code Section 13241 provides that factors to be considered by a regional board in establishing water quality objectives include: past, present and probable future beneficial uses of water; environmental characteristics of the hydrographic unit under construction, including the quality of water available thereto; water quality conditions that could reasonably be achieved through the coordinated control of all factors which affect water quality in the area; economic considerations; the need to develop housing in the region; and the need to develop and use recycled water. Because the Regional Board failed to follow the appropriate procedure and consider the relevant factors, the wasteload and load allocations are invalid.

- The DO, benthic algae, chlorophyll-a, *Microcystis*, and microcystin targets for the Project and Iron Gate Hatchery are more stringent than necessary and result in *de facto* water quality objectives. As discussed above, the modeling and technical analysis provide skewed information that results in nutrient-related targets that require much larger nutrient reductions than necessary to achieve water quality objectives. Even after accounting for a margin of safety, these targets are unnecessarily stringent or beyond what are necessary to protect the designated beneficial uses. In effectively establishing a new nutrient water quality objective, the Regional Board should have complied with the procedure for adopting revised objectives and considered the relevant factors. Water Code Section 13241 provides that factors to be considered by a Regional Board in establishing water quality objectives include: past, present and probable future beneficial uses of water; environmental characteristics of the hydrographic unit under construction, including the quality of water available thereto; water quality conditions that could reasonably be achieved through the coordinated control of all factors which affect water quality in the area; economic considerations; the need to develop housing in the region; and the need to develop and use recycled water. Because the Regional Board failed to follow the appropriate procedure and consider the relevant factors, the nutrient-related targets are invalid.

- The temperature targets, wasteload and load allocations for the Project and Iron Gate Hatchery are more stringent than necessary and result in *de facto* water quality objectives. As discussed above, the temperature effects of the Project and Iron Gate Hatchery are consistent with a BIP and the application of a zero thermal load as a year round margin of safety is inappropriate in this instance. In effectively establishing a new thermal water quality objective, the Regional Board should have complied with the procedure for adopting revised objectives and considered the relevant factors.

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
PacifiCorp asserts that temperature targets, wasteload and load allocations for the Project and Iron Gate Hatchery are more stringent than necessary and result in *de facto* water quality objectives. This conclusion is based on PacifiCorp's previous argument that the KHP, including the Hatchery, is subject to the BIP standard and not the temperature objectives in the Basin Plan. As a result, PacifiCorp argues that the Regional Board should have complied with the procedure for adopting revised objectives and considered the relevant factors.

TMDLs require a quantitative numeric pollutant target established at a level necessary to achieve water quality standards in an impaired waterbody. (33 USC §1313(d)(1)(C).) The Clean Water Act, federal regulations, case law and interpretive guidance from EPA all describe TMDLs in this way. (See Office of Chief Counsel Memo, *The Distinction Between A TMDL's Numeric Targets and Water Quality Standards* (June 12, 2002).) The TMDL implements existing water quality standards that are made up of use designations, water quality criteria based on those uses, an antidegradation policy, and implementation policies. When expressed in narrative terms, the objective will need to be translated into a number that articulates the existing criteria to meet TMDL requirements; however, this process does not establish a new water quality standard. TMDLs are mechanisms to implement already existing standards. TMDL targets are not designed to rebalance the policy interests underlying [existing] standards." (OCC memo at 6.) Changing a standard or designated use involves a separate process not appropriately before the Regional Water Board and described in more detail in K53. As explained in K40, assigned load allocations are also required to meet the BIP standard, so we need not analyze a BIP standard under Water Code section 13241.

In addition, the load allocation is not directly enforceable and must be viewed in context with the accompanying implementation plan. Even though the load allocations and targets are not new water quality standards, Regional Board staff considered relevant factors of the type listed in Water Code section 13241 when developing the TMDL implementation plan. (See also K54.) Finally, the Regional Water Board will consider any additional information that PacifiCorp provides that relate to relevant factors listed in Water Code section 13241, as they apply to the TMDL load allocations and targets.

K56. Comment(s):
The pro-dam removal crowd is making false statements when they say that Lake Copco is the only part of the Klamath with algae build-up and the floating white foam of bacteria. Too much truth has been lost by believing these psudo-environmentalists who want to take down the dam.

Comment(s) Made By:
Bodnar

Response:
Please see responses to Comments K3 and K7.

K57. Comment(s):
Removal of the dams on the mainstem Klamath River will not restore the river to a condition more favorable to human and fisheries. Dam removal will result in lower flows resulting in warm polluted waters with a high risk of fish disease. Please do not remove the dams and restore the Klamath River.

Comment(s) Made By:
Briggs

Response:
This comment is not relevant to the TMDL. The TMDL does not have any authority over the dam removal process.

K58. Comment(s):
Dam removal as an essential step in achieving the water quality objectives and standards laid out in the draft TMDL, however dam removal is still at least twelve years away. This puts added importance on creation of tough, enforceable load allocations for PacifiCorp in the interim period between now and any removal date. Current water quality conditions in the Klamath River are simply unacceptable. As a fisheries biologist monitoring salmon and sturgeon populations in the Klamath this year alone, I have had to take three courses of antibiotics to deal with ear infections resulting from diving in the Klamath. This year again signs have been posted warning river users that there are harmful levels of Mycrocystin algae, however we are conducting projects that necessitate diving in the river to gather data.

Comment(s) Made By:
Harling – Mid Klamath Watershed Council

Response:
Please see the response to comment X6.

TRIBUTARIES

L1. <u>Comment(s):</u>
There are watersheds under the imposed TMDL, Antelope and Butte Creeks, where the water will never drain into the Klamath River.

<u>Comment(s) Made By:</u>
Bennett – Siskiyou County Supervisor, District 4

<u>Response:</u>
The Butte Valley Hydrologic Area (HA) is not subject to the Klamath TMDL load allocations and targets as it was not included in the technical analysis. However, the Butte Valley HA will be included in the scope of both existing and future basinwide and regionwide nonpoint source program controls, some of which are proposed as part of the implementation plan. Additionally, compliance with the North Coast Region Basin Plan water quality objective for temperature is required throughout the region regardless of the presence of downstream waterbodies, or impairment status.

L2. <u>Comment(s):</u>
The footnote in section 1.1 defines the terms "watershed" and "basin" stating that in this report that they" ... are synonymous and will be used to refer to the area that drains to the Pacific Ocean at Requa.". Neither waters from Antelope Creek nor Butte Creek ever flow to the Pacific Ocean or the Klamath River. Antelope Creek flows into Antelope Sink while Butte Creek Flows into Butte Valley where they both either disappear into the ground or evaporate. In fact, the whole Butte Subbasin does **not** naturally flow into the Pacific Ocean or the Klamath River. Therefore, these watersheds should not be encumbered with the restrictions and requirements of the Klamath River TMDL plan and should be removed.

<u>Comment(s) Made By:</u>
Chapman – Campbell Timber Management

<u>Response:</u>
Please see the response to comment L1. The Butte basin is not mentioned in the Action Plan. It is worth noting that a portion of the water that sinks into the ground flows under Mahogany Mountain to Lower Klamath Lake and the Klamath River (USGS, 1995)

United States Geological Survey (USGS), 1995. Ground Water Atlas of the United States: California and Nevada; HA 730-B. Accessed on February 23, 2010. Available at: <http://pubs.usgs.gov/ha/ha730/ch_b/index.html>.

L3. <u>Comment(s):</u>
If the above watershed areas are not removed from the plan, what is the legal authority that allows them to be included? The water in Antelope and Butte Creeks do not flow

outside of state boundaries; are not navigable or tributary to navigable waters; or are not involved in interstate commerce, and therefore, are not under federal jurisdiction as they are not "Waters of the United States" and federal rules like the Clean Water Act do not apply. The impairments being addressed by the Klamath River TMDL is under the federal law; however, both Antelope Creek and Butte Creek do not fall within the definition of "Waters of the United States". Therefore, these watersheds should not be encumbered with the restrictions and requirements of the Klamath River TMDL plan and should be removed.

Comment(s) Made By:
Chapman – Campbell Timber Management

Response:
Please see the response to comment L1. In regards to authority, the Policy for the Implementation and Enforcement of the Nonpoint Source Pollution Control Program (NPS policy) requires that all nonpoint sources have a regulatory program in place that is compliant with water quality standards, regardless of any listing status. The NPS policy implements state law, as described by the Porter-Cologne Water Quality Control Act.

L4. Comment(s):
The Draft TMDL states that in the natural baseline conditions scenario, natural and TMDL conditions were represented for tributaries to the Klamath, depending on the tributary (p. 3-9). This statement does not clearly identify what conditions were used to establish the natural baseline.

Comment(s) Made By:
Hockaday – Montague Water Conservation District

Response:
The natural temperature and flow conditions are described in Section 3.3.3.2. A description of the tributary nutrient boundary conditions applied in the natural conditions and California compliance condition scenarios has been added to Appendix 7.

L5. Comment(s):
The mainstem Klamath River TMDL must include the strongest possible load allocations at the mouths of the Lost, Scott and Shasta Rivers for flow and nutrients.

Comment(s) Made By:
Klamath Riverkeeper – Various

Response:
Regional Water Board staff are not proposing any load allocations for flow as part of this TMDL. The proposed nutrient load allocations for California tributaries are at levels

necessary to achieve water quality standards. This includes nutrient load allocations for the Lost River previously established by the USEPA.

L6. Comment(s):
Significant areas of Siskiyou County included in the Draft TMDL have absolutely no potential to affect the listed impairments either due to the lack of any hydrological connection whatsoever, or the absence of a hydrological connection that exists during periods that could affect listed impairments. For example, Butte Valley, Antelope Creek watershed, and numerous low gradient, ephemeral watersheds should be left out of the Draft TMDL.

Comment(s) Made By:
Kobseff – Siskiyou County Board of Supervisors

Response:
Please see the response to comment L1.

L7. Comment(s):
The Draft TMDL concludes that compliance with other tributary's existing loads is sufficient to meet DO and nutrient objectives in the Klamath (p. 4-34). Nonetheless, the Draft TMDL applies the nonpoint source nutrient control measures to the tributaries. In doing so, the Draft TMDL fails to show that such nutrient controls are necessary.

Comment(s) Made By:
Krum – Siskiyou Resource Conservation District

Response:
Regional Board staff have revised the Klamath implementation plan so that the Scott and Shasta River basins will continue to be regulated through their existing TMDL conditional waivers. These waivers expire in 2011 and 2012 respectively and at that time the Regional Water Board will consider whether or not to extend those waivers. It is the intent of the Regional Water Board staff to develop a draft conditional waiver for agricultural activities in the Klamath Basin with adoption scheduled for December 2012. The Regional Water Board will decide whether dischargers in the Scott and Shasta basins would be included in the future agricultural waiver or whether they would continue to be regulated through renewed watershed-specific TMDL waivers. It is the goal of the Regional Water Board to consistently regulate agriculture throughout the Klamath basin and throughout the region with the understanding that local conditions and programs must also be considered. The Regional Water Board has the authority to require additional measures in the Scott and Shasta basins in order to implement the Klamath basin TMDL and attain water quality objectives in those basins.

L8. <u>Comment(s):</u>
The Klamath River TMDL is far too overreaching in its extent when considering sediment, particularly when given the fact that there are already pre-existing TMDL's on the Shasta River, Scott River, and Salmon River. To apply one TMDL essentially over the top of another existing TMDL is confusing and not necessary.

<u>Comment(s) Made By:</u>
Sumner – Siskiyou County Public Works

<u>Response:</u>
Please see the response to comment L7.

L9. <u>Comment(s):</u>
Part of the TMDL boundary including a large portion of Siskiyou County east of the Cascade Mountain Range (Butte Valley) does not need to be included as most of it has no connectivity to the main stem Klamath River with respect to sediment.

<u>Comment(s) Made By:</u>
Sumner – Siskiyou County Public Works

<u>Response:</u>
Please see the response to comment L1.

L10. <u>Comment(s):</u>
Section 4.1.3, Pollutant Source loads – Overview Table 4.2. With the exception of the Shasta River, CDFG notes all "Current Annual Source Loads" from the tributaries to the Klamath are attributed to natural baseline conditions. With the degree of human settlement in the Klamath Basin, and impacts caused by land use including timber harvest and agricultural practices in many of the tributaries, CDFG does not agree with this conclusion.

<u>Comment(s) Made By:</u>
Stacey – California Department of Fish and Game

<u>Response:</u>
The Regional Water Board in principle does not disagree with this comment. The concentration values assigned to the tributaries as targets come from a limited number of samples from a subset of tributaries that have a moderate level of disturbance. The estimates could be revised as additional monitoring is conducted on the tributaries. However the targets for most tributaries are likely not to be significantly different from reference conditions. The Regional Water Board staff compared concentration values used for purposes of conducting the natural conditions baseline model scenario (reported in Table 5.16) to estimated ecoregions reference condition concentrations published by

USEPA 2000 (*Ambient Water Quality Criteria Recommendations: Information Supporting the Development of State and Tribal Nutrient Criteria – Rivers and Streams in Nutrient Ecoregion II)*. The TMDL tributaries targets are only marginally above or below the estimated reference conditions for the Coast Range, Klamath Mountains, and Cascades ecoregions. The differences continue to be evaluated as additional monitoring data becomes available.

<u>Reference Used in L10 Response:</u>

USEPA. 2000. Ambient Water Quality Criteria Recommendations: Information Supporting the Development of State and Tribal Nutrient Criteria – Rivers and Streams in Nutrient Ecoregion II. Office of Water EPA 822-B-00-015.

L11. <u>Comment(s):</u>

I manage only about 6000 acres in the antelope creek and butte creek watershed – and they never drain into the Klamath – those would not even be – they don't drain into waters of the US government and they are not covered by the clean water act, so they are going beyond their authority.

<u>Comment(s) Made By:</u>

Chapman – Campbell Timber Management

<u>Response:</u>

Please see the response to comment L1.

L12. <u>Comment(s):</u>

There is ample evidence that the tributaries provide clean water for fish and they're lumped into this TMDL, what we're asking for is that a distinction be made between the mainstem of the Klamath and the tributaries.

<u>Comment(s) Made By:</u>

Schuyler – Klamath National Forest

<u>Response:</u>

Regional Water Board staff acknowledge the Klamath River has different water quality issues than the tributaries. Regional Water Board staff evaluated the nutrient and temperature conditions and source loading separately. Regardless, all sources of non-point source discharges must be addressed through a regulatory mechanism pursuant to the NPS policy.

L13. <u>Comment(s):</u>

Since there is ample evidence that the tributaries to the Klamath River (except the Scott and Salmon) originating on NFS lands provide adequate cool and clean water for fish, we are requesting that the Action Plan be restricted to the mainstem Klamath River.

Comment(s) Made By:
Schuyler – Klamath National Forest

Response:
The USFS should submit their evidence during the next Clean Water Act Section 303(d) list update data solicitation period, following consultation with Regional Water Board staff. Temperature and nutrient load allocations have been proposed for the entire watershed because: (1) tributaries contribute to mainstem loading, (2) tributaries have been impacted by human activities, and (3) the NPS policy requires that all sources of non-point source pollutants, regardless of a waterbody's impairment status, be regulated through either a prohibition, waste discharge requirements, or a waiver of waste discharge requirements. Note that cool water isn't the standard, but rather natural receiving water temperatures.

L14. Comment(s):
More needs to be done to raise water quality in the Klamath and its tributaries like the Shasta and Scott rivers so that the Salmon runs and Steelhead runs are better.

Comment(s) Made By:
Sanguinetti

Response:
Regional Water Board staff agree. The Klamath TMDL Action Plan in conjunction with other completed action plans in the Klamath River basin are intended to address water quality impairments in both the Klamath mainstem and its tributaries.

L15. Comment(s):
Several tributaries to the Klamath River already have TMDLs and/or TMDL implementation plans. The Draft TMDL proposes to replace or add to these existing TMDLs even though it is acknowledged that the existing TMDLs are adequately protective of water quality. It is neither necessary nor appropriate for the Draft TMDL to add to or replace the work that has already been done.

Comment(s) Made By:
Rice and Oldfield – California Farm Bureau Federation and California Cattlemen's Association

Response:
Please see the response to comment L7. Please note that the existence of a TMDL Action Plan does not guarantee or imply adequate protection of water quality. Review of progress towards water quality compliance, for example in the context of waiver renewals, may identify actions that are missing, inadequate, or inappropriate, and that should be modified during waiver renewal.

L16. Comment(s):
A substantial amount of evidence is available to indicate that the minor Klamath tributaries are not impaired by human activities in their capacity to provide adequately cool and clean water for salmonids (Belchik, 2003; Bartholow, 2005; Sutton and others, 2007). The consultation record for compliance with the Endangered Species Act also supports the use of these streams by listed salmonid species (Oak Flat Project BA, 2004; Thorn Seider Project BA, 2009). Data presented in the Public Review Draft (Table 5.19, page 5-28 and Table 6.5, page 6-30) indicate that the minor tributaries are within natural baseline conditions for dissolved oxygen, nutrients, and temperature. Peer reviews for the draft TMDL report indicated concerns with the data and models used to show impairment of these tributaries (for example, see review comments from Dr. Characklis). I understand that these tributaries are included in the 303(d) listings through the "tributary rule." However, the available scientific evidence indicates that no changes in land management are needed to protect water quality, or that such changes could improve water quality. I therefore request that the TMDL Action Plan be geographically restricted to the main stem of the Klamath River and the major tributaries that are separately listed for temperature and nutrient impairment. This would allow the limited available resources of the USFS to be directed at watersheds and reaches that can be improved through land management actions.

Comment(s) Made By:
Moore – U.S. Forest Service, Pacific South West Region

Response:
The fact that a tributary mouth provides a thermal refuge for salmonids in the Klamath River does not imply that they are within baseline temperature conditions. The USFS's own reports (i.e. de la Fuente and Elder, 1998) clearly show that human activities have contributed to severe disruption of riparian environments. The process for listing and delisting water bodies is described in the Water Quality Control Policy for Developing California's Clean Water Act Section 303(d) List. See also response to comment L13.

L17. Comment(s):
- The Scott and Shasta River drainages have their own plans approved by your board and you still want to put another layer of regulations.
- Attributing additional limiting factors to the Scott and Shasta watersheds is simply wrong.
- Requirements placed on the Scott River watershed should be removed from the Klamath TMDL at this time in order to clearly understand the effectiveness of the current measures being taken to adhere to the Scott River TMDL.

Stated within the Scott River TMDL the Regional Water Board staff was directed to complete a trend monitoring plan by September 8, 2007 to "determine the effectiveness of the Scott River TMDL". The Regional Water Board Staff after nearly two years of the stated date for completion presented the draft Scott River Watershed Water Quality Compliance and Trend Monitoring Plan to the Regional Board; therefore, not allowing for the stakeholders' in the watershed to effectively evaluate progress, which in all fairness should be allowed to happen before additional regulations are considered.

Comment(s) Made By:
Bennett – Siskiyou County Supervisor, District 4
Fowle
Gilmore – Scott River Watershed Council

Response:
Please see the response to comment L7. Additionally, the Scott River Watershed Water Quality Compliance and Trend Monitoring Plan was developed to provide information describing water quality conditions in relation to water quality standards over a long-term time-frame (i.e. decades).

L18. Comment(s):
The Draft Klamath River TMDL and Action Plan attempt to revise the Scott River TMDL and Action Plan by adding protection measures for Nutrient and Organic Matter loads, more stringent shade requirements and a change in process for failure to comply with TMDL actions. None of these conditions were identified or discussed in the original Scott River TMDL. These additional conditions represent either a major amendment to the Scott River TMDL, or a completely new TMDL, developed and implemented without following the procedures of public and peer review, and scientific documentation of changed conditions in the Scott River.

Comment(s) Made By:
Gilmore – Scott River Watershed Council

Response:
Please see the response to comment L7.

L19. Comment(s):
This TMDL attempts to regulate watersheds with existing TMDLs by adding regulations for additional impairments. The Regional Board staff failed to show that additional load reductions in the Shasta River basin are necessary to achieve water quality standards in the Klamath River. In fact, the Draft Klamath TMDL concludes “The Klamath River TMDL analysis found that the load reductions called for in the Shasta River TMDL are sufficient to meet water quality standards in the Klamath River” (p.6-21). Thus, why are WDRs and/or conditional waivers proposed for the Shasta River (p.6-22).

Comment(s) Made By:
Hockaday – Montague Water Conservation District

Response:
Please see the response to comment L7. Please also note that the load allocations assigned to the Shasta River in the Klamath TMDL use parameters and units required by the Klamath TMDL model, but are derived from and equivalent to the load allocations presented in the Shasta TMDL, and are not additional load reductions.

L20. Comment(s):
There is no evidence presented to justify why "[p]arties discharging sediment to the Shasta River basin must also comply with the prohibition on the discharge of excess sediment that is proposed as part of this Klamath River TMDL implementation plan (section 6.5.2).

Comment(s) Made By:
Hockaday – Montague Water Conservation District

Response:
In response to numerous comments from individual landowners, staff is recommending removal of the sediment prohibition proposed in the draft TMDL. Instead, staff is recommending a simple basinwide prohibition on discharges in violation of water quality objectives the Klamath River basin. This would provide regulatory certainty to those landowners with minimal or no discharge from land use activities. It will not be used in place of the future conditional waiver for agriculture to be developed at a later date (see 6.5.6 of the TMDL staff report), but provides for minimum water quality protection to allow time to develop the agricultural waiver program through a public process.

L21. Comment(s):
The Draft Klamath River TMDL incorrectly states that nutrient-related targets were imposed by the Shasta TMDL and instead imposes nitrogen, phosphorous, and organic matter loads on the Shasta not contemplated by the Shasta River TMDL.

Comment(s) Made By:
Hockaday – Montague Water Conservation District

Response:
The Shasta River nutrient load allocations expressed in the Klamath River TMDL are based on and equivalent to the nutrient loads that result from full compliance with the Shasta River TMDL. The Shasta TMDL expresses these loads in different metrics than those expressed in the Klamath TMDL, but the loads are the same. Attainment of the Shasta River nutrient TMDL load allocations constitutes compliance with the Klamath River nutrient TMDL load allocations.

L22. Comment(s):
The Draft TMDL states: "Parties discharging sediment in the Shasta River basin must also comply with the prohibition on the discharge of excess sediment that is proposed as part of this Klamath River TMDL implementation plan (section 6.5.2)." (p. 6-22) Sediment was not addressed by the Shasta River TMDL because the Shasta River is not impaired by sediment. In addition, the sediment controls are imposed despite the fact that upon compliance with the Shasta River TMDL, the Shasta River has a negligible effect on the Klamath River (p. 4-25).

Comment(s) Made By:
Hockaday – Montague Water Conservation District

Response:
The sediment prohibition has been removed from the Klamath implementation plan and requirements for discharges in the Shasta River basin have also been removed. However, a basin does not have to be listed as impaired on the 303(d) list in order for the Regional Water Board to take action to regulate a discharge to waters of the State. In fact, the NPS policy (see section 6.1.4 of the staff report) requires the Regional Water Board to regulate all sources of pollution, regardless of the 303(d) listing status in a given basin.

L23. Comment(s):

- The Draft .Klamath River TMDL requires WDRs and/or conditional waiver WDRs that will supersede the WDRs and waivers required by the Shasta River implementation plan that will merely "consider" the load allocations imposed by the Shasta River TMDL. The Shasta River Action Plan stated that the Regional Board would take appropriate permitting and/or enforcement action if the implementation actions failed or proved inadequate; it did not contemplate an entirely different implementation scheme imposed by another TMDL. 23 CCR § 3908. Further there has been no presentation by the Board to the Shasta TMDL Responsible Parties that the conditions of the existing TMDL are insufficient or are not currently being met as required per the Shasta TMDL when loads allocations or permitting requirements are changed.
- The Draft TMDL contains a dissolved oxygen target and nutrient-related targets and allocations for tributaries. Although TP, TN, and CBOD allocations are consistent with the approved Shasta River TMDL and no additional load reductions are required, the Draft Klamath TMDL imposes the same regulatory mechanisms to implement the tributary allocations and targets as that required for watershed-wide implementation actions (p.6-17).

Comment(s) Made By:
Hockaday – Montague Water Conservation District

Response:
In response to public comment, the Shasta River TMDL conditional waiver will remain in effect until it expires in 2012, at which point the Regional Water Board will consider

whether to address Shasta River basin discharges through a basinwide or regionwide agricultural waiver or will extend the current Shasta-specific waiver. The Regional Water Board has the authority to require additional measures as needed to attain the load allocations set forth in the Klamath and Shasta basin TMDLs.

L24. Comment(s):
The Draft TMDL failed to show that the nutrient reductions, sediment controls, and implementation measures are necessary to achieve water quality objectives in the Scott or Klamath Rivers.

Comment(s) Made By:
Krum – Siskiyou County Resource Conservation District

Response:
The need for water quality control measures in the Klamath basin is precisely what is shown by the draft TMDL. These measures are necessary, but no additional measures are required by the Klamath TMDLs in the Scott and Shasta basins at this time pending future evaluation of the effectiveness of TMDL implementation in those basins by the Regional Water Board.

L25. Comment(s):
Data affirming a need to revise existing TMDLs or justify imposing additional implementation measures on responsible parties in the Shasta River basin are absent in the report. This is reaffirmed through peer review comments describing the lack of information used to determine tributary conditions and the lack of discussion of the uncertainty in the models (see Appendix 7, p. 6-8, 15, 6-17, 23, 28, 34). The Draft TMDL failed to show that the nutrient reductions, sediment controls, and implementation measures are necessary to achieve water quality objectives in the Shasta River.

Comment(s) Made By:
Hockaday – Montague Water Conservation District

Response:
Existing TMDLs were not revised. The analysis showed that existing TMDL allocations are sufficient to meet water quality objectives in the Klamath River. However, in order to implement the TMDL successfully and meet the load allocations in the Klamath Basin including the Scott and Shasta basins, it may be necessary to require additional implementation measures than those required in the existing tributary TMDLs. As stated in previous responses, the Regional Water Board will maintain the existing Shasta River TMDL waiver until it expires, at which point the need for additional measures will be considered.

L26. Comment(s):

- The Regional Board failed to consider equity in assigning these reductions and controls to the tributaries beyond what is necessary to comply with the existing TMDLs and beyond what is sufficient to achieve water quality standards in the Klamath River. In determining how the allowable loading capacity can be allocated among various sources, the Regional Boards must consider numerous factors, including cost, technical achievability, and equity. Impaired Waters Guidance at p. 5-18. The decision to apply the watershed-wide allocations, targets, and implementation measures to tributary basins with existing TMDLs in place was not the result of an acceptable balancing of these factors.
- In determining how the allowable loading capacity can be allocated among various sources, the Regional Boards must consider numerous factors, including cost, technical achievability, and equity. (Impaired Waters Guidance at p. 5-18). The decision to apply the watershed-wide allocations, targets, and implementation measures to tributary basins with existing TMDLs in place was not the result of an acceptable balancing of these factors.

Comment(s) Made By:
Hockaday – Montague Water Conservation District
Krum – Siskiyou County Resource Conservation District

Response:
See response to comment O22.

L27. Comment(s):
For temperature, for example, the Draft Klamath River TMDL relies on the analyses in the Shasta TMDL as evidence of temperature impairment, including the human contribution to elevated temperatures in these basins. (p. 2-52) Aside from the inconsistency shown in relying on modeling of natural conditions, rather than TMDL compliant conditions, to show that the Scott and Shasta Rivers have the potential to serve as thermal refugia, the results are not persuasive. The slight potential of the Shasta River to serve as thermal refugia under "'natural" conditions is used to justify the sediment controls imposed on the tributaries. (4-30-4-31) However, the Shasta TMDL already allocated loads and assigned responsibility for enacting implementation measures to address all human-caused temperature impairment in the basins and which did not include sediment controls. The existing tributary TMDLs result in the achievement of water quality objectives in the tributaries, including the Shasta River. Therefore, to rely on "natural" conditions to show a need for sediment controls results in targets that are unnecessary to achieve water quality objectives (because TMDL compliant conditions already achieve water quality objectives).

Comment(s) Made By:
Hockaday – Montague Water Conservation District

Response:
The evaluation of thermal refugia under natural conditions was done to evaluate whether a flow allocation was warranted. However, no flow allocations have been assigned. The sediment discharges addressed by the sediment-related temperature allocations are already prohibited by the Basin Plan.

L28. Comment(s):
For nutrient and organic matter, the Draft TMDL concludes that compliance with the Shasta River TMDL is sufficient to achieve reduced loads to the Klamath and other tributary's existing loads are sufficient to meet DO and nutrient objectives in the Klamath. (p. 4-34) Nonetheless, the Draft TMDL applies the nonpoint source nutrient control measures to the tributaries. *Id.* Given the large nutrient and thermal loads coming from upstream in the Klamath River system, and the negligible impact of the Shasta River on Klamath River temperature and nutrient levels recognized in the Draft Klamath TMDL, it is inequitable to require responsible parties in the Shasta River basin to achieve additional temperature and nutrient reductions, beyond what is required by the existing TMDLs.

Comment(s) Made By:
Hockaday – Montague Water Conservation District

Response:
The Shasta River nutrient load allocations expressed in the Klamath TMDL are based on the nutrient loads that result from full compliance with the Shasta River TMDL. The Shasta TMDL expresses these loads in different metrics than those expressed in the Klamath TMDL, but the loads are the same. Compliance with the Shasta nutrient TMDL constitutes compliance with the Klamath nutrient TMDL. Similarly, compliance with the Shasta Temperature TMDL constitutes compliance with the Klamath temperature TMDL.

L29. Comment(s):
The TMDL states that it will impose similar potential shade targets and sediment allocations as the Scott TMDL, when it contains a more stringent sediment target of zero miles of human-caused channel alteration and additional nutrient load allocations not contemplated in the Scott TMDL.

Comment(s) Made By:
Krum – Siskiyou County Resource Conservation District

Response:
The draft has been revised and the watershed-wide allocations in the Klamath TMDL no longer apply to the major tributaries. Dischargers in the Scott River will continue to be regulated by the existing Scott TMDL waiver.

L30. Comment(s):

- The TMDL is inconsistent with the Scott River TMDL as it imposes new load allocations, addressing different pollutants and targets, and requires new implementation measures, conditions, permitting and waiver requirements to the Scott River watershed. The Draft Klamath River TMDL must be re-drafted to eliminate any additional conditions, reporting, permitting and waiver requirements for the Scott River watershed that are different from those contained and approved in the Scott River TMDL.
- By assigning sediment targets and nutrient reduction to the Scott River and especially by imposing superseding WDRs and/or conditional waivers on grazing and irrigated activities in the basin, the draft TMDL effectively revises the Scott TMDL.
- The Klamath TMDL includes additional regulations on the Shasta and Scott. Both the Shasta and Scott watershed have TMDLs in place. Additional regulation through another TMDL is unnecessary and unreasonable.
- Given the current requirements stated in the Klamath River TMDL, the Scott River watershed and its stakeholders would be subject to additional regulatory requirements that will distract from the efforts currently being made to uphold the original goals stated within the Scott River TMDL.
- Imposing additional requirements through the Klamath River TMDL on the Scott River watershed at this time will dilute ongoing efforts to adhere to the Scott River TMDL; therefore, causing a significant impact obtaining the goals outlined within the Scott River TMDL. This in turn will jeopardize stakeholders' confidence within the Scott River and impact the willingness to work toward common goals in the future.

Comment(s) Made By:
Gilmore – Scott River Watershed Council
Krum – Siskiyou County Resource Conservation District
Morris- Siskiyou County Farm Bureau

Response:
The Klamath TMDL assigns load allocations that are necessary to meet the water quality objectives in the Klamath basin. The Klamath River is listed for nutrient impairment and therefore load allocations for nutrients and organic matter were assigned to the Scott River as for all tributaries in the Klamath basin in order to meet nutrient and dissolved oxygen standards in the mainstem Klamath River. The current loading of nutrients and organic matter from the Scott River is sufficient to meet the Klamath TMDL, therefore the Klamath TMDL requires maintenance of existing nutrient loading at the mouth of the Scott River. Requirements in the Scott and Shasta River basins have been removed from the Klamath TMDL and discharges in those basin will continue to be regulated through the existing Scott and Shasta TMDL waivers. The Regional Board will decide as these waivers reach their expiration dates whether the existing TMDL waivers in the Scott and Shasta Basin will be incorporated into basinwide ore regionwide waivers or will be renewed or revised.

L31. Comment(s):

The Draft Klamath TMDL implementation plan proposes WDRs and/or conditional waivers that will succeed those required under the Scott River TMDL Action Plan and that will merely "consider" the load allocations contained in the Scott River TMDL. (p. 6-40-6-41) The Scott River implementation plan was "designed to encourage and build upon ongoing, proactive restoration and enhancement efforts." 23 CCR § 3907. If the implementation actions failed to be implemented or proved inadequate, the Regional Board "shall take appropriate permitting and/or enforcement actions." If the implementation actions contained in the Scott River implementation plan have failed or proved inadequate, the Regional Board must first explain the basis for this finding and follow the appropriate process mutually agreed upon in the Scott River TMDL for such permitting and enforcement actions.

Comment(s) Made By:

Krum – Siskiyou County Resource Conservation District

Response:

The need for additional measures will be considered when the Scott River TMDL waiver expires. The conditional waiver for agricultural discharges, whether for the Klamath Basin or the entire region, will also encourage and build upon ongoing proactive restoration and enhancement efforts as in the Scott TMDL waiver. The agricultural waiver will be developed through a public process that will begin after adoption of the Klamath TMDL. It must address all discharges from agricultural operations to be compliant with the NPS policy, regardless of 303(d) listings or impairments. The NPS policy requires the Regional Board to regulate all discharges to waters of the State.

L32. Comment(s):

- The TMDL assigns dissolved oxygen targets and allocates nutrient loads to the tributaries, including the Scott River. Even though it recognizes that the Scott River TMDL Action Plan does not include measures to control discharges of these pollutants, it requires that responsible parties in the Scott River basin implement measures to control the discharge of nutrients and organic matter. In order to avoid confusion, language should be added to the Klamath River TMDL that states clearly and unequivocally that the Scott River watershed is not subject to any additional conditions, reporting, permitting and waiver requirements over and above those contained in the Scott River TMDL and its Action Plan.
- The Draft TMDL states that the load reductions called for in the Scott TMDLs "are sufficient to meet water quality standards in the Klamath River." (p. 6-22). If this is the case, then the additional sediment controls and nutrient load allocations imposed on the Scott River by the Klamath TMDL are not justified.

Comment(s) Made By:

Krum – Siskiyou County Resource Conservation District

Response:
The requirement to implement additional measures in the Scott River basin to control the discharge of nutrients and organic matter has been removed from the Klamath implementation plan. The need for additional measures will be considered during evaluation of performance and effectiveness of the Scott TMDL waiver.

L33. Comment(s):
The TMDL relies on modeling of natural conditions, rather than TMDL compliant conditions, to show that the Scott and Shasta Rivers have the potential to serve as thermal refugia. This slight potential to serve as thermal refugia under "natural" conditions is used to justify the additional sediment control imposed on responsible parties in the tributary basins (4-30-4-31).

Comment(s) Made By:
Krum – Siskiyou County Resource Conservation District

Response:
The statement is incorrect. The June draft Klamath TMDL did not impose additional sediment controls beyond those already needed to meet the Scott TMDL sediment load allocations. The evaluation of thermal refugia under natural conditions was done to evaluate whether a flow allocation was warranted. However, no flow allocations have been assigned.

L34. Comment(s):
- Conditions in the Scott and Shasta affect conditions in the Klamath River. Thus, changes to the WDRs and/or Conditional Waivers in these waterbodies that would weaken the Implementation Planning and/or Timber Harvest and Agricultural land use standards and controls would compromise the TMDL. Such changes would require re-visitation to these respective TMDL implementation plans.
- WDR and Conditional Waiver language are considered binding and enforceable. If they are ignored or violated, such conditions can be legally compelled to be obeyed. To change the conditions of an approved implementation plan would necessitate that it be amended according to the same process by which it was approved. In this case such changes would require substantiation that any such changes must be equal to or better than the previously applied conditions.

Comment(s) Made By:
Levine –Coast Action Group

Response:
These statements are overly broad. There may be valid reasons to make changes to WDRs or waivers that appear to relax standards but don't require "re-visiting" TMDL implementation plans.

L35. Comment(s):
Implementation of the Scott, Shasta, and Klamath TMDLs relies upon WDRs and conditional waivers. Any diminished capability in the Regional Board administration of these WDRs and Conditional Waivers (possibly by State Wide WDRs and Waivers as proposed by the State Board) would necessarily affect the potential effectiveness of any TMDL that relies on these WDRs and Waivers for pollutant control. Thus the Implementation policy effectiveness of these TMDLs would, and should, be called into question. Loss of WDR and Waiver utility should bring the approved Scott and Shasta TMDL Implementation language into question.

Comment(s) Made By:
Levine – Coast Action Group

Response:
Any statewide WDRs and/or waivers should to implement TMDL allocations and water quality standards in the Basin Plan, whether they are adopted by the State Water Resources Control Board or the Regional Water Board.

L36. Comment(s):
The Scott and Shasta TMDLs must be reconciled to comply with strong mainstem TMDL standards, not the other way around.

Comment(s) Made By:
Terence – Klamath Riverkeeper

Response:
The Klamath implementation plan proposes the development of new conditional waivers that will apply either basinwide or regionwide and require implementation of water quality control measures regardless of the presence of a TMDL or whether the basin is listed as impaired on the State 303(d) list. The implementation strategy is to promote consistency in regulation throughout the basin and region with considering and building on local ongoing efforts to improve water quality. The effectiveness of the Scott and Shasta River TMDL waivers will be considered as they approach expiration and the Regional Water Board will decide whether to extend them or to regulate those basins through the basinwide or regionwide waiver.

L37. Comment(s):
It seems that the non-compliant Scott and Shasta Rivers warrant an additional step describing what actions will be taken in the event of non-compliance. If the language in the Scott and Shasta TMDLs cannot be made more enforceable by mandating compliance with tough mainstem TMDLs, they will need to be reopened and adjusted for consistency with the Clean Water Act and other clean water laws and regulations.

Comment(s) Made By:
Terence – Klamath Riverkeeper

Response:
Requiring these actions does not necessitate reopening the Shasta or Scott TMDLs. The sufficiency of the Scott and Shasta implementation plans will be considered separately from Klamath implementation. In particular, the 5-year duration of waivers provides the opportunity for evaluation of waiver effectiveness and modification.

L38. Comment(s):
This TMDL in its initial stages was going to be just for the Klamath River, it has become a document for the entire Basin – it's a violation of 303(d).

Comment(s) Made By:
Fowle

Response:
The geographic scope of the TMDL allocations has been clarified and the watershed-wide allocations do not apply to the major tributary basins. Please note however that the Klamath River 303(d) listings are watershed listings not river reach listings, and as such apply to tributaries as well as the mainstem. Regardless, a basin does not have to be listed as impaired on the 303(d) list in order for the Regional Water Board to take action to regulate a discharge to waters of the State. In fact, the NPS policy (see section 6.1.4 of the staff report) requires the Regional Board to regulate all sources of pollution, regardless of the 303(d) listing status in a given basin.

L39. Comment(s):
The proposed approach of continuing the status quo in the Shasta and Scott watersheds is unfortunate, given the acute water quality problems and slow pace of TMDL implementation there.

Comment(s) Made By:
Fetcho – Yurok Tribe
Crosby – Karuk Tribe
Bowman – Quartz Valley Indian Reservation

Response:
The Scott and Shasta basin implementation efforts will be reviewed by the Regional Water Board as the expiration of the conditional waivers associated with those TMDLs approaches. The goal of the Klamath implementation plan is to provide basinwide consistency in TMDL implementation while taking into consideration ongoing efforts at the local level. Responsible parties in the Scott and Shasta Basins are required by the existing Scott and Shasta TMDL waiver to implement the measures identified in those Action Plans.

L40. Comment(s):
Staff did not provide evidence that water quality standards are being violated in the Shasta River beyond the impairments indentified on the 303(d) list and redressed by the Shasta River TMDL. Therefore, any reference or adding impairments, reallocating pollutant loads or additional permitting requirements other than that identified in the Shasta TMDL must be removed from the Draft Klamath TMDL.

Comment(s) Made By:
Hockaday – Montague Water Conservation District

Response:
The Shasta River nutrient load allocations expressed in the Klamath TMDL are based on the nutrient loads that result from full compliance with the Shasta River TMDL. The Shasta TMDL expresses these loads in different metrics than those expressed in the Klamath TMDL, but the loads are the same. Compliance with the Shasta Nutrient TMDL constitutes compliance with the Klamath Nutrient TMDL. Similarly, compliance with the Shasta Temperature TMDL constitutes compliance with the Klamath Temperature TMDL. No impairments have been added to the Shasta River 303(d) listing.

L41. Comment(s):
The TMDL cannot establish TMDLs for the Scott River for pollutants which are not included on the State's 303(d) list as impairments to the Scott River. The Klamath TMDL should be entirely separate from the Scott TMDL as delineated in the 303(d) list. If the Regional Board believes that the Scott River is impaired by these pollutants, it must identify them as such on the State's 303(d) list and submit it to EPA for approval along with documentation. We fully expect the Board staff to respond that it is not setting a new TMDL for the Scott or Shasta but rather redressing violations of standards in the Klamath and revising implementation measures in the Scott and Shasta. Should staff take this position they would blatantly abuse the CWA Listing Process as they would not have shown that water quality standards are being violated in the Scott and Shasta by these pollutants.

Comment(s) Made By:
Krum – Siskiyou County Resource Conservation District

Response:
State water quality standards are made up of water quality objectives, beneficial uses, and the State anti-degradation policy. This means that even if a waterbody is meeting water quality objectives, dischargers are still not permitted to cause a reduction in water quality due to human activity. The 303(d) list is the way the state identifies waterbodies not meeting water quality standards. The 303(d) listed waters are given higher priority in TMDL development. A waterbody's status on the 303(d) list, while it may influence priorities, in no way limits the Regional Water Board's authority to regulate discharges of

waste to waters of the State. In fact, the Regional Board is required to do so pursuant to the NPS policy. However, no new requirements are proposed in the Klamath implementation plan for the Scott and Shasta basins at this time.

L42. Comment(s):
The TMDL attempts to skip the CWA 303(d) listing process and impose new TMDLs for dissolved oxygen and nutrients in the Scott River and sediment and nutrients in the Shasta River. Most importantly, the Klamath TMDL attempts to skip an opportunity for public comment as required in the 303(d) listing policy.

Comment(s) Made By:
Krum – Siskiyou County Resource Conservation District

Response:
Please see the response to comments L7 and L41.

L43. Comment(s):
The Draft TMDL expands regulation of discharges to streams and for pollutants which are not even listed as impaired. The Draft TMDL proposes to require measures to control discharges of nutrients and organic matter from grazing and irrigated agriculture in the Scott River watershed even though that tributary is not listed as impaired for either nutrients or organic matter.

Comment(s) Made By:
Rice and Oldfield – California Farm Bureau Federation and California Cattlemen's Association

Response:
Please see the response to comments L7 and L41.

L44. Comment(s):
In June 2009 the Regional Board reviewed petitions to list the Scott for additional impairments, but found no additional water quality impairments in the Scott River. Now, two months later, the TMDL attempts to regulate the Scott for these very same impairments. This is arbitrary and intentionally avoids process set up by CWA.

Comment(s) Made By:
Krum – Siskiyou County Resource Conservation District

Response:
The statement above misrepresents the information that was reviewed by the Regional Water Board in June 2009. In 2009, Regional Water Board staff reviewed Surface Water Ambient Monitoring Program (SWAMP) data following the guidelines in the Listing

Policy (SWRCB 2004) to determine whether to place the Scott River on the 2008 303(d) List for the following constituents: aluminum, ammonia as N, arsenic, cadmium, total chromium, copper, lead, mercury, nickel, selenium, silver, zinc, chloride, DDT, PCBs, pesticides, specific conductance, and sulfates. Upon analyzing these data, staff determined that listing the Scott River for these specific parameters was not warranted. In June 2009, the Regional Water Board reviewed and upheld the recommendations of staff.

No data for the Scott River was reviewed in the 2008 303(d) listing process on any of the parameters addressed in the Klamath River TMDL Staff Report. Thus, the statement that the TMDL regulates the Scott River for parameters for which the Regional Water Board determined that it was not impaired is inaccurate.

Additionally, the Klamath TMDL implementation plan no longer includes any new requirements for dischargers in the Scott and Shasta River basins. Please see the response to comment L7.

References used in Response L44:

State Water Resources Control Board (SWRCB). 2004. Water Quality Control Policy for Developing California's Clean Water Act Section 303(d) List. Adopted September 2004. 28pp.

L45. Comment(s):

There are concerns with failure to follow process with the Clean Water Act and the listing policy of 2004. The Shasta has its own listing process. New loads were brought into the Shasta without following the 303(d) process.

Comment(s) Made By:

Black

Response:

Please see the response to comments L7 and L21, among others that address this issue. The Klamath TMDL proposes no new load allocations in the Shasta basin.

L46. Comment(s):

MKWC is concerned with the "status Quo" approach to the Scott and Shasta watersheds, especially at a time when these two watersheds are showing the lowest August flows on record. We feel it is imperative to pick up the pace on implementing the TMDLs in these watersheds. Recent de-watering events on the Scott and Shasta are mirrored in some tributaries in the Middle Klamath, particularly Seiad Creek. Seiad Creek is the largest producer of Coho smolt of any tributary within the Middle Klamath subbasin, and had been routinely pumped dry for longer and longer periods in the summer since the late 1970's. MKWC also encourages the board to fast-track implementation of the Klamath TMDL. Many of the water problems on the Klamath (and their causes, e.g. Scott and

Shasta flows, mainstem dams, agricultural pollution) were identified decades ago, yet remediation has been largely absent.

Comment(s) Made By:
Harling – Mid Klamath Watershed Council

Response:
Please see the response to comment X1. The Klamath TMDL Action Plan is intended to remediate water quality issues under the Regional Water Board's authority.

SEDIMENT RELATED COMMENTS

M1. Comment(s):
The Klamath River should be listed as impaired for sediment.

Comment(s) Made By:
Carnam

Response:
The Regional Water Board and staff have proposed that many of the Klamath River tributaries between Happy Camp and Iron Gate be placed on the 303(d) list for sediment impairment. The Klamath River watershed downstream of Weitchpec is currently listed as impaired for sediment. If the commenter has information indicating sediment impairment, please submit the data during the next 303(d) data solicitation period.

M2. Comment(s):
Difficult to determine cause of sediment alteration, better alternative is "a decreasing trend in the number (or volume) of potential road-related source areas for landslides."

Comment(s) Made By:
Cover – CSU Stanislaus

Response:
The road-related landslide target has been modified, as suggested.

M3. Comment(s):
We support the proposed watershed-wide prohibition on the discharge of excess sediment.

Comment(s) Made By:
Fetcho – Yurok Tribe
Crosby – Karuk Tribe
Bowman – Quartz Valley Indian Reservation

Response:
Thank you for your support. This prohibition has been replaced by a basinwide prohibition on the discharge of waste.

M4. Comment(s):
Please provide additional explanation regarding the excess sediment watershed target.

Comment(s) Made By:
Hashimoto and Ziegler – USEPA

Response:
Regional Water Board staff have revised the road-related landslide target. The revised target calls for a decreasing number of potential road-related landslide source areas. The revised target is more directly linked to implementation measures called for in the Action Plan.

M5. Comment(s):
Statement: Chapter 4, Section 4.1, 1st paragraph, page 4-1, states "The water quality parameters (or pollutants) considered in this Klamath River TMDL source analysis include: ……"
Comment: Why does the pollutant source list and analysis not include sedimentation as listed for some of the lower Klamath River segments. Sedimentation should be listed as a water quality parameter and a source analysis performed.

Comment(s) Made By:
Hicks – U.S. Bureau of Reclamation

Response:
Regional Water Board staff did not undertake a sediment TMDL as part of this process. A sediment source analysis is inappropriate at this time because we are not establishing a sediment TMDL. Control of sediment as part of this action is being done in order to achieve compliance with the State non-point source policy.

M6. Comment(s):
Section 6.5.1.2 states "The TMDL found that sediment discharges in the Klamath River basin have a potential cumulative impact on water temperatures through the alteration of channel structure particularly in the tributary basins." What is the basis for this statement? The Klamath River is not impaired for sediment, and I see no science supporting the conclusion that sediment is raising the temperature of the river. To implement the measures proposed for "potential" that has not been demonstrated seems to be overkill. Furthermore, the remainder of Section 6.5.1.2 is ambiguous and could be interpreted in several different ways.

Comment(s) Made By:
Sumner – Siskiyou County Public Works

Response:
Sediment effects on stream temperatures are discussed on pages 2-68, 2-69, 4-30, and 4-31. Regional Water Board staff have reviewed Section 6.5.1.2 and find the language to be clear. Without further information Regional Water Board staff cannot address the comment further.

M7. Comment(s):
Section 6.5.2 within the boxed area contains two bulleted comments. The first is problematic when one attempts to define "threatened discharge" of excess sediment. The second bullet defines excess sediment as being "soil, rock, and/or sediments (e.g. sand, silt or clay)". This begs the question-what is not sediment? Please define "could be deleterious to beneficial uses or cause a nuisance". This language is again ambiguous, and the concern is what may be considered beneficial or a nuisance to some is not to others.

Comment(s) Made By:
Sumner – Siskiyou County Public Works

Response:
The excess sediment prohibition proposed in the Draft Klamath TMDL Staff Report has been removed and is no longer part of the proposed TMDL.

M8. Comment(s):
I don't think it's focused enough in its explanation of why sediment is a problem. The Regional Board made a nexus to it and I don't see the science. The Board defines sediment as rock, clay, sand, soil – what is not soil? Sediment has not been shown to be problem – we will cooperate to the extent we can but we will keep public safe as a priority and when there are specific problems we will deal with it.

Comment(s) Made By:
Sumner – Siskiyou County Public Works

Response:
Sediment effects on stream temperatures are discussed on pages 2-68, 2-69, 4-30, and 4-31.

M9. Comment(s):
They're some timelines for sediment surveys, the timelines are much too tight – we've got to locate funding and it can't be done instantaneously.

Comment(s) Made By:
Schuyler – Klamath National Forest

Response:
The timelines have been removed from the Action Plan and will be incorporated in the USFS waiver currently under development with consultation from the USFS. Public review and adoption of this waiver is anticipated to occur prior to the adoption of the Klamath TMDLs.

M10. Comment(s):
Sediment actually blocks the sun and cools the water.

Comment(s) Made By:
Cook – Siskiyou County Supervisor, District 1

Response:
Regional Water Board staff have reviewed a tremendous amount of literature describing the temperature dynamics of streams, and has never encountered a published account of sediment cooling water. While sediment can lead to light not penetrating as far into the water column, unless the sediment is reflective and floating on the surface, the majority of the thermal energy will still be absorbed by the water.

M11. Comment(s):
Issues with the word "fail". Target 3 is not tied to stream temperatures. Recommend deleting targets 2&3, which are addressed by target 1 and FPRs.

Comment(s) Made By:
Salvestro – Fruit Growers Supply Co.
Quirmbach – Timber Products Co.

Response:
Regional Water Board staff use the term "stream crossing failure" consistent with the definition used by Furniss, et al (1998). This defines stream crossing failure as the condition when the flow of the stream overwhelms the hydraulic capacity of the culvert. Stream crossing failures can lead to mass wasting and/or fluvial erosion leading to reduced riparian shade.

Reference used in Response M11:
Furniss, M.J., T.S. Ledwith, M. A. Love, B. C. McFadin, S.A. Flanagan. 1998. Response of road-stream crossings to large flood events in Washington, Oregon, and Northern California. USDA Forest Service. September 1998, 14 pp.

M12. Comment(s):
The watershed target for stream crossing failures at less than 1% of all road-stream crossings during a 100-year recurrence interval or smaller storm is not achievable. Sufficient funds are not available to reconstruct the tens of thousands of miles of National Forest System Roads within the North Coast Region so that every stream crossing is rebuilt to withstand a 100-year storm. The Northwest Forest Plan requires that crossings on new roads be constructed to survive a 100-year flood but has no similar requirement for existing roads. A more useful target would be the elimination of diversion potential on 90% of stream crossings with existing diversion potential within 10 years. A more

realistic target for improving crossings would be the replacement of 80% of the highest priority undersized or damaged culverts to meet the 100-year flood standard within then next 20 years.

<u>Comment(s) Made By:</u>
Moore – U.S. Forest Service, Pacific South West Region
Kelley – U.S. Forest Service, Six Rivers National Forest

<u>Response:</u>
The target represents the condition that ensures achievement of the allocation. It is not expected to be met in a short time frame, but is meant to be the target that conditions trend toward. USFS compliance with the TMDL will be based on compliance with the USFS waiver, which is likely to incorporate the goals expressed in the comment, along with an agreed upon framework for inventory and prioritization.

M13. <u>Comment(s):</u>
The target for human-caused sediment-related channel alteration is defined as an increase in channel width or decrease in depth (p. 5-14). Measuring compliance for this target will be very difficult. Sediment indicators used in other TMDLs, such as V*, subsurface fines, or surface fines, would be more reliable measures.

<u>Comment(s) Made By:</u>
Moore – U.S. Forest Service, Pacific South West Region

<u>Response:</u>
The statement is incorrect. The target for human-caused sediment-related channel alteration is defined as no increase in temperature that arises from sediment discharges. Changes in width, depth, and riparian shade are identified as mechanisms by which temperature change can occur.

M14. <u>Comment(s):</u>
According to Klamath National Forest Planner Jim Anderson, studies indicate that the largest contributions to sediment load in the Klamath Basin are from natural causes, including landslides and erosion after fire.

<u>Comment(s) Made By:</u>
Gierak

<u>Response:</u>
This may be true, but not a reason for ignoring human caused sediment delivery.

M15. Comment(s):
Action Plan, Pg. 11. Conditional Prohibition on Discharge of Excessive Sediment. This section outlines the main requirements expected by the Water Board relative to meeting TMDL requirements: 1/ prevent or minimize future sedimentation risks and 2/ inventory, prioritize, schedule, implement, monitor and adapt. These actions are the heart of complying and moving towards compliance of the TMDL requirements. If the responsible parties have outlined strategies to achieve the above requirements such as approved water quality improvement plans and those are agreed upon through MOUs of MAAs with the Water Board, it is unclear and confusing the additional requirements outlined in the subsequent Table 4-17. Table 4-17 does acknowledge existing federal policy such as the Northwest Forest Plan and BMPs but the additional project driven waiver requirements are very confusing when linked the TMDL actions.

Comment(s) Made By:
Kelley – U.S. Forest Service, Six Rivers National Forest

Response:
The conditional prohibition on discharge of excess sediment has been eliminated from the Klamath TMDL Action Plan. The state nonpoint source policy requires that all nonpoint source discharges be regulated through prohibitions, waste discharge requirements, or waivers thereof. The revised USFS waiver is intended to address TMDL requirements.

THERMAL REFUGIA

N1. Comment(s):
Creek mouth restoration in the form of digging out sediment loading and hand carving pools needs to take place to help sustain the cold water refugee's as suitable spawning habitat.

Comment(s) Made By:
Carnam

Response:
The Thermal Refugia Protection Policy proposed in the Klamath TMDL implementation plan seeks to protect areas at the mouths of tributaries along the Klamath River mainstem and in the lower canyon reach in the Scott River. The policy has been revised to specifically restrict discharges associated with suction dredging and would not apply to the type of restoration the commenter referrers to. Any large scale restoration project with significant discharges would need to be permitted by a 404 dredge/fill permit from the Army Corp of Engineers, which also requires a 401 water quality certification from the Regional Water Board. Small habitat restoration projects that require a federal permit can be enrolled under State Water Resources Control Board General 401 Water Quality Certification Order For Small Habitat Restoration Projects.

N2. Comment(s):
Greater emphasis needs to be placed on preventing debris flows in the basins where flow refugia exist. Although an instream buffer around flow refugia (pages 6-30 and 6-31) would certainly be important for preserving flow refugia, tributary sediment dynamics are much more critical to the value of thermal refugia. Basins with cold-water refugia should receive special protections in upslope and headwater areas, not just around the mouth of the stream.

Comment(s) Made By:
Cover – CSU Stanislaus

Response:
Regional Water Board staff agree that reducing the incidence of debris flows is a critical measure to protect thermal refugia at the mouths of tributary streams. Measures to reduce the risk of human-related mass wasting events triggering debris flows have been incorporated into the Klamath River TMDL implementation plan. The TMDL contains three sediment related targets, one that addresses sediment discharges that have the potential to cause channel alterations (i.e. debris flows) and two that address road-related sediment sources and stream crossing failures. The implementation plan measures to meet these targets will be incorporated into the appropriate permitting mechanisms as part of TMDL implementation.

N3. Comment(s):
We strongly support the language in section 6.5.3.1 that Regional Water Board "recommend that the State Water Board staff issuing water rights permits to divert surface water in the Klamath River basin in California consider the impact of increased diversions on tributaries that provide thermal refugia." We fully support the proposed protections for thermal refugia, including the prohibition of waste discharge (e.g. suction dredge mining) in the mainstem Klamath River and in the lower sections of tributaries whose lower reaches serve as refugia.

Comment(s) Made By:
Fetcho – Yurok Tribe
Crosby – Karuk Tribe
Bowman – Quartz Valley Indian Reservation

Response:
Thank you for your support. Please note that the prohibitions have been removed in favor of a more comprehensive Thermal Refugia Protection Policy and in light of the existing Basin Plan prohibition on point source discharges in the mainstem Klamath River. See section 6.5.4 of the staff report for more details on these proposed revisions.

N4. Comment(s):
Also to be noted and included for protection is a reach of approximately 5 miles that during the summer serves as a thermal refuge to salmonids in the mainstem Scott River.

Comment(s) Made By:
Fetcho – Yurok Tribe
Crosby – Karuk Tribe
Bowman – Quartz Valley Indian Reservation

Response:
The Thermal Refugia Protection Policy provides protection for three of the creeks that tributary to the Scott River in this reach. Regional Water Board staff will consider recent data submitted by the Quartz Valley Tribe documenting the need for protection in the thermal reach referred to in the comment. The list of thermal refugia in the Klamath basin may be revised to include this reach through the process described and at the discretion of the Regional Water Board's Executive Officer.

N5. Comment(s):
The goal of protecting tributary refugia will be confounded by increased peak flows caused by timber harvest and road building in the rain-on-snow zone (3,500-5,000 ft elevation), which the TMDL continues to ignore.

Comment(s) Made By:
Fetcho – Yurok Tribe
Crosby – Karuk Tribe
Bowman – Quartz Valley Indian Reservation

Response:
Comment noted. While the TMDL source analysis did not analyze the impacts of these activities in the rain-on-snow zone compared to other locations, the implementation plan addresses the impacts of timber harvest and road building. Implementation plan measures will most likely be sufficient to address the impacts of these activities in the rain-on-snow zone as well as elsewhere. If evidence shows additional measures are needed in this zone, the Regional Water Board may consider amending the TMDL implementation plan as part of the adaptive management strategy.

N6. Comment(s):
Allow the Corps of Engineers to dredge the entrances to lower basin tributaries to allow fish passage into these streams which are the normal spawning grounds for Coho Salmon.

Comment(s) Made By:
Gierak

Response:
The Regional Water Board staff evaluate these type of restoration projects on a project-by-project basis. Such a project would be permitted through a 401 water quality certification if it were demonstrated that water quality would be protected, but should also be closely coordinated with both state and federal wildlife agencies to assure that benefits to fish and fisheries would be achieved by such projects.

N7. Comment(s):
In some years, you may have a flood that takes out the refugia, and I don't believe that natural is always the best. I believe that if need be we should be able to go in there to remove material to make a refugia for the fish to rest.

Comment(s) Made By:
London

Response:
The TMDL implementation plan would not prevent restoration of lower basin tributaries and the Regional Water Board is not opposed to this type of work if it would be beneficial to fish populations. It is conceivable that suction dredging equipment could be utilized in such a restoration project, but the project must be for the benefit of fish populations. The habitat improvements must not be ancillary to the main purpose of extracting gold. In any case, such projects should be presented to and approved by the

state and federal wildlife agencies with primary responsibility for fish and fishery resource protection, restoration, and recovery.

N8. Comment(s):

My concern is that I do not feel that the current TMDL, as written, assures any further protection to cold water refugia beyond the LRMPs and may in fact help to seal their fate as continuing to decline.

Comment(s) Made By:

Riggan

Response:

The TMDL works with the LRMPs to set targets and allocations to protect beneficial uses. Where the measures specified in an LRMP are sufficient, no further measures are needed. However, the TMDL requires reporting to the Regional Water Board which will be implemented through the proposed USFS conditional waiver. The Regional Water Board intends to track progress on addressing sediment discharges from the road network on National Forest lands. Addressing these potential sediment discharge sites will assure further protection of cold water refugia. The implementation plan also proposes a Thermal Refugia Protection Policy that was not in the June 2009 draft staff report. This policy can now be found in section 6.5.4 of the December 2009 draft.

N9. Comment(s):

Klamath River refugial streams should receive special protection from livestock waste, sediment and dredge mining.

Comment(s) Made By:

Pace, Beck, Gillespie – North Group-Redwood Chapter-Sierra Club & Friends of Del Norte

Response:

The Klamath implementation plan proposes a Thermal Refugia Protection Policy that affords refugia special protection from dredge mining and other activities, and places higher priority on watershed restoration activities in those streams. The proposed agricultural waiver and the new prohibition included in the Klamath implementation plan (sections 6.5.2 and 6.5.6) will address livestock waste in all streams as well as riparian management and livestock access to streams on grazing lands. The agricultural waiver will be developed through a process separate from the Klamath TMDL process. The Regional Water Board is scheduled to consider adoption of the proposed waiver by December 2012.

N10. Comment(s):
Examples of streams which are key refugial streams but not identified as Key Watersheds by the US Forest Service are Canyon, Kelsey and Boulder Creeks on the Scott. Cold water delivered to the Scott River from these streams is what is keeping Scott River salmon from being extirpated. These streams and the refugia they form deserve and need special protection.

Comment(s) Made By:
Pace, Beck, Gillespie – North Group-Redwood Chapter-Sierra Club & Friends of Del Norte

Response:
These streams are recognized as providing thermal refugia to the Lower Scott River in Table 6.5 of the Klamath River TMDL staff report.

N11. Comment(s):
The draft TMDL does not define a thermal refugia. There are no thermal characteristics, sizes, habitat, fish use (number, species, period, lifestage), period of thermal protection, persistence (inter- and intra-annual). There is no formal discussion of how they are modified by natural conditions or by man made activities. Appendix 8 includes maps of known thermal refugia, but no specifics are provided, rather it simply looks like Regional Board Staff simply identified that nearly every named tributary below the Shasta River was a refugia. Some of these are not persistent through the summer or perhaps year-to year, some are not notably colder than the Klamath River, some are inaccessible to anadromous fish, others enter the river where the benefit of cold water is minimal due to limited habitat. The restriction of 1,500 feet above and below the refugial areas defined in Appendix 8 adds up to nearly 50 miles of river, or approximately 25 percent of the main stem below Iron Gate Dam (and this does not include the physical size of the refugia). What resources are available to manage this considerable length of river? A rapid assessment of all refugia, as per USBR (2006) is recommended to define the functional value of these unique areas.

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
Section 6.5.4 provides a definition of a thermal refugia that was taken from:

Watercourse Engineering, Inc. (Watercourse). 2005. *Klamath River Thermal Refugia Study: Flow and Temperature Characterization: Summer, 2004.* Prepared for the U.S. Bureau of Reclamation with assistance from the Yurok and Karuk Tribes. February 17.

The staff report has been revised to provide a timeframe when the discharge restrictions within buffer areas around known thermal refugia locations would apply: April 15 – September 15. This time period is based on average temperature in the Klamath mainstem taking into account interannual variability and with consideration for the short-term impacts of suction dredging discharges on water quality and fish habitat. The process for identifying refugia in the Klamath basin is described in the staff report and was not arbitrary as the commenter suggests. The process is described in section 6.5.4.1 of the staff report. While these locations may not function as refugia every year because of inter-annual variability in their form, Regional Water Board staff maintain that it is appropriate to provide for their protection not just in years in which they are functioning, but in all years. Changing the list of refugia based on yearly conditions is not a workable approach. The commenter misquotes the staff report in stating that a 1,500 foot buffer is recommended for all refugia. As stated in section 6.5.4.2, the default buffer is only 500 feet, while a 1,500 foot buffer is recommended only in tributaries where the cold water plume extends beyond 500 feet downstream making a 500 foot buffer insufficient. While the USBR study referred to in the comment provides a viable method of describing the characteristics of refugia, Regional Water Board staff compiled the list of refugia by consulting with fish biologists in the Klamath basin and through a review of the available studies on the topic. The list of refugia may be revised through the process described in section 6.5.4.3 of the staff report. The State Water Board is developing a rapid assessment tool in the context of its Wetland and Riparian Area Protection Policy. The Regional Board is a participant in that process and will consider its utility for the Refugia Policy in the future.

N12. <u>Comment(s):</u>
As alluded to in the wording, these prohibitions (on discharges that adversely affect thermal refugia) are a “precautionary” measure based only on an opinion. There is an “assumption” that it is harmful unless proven otherwise. There are no peer review field studies (science) to back up the opinion. You cannot prohibit an activity just because someone feels that it might be harmful. This would not be reasonable and raises questions as to whether or not the regulation is arbitrary and capricious.

<u>Comment(s) Made By:</u>
Armstrong – Siskiyou County Supervisor, District 5

<u>Response:</u>
The TMDL implementation plan does not prohibit an activity, it restricts the discharge of waste associated with suction dredging activities within a specified area and timeframe in and around the mouths of certain Klamath River tributaries. The discharge of waste within the thermal refugia areas is allowed if the discharge is regulated through a permit or 401 water quality certification issued by the Regional Water Board.

N13. <u>Comment(s):</u>
The California Department of Fish and Game (CDFG, 1997) concluded, “Suction dredging can have significant short-term and localized adverse impacts on local benthic invertebrate abundance and community composition. However, over the longterm, the impacts appear to be less than significant.

In a recent 2003 study by Peter B. Bayley, response of fish to cumulative effects of suction dredge and hydraulic mining in the Illinois subbasin, Siskiyou National Forest, Oregon, concluded: "The statistical analyses did not indicate that suction dredge mining has no effect on the three responses measured, but rather any effect that may exist could not be detected at the commonly used Type I error rate of 0.05. The reader is reminded of the effect of scale. Localized, short-term effects of suction dredge mining have been documented in a qualitative sense. However, on the scales occupied by fish populations such local disturbances would need a strong cumulative intensity of many operations to have a measurable effect…"

Comment(s) Made By:
Armstrong – Siskiyou County Supervisor, District 5

Response:
Regional Board staff have reviewed the scientific literature on suction dredging that shows suction dredging effects on certain water quality and habitat parameters are less than significant over the long-term. The Thermal Refugia Protection Policy is not intended to address these types of effects. It addresses short-term impacts to thermal refugia on a seasonal basis, which have been documented in the literature in both a qualitative and quantitative sense. See the expanded literature review in section 4.2.4 of the staff report.

N14. Comment(s):
A U.S. Army Corps of Engineers study on suction dredge mining found de minimis impact on aquatic resources and provided "official recognition of what suction dredgers have long claimed: that below a certain size [4 inches], the effects of suction dredging are so small and so short-term as to not warrant the regulations being imposed in many cases. To regulate for potential for harm, where NO harm has been shown to exist is unjustifiable and must be challenged."

Comment(s) Made By:
Armstrong – Siskiyou County Supervisor, District 5

Response:
Before the ban on suction dredging was passed by the State Senate, the CDFG permit authorized the use of suction dredges up to 8 inches in diameter on the mainstem Klamath River. This same US Army Corps study also states that "operation of suction dredges with an intake nozzle size of greater than 4 inches generally has more than de minimis effects on the aquatic environment and therefore requires authorization from the Corps under Section 404." (Army Corps of Alaska, 1994). Reference cited:

Army Corps of Alaska. 1994. Application to the "Excavation Rule" to Recreational Placer Mining Activities in Alaska for the Purpose of the Corps' Section 404 Regulatory Program: Special Public Notice 94-10. US Army Corps of Engineers. September, 1994.

N15. Comment(s):
Suction dredge mining provides seasonal income to sustain local grocery stores, gas stations and other businesses. Without tourism revenue to support these basic services, continued residence in the small communities along the Klamath River will become difficult.

Comment(s) Made By:
Armstrong – Siskiyou County Supervisor, District 5

Response:
The TMDL implementation plan makes a recommendation to the Department of Fish and Game and State Water Resources Control Board to restrict suction dredging discharges from specific areas of the mainstem Klamath River during a certain time frame. It does not make a recommendation to prohibit suction dredging entirely and the specified thermal refugia only represent a portion of the total area available to suction dredging. The limitations being recommended are not expected to have a significant effect on local businesses or tourism since they will most likely not reduce the number of people suction dredging recreationally.

N16. Comment(s):
The suction dredge operators can clear and deepen this area and make it fish friendly again.

Comment(s) Made By:
Bennett – Siskiyou County Supervisor, District 4

Response:
The TMDL implementation plan encourages restoration of thermal refugia areas through activities that will enhance their function. Any proposed activity must have the primary purpose of improving fish habitat, and the party conducting the activities must have the required permits. Additionally, the restoration project should take place at a time of year when the thermal refugia are not being utilized by fish.

N17a. Comment(s):
The implementation plan "proposes a prohibition on the discharge of excess sediment to address all sediment sources in the Klamath River basin not currently regulated through an existing permit or conditional waiver. The implementation plan also proposes a prohibition on the discharge of waste in and around known thermal refugia locations in the Klamath River in California to protect their function in mitigating adverse water quality conditions."

Regulations must be reasonable. Any regulation that is prohibitive is unreasonable.

Comment(s) Made By:
Foley

Response:
The proposed sediment prohibition has been removed from the Klamath implementation plan. Staff is proposing a prohibition of discharges that violate water quality standards and are not authorized by the State or Regional Water Boards, which a simple restatement of the law as it already exists. In addition, the implementation plan includes a policy to protect the function of thermal refugia in the Klamath basin. A literature review on the effects of suction dredging on water quality and fish habitat related to thermal refugia has been added to the staff report (section 4.2.4). Based on these findings, the policy recommends that the Department of Fish and Game and the State Water Resources Control Board restrict suction dredging discharges in thermal refugia areas specified in the policy during certain times of the year.

The Klamath TMDL analysis found that "the proper functioning of thermal refugia areas in the Klamath River Basin is necessary to meet the Basin Plan water temperature objective since these areas of cold water in the mainstem Klamath River are representative of natural water temperatures (section 4.2.4.2 of the TMDL staff report)." Suction dredging discharges in thermal refugia areas in the Klamath River that impair the function of those refugia when they are being used by fish to escape high water temperatures in the mainstem may constitute a violation of the Basin Plan water temperature objective. Elements of the proposed Thermal Refugia Protection Policy are entirely reasonable in that they specifically address the potential for impacts to beneficial uses and violation of the water temperature objective in the Basin Plan, but allow for permitting based on further study and analyses.

N17b. Comment(s):
Material that is processed through a suction dredge produces no "excess" sediment or any other substance that was not already in the river. The dredge adds nothing.

Comment(s) Made By:
Foley

Response:
The fact that the dredge material is from the streambed does not disqualify it as a discharge of waste.

"The re-introduction of stream water (as turbid water) or total suspended solids into the water column, through the process of suction dredging and sluicing, constitutes a discharge of a pollutant under the Clean Water Act. The Ninth Circuit has held that material separated from gold and released into a stream, during placer mine activity, constitutes a pollutant; and even though "the material discharged originally [came] from the streambed itself, [its] resuspension [in the stream] may be interpreted to be an addition of a pollutant under the Act." Rybachek v. U.S. EPA, 904 F.2d 1276, 1282, 1285-86 (9th Cir. 1990).” (EPA, 2007).

Reference cited:

USEPA. 2007. U.S. EPA Response to Comments Small Suction Dredge General Permit. U.S. Environmental Protection Agency, April, 2007.

N18. Comment(s):

The implementation plan states that Regional Water Board staff is addressing the impacts of suction dredging as a precautionary measure following the recommendation of fisheries biologists. This precaution is unreasonable, arbitrary and capricious.

Comment(s) Made By:

Foley

Response:

Regional Board staff believe the implementation measures are necessary to protect the beneficial uses of the Klamath Basin and also find them reasonable considering suction dredging would only be limited during certain times of the year and in discrete locations. Also, see response to comment N17 above.

N19. Comment(s):

The only fisheries biologists that were consulted by the agency were those that have written unfavorably regarding suction dredge mining. Much that these biologists said was nothing more than opinion, not science. Regulations must be based on the best available science, not opinion. I have personally seen to it that the water boards have been the recipient of many peer reviewed studies that show that suction dredging has "de-minimus" or "inconsequential" effects on fisheries and aquatic environment, none were used.

Comment(s) Made By:

Foley

Response:

Thank you for your submittal of these studies. Staff considered them, as well as other studies, in the development of the Thermal Refugia Protection Policy. The revised staff report now includes a brief literature review in support of the policy. The proposed Thermal Refugia Protection Policy is necessary for the protection of the beneficial uses of waters of the State; the charge of the Regional Water Board. The proposed policy recommends reasonable restrictions on the discharge of waste associated with suction dredging activities in and around known thermal refugia locations during certain time periods in order to protect their function in the mainstem Klamath River when they are being utilized by cold-water fish species. There are several studies that show the potential of suction dredging activities to adversely impact water quality. While some of these impacts may be “de-minimus” in the long term, they have the potential to impair thermal refugia function in the short term. See response to comment N14 for a discussion of the Army Corp study that found a 'de minimus' effect from suction dredges less than 4" in diameter. See also response to comment N20 below for more on the potential impacts of suction dredging.

N20. Comment(s):
The ban on suction dredging within refugia due to an alleged potential for current suction dredging operations to increase temperature is nowhere justified *in situ* on the Klamath River or in the scientific literature.

Comment(s) Made By:
Kobseff – Siskiyou County Board of Supervisors

Response:
The Regional Board consulted with fisheries biologists to identify the locations of thermal refugia used by salmonids in the Klamath Basin. The recommendation to restrict suction dredging discharges in the Klamath Basin was based on many peer reviewed studies. While some point to the negligible long-term nature of some impacts as the commenter suggests; they also show considerable short-term impact. See section 4.2.4 for a review of the scientific literature regarding the impacts of suction dredging discharges related to water quality and fish habitat.

For example:
- Excavation by dredging directly causes significant local changes in channel topography and substrate conditions, particularly in small streams (Harvey, 1998).
- Streambank disturbance and destruction of riparian habitat has been documented in the Siskiyou National Forest in Oregon (Nawa, 2002).
- Miners commonly pile rocks too large to pass through their dredges. These piles can persist during high flows and, as imposed topographic high points, may destabilize channels during high flows (Harvey, 1998).
- Pools can be filled by sediments mobilized by upstream dredging (Thomas 1985; Harvey 1986).
- The number of rainbow trout in a small pool in Butte Creek, California declined by 50% after dredging upstream of the pool filled 25% of the pool volume (Harvey 1986).
- While deposition of bedload would be most severe close to dredging sites, disruption of the continuity of bedload transport can have unpredictable consequences downstream, including both erosion and deposition (Womack and Schumm 1977).
- "The majority of suction dredge operators in Canyon Creek did not work long periods or disturb large areas of the streamed. Dredging impacts upon the channel geomorphology were confined to the area dredged and the area immediately down stream." (Hassler, T.J., W.L. Somer and G.R. Stern. 1986.)
- "Operation of suction dredges with an intake nozzle size of greater than 4 inches generally has more than de minimis effects on the aquatic environment and therefore requires authorization from the Corp under Section 404." (Army Corps, 1994)

N21. Comment(s):
The mining community has made these arguments and many others ad-nausea. The various agencies simply disregard what they don't want to hear in favor of implementing their own pre-determined agenda. Here is only example of their reasoning: "Where threatened or endangered species exist, mangers would be prudent to assume activities such as dredging are harmful unless proven otherwise.”

Comment(s) Made By:
Foley

Response:
The quote given in the comment is a recommendation of a fisheries biologist that Regional Water Board staff considered in developing the policy recommendations and assessing the relative risks presented by suction dredging discharges during the season when refugia are crucial to meeting the water temperature objective. The recommendation to restrict discharges in thermal refugia locations was based on the available science in addition to the recommendations of fisheries biologists.

N22. Comment(s):
They propose to take people's livelihood and property and prohibit them from making a living on mere assumption.

Comment(s) Made By:
Foley

Response:
The TMDL implementation plan does not take anyone’s livelihood, nor does it prohibit people from making a living. It restricts discharges of waste associated with suction dredging activities in certain locations during certain time periods that are critical for fish species survival. The Thermal Refugia Protection Policy does not restrict all mining and in all locations. It proposes lifting a prohibition on the entire Klamath mainstem, if suction dredging is determined to be a point source discharge, except in these sensitive areas where heightened protection and additional analyses is necessary. See response to comment N24 below concerning the issue of ‘private property takings’.

N23. Comment(s):
You can't prove that something is NOT harmful. This is like trying to prove a negative, it cannot be done.

Comment(s) Made By:
Foley

Response:
Regional Water Board staff recognize that studies have shown that suction dredging has limited spatial impacts on turbidity and has limited duration impact on macroinvertebrate communities downstream of the dredge. These impacts were considered by the Regional Water Board staff when recommending where and when to restrict discharges of waste from suction dredging and other activities in the Klamath basin.

N24. Comment(s):
In 1866 the 39th Congress of the United States enacted a law that still stands today. It is commonly referred to as the Mineral Estate Grant of 1866. Its federal register designation is: HR365. One excerpt from this document states: “That the mineral lands of the public domain, both surveyed and unsurveyed, are hereby declared to be free and open to exploration and occupation by all citizens of the United States"

This document makes mining claims "private property" in the truest sense. It grants the actual land to the claimant and severs ownership from the Federal Government. Since the congress has declared that the mineral lands are free and open, and this is the supreme law of the land, it follows that no state or agency can prohibit what Congress has enacted. The Supremacy Clause of the US constitution provides that no rule or regulation imposed by any state agency is valid.

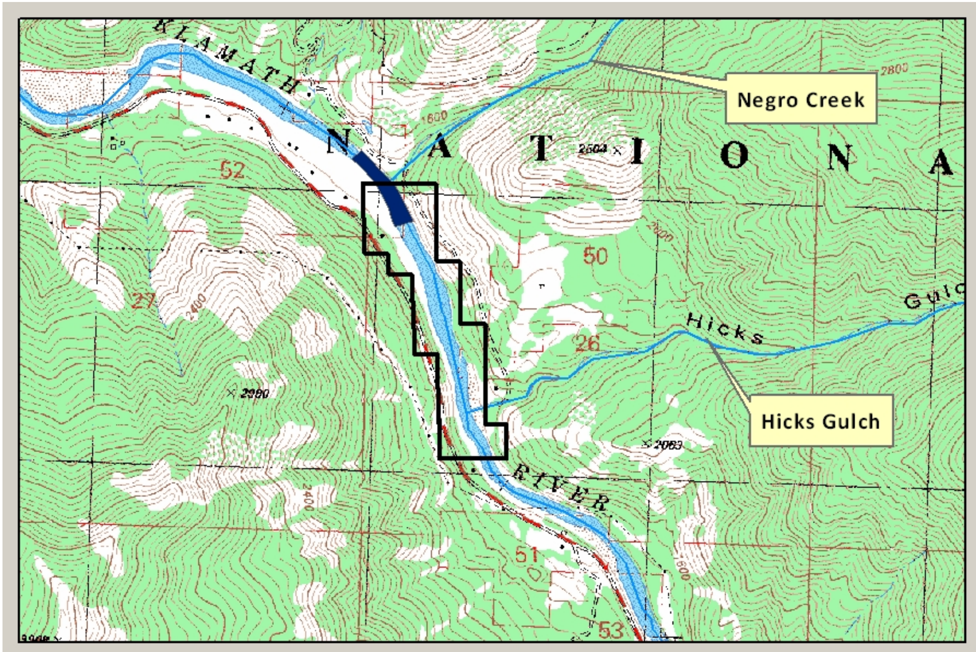
Comment(s) Made By:
Foley

Response:
The suction dredge discharge restrictions in thermal refugia have been clarified in the revised Staff Report. The implementation plan recommends that the Department of Fish and Game and the State Water Resources Control Board restrict suction dredging discharges from certain areas in the Klamath basin in any permit developed for discharges associated with suction dredging.

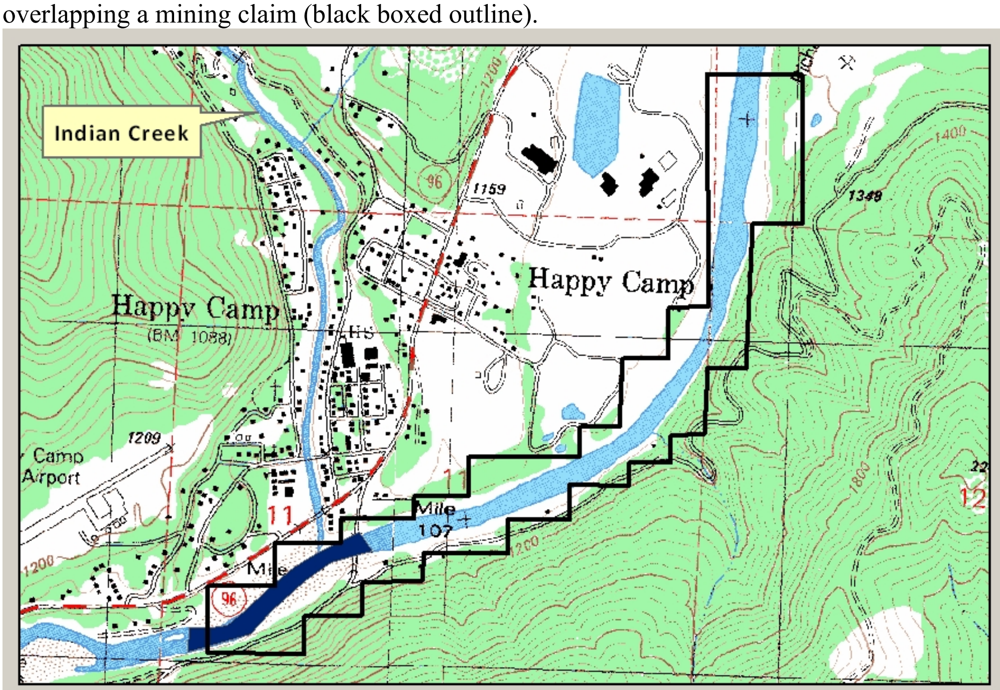
It appears that the Mining Estate Grant of 1866 was intended to prevent the federal government from nationalizing private mines. During the early settlement of the West, the United States retained rights to minerals while still allowing settlement, a term referred to as a split estate. At that time Eastern States were interested in paying down the enormous debt accrued by the civil war and proposed using California and Nevada minerals to pay its creditors. The proposal caused an outcry by private mining interests in the West and led to the 1866 Act. It recognizes miners’ rights to establish a property in the mineral estate which would require compensation if taken by the federal government. It also codified the practice of allowing the settlement of the surface estate for uses other than mining that would be governed by specific land disposal laws. The mineral estate would be governed by mining laws. (See http://www.stewards.us/cornerstone/may1998/csmay98-1.asp.)

The Mining Estate Grant provides protection against the nationalizing of western mines, but it does not stand for the proposition that mining is not subject to any rules intended to protect the environment, public health and welfare. To the contrary, the United States Supreme Court has found that the Mining Act of 1872 and subsequent amendments does not preempt state environmental laws. (*California Coastal Comm'n. v. Granite Rock Co.* (1987) 480 US 572, 581.) Forest Service regulations explicitly require compliance with federal and state environmental laws. (*See e.g.* 36 CFR §228.5.) If a permit is developed that restricts suction dredging discharges in certain locations during certain times of the year, Regional Board staff do not agree that this would amount to a taking of private property for several reasons. The Klamath TMDL implementation plan proposes restrictions on suction dredge discharges only in certain sensitive locations and during certain times. Also, it does not restrict all mining; rather, it only applies to the type of mining that discharges waste. Regional Water Board staff analyzed the location of 28 New 49ers mining claims in the Klamath Basin and compared them with the areas for protection of thermal refugia. The documentation of the claims was found on the New 49ers' website. Only seven claims overlapped the thermal protection areas, and among most of those, the claim area is significantly larger then the proposed restricted area. The maps below show an example of three of the seven and where the thermal refugia and mining claims would overlap. They give an example of a small, medium, and large amount of overlap. The proposed protection does not deprive miners the ability to mine the majority of their claims using suction dredges, and is necessary for the reasonable protection of water quality.

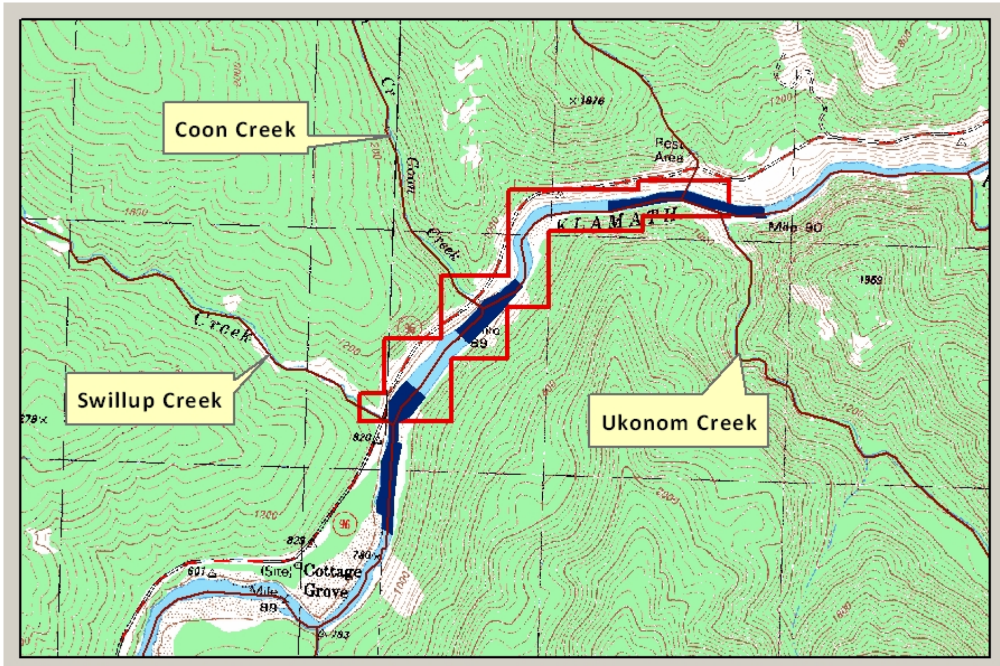
The status of discharges from suction dredges as a point or nonpoint source is currently unclear. If such discharges were determined to be point sources, they would be prohibited by an existing prohibition on point sources in the Klamath basin. The implementation plan proposes to lift the Basin Plan prohibition on suction dredging discharges, except in the buffer areas designated in the proposed Thermal Refugia Protection Policy. Suction dredging would also be subject to the requirements of a future NPDES permit that would address all potential water quality impacts from suction dredging.



Map showing the proposed thermal refugia buffers at the mouth of Negro Creek (in dark blue) overlapping a mining claim (black boxed outline).



Map showing the proposed thermal refugia buffers at the mouth of Indian Creek (in dark blue) overlapping a mining claim (black boxed outline).



Map showing the proposed thermal refugia buffers at the mouths of Swillup, Coon, and Ukonom Creeks (in dark blue) overlapping a mining claim (red boxed outline).

N25. Comment(s):
Rather than increase temperature, suction dredging cools the water by creating deeper pools. The Regional Water Board must consider only the listed impairments to water quality that may be affected by suction dredging. Despite what may be implied by the Draft TMDL, the Klamath is not listed for sediment.

Comment(s) Made By:
Kobseff – Siskiyou County Board of Supervisors

Response:
The Thermal Refugia Protection Policy protects thermal refugia from impacts from discharges of waste within the areas surrounding the refugia and in certain critical time periods. As stated in an earlier response the Regional Water Board would consider the use of suction dredges to enhance the functions of thermal refugia in the Klamath Basin if the appropriate permits are obtained and the restoration work is done with consideration for the use of thermal refugia by cold water fish. Incidentally, the Klamath basin is listed for sediment from the junction with the Trinity River to the mouth.

N26. Comment(s):
Dredging actually decreases the temperature and it creates refugia.

Comment(s) Made By:
Cook – Siskiyou County Supervisor, District 1

Response:
See response to comment N25 above.

N27. Comment(s):
Nobody is moving enough sediment by dredging that they are going to make the water shallow or wide enough to increase temperature.

Comment(s) Made By:
Costales – Siskiyou County

Response:
This is not the impact of suction dredging that is addressed by the Thermal Refugia Protection Policy. The policy is intended to restrict suction dredging discharges in and around thermal refugia at certain times and locations to prevent impacts to the function of those refugia.

N28. Comment(s):
Suction Dredging should be subject to WDRs and NPDES permitting processes (NPDES due to the fact that this is a point source input of pollutants). Suction dredging activity must be in conformance with the Basin Plan (including Basin Plan Anti-degradation language).

Comment(s) Made By:
Levine – Coast Action Group

Response:
The status of a discharge from a suction dredge as a point or nonpoint source is currently undefined in California, but other states have designated it a point source and developed NPDES permits to address these discharges. See section 6.5.4.5 of the Klamath TMDL staff report for more on the Regional Water Board staff approach to regulating suction dredging in compliance with water quality standards.

N29. Comment(s):
Given the likely adverse impacts of multiple mobile suction dredging operations, of which there are hundreds every year in the basin, suction dredge mining of any type (motorized or manual) should be required to have NPDES permits for its discharges and be consistent with the General Plan. In most areas it should be prohibited until and unless it can be definitively shown to be biologically benign as to resident and anadromous fishes and other aquatic species.

Comment(s) Made By:
Spain – Institute for Fisheries Resources & Pacific Coast Federation of Fishermen's Associations

Response:
The TMDL implementation plan has been revised to include a discussion of the point source/nonpoint source status of suction dredging discharges (section 6.5.4.5).

N30. Comment(s):
KRK supports strong, independent pollution limits and frequent monitoring on suction dredgers who disturb critical fish habitats. Those limits and monitoring results will be an important part of any environmental analysis of the practice, which sucks up river bottom and spits it back out.

Comment(s) Made By:
Terence – Klamath Riverkeeper

Response:
The California Department of Fish and Game is developing an SEIR for their suction dredging permitting program in coordination with the State Water Resource Control Board. The Regional Water Board will participate in this process and ensure that any future permits are sufficient to meet water quality standards.

N31. Comment(s):
In addition, the taking of water from property owners in the Shasta River system or the taking of mining claims through use prohibitions at the confluence of rivers and creeks with the Klamath would appear to be unconstitutional conditions.

Comment(s) Made By:
Armstrong – Siskiyou County Supervisor, District 5

Response:
The Klamath implementation plan does not propose the taking of water from property owners in the Shasta River system (see general response X1). See also response to comment N24 addressing the alleged 'taking of mining claims'.

N32. Comment(s):
MKWC applauds the proposed protections for thermal refugia, including the prohibition of waste discharge within 500 to 1,500 feet of tributary mouths that provide thermal refugia. We encourage the regional board to take an expansive approach to this designation in light of the fact that clean, cold thermal refugia along the Klamath main stem corridor has been severally impaired by over-allocation of tributary water, particularly in the upper reaches of the Mid Klamath Subbasin between Iron Gate Dam

and the town of Happy Camp, the warmest part of the river. Juvenile fish kills go largely unnoticed by the media, but significant numbers of juvenile mortalities are witnessed and recorded almost yearly during the warmest months of the summer season. Protection and expansion of thermal refugia on the Klamath River is essential for fish health and survival.

Comment(s) Made By:
Harling – Mid Klamath Watershed Council

Response:
Thank you for your support. Regional Water Board staff agree that protection of thermal refugia on the Klamath River is essential for fish health and survival.

APPROACH and MODE OF COMPLIANCE

O1. Comment(s):
The implementation plan must explain that compliance with the required implementation measures imposed on specific dischargers through permit or waiver is sufficient to establish compliance with the respective TMDL.

Comment(s) Made By:
Addington and Danosky – Klamath Water Users Association & Tulelake Irrigation District

Response:
This is the method used in the implementation plan. The plan will be implemented through permits or waivers only for discharges over which the responsible parties have control.

O2. Comment(s):
The California Department of Fish and Game in their requirements have already identified regulation that will do the same thing as your TMDL's. The Northwest Forest plan and Federal Clean Water Act have already addressed some of the same concerns that you are trying to implement.

Comment(s) Made By:
Bennett – Siskiyou County Supervisor, District 4

Response:
The TMDL implementation plan works other existing regulatory programs and requirements while maintaining independent enforcement authority. For example, the Regional Water Board cannot enforce the Northwest Forest Plan, but the USFS implementation of the plan can be used to meet the conditions of a waiver adopted by the Regional Water Board for USFS activities. The TMDL implements the Clean Water Act, as delegated to the Regional Water Board by the USEPA.

O3. Comment(s):
Modoc County Farm Bureau believes the appropriate action for the Regional Water Board to take is to continue the current situation of voluntary conservation practices until there is some evidence to show these practices are not successful in protecting water quality and more restrictive actions are required.

Comment(s) Made By:
DePaul – Modoc County Farm Bureau

Response:
The State Nonpoint Source Policy (NPS Policy) requires the Regional Board to regulate all nonpoint source discharges with the appropriate combination of regulatory tools. The NPS Policy was, in part, adopted to make the implementation of water quality management practices mandatory and enforceable. Regulation of agriculture in the Klamath basin will be considered as part of the development of the conditional agricultural waiver. To comply with the NPS Policy, the agricultural waiver must make the implementation of management practices enforceable. That said, a regulatory program can accommodate locally generated programs that are designed to achieve and demonstrate compliance.

O4. Comment(s):
The implementation plan should target tributaries to facilitate cost-effective implementation consistent with allocations. More specific watershed planning based on the analytical framework of the TMDL can help direct implementation. Lost River basin would be a prime area for encouraging basinwide efforts to manage and/or control water quality improvements.

Comment(s) Made By:
Hashimoto and Ziegler – USEPA

Response:
The TMDL implementation plan addresses each of the major tributary watersheds in the Klamath basin in the staff report. Some of the tributaries have their own TMDL implementation plans that target water quality problems specific to those tributaries. The implementation plan encourages basinwide efforts through:

1. the proposal of an MAA with the US Bureau of Reclamation, US Fish and Wildlife Service, and Tulelake Irrigation District;
2. the agricultural waiver that will allow for group compliance and water quality management on a watershed scale;
3. continued implementation of the Scott and Shasta TMDL implementation plans;
4. the proposed tracking and accounting program that will provide a methodology for downstream dischargers to mitigate their impacts by implementing load reduction project upstream; and
5. a waiver mechanism to address all USFS nonpoint source activities.

O5. Comment(s):
TMDL load allocations and numeric targets must also be integrated into all water quality permits issued for the mainstem Klamath River.

Comment(s) Made By:
Klamath Riverkeeper – Various

Response:
Staff agree and one of the main functions of the Klamath implementation plan is ensure TMDL measures are incorporated into the various Regional Water Board regulatory programs that addresses the TMDL targets and allocations. The way in which the targets and allocations are addressed in permits depends on whether the permit is an NPDES permit for a point source discharge(s) or a nonpoint source permit for a nonpoint source discharge(s). While NPDES permit are required to translate TMDL targets and allocations directly into effluent limitations in the permit, nonpoint source permits typically include measures such as the requirement to implement BMPs to address the targets and allocations.

O6. Comment(s):
Enforcement mechanisms must be included to ensure load allocations are met in a timely fashion.

Comment(s) Made By:
Klamath Riverkeeper – Various

Response:
The revised implementation plan chapter of the staff report describes the Regional Water Board's enforcement options and the State Enforcement Policy which directs the Regional Water Board to use its enforcement tools to achieve water quality compliance. By ensuring all nonpoint source discharges are regulated through a combination of permitting mechanisms and/or prohibitions, the Klamath implementation plan makes the load allocations and targets enforceable.

O7. Comment(s):
The Klamath TMDL Implementation Strategy should be consistent with:
ESA Recovery Strategy for California Coho Salmon, Federal ESA Coho Recovery Plans (The National Marine Fisheries Service (NMFS) will shortly be releasing a draft coho recovery plan for the SONCC ESU of which Klamath coho salmon are a part), Basin Plan for the North Coast, California Water Code, and California Environmental Quality Act.

Comment(s) Made By:
Levine –Coast Action Group

Response:
Regional Board staff believe the implementation plan is consistent with these various plans.

O8. Comment(s):
Section 6.1.5 Regulatory Tools

In the description of the Regional Board's regulatory tools, the Implementation Plan states the TMDL process provides for non-point and point source control tradeoffs. While challenging to regulate, non-point sources of pollutants cannot be ignored, especially in rural communities where point source discharges are rare. An equitable balancing of load allocations between all pollutant sources is necessary to avoid placing an unreasonable burden on one or two “easily" regulated point sources.

Comment(s) Made By:
Stacey – California Department of Fish and Game

Response:
The TMDL implementation plan places equal importance on regulating all sources of pollution in the Klamath basin that contribute to the water quality impairments. The allocations assigned to the Iron Gate Fish Hatchery are necessary to meet the TMDL in the Klamath basin.

O9. Comment(s):
Lack of staff resources will prevent implementation and monitoring plans from being carried out. We believe those staff resources are needed for an effective action plan must be quantified and spelled out in the Implementation and Monitoring sections (Action Plan). This will connect the dots between the listed TMDLs---the implementation and monitoring plans---and the necessary staff resources, putting them all within the Basin Plan amendment.

The logic and wisdom of the letter from John Corbett to the state legislature requesting 13 more staff for the Klamath River Action Plan dated August 31, 2007 should be a part of the Implementation and Monitoring sections and imbedded in the Action Plan. The Action Plan should set out a ten-year schedule with the estimated number of staff required in each of those years. The Board's adopted Work Plan to Control Excess Sediment in Sediment Impaired Water Sheds is an excellent example of this approach.

The Clean Water Act and Porter Cologne Act mandate this project. It is not optional. Putting the price tag on the package communicates to the State Board and the legislature their responsibility for compliance with those laws.

Comment(s) Made By:
Myers – Sierra Club, Redwood Chapter

Response:
Staff considered available resources and crafted the implementation plan and nonpoint source program elements to make them as efficient as possible and work with existing land management programs. Staff agree that no amount of discharger reporting can substitute for staff in the field working with dischargers, but, at least in the immediate future, staff need to work with resources currently available.

O10. Comment(s):
There needs to be some sort of "fail- safes" for the Klamath River. There needs to be fail-safes or a "back up plan" when one of the responsible parties messes up, in order to mitigate an accidental spill for instance.

Comment(s) Made By:
Schmidt

Response:
The TMDL will be periodically reassessed by the Regional Board to gauge progress towards compliance with the load allocations and targets. The Regional Board will at that time consider the need for additional measures or a "back up plan". The TMDL implementation plan chapter now contains a revised discussion of reassessment of the TMDL (Chapter 7) with more discrete milestones and timelines for compliance. With respect to spills, the Regional Water Board does and will continue to respond to reports from the public and staff observations of spills, discharges, and releases as they come up.

O11. Comment(s):
The Klamath River TMDL implementation plan is logical and the strategy offered is workable. Most of the implementation plan looks good on paper, but it is critically important that Regional Water Board staff have the resources and political support needed to follow through and ensure that the plan is successfully implemented.

Comment(s) Made By:
Spain – Institute for Fisheries Resources & Pacific Coast Federation of Fishermen's Associations

Response:
The various permitting tools and prohibition proposed in the Klamath implementation plan to regulate all sources of pollution are sufficient to ensure compliance with the TMDL. Regional Board staff recognize that staffing limitations will necessitate efficiency and prioritization of pollution control efforts.

O12. Comment(s):
Compliance with water quality standards must be achieved within the next decade if we are going to avoid extirpation of Coho and the listing of Klamath River Chinook under state and federal endangered species laws. This means that a strategy that utilizes "collaborative" and "voluntary compliance" approaches with the polluters is a recipe for failure. Klamath River Salmon and Klamath River Communities cannot wait for another Action Plan, which relies on voluntary efforts and unmonitored implementation of BMPs, completion of unenforceable ranch and farm plans, etc. Klamath Salmon and Klamath Communities want and deserve a prescriptive Action Plan for the Klamath, which uses a full range of regulatory approaches as appropriate. Experience with the Shasta and Scott

clearly indicate that such an approach is the only one that will get the job of restoring Klamath River water quality accomplished anytime soon.

Comment(s) Made By:
Pace, Beck, Gillespie – North Group-Redwood Chapter-Sierra Club & Friends of Del Norte

Response:
The State Nonpoint Source Policy requires the Regional Water Board to address all sources of pollution in the Klamath basin through enforceable mechanisms such as WDRs, waiver of WDRs, and/or prohibitions. Fulfilling the requirements of the policy is one of the objectives of the Klamath implementation plan. These mechanisms provide an enforceable means of compliance with the TMDL. Regional Board staff intend to employ a "collaborative" approach in the development of those waivers or WDRs to ensure that stakeholders have substantive input into the development of the waivers or WDRs and that the waiver or WDR program works together with local ongoing efforts to protection water quality. Timelines and implementation of water quality practices must be included in the any waivers or WDRs.

O13. Comment(s):
How is WQ ever going to effectively administer anything but politically motivated onerous reactionary blanket requirements with little provision for unbiased baseline study and monitoring?

Comment(s) Made By:
Cozzalio

Response:
Regional Water Board staff will develop regulatory mechanisms for water quality management and will administer a water quality control strategy that complies with state law and policy as directed by the State and Regional Water Boards. There are provisions for continuous monitoring of the Klamath basin to measure the effectiveness of the implementation plan. In addition, there is already a robust, multi-agency program of water quality monitoring in place that includes both ongoing routine and special studies to characterize water quality conditions and factors in the Klamath River watershed.

O14. Comment(s):
Once the generic and limiting TMDL conditions are imposed and assets removed, the ability to rapidly respond to sudden conditions and experimental opportunities will be gone. Options such as water retentions and augmentations at different times will disappear.

Comment(s) Made By:
Cozzalio

Response:
The Regional Water Board is open to the possibility of innovative methods to achieve TMDL objectives where appropriate.

O15. Comment(s):
The only inevitable option for a river that will never be able to meet water quality requirements is to remove all human contact from the caretakers with the knowledge, experience, and consequence to make the most effective decisions regarding the Klamath, at which point WQ can then alter the ‘natural background requirements’ amid the destruction they have caused.

Comment(s) Made By:
Cozzalio

Response:
The TMDL acknowledges that the Klamath River under natural conditions was likely warm in the warmer parts of the year, and enriched with respect to nutrients. The TMDL Action Plan takes account of this. The Action Plan does not contemplate removing all human contact, but rather is built around working with landowners and resource managers to implement the most effective water quality measures. TMDL implementation is a continuous process and will undergo future reassessment to measures effectiveness and consider public input.

O16. Comment(s):
The current issue of the Klamath Water Users Association quarterly newsletter has an article on the Klamath TMDL which contains this statement: “KWUA staff has been in contact with NCRWQCB to ask questions about the TMDL and how it will affect local landowners. Currently the NCRWQCB is working with landowners on the Scott and Shasta Rivers to implement TMDL's. They are planning to use the same model for implementation with the Klamath basin. This includes working cooperatively with Resource Conservation Districts (RCD's) and landowners to implement measures to better water quality.” I would like to know whether or not NCWQCB staff have made such a commitment to KWUA. Are you planning to use the approach used in the Scott? the Shasta?

Comment(s) Made By:
Pace

Response:
The Klamath implementation plan seeks to take a consistent approach to regulating irrigated agriculture throughout the Klamath basin considering the existing regulatory approaches in Oregon as well as the North Coast Regional Water Board approach in the Scott and Shasta basins and regulatory programs for agriculture in place in other

Regional Water Boards in California. In the Scott and Shasta River basins, landowners are required to implement management measures to address the TMDL impairments with the local RCD acting as the entity that coordinates the program and reports periodically to the Regional Water Board. There are also WDRs and a waiver in the Central Valley Region (Region 5), and a conditional waiver in the Central Coast Region (Region 3) that were adopted in 2005-2006 and 2004 respectively. In both regions, there is an option for landowners to cooperate in group water quality management plans that are developed by the local entity working cooperatively with the Regional Water Board. In Oregon, a regulatory process exists whereby landowners comply with group agricultural water quality management plans that apply to different subbasins in Oregon, including the Lost River and Klamath Headwaters subbasins that are part of the Klamath River basin in Oregon. Because the Lost River is in both Oregon and California, it is desirable to keep programs in the two states as consistent as possible. The major difference between California and Oregon is the requirement in California for the water quality control agency to directly regulate discharges of waste, i.e., issue a permit, while water quality regulation in Oregon is primarily the responsibility of the Oregon Department of Agriculture.

The similarity among all these agricultural water quality control programs in California is that they utilize existing programs and local entities to implement management practices to comply with the WDRs/waivers. The reason for this approach is that it is the most effective way to achieve compliance with water quality standards on a wide scale. The advantage of cooperative implementation is that it leverages existing water quality programs and funding sources to achieve water quality goals; and in the case of the Klamath basin, to achieve the TMDL allocations and targets. Moreover, landowners and operators are well situated for determining appropriate water quality protections for site-specific parcels because they have detailed knowledge and understanding of the area. This approach can work, especially when working with the Regional Water Board cooperatively. The Regional Water Board has limited staff available to administer the proposed agricultural waiver program and so must leverage existing efforts as much as possible.

The details of the waiver program have not been proposed and will be developed in a process that will be initiated after adoption of the Klamath TMDLs. Regional Water Board staff will include effective implementation measures and monitoring and reporting requirements as needed to ensure the protection of water quality.

O17. Comment(s):

- The injury or harm caused by an activity being regulated is also held to a standard of "substantial," significant, serious or appreciable injury as well as being a substantial factor or contributor to the injury. (The action must have been a significant factor enough to have independently caused the injury by itself.) This would be contrasted with injuries/damage that are "de minimis" or of minimum importance – something that causes an impact that is so little, small or insignificant that the law will not consider it.

- If one can point to evidence of a direct cause and effect relationship between a specific activity and alleged pollution, then it is a point source condition, which can be regulated. The question arises whether imposing "basin-wide" or "watershed-wide" regulatory conditions on activities in tributaries to address alleged pollution miles away in the Klamath River or vague cumulative effects in a system can stand up to scrutiny under standards of proximate cause, proof of substantial injury and substantial factor analysis, particularly when such pollution has not been identified as an immediate local problem.

- There is also a question as to whether regulating most human activities attributed as the source of non-point source pollution would stand up to scrutiny and burdens of proof under these standards, or whether it would be more appropriate to improve overall conditions through voluntary incentive-based programs. (p. 2-3)

- Conditions required for mitigation of pollution fail to meet the standards of "essential nexus" and "rough proportionality" set forth in Nollan v. California Coastal Commission, 483 U.S. 825 (1987) and Dolan v. City of Tigard, 512 U.S. 374 (1994). In these decisions, the Supreme Court of the United States indicated that the conditions/mitigations/exactions required of an individual must be specifically related to the polluting activity itself and roughly proportionate to that impact. In addition, as stated in Dolan: "Under the well-settled doctrine of 'unconstitutional conditions', the government may not require a person to give up a constitutional right- here the right to receive just compensation when property is taken for a public use-in exchange for a discretionary benefit conferred by the government where the property sought has little or no relationship to the benefit. See Perry v. Sindermann, 408 U. S. 593 (1972); Pickering v. Board of Ed. Of Township High School Dist., 391 U. S. 563, 568 (1968)."

- The imposition of watershed-wide conditions is not proportionate to the alleged "pollution" caused locally by specific activities.

Comment(s) Made By:
Armstrong - Siskiyou County Supervisor, District 4

Response:
Marsha Armstrong, Siskiyou County Supervisor, raised an issue about "causation" as it relates to regulation. Much of the comment cites legal principles applicable to tort causes of action, or in the *Nolan* and *Dolan* cases, the legal standards for requiring mitigation in a specific permit, usually a building permit. Armstrong's argument is that the Regional Water Board must show a specific injury to water quality that was purposefully caused by a specific landowner before imposing a general regulation would apply to that individual. This comment misunderstands the legal standards for general rulemaking, and also the nature of non-point source pollution which the Klamath TMDL addresses. That said, Regional Water Board staff has responded to Siskiyou County's general complaints regarding burdensome and duplicative regulations and made many changes to the plan to

address this. See also response to comment O22. It is staffs' intent to develop an implementation plan that provides effective water quality protection but also is efficiently administered with the least burden to individual landowners.

The regulatory measures proposed in the Klamath TMDL address activities and associated discharges that contribute to water quality impairments in the Klamath basin. The nonpoint source regulatory measures proposed in the Klamath TMDL for future adoption will only apply to parties discharging waste to waters of the state or to areas that could affect the quality of waters of the state. Activities that do not discharge waste are not subject to regulation by the Regional Water Board. In addition, nonpoint source discharge permits and waivers assign responsibility to an individual for their discharge only.

Dischargers are required to file a Report of Waste Discharge for discharges that could affect the quality of waters of the state. The Porter Cologne Water Quality Act, section 13260 provides:

"Any person discharging waste, or proposing to discharge waste within any region that could affect the quality of the waters of the state, other than in to a community sewer system… shall file with the appropriate regional board a report of the discharge"

Discharges of waste that are not subject to NPDES permits for point source discharges typically include runoff from nonpoint sources such as agricultural activities and waste discharges to land or to groundwater. When viewed in isolation, nonpoint source discharges from one parcel of land may or may not cause a violation of water quality standards or cause impairments, depending on the size and scope of activity; however, cumulatively these activities can and do contribute to water quality impairments. The sources that are proposed for regulation by the Klamath TMDL have all been identified by the technical TMDL analysis as sources of waste discharge to waters of the state that cause or contribute to water quality impairment in the Klamath basin. Moreover, the Regional Water Board is required to regulate all nonpoint sources of discharges, independent of the TMDL process. The Regional Board may consider a general WDR or waiver for similar discharges from many individuals under Water Code section 13269. General waivers are one mechanism that minimizes the burden on individual landowners by reducing paperwork and fees required for individual WDRs, and allowing watershed groups to collaborate on the formation and content of the waiver. In addition to this very collaborative approach, to developing the agricultural waiver for example, as proposed in the implementation plan, parties will have notice and opportunity to comment before the Regional Water Board considers adoption.

The Klamath TMDL implementation plan encourages parties to participate in the development of the future agricultural waiver program. Parties may raise the issue of burdens of proof and legal standards at that time. Generally, the Regional Water Board must show that a land use activity results in discharges of waste could affect the quality of waters of the state. Armstrong's citations of Nollan *v. California Coastal Commission*, 483 U.S. 825 (1987) and *Dolan v. City of Tigard*, 512 U.S. 374 (1994) are inapposite. Both cases address the proper scope of dedications and exactions demanded by local government in the context of issuing individual building permits. The Klamath TMDL adoption is a quasi-legislative or rule making action, not an adjudicatory action (i.e. issuance of an individual permit).

The Regional Water Board has supported the idea of locally-led efforts to implement best management practices for non-point source activities as shown in the Scott and Shasta watersheds. The Regional Water Board agrees that a collaborative approach with landowners can be very effective in water quality improvements as landowners are more familiar with each parcel and what measures would be most appropriate to minimize water quality impacts. Chapter 10 of the TMDL staff report describes various incentive programs available to dischargers to help with the costs of implementing water quality protection measures.

O18. Comment(s):

- Temperature, low dissolved oxygen and mycrosystin per se are not “wastes” under Section 13050 of the Porter Cologne Water Quality Control Act and, therefore, are not pollutants. Solar radiation comes from the sun and should not be regulated as a pollutant as it is on the Scott River and is proposed on the Klamath. Water discharges that have been warmed by human activity and nutrients deposited from human or domestic animal activities could be pollutants if they unreasonably affect beneficial uses. These, in turn, could contribute to conditions of low dissolved oxygen harmful to fish and environments conducive to the growth of mycrosystin.

- Diversions of the flow of water are not “wastes”. They are a beneficial use of the water and should not be regulated as a pollutant.

Comment(s) Made By:
Armstrong - Siskiyou County Supervisor, District 4

Response:
The Klamath TMDL does not purport to regulate water diversions under waste discharge requirements. For an expanded discussion on flows, see general response X1. Heat is a pollutant under the federal Clean Water Act, and temperature control measures are implemented typically in the context of waste discharge permits for sediment and nutrient discharges, or other appropriate permit (i.e. water quality certification). Temperature can be a discharge of waste from a dam tailrace or thermal discharge, usually associated with power plant cooling. Low DO is a response variable associated with nutrient and organic matter enrichment. Mycrosystin is also a response variable, a toxin release from algae which result from elevated nutrient levels. Both DO and mycrosystin are controllable water quality factors, and related management measures are typically incorporated into nutrient discharge requirements or other appropriate permit.

O19. Comment(s):
You have proposed TMDLs for pollutants that are not issues in this watershed.

Comment(s) Made By:
DePaul - Modoc County Farm Bureau

Response:
The proposed TMDLs addresses pollutants impairing the beneficial uses of the Klamath basin as identified on the State 303(d) list of impaired waters. It is not clear what 'issues' the commenter is referring to.

O20. Comment(s):
Imposing load allocations for additional non-listed impairments on 303(d)-listed water bodies cannot be done in the short-circuit manner proposed through the Klamath TMDL. Impairments and, thus, TMDLs must go through the full, established process.

Comment(s) Made By:
Kobseff – Siskiyou Co Board of Supervisors

Response:
The entire Klamath Basin, including the tributaries, is listed for nutrients, organic matter and water temperature. However, the staff report has been revised and now makes clear that the Klamath TMDL allocations and targets only apply in areas of the Klamath basin that are not already subject to an existing TMDL.

O21. Comment(s):
Under the dormant commerce clause, state regulations have no impact on anyone who uses the river.

Comment(s) Made By:
Gierak

Response:
The dormant commerce clause is a legal doctrine that prohibits state legislation that affects interstate commerce, and acts to prohibit economic protectionism by a state and discrimination against nonresidents of a state. The Klamath TMDL does not contain any element that would invoke this legal doctrine.

O22. Comment(s):
The Klamath TMDL fails to meet standards of "reasonableness." California State Water Resources Control Board Policy for Water Quality Control anticipates a weighing and balancing of competing uses: "Activities and factors which may affect the quality of the waters shall be regulated to attain the highest water quality which is **reasonable,** considering **all demands being made and to be on those waters and the total values involved**, beneficial and detrimental, economic and social, tangible and intangible."

Comment(s) Made By:
- Armstrong - Siskiyou County Supervisor, District 4
- Cantrall – Modoc County Board of Supervisors
- DePaul Modoc County Farm Bureau
- Rice and Oldfield – California Farm Bureau Federation and California Cattlemen's Association
- Morris- Siskiyou County Farm Bureau

Response:
The above group of commenters is asserting that the Klamath implementation plan is 'unreasonable', but they provide no specific examples to support this claim. Since the comment addresses the reasonableness of the implementation plan in general, the following response includes a general description of how the Regional Water Board considered the reasonableness of the implementation measures. The implementation plan includes measures that support the continued viability of existing uses of water in the Klamath Basin. The plan proposes regulations and the future development of permits to address discharges to water of the state not already authorized under a permit or waiver. The recommended measures are necessary to meet statewide policy and attain water quality standards. Concerning the control of discharges associated with agriculture, the primary interest of the above commenters, the implementation plan proposes the development of a conditional waiver through a separate stakeholder process. In response to numerous public comments from individual landowners, the interim requirements for individual landowners and operators have been removed in lieu of integrating TMDL requirements into a basin-wide or region-wide programmatic permitting approach for consistency. The conditions of the waiver will be considered as part of the waiver development process. Regional Water Board staff specifically removed requirements on agriculture activities from the June 2009 draft in order to develop a reasonable agriculture program through a more robust stakeholder process than could be provided within the context of TMDL development. This allows the stakeholder process to focus specifically on the development of the agricultural program and the development of appropriate regulatory controls on agricultural discharges. In the interim, the TMDL includes the following recommendations to agricultural dischargers that Regional Water Board staff find entirely reasonable:
1. Document current water quality control practices,
2. Attend water quality training, and
3. Organize into groups to comply with waiver.

O23a. Comm ent(s):
The watershed-wide Klamath TMDL is extremely restrictive of agricultural, timber and mining activities. The imposition of this enormous new regulatory scheme over businesses and economic activities in northern Siskiyou County fails to meet standards of reasonableness.

Comment(s) Made By:
Armstrong - Siskiyou County Supervisor, District 4

Response:
See comment above for a discussion of the reasonableness of the implementation measures related to agriculture. The measures related to timber harvest activities are intended to work with the existing TMDL regulatory programs and the requirements in the Board of Forestry's Anadromous Salmonid Protection Rules. The measures proposed to protect thermal refugia are likewise reasonable because they only recommend restrictions on mining within targeted areas that are essential to the support of salmonid populations in the Klamath basin. The thermal refugia areas included in the policy where identified with input from fisheries biologists working in the Klamath basin. The proposed measures do not represent an enormous new regulatory scheme and still allow for the dredging community to mine in the Klamath basin, provided there is no suction dredging in and around the identified thermal refugia. The proposed thermal refugia protection policy does not prohibit all types of mining, and only prohibits suction dredge discharges in a certain locations. See response to comment N24. The implementation plan will have minimal economic impact because the recommendations will not eliminate the benefits to the local economy associated with recreational suction dredging, i.e. supplies purchased at local stores and lodging.

O23b. Comment(s):
The TMDL poses regulations that largely promote the beneficial use of cold water fisheries to the detriment and exclusion of other uses of those waters and adjacent lands for agriculture, mining activities, hydropower dams, timber harvest, road use, etc. The TMDL fails to take into consideration and balance the impacts of the proposed regulations on local community well-being, local economies, the needs and continued viability of other existing uses.

Comment(s) Made By:
- Armstrong - Siskiyou County Supervisor, District 5
- Bennett – Siskiyou County Supervisor, District 5
- Cantrall – Modoc County Board of Supervisors
- DePaul - Modoc County Farm Bureau
- Fowle
- Morris- Siskiyou County Farm Bureau
- Rice and Oldfield – California Farm Bureau and California Cattlemen's Association

Response:
The Regional Board does not regulate beneficial uses; it regulates discharges of waste that could affect beneficial uses of waters of the state. The terminology can be confusing because the regulated activities can involve both users of water (beneficial uses) and dischargers of waste that impact the beneficial uses. While the Regional Water Board protects water quality at a level sufficient to be used beneficially, for example by agriculture, it also regulates discharges of waste associated with agriculture. So, when

Porter Cologne requires the Regional Water Board to protect all beneficial uses, including water used as agricultural supply water, it is requiring that the water quality be sufficient for that purpose. The TMDL is set to protect the cold water fishery because it is the most sensitive beneficial use in the Klamath basin. This means that the cold water fishery requires the highest water quality, which, in the context of the Klamath TMDL, refers to adequate nutrient concentrations and water temperatures. Doing this is not at the expense of the quality of water used for agricultural supply or any other use; on the contrary, it is protective of those other uses. The implementation plan in no way excludes any of the industrial, recreational and municipal water quality needs.

The issue the commenters above raise is the economic impact of regulating discharges of waste associated with land use activities that put water to a beneficial use, such as agriculture; and is a separate issue. The Regional Water Board reviews a variety of factors under Water Code section 13241 when establishing water quality standards and certainly considers the ‘burdens’ of regulation in relation to the benefits to water quality in every action, including Basin Plan amendments. The implementation plan does this by including measures that are reasonable while being sufficient to achieve water quality standards. See response to comment O22 for a description of how the implementation measures meet the standards of reasonableness and Chapter 10 of the TMDL Staff Report for a discussion of the economic costs of implementing reasonably foreseeable compliance measures, including agricultural BMPs.

O24. Comment(s):
The Regional Board’s economic analysis fails to specifically and meaningfully address the reasonableness of the costs associated with implementing the EPA Lost River TMDL.

Comment(s) Made By:
Addington and Danosky – Klamath Water Users Association & Tulelake Irrigation District

Response:
The economic analysis is not required to address reasonableness of the costs associated with implementation. The purpose of the economic analysis is to provide the costs of reasonably foreseeable compliance measures. The TMDL also identifies sources of funding for implementing compliance measures in Chapter 10 – Economic Analysis. The reasonableness of the implementation plan measures is addressed in response to comment O22.

O25. Comment(s):
We believe that Sections 13000 and 13241 of the California Water Code do require a far more in depth analysis of the economic impacts of these proposed regulations than you have presented in Chapter 10. We would then strongly suggest that each proposed regulation be analyzed to determine if its perceived benefits to cold-water fisheries is “reasonable”, given its impact on the other uses.

Comment(s) Made By:
DePaul - Modoc County Farm Bureau

Response:
TMDLs are mechanisms to implement already existing standards, and are not designed to rebalance the policy interests underlying the already existing standards (SWRCB, 2002). Changing a standard or designated use involves a separate process not appropriately before the Regional Water Board. TMDLs require a quantitative numeric pollutant target established at a level necessary to achieve water quality standards in an impaired waterbody. (33 USC §1313(d)(1)(C).) The Clean Water Act, federal regulations, case law and interpretive guidance from EPA all describe TMDLs in this way (SWRCB, 2002). The TMDL implements existing water quality standards that are made up of use designations, water quality criteria based on those uses, an antidegradation policy, and implementation policies. When expressed in narrative terms, the objective will need to be translated into a number that articulates the existing criteria to meet TMDL requirements; however, this process does not establish a new water quality standard. Therefore, the balancing under Water Code section 13241 is not strictly required; however, as discussed in more detail in response to comment O22 and below, the proposed implementation plan does take into consideration relevant factors, and is reasonably balanced. The economic analysis meets the requirements of Sections 13000 and 13241 by considering the cost of implementing reasonably foreseeable compliance measures. The costs are reasonable, and allow for implementation on a reasonable time schedule. See also response to comments O22 above.

Reference Cited in Response:
State Water Resources Control Board. 2002. Office of Chief Counsel Memo, *The Distinction Between A TMDL's Numeric Targets and Water Quality Standards*. June 12, 2002.

O26. Comment(s):
Regional Board has 'Selected' (as in the Shasta TMDL) the position that since the 'cold water fisheries' is the most 'sensitive' use, that all other uses are subject (therefore inferior) to requirements for 'cold water conditions', even though those conditions have never naturally prevailed in the mid and upper Klamath, creating a hierarchy rather than an equality of uses. That hierarchy in an area historically incapable of attaining those imposed criteria sets a scenario promoting the demise of all other uses.

Comment(s) Made By:
Cozzalio

Response:
The TMDL water quality targets and allocations are attainable and in no way promote the demise of other activities that use water. They are set to achieve compliance with water quality objectives that are protective of all beneficial uses.

O27. Comment(s):
The Regional Board has ignored historical and current conditions to maintain assignment of 'impairments' and selected 'beneficial uses' (e.g. no acknowledgement of other established ecosystems and resource uses such as lake fisheries and Copco residential beneficial uses, while including pre dams historically present algae 'aesthetics' as an 'impairment' to tourist sensibilities).

Comment(s) Made By:
Cozzalio

Response:
The TMDL staff report (section 2.2) shows that the TMDL considers all uses in the Klamath basin and is fully protective of the beneficial uses of Copco Lake, which is currently impaired by microcystin.

O28. Comment(s):
The way that the Draft TMDL is written, every existing or potential impact to cold-water fisheries, no matter how small or unlikely, is considered sufficiently important to warrant regulation.

Comment(s) Made By:
Rice and Oldfield – California Farm Bureau and California Cattlemen's Association

Response:
The implementation plan addresses sources of pollution identified in the technical TMDL analysis. The technical analysis finds that current and legacy human caused sources in the basin are collectively impairing water quality and the cold water fishery. The TMDL implementation plan is required to address all discharges to waters of the state that the TMDL analysis has identified as contributing to the water quality impairments in the Klamath basin. Actions required of dischargers through Regional Water Board permits are proportionate to the severity of the discharge and its relative contribution to the water quality impairment. While the specifics of the planned conditional waiver for agriculture are yet to be decided, it will accommodate various categories of activities based on size and relative impact on water quality. Activities that do not discharge waste to areas that could affect waters of the state do not need a permit (or waiver). Generally, nonpoint source permits (including waivers) require implementation of reasonable best management practices and monitoring and reporting.

O29. Comm ent(s):
Pollutant reductions in Oregon are key to the successful reduction of nutrient concentrations in California downstream, yet Oregon's authority to regulate non-point source discharges (i.e. irrigation tailwater return flow) is weak. We need to know more about the proposed development of a Management Agency Agreement (MAA) between

USBR, USFWS and the Regional Water Board to implement the Lost River and Klamath River TMDLs, as well as the MOU between U.S. EPA, Oregon Department of Environmental Water Quality (ODEQ) and the Regional Water Board.

Comment(s) Made By:
Harling – Mid Klamath Watershed Council

Response:
The details of the proposed Management Agency Agreement (MAA) between USBR, USFWS and the Regional Water Board have not been developed, except that staff are recommending that Tulelake Irrigation District be added as a party. Regional Water Board staff anticipate providing updates to the Regional Water Board and public during future board meetings. The MOA between U.S. EPA, ODEQ, and the Regional Water Board is available on our website at: http://www.waterboards.ca.gov/northcoast/water_issues/programs/tmdls/klamath_river/090630/Klamath_Implementation_MOA_signed_090630.pdf.

WATERSHED-WIDE IMPLEMENTATION

P1. Comment(s):
Very little funding is available to support stand-alone environmental projects. Therefore, most of the measures discussed below would be implemented in conjunction with highway projects.

Comment(s) Made By:
McGowen – Caltrans

Response:
The Regional Water Board wishes to work with Caltrans to implement projects in the most cost-effective manner but at the same time prioritizing based on threat to water quality. The Guidance on the Control of Sediment Discharges addresses discharges of sediment in the Klamath Basin and recommends that dischargers inventory and prioritize existing and potential sources of sediment and address those sources on a time schedule. The TMDL implementation plan includes the requirement for Caltrans to provide this priority list and time schedule for sediment sources associated with its facilities. The scheduling may be coordinated with highway project scheduling, but high priority sediment discharges may need to be addressed on a shorter timeframe than proximity of highway project in time and space.

P2. Comment(s):
The proposal may require increased on-site mitigation and result in significant increases in costs if shade replacement requires natural shade.

Comment(s) Made By:
McGowen – Caltrans

Response:
The TMDL temperature allocation requires natural shade be maintained and/or restored. If trees are removed as part of a Caltrans project – the site must be replanted so natural shade conditions can be achieved. The exact mitigation ratios would be addressed in the 401 water quality certification.

P3. Comment(s):
SB 857 does not require Caltrans to inventory the existing barriers nor does it require Caltrans to establish a remediation priority list and time schedule for modifying the barriers as proposed. SB 857 ties Caltrans' obligations to projects using state or federal transportation funds and does not require Caltrans to remediate barriers independent of a highway project.

Comment(s) Made By:
McGowen – Caltrans

Response:
Here is the text of SB 857 – "The Director of Transportation shall prepare an annual report describing the status of the department's progress in locating, assessing, and remediating barriers to fish passage." The TMDL implementation plan is intended to work with existing requirements and has noted the importance of assessing and remediating fish barriers in protecting and restoring the COLD beneficial use of the Klamath Basin. Barriers prevent fish from reaching cold water refugia that have been recognized in the TMDL as essential for maintaining the natural temperature regime in the Klamath Basin. The Senate Bill goes on to declare that "having this information (the number and extent of existing barriers to fish migration at state road stream crossing) would enable the department to better predict the time and funding required to complete transportation projects." While Caltrans is not required to address barriers unless they are part of a project, it does require the assessment and requires Caltrans to track progress towards addressing fish barriers. The TMDL requirements are consistent with the requirements of this bill. Regional Board staff removed the recommendation that compliance with SB 857 be included in the CalTrans NPDES permit.

P4. Comment(s):
Refusal to grant rights of entry restricts Caltrans ability to completely inventory and assess fish passes barriers associated with drainage from the state highway system.

Comment(s) Made By:
McGowen – Caltrans

Response:
Regional Water Board staff understand this limitation and it should be noted in the inventory.

P5. Comment(s):
Between the requirements established in SB 857 and the additional measures agreed to by Caltrans in the May 26, 2009 letter, there are sufficient legal and regulatory tools to remedy the fish passage barriers without including a duplicate fish passage barrier requirement in the Basin Plan by means of a TMDL.

Comment(s) Made By:
McGowen – Caltrans

Response:
This approach is streamlined and efficient. If it's 'duplicative', then there should be no additional efforts required to meet TMDL requirements.

P6. Comment(s):
You have no concept of what happens in our area in a flood situation, planting trees along the streams to improve shade will be washed away in a flood, the Stream beds are changed and areas where fish once pooled are filled with rock and gravel.

Comment(s) Made By:
Bennett – Siskiyou County Supervisor, District 4

Response:
Regional Water Board staff are familiar with the effects of large floods on stream environments. The riparian shade allocations are set at natural levels, corresponding to natural riparian vegetation conditions, including those that result from periodic floods.

P7. Comment(s):
These large mature trees need to be left near the river to provide shade and reduce water temperature.

Comment(s) Made By:
Carnam

Response:
The Klamath River water temperature allocation promotes the retention of tress providing shade to watercourses.

P8. Comment(s):
The proposed watershed-wide protections for riparian shade and class III (ephemeral) streams concerning private land timber harvest are necessary and good.

Comment(s) Made By:
Fetcho – Yurok Tribe
Crosby – Karuk Tribe
Bowman – Quartz Valley Indian Reservation

Response:
Thank you for your support. Staff have revised the language related to riparian shade requirements, but feel the modification provides for a level of protection consistent with the original language. The provision to prohibit the harvest of channel zone trees in a Class III stream has been removed from the most recent draft because it was found to be inconsistent with the findings of the TMDL technical analysis related to the impact of sediment on water temperature.

P9. Comment(s):
We support the protections for riparian vegetation.

Comment(s) Made By:
Fetcho – Yurok Tribe
Crosby – Karuk Tribe
Bowman – Quartz Valley Indian Reservation

Response:
Thank you for your support.

P10. Comment(s):
Clear cold streamflow from mid-Klamath River tributaries is greatly reduced due to over dense vegetation due to fire-suppression. The over-dense vegetation draws more water for evapotranspiration and decreases openings at higher elevations where snowpack can accumulate. This condition is also causing larger more intense wildfires that are not good for water quality. Streamflow and water quality in these watersheds can't be improved unless the condition of the vegetation in these watersheds is restored. Most of these watersheds need huge amounts of non-commercial thinning, mechanical fuel treatments, judicious underburning, and a small amount of judicious commercial thinning. These fire-adapted ecosystems must be restored to protect and improve water quality in the tributaries.

Comment(s) Made By:
Grunbaum

Response:
Regional Water Board staff support a holistic approach to managing landscapes.

P11. Comment(s):
The proposed Action Plan only allows openings within 150 feet of the creeks – 85%-65% in two riparian management areas. Good luck getting pine regeneration underneath that kind of canopy – that is not sustainable.

Comment(s) Made By:
Chapman – Campbell Timber Management

Response:
Regional Water Board staff expect the natural processes that have created variable light availability in the past (e.g. fire, pests, disease, mass wasting, etc.) will continue in the future. Additionally, see the response to comment P30.

P12. Comment(s):
On a Class I stream, looking at 75 ft inner and 75 ft outer zone – what is additional shade that the outer zone provides?

Comment(s) Made By:
Chapman – Campbell Timber Management

Response:
See the response to comment P30.

P13. Comment(s):
One of the load allocations is in terms of shade and there is a single number they are looking for and we want a range of numbers for shade and that it will change due to natural disturbances.

Comment(s) Made By:
Schuyler – Klamath National Forest

Response:
The comment is incorrect. The TMDL load allocation for water temperature does not require a single number to represent required shade conditions.

P14. Comment(s):
We want more flexibility in conifer plantations in riparian areas. We have to get in there to manage those plantations to accelerate the development of larger trees and better shade. Just leaving a thicket of un-thinned trees does not meet anyone's targets.

Comment(s) Made By:
Schuyler – Klamath National Forest

Response:
The Klamath TMDL allows for this kind of management flexibility in the riparian zone: "Regional Water Board staff acknowledge that it may be necessary in some cases to remove some riparian vegetation to hasten recovery towards site potential effective shade conditions." (Staff Report, p 6-26)

P15. Comment(s):
We are requesting a range of shade targets rather than a single number, to account for natural disturbances: fire and floods.

Comment(s) Made By:
Schuyler – Klamath National Forest

Response:
The TMDL load allocation for water temperature does not require a single number to represent required shade conditions.

P16. Comment(s):
We are looking for flexibility in managing conifer plantations established in riparian reserves, to accelerate larger trees and associated shade development.

Comment(s) Made By:
Schuyler – Klamath National Forest

Response:
This language comes from page 6-26 of the Klamath River TMDL Staff Report: "Regional Water Board staff acknowledge that it may be necessary in some cases to remove some riparian vegetation to hasten recovery towards site potential effective shade conditions."

P17. Comment(s):
6.5.1.1-Riparian Allocations and Targets (page 6-26 of the Public Review Draft). Concerned with two modifications in the fifth sentence on page 6-26 which states "The riparian management area should be large enough to include any trees which have the potential to provide shade to surface waters once they reach their site potential height". This sentence modifies the concept of effective shade by introducing site-potential vegetation as a significant factor in shading and by requiring tree retention regardless of the sun angle at which a particular tree is providing shade to a stream. Chapter 3, page 3-2 (third full paragraph) of the Sound Watershed Consulting (SWC) review states "Research shows that effective shading can be provided by buffer widths ranging from 30 to 100 feet (10m to 30 m) depending on stand type, age, and location." There is no mention of site-potential vegetation in this reference and I am not aware of any other scientific literature which correlates riparian area size and site-potential vegetation in regards to the protection of stream temperatures. The site potential reference seems to imply that the shade provided by trees less than site potential height is somehow inferior to the shade provided by trees at site potential height. I am unaware of any scientific literature that supports such an implication.

Comment(s) Made By:
Quirmbach – Timber Products Company
Salvestro – Fruit Growers Supply Company

Response:
Regional Water Board staff disagree that the specified language modifies the concept of effective shade. Rather, the language is intended to clarify implementation of the riparian shade allocation and provide the basis for the implementation recommendations specific to each land use, as stated on page 6-25. The sentence addresses the situation where past management or disturbance has resulted in shade levels that are less than site potential. Removal of trees that would otherwise result in stream shade if left to grow would prolong shade levels that are below the site potential shade. The concept is simple: don't remove trees that are now, or will be in the future, providing shade to a watercourse.

P18. Comment(s):
Section 6.5.1.1-Riparian Allocations and Targets (page 6-26 of the Public Review Draft). With regard to microclimate effects on water temperatures within riparian areas, Chapter 3, page 15-16 of the Sound Watershed Consulting (SWC) review states "Industry findings are consistent with an earlier review by regional experts (Ice et al. 2002) who concluded that research had not been able to measure a microclimate effect on water temperature where there was a buffer 15 m wide or greater. Where buffers are narrower or absent, it becomes impossible to separate the microclimate effect from the more significant solar insolation effect."

Comment(s) Made By:
Quirmbach – Timber Products Company
Salvestro – Fruit Growers Supply Company

Response:
There has been very little study of this phenomenon, as worded in the report. The literature is clear that microclimate changes occur as a result of vegetation manipulation. The literature is also clear that air temperature, wind speed, and relative humidity act on stream temperatures. These effects are not difficult to calculate, based on thermodynamic principles. The dearth of studies that link vegetation alteration to microclimate, then to water temperature, (the SWC literature review evaluated two papers related to this topic) is not reason to assume that first principles of thermodynamics are not valid in managed stream environments.

Reference used in Response P18:
Sound Watershed Consulting (SWC) 2008. Scientific Literature Review of Forest Management Effects on Riparian Functions for Anadromous Salmonids, for the California State Board of Forestry and Fire Protection. 328 p.

P19. Comment(s):
Section 6.5.1.1-Riparian Allocations and Targets (page 6-26 of the Public Review Draft). The Forest Practice Rules (FPRs) require that all perennial watercourses (i.e. Class I and Class II) have buffers greater than 15 meters. It should also be noted that the high level of canopy retention required by the FPRs within buffers results in the retention of trees moving towards and eventually achieving site-potential heights. The Board of Forestry's proposed "Anadromous Salmonid Protection Rules, 2009" rule package (scheduled for adoption this fall) requires additional provisions for Class I and a subset of Class II watercourses mandating retention of the largest trees. These measures constitute additional requirements which set riparian areas on a track toward being dominated by trees which will reach or have reached site-potential heights. In order to be consistent with science as well as a lack of necessity due to existing FPRs, I recommend that all references to site potential vegetation be eliminated from Section 6.5.1.1 of the Public Review Draft.

Comment(s) Made By:
Quirmbach – Timber Products Company
Salvestro – Fruit Growers Supply Company

Response:
See the response to comment P30. The site-potential vegetation concept is appropriate and consistent with the water quality objective for temperature; however, the Anadromous Salmonid Protection Rules are also a legitimate means of complying with the water quality objective for temperature in most situations.

P20. Comment(s):
Section 6.5.1.1-Riparian Allocations and Targets (page 6-26 of the Public Review Draft). My second concern with the fifth sentence on page 6-26 of the Public Review Draft is in regard to the requirement to retain all trees which have the potential to shade surface waters regardless of the sun angle at which a particular tree is providing shade to a stream. Chapter 3, page 3 (third bullet item) of the Sound Watershed Consulting (SWC) review states "Vegetation that blocks incoming solar radiation at low solar angles (i.e., at dawn and dusk, and during fall-winter seasons) is less important for reducing stream heating from direct radiation (Moore et al. 2005). The lower the angle, the more solar radiation is reflected." The fifth sentence on page 6-26 of the Public Review Draft is not consistent with this scientific principle since there is no mention of solar angles in the sentence.

Comment(s) Made By:
Quirmbach – Timber Products Company
Salvestro – Fruit Growers Supply Company

Response:
According to the Solar Pathfinder instrument, only 46% of daily solar insolation occurs between the hours of 10 am and 2 pm. Page 6 of the SWC (2008) document provides the background behind the bulleted statement on page 3:

> Direct solar radiation on the water's surface is the dominant source of heat energy that may be absorbed by the water column and stream bed. Absorption of solar energy is greatest when the solar angle is greater than 30° (i.e., 90 to 95 % of energy is absorbed as heat) and absorption declines (i.e., reflection of radiation increases) as the solar angle declines. Therefore, riparian vegetation that blocks direct solar radiation along the sun's pathway across the sky is the most effective for reducing radiant energy available for stream heating (Moore et al. 2005).
> Sound Watershed Consulting (2008), page 6.

The basis of the statement that solar radiation outside of the 10 am to 2 pm time period is less important appears to be the relationship of solar angle to reflectivity. While it is certainly true that the reflection of solar radiation off the surface of water, commonly known as albedo, varies with solar angle, the phenomenon is overstated. For instance, at an angle of 15° water still absorbs 80% of the incoming solar radiation (and 85% at 20°). Therefore, the statements are true, but improperly imply that solar insolation at low angles is irrelevant.

Reference used in Response P20:
Sound Watershed Consulting (SWC) 2008. Scientific Literature Review of Forest Management Effects on Riparian Functions for Anadromous Salmonids, for the California State Board of Forestry and Fire Protection. 328 p.

P21. Comment(s):
Section 6.5.1.1-Riparian Allocations and Targets (page 6-26 of the Public Review Draft). The "potential" provision in the fifth sentence (of page 6-26) is problematic for implementation. For example, a tree that is 60 feet away from a stream often is not providing shade to the stream because there is a tree 30 feet away which is blocking the shade provided by the tree 60 feet away. However, under the fifth sentence on page 6-26, would the tree that is 60 feet away still have to be retained because it could potentially provide shade if the tree 30 feet away blows over and recruits large wood to the stream? If the answer to this question is yes, then the riparian zone becomes a no harvest zone which is in conflict with the last sentence of Section 6.5.1.1 (page 6-26) of the Public Review Draft which states that the removal of some riparian vegetation may be necessary. In lieu of focusing on the ability of individual trees to provide shade, I recommend that the Public Review Draft rely on the FPRs to implement shade standards since those regulations are more focused on the collective ability of the entire riparian area to provide shade to a stream. This focus is more easily implemented in the field and has been shown to be effective in preventing water temperature impacts.

Comment(s) Made By:
Quirmbach – Timber Products Company
Salvestro – Fruit Growers Supply Company

Response:
The intent of the identified language is to ensure that riparian areas providing stream shade at levels below the site potential are not managed in a way that prevents them from reaching site potential. The issue is not expected to come up in the forestry context if the Anadromous Salmonid Protection Rules are implemented. See response to comment P30.

P22. Comment(s):
Section 6.5.7.3 of the Public Review Draft. This section proposes specific prescriptions for shade canopy retention within riparian areas. The prescriptions are based on whether or not a given riparian area meets a set of "Reference Shade Conditions" (see page 6-44). The allocation for shade set out in Section 6.5.1.1 is "effective shade". However, the Reference Shade Conditions subsection of Section 6.5.7.3 relies upon measures of

overstory canopy which is a not a direct measurement of effective shade. All of the prescriptive measures of Section 6.5.7.3 should be deleted from the Public Review Draft in favor of monitoring the amount of effective shade being provided by existing and recently adopted FPRs. This would minimize confusion since such prescriptive standards will amount to a separate, overlapping standard that timberland owners will have to comply with.

Comment(s) Made By:
Quirmbach – Timber Products Company
Salvestro – Fruit Growers Supply Company

Response:
It is appropriate to consider the relationship of tree height and density to effective shade levels; however, this section of text has been replaced with language incorporating the Anadromous Salmonid Protection Rule riparian requirements.

P23. Comment(s):
Section 6.5.7.3 of the Public Review Draft. The last paragraph on page 6-44 requires that all trees which are shading a stream must be retained if the majority of trees have not reached their site-potential height. Since most of the private forests within the Klamath River Basin are second growth, most trees within riparian areas will not be at full site-potential height (if that can be readily determined). Therefore, even a well-stocked riparian area providing high levels of effective shade will have to be investigated as to whether or not a tree outside the WLPZ is providing shade. This amounts to a costly, unnecessary effort since, under the scenario provided, high levels of effective shade are being provided. We envision Pre Harvest Inspections (PHIs) being delayed or postponed until the critical months (June thru September) in order to demonstrate protection. I recommend deletion of any reference to site potential heights within Section 6.5.7.3 of the Public Review Draft since such references are not scientifically supportable as being relevant to providing effective shade to streams.

Comment(s) Made By:
Quirmbach – Timber Products Company
Salvestro – Fruit Growers Supply Company

Response:
This language has been replaced with language compatible with the Anadromous Salmonid Protection Rule riparian rules; please see the response to comment P30. Additionally, the amount of shade provided in the summer months can be measured at any time of year using a solar pathfinder, angular canopy densitometer, or by evaluating the known solar angles for critical times of year. Tree height is related to effective shade levels.

P24. Comment(s):
Section 6.5.7.3 of the Public Review Draft. The first paragraph on page 6-45 outlines one additional measure for the protection of Class III watercourses. The proposed measure has a similar goal (protection of channel stability) to proposed protection measures in the Board of Forestry's (BOF’s) Anadromous Salmonid Protection rules (proposed 14 CCR 916(936,956].9(h)). However, the BOF's proposed language goes beyond channel stability and provides for the protection of bank stability. To eliminate potential confusion, I recommend deletion of this protection measure on page 6-45 due to a lack of necessity and the potential for duplication and confusion with the Forest Practice Rules.

Comment(s) Made By:
Quirmbach – Timber Products Company
Salvestro – Fruit Growers Supply Company

Response:
The Anadromous Salmonid Protection rules contain language restricting timber harvest in class III channel zones, unless explained and justified in the timber harvest plan and approved by the Cal Fire director. Regional Water Board staff have found, through experience, that such language creates a soft rule that cannot be relied on for protection of water quality.

P25. Comment(s):
The most significant factor for temperature change in the Salmon River has yet to be identified and is anthropogenic landscape level shifts in vegetation patterns, and the temperatures that have and will continue to rise because of it.

Comment(s) Made By:
Riggan

Response:
It is not possible to address the comment or incorporate the relevant concepts without more information regarding the temperature factors proposed.

P26. Comment(s):
However, as typical with this and all other of the regulations, this TMDL allows 0% human riparian impact (management) and no variation for any circumstances except through onerous, time consuming, uncertain, and costly ‘approvals’. This very condition exacerbates impacts on the river, as owners will no longer be able to respond to emergency conditions to mitigate damage to riparian areas that otherwise may ‘naturally’ occur, nor may they perform routine procedures prohibited under the TMDL blanket regulations but proven beneficial under site specific defined circumstances, therefore allowing the passive degrading of environment both at the site and below.

Comment(s) Made By:
Cozzalio

Response:
It is impossible to address the comment because the "routine procedures prohibited under the TMDL blanket regulations but proven beneficial under site specific defined circumstances" are not defined. Please note that the TMDL Action Plan allows for activities in the riparian zone, and does not require 0% management.

P27. Comment(s):
The effective shade versus channel width in figure 5.4 (p. 5-12) depicts targets for shade for idealized streams that have not experienced a recent disturbance. In order to account for the temperature load allocation for shade that incorporates the definition of natural shade as provided on p. 5-11, a range of shade values that incorporated fire and flood effects would be more appropriate.

Comment(s) Made By:
Moore – U.S. Forest Service, Pacific South West Region
Kelley – U.S. Forest Service, Six Rivers National Forest

Response:
The targets are intended as a guide for riparian management, and may be modified based on site-specific conditions, as stated on page 6-26 of the TMDL staff report.

P28. Comment(s):
The Public Review Draft implementation plan on p. 6-26 acknowledges that it may be necessary in some cases to remove some riparian vegetation to hasten recovery towards site potential effective shade conditions. These opportunities most likely exist in plantations, particularly in areas where past harvest activities did not provide adequate buffers to shade stream courses. The implementation plan should not restrict or be prescriptive regarding riparian canopy cover in plantations. In order to accelerate long term recovery of shade, recruitment of large woody debris, and reduction of wildfire risk in riparian reserves within plantations, canopy cover may need to be reduced by 40 to 60% depending upon the age and species. Such reductions trade a short-term impact for a long-term gain should be considered as restoration activities.

Comment(s) Made By:
Moore – U.S. Forest Service, Pacific South West Region
Kelley – U.S. Forest Service, Six Rivers National Forest

Response:
Regional Water Board staff agree that there may be situations where projects as described are appropriate. However, we disagree that treatment of riparian cover in plantations should be an unregulated activity.

P29. Comment(s):
More stringent shade and root strength removal restrictions on Class III watercourses, which are intermittent headwater streams, are needed to prevent landsliding, elevated water temperature and alteration to channel structure.

Comment(s) Made By:
Pace, Beck, Gillespie – North Group-Redwood Chapter-Sierra Club & Friends of Del Norte

Response:
Regional Water Board staff disagree that class III streams deserve blanket temperature protections.

P30. General Response to Comments P11, P12, P19, P21, P23, P32, P34, P38, P39, P40, P43, P44, P50, P53, P55, P56, P57, P58, P59, and P60 :
Since the Draft Staff Report for the Klamath River TMDLs (staff report) was written and released, the California Board of Forestry had adopted revisions to the Forest Practice Rules in a package of rule changes called the Anadromous Salmonid Protection (ASP) Rules. Regional Water Board staff have reviewed the ASP rules and determined that the new rules substantially increase riparian retention standards, and are much more protective of stream temperatures than the previous rules. While the ASP rules are expected to address temperature issues in the majority of timber harvest situations, they don't ensure compliance with the water quality objective in all cases. For instance, the ASP rules only apply in watersheds that are within the range of anadromous salmonids, while the water quality objective for temperature applies to all waters of the state, regardless of what species are present.

Regional Water Board staff prefer to rely on the California Forest Practice Rules to address water quality concerns related to timber, and wish to avoid establishing different rules governing the same activity, if possible. Therefore, Regional Water Board staff have revised the Klamath River TMDL Action Plan so that it relies on the riparian protections contained in the ASP rules, but extends these protections to all waters of the state within the Klamath Basin. Additionally, because the ASP rules do not ensure compliance with the water quality objective in all cases, Regional Water Board staff have included language that explicitly acknowledges the Regional Water Board's authority through the Porter-Cologne Water Quality Control Act to require measures to protect beneficial uses that go beyond the protections afforded by the ASP rules if appropriate. The revised Action Plan also allows for alternative measures to protect stream temperatures in locations where the ASP rules don't apply, if it can be demonstrated that the alternative measures achieve the water quality objective for temperature.

P31. Comment(s):
The following is in reference to Section 6.5.7 Timber Harvest. How would the additional timber harvesting restrictions improve the temperature of the
Klamath River Watershed in regards to Antelope and Butte Creek since neither of these flows into the Klamath River Watershed?

Comment(s) Made By:
Chapman – Campbell Timber Management

Response:
The purpose of protecting stream temperatures in Antelope and Butte Creeks is not to improve temperatures in the Klamath River. The Regional Water Quality Control Board has the obligation to ensure that water quality objectives are met in all waters of the state, including Antelope and Butte Creeks, regardless of whether they have a hydraulic connection to other waters of the state. Also, please see the responses to comments L1, L2, and L3.

P32. Comment(s):

- The following is in reference to Section 6.5.7 Timber Harvest. For Class I streams, what is the addition from shade canopy to the Class I stream from the outer 75' versus the inner 75'? Is this information from a model or empirical data? Shouldn't this distance change with the slope aspect that the timber is growing on, i.e., with the exception of trees that are directly along the stream, north slopes would contribute very little to the shading of streams.
- The following is in reference to Section 6.5.7 Timber Harvest. For Class II streams, what is the addition from shade canopy to the Class I stream from the outer 50' versus the inner 50'? Is this information from a model or empirical data? Shouldn't this distance change with the slope aspect that the timber is growing on, i.e., with the exception of trees that are directly along the stream, north slopes would contribute very little to the shading of streams.

Comment(s) Made By:
Chapman – Campbell Timber Management

Response:
See response to comment P30.

P33. Comment(s):
The following is in reference to Section 6.5.7 Timber Harvest. Under the current forest practice regulations (FPR), what is the current above baseline sediment that comes from

harvesting of Class III streams in the dryer geographic regions (Siskiyou County) of the plan? What scientific information did the Regional Water Board staff use to determine that current FPRs including the threatened and impaired rules are inadequate for Class IIIs?

Comment(s) Made By:
Chapman – Campbell Timber Management

Response:
Baseline sediment loading from class III streams has not been estimated. In a review of the scientific literature relevant to timber harvest effects on stream function prepared for the California Board of Forestry, Sound Watershed Consulting presented the following information relevant to this topic:

Buffer strips may reduce the potential for bank erosion in areas where tree roots intersect banks (Abernethy and Rutherfurd 1999; CH2Mhill and WWA 1999). In a detailed engineering study of bank stability from riparian vegetation, Simon and Collison (2002) identified a 32% increase the stability of stream banks through root reinforcement and a 71% increase from hydrologic reinforcement during dry antecedent conditions. In studies of unbuffered headwater channels, bank erosion following disturbance from yarding was extensive (Rashin et al 2006).
Sound Watershed Consulting, 2008.

Please refer to the Board of Forestry's website for further information about references cited in the Sound Watershed Consulting (2008) document.

Reference used in Response P33:
Sound Watershed Consulting (SWC) 2008. Scientific Literature Review of Forest Management Effects on Riparian Functions for Anadromous Salmonids, for the California State Board of Forestry and Fire Protection. 328 p.

P34. Comment(s):
The following is in reference to Section 6.5.7 Timber Harvest. The minimum canopy closure that is the "reference shade condition" has ecological considerations beyond what has been indicated in the plan. For example, the sustainability of maintaining a pine or mixed conifer forest type is highly unlikely due to inadequate light available for pine regeneration. Therefore, what are the implications of long term forest type conversion along all the streams within the basin that currently are pine or mixed conifer forest type? What impact does this change have on wildlife dependent on riparian forest that includes pines, forest fire resiliency, and long term sustainability?

Comment(s) Made By:
Chapman – Campbell Timber Management

Response:
Regional Water Board staff have revised the Action Plan, as described in response to comment P30. However, in regards to the ecological considerations raised by the commenter, Regional Water Board staff expect that the natural processes that have created variable light availability in the past (e.g. fire, pests, disease, mass wasting, etc.) will continue in the future.

P35. Comment(s):
The following is in reference to Section 6.5.7 Timber Harvest. Did the baseline sedimentation and shade budgets take into account natural disturbances such as wildfire? Historical data is available that would present a reasonable indication of stand replacement fire occurrences within the different regions that could be used to develop a mosaic of stand age classes that would be expected to occur under natural conditions. The point being that shade and sedimentation under modeled "ideal" conditions is not realistic or sustainable and the true baseline should be "natural" conditions.

Comment(s) Made By:
Chapman – Campbell Timber Management

Response:
Regional Water Board staff expect wildfires will continue to occur in a way that results in diverse stand age classes. The Action Plan only addresses sediment and solar loading that result from human activities, and requires that natural shade levels be achieved.

P36. Comment(s):
The following is in reference to Section 6.5.7 Timber Harvest. What is the rational for increased restrictions for timber harvesting along Class I, II, and III streams in California while protection of streams in Oregon is and will continue to be less restrictive? This further puts the California timber industry at a competitive disadvantage to Oregon especially within this basin where logs from this region are sold to local forest product manufacturing facilities in both states.

Comment(s) Made By:
Chapman – Campbell Timber Management

Response:
The Regional Water Board has the obligation to ensure that water quality objectives are met in all waters of the state, consistent with California law.

P37. Comment(s):
Another valid improvement for TMDL implementation is increased timber harvest restrictions in Class III water courses, intermittent headwater streams, to prevent

alteration to channel structure. This is needed since these areas are often steep and unstable.

Comment(s) Made By:
Fetcho – Yurok Tribe
Crosby – Karuk Tribe
Bowman – Quartz Valley Indian Reservation

Response:
Regional Water Board staff agree with the comment.

P38. Comment(s):

- The California Forestry Association encourages staff delete these recommendations and in the alternative recommend the Regional Water Board recognize the existing California Forest Practice Act (FPA), Forest Practice Rules (FPR), and timber harvest plan review and approval process as effective in protecting the quality and beneficial uses of water in the forest management context. Therefore, no further implementation measures are necessary.
- Regional Water Board staff states throughout the Public Review Draft that it intends to recognize existing regulatory mechanisms for the protection of water resources and will coordinate with other agencies. California Forestry Association (CFA) supports Regional Water Board efforts to minimize and eliminate the duplication of efforts to restore, enhance, and maintain the quality and beneficial use of the State's waters and encourage other state and federal agencies to follow suit. And yet, despite existing FPRs regulating all aspects of timber operations throughout the Klamath region, including rule packages that focus specifically on the protection of water quality, staff has ignored their own recommended additional prescriptive implementation measures for canopy shade percentages and stream buffer widths without adequate scientific justification. The existing FPA and FPR have proven effective in protecting the quality and beneficial uses of water and should be recognized as such. Beyond consulting on all water quality-related regulations under consideration by the Board of Forestry (BOF) regional boards have a formal role in the implementation of the rules in a manner consistent with other laws, including, but not limited to the Porter-Cologne Water Quality Control Act through the review and approval of timber harvest plans.
- The T/I Rules are being reviewed to determine their adequacy in protecting and restoring the species, its habitat, and other beneficial uses of water. The BOF released draft amendments to the Threatened and Impaired Watershed (T/I) rules for public comment on May 8, 2009 and is committed to adopting of any regulatory amendments by October 2009 for implementation on January 1, 2010.

Comment(s) Made By:
Dias – California Forestry Association

Response:
See response to comment P30.

P39. Comment(s):
Basin-wide application is inconsistent with that purpose because populations of anadromous salmonids do not exist basin-wide due to natural and anthropogenic barriers. Temperatures above the Iron Gate and Copco Reservoirs may actually be too cold for anadromous salmonids for optimal growth and survival. And finally, basin-wide expansion of the T/I rules is unnecessary because the existing FPRs are already protecting water temperatures. Staff has failed to demonstrate how historic, previous or current private forest practice measures are allowing water temperatures to increase. Monitoring data indicates stream water temperatures remain constant and meet water quality objectives following timber harvesting under existing FPRs.

Comment(s) Made By:
Dias – California Forestry Association

Response:
See response to comment P30. Additionally, see responses to P49 and P55 below.

P40. Comment(s):
Consider Anadromous Salmonid Protection Rules in the development of the Klamath River TMDL Action Plan.

Comment(s) Made By:
Dixon – Board of Forestry and Fire Protection

Response:
See response to comment P30.

P41. Comment(s):
Green Diamond Resource Company's Aquatic Habitat Conservation Plan (AHCP) provides equal or superior measures to the Klamath River TMDL.

Comment(s) Made By:
Ewald – Green Diamond Resource Company

Response:
Regional Water Board staff expect that Green Diamond Resource Company's AHCP could provide equal or better protection than the measures described in the Klamath TMDL Action Plan.

P42. Comment(s):
Identify Green Diamond Aquatic Habitat Conservation Plan as being an effective means of implementing the TMDLs.

Comment(s) Made By:
Ewald – Green Diamond Resource Company

Response:
Regional Water Board staff expect that the measures to protect water quality afforded by Green Diamond Resource Company's AHCP will be sufficient to comply with the TMDL in some areas while there may be a need for additional measures in others. Accordingly, staff will continue working with Green Diamond Resource Company on Waste Discharge Requirements (WDRs) that will apply to road-related discharges on lands managed under the AHCP. Compliance with those WDRs will constitute TMDL implementation for those discharges addressed by the WDRs.

P43. Comment(s):
In the South Fork Trinity lands owned by Green Diamond, standard Forest Practice Rules are appropriate and will meet the temperature objective.

Comment(s) Made By:
Ewald – Green Diamond Resource Company

Response:
See response to comment P30.

P44. Comment(s):
The results of 11 years of stream temperature monitoring of Beaver, McKinney, Barkhouse, and Collins Creeks indicate:
1. Peak summer stream water temperature have not increased following timber harvesting.
2. Peak summer stream water temperatures have remained constant following timber harvesting.
3. Threatened and Impaired rule Watercourse and Lake Protection Zones provide adequate shade to maintain existing water temperatures between 13C to 16C.
4. Existing timber harvesting plans with Class I, II protection zones are meeting water quality objectives by maintain cold stream water temperatures that support anadromous salmonids.

Comment(s) Made By:
Farber – Timber Products Company

Response:
Regional Water Board staff acknowledge that the data presented indicates a relatively stable temperature regime, as measured by the maximum of the weekly average temperature. However, the timber harvest information provided does not indicate to what degree timber harvest activities occurred in the riparian zone, nor does it discuss the amounts of canopy reduction that occurred as result of these harvests. As a result, the information cannot be used to evaluate the effects of the Forest Practice Rules on stream temperature. See also response to comment P30.

P45. Comment(s):
During timber operations stream water temperatures in Shovel Creek ranged from 12.5 in 1997 and 2001 to 14.1 in 1998. Strong ground water spring influence creates very cold stream temperatures when shade canopy over both Class I and II streams is typically < 50% canopy closure. In summary, the results of 11 years of stream literature monitoring on Shovel Creek indicate:

1. Peak summer stream water temperature have not increased and have remained constant following timber harvesting.
2. Standard rule Watercourse and Lake Protection Zones provide adequate shade to maintain existing water temperatures between 12.5C to 14C in the Cascades.
3. Existing timber harvesting plans with Class I, II protection zones are meeting water quality objectives by maintain very cold stream water temperatures in the Cascades.

Comment(s) Made By:
Farber – Timber Products Company

Response:
Regional Water Board staff acknowledge that the data presented indicates a relatively stable temperature regime, as measured by the maximum of the weekly average temperature. However, the timber harvest information provided does not indicate to what degree timber harvest activities occurred in the riparian zone, nor does it discuss the amounts of canopy reduction that occurred as result of these harvests. As a result, the information cannot be used to evaluate the effects of the Forest Practice Rules on stream temperature.

P46. Comment(s):
The TMDL references Sullivan et al. 2000 to describe stream water temperatures that support salmonids. In this study direct measurement of coho salmon versus water temperatures found a range of 14.3^{o} C to 18.0^{o} C that support optimal food consumption and growth conditions. As stated by the researchers the approximate peak of consumption and growth for coho was 17.0^{o} C. Temperatures both colder and warmer than 17.0^{o} C represented reductions in both consumption and growth. Therefore, water temperature criteria described in the TMDL and in the risk assessment of Sullivan et al. 2000 represent temperatures that could reduce the growth of coho salmon, not increase.

Comment(s) Made By:
Farber – Timber Products Company

Response:
The conclusion of Sullivan and others is consistent with USEPA's temperature criteria guidance incorporated into the Klamath TMDL. These criteria are validated by field studies conducted in northern California that indicate coho aren't found in streams with an MWAT above 16.8^{o} C. The information quoted by the commenter is based on 100% satiation (i.e. the fish can always eat until full), which is an uncommon condition in streams.

P47. Comment(s):
Water temperatures within the range of 14.3 ^{o} C to 18.0 ^{o} C MWAT support healthy coho salmon and the TMDL should reflect this understanding.

Comment(s) Made By:
Farber – Timber Products Company

Response:
The comment runs contrary to the findings of research conducted in northern California, discussed in Section 1.5.3 of Appendix 4. That research indicates coho don't persist in streams with an MWAT above 16.8^{o} C.

P48. Comment(s):
Numerous other physical conditions may cause stream water temperature to increase above natural receiving water temperatures. These physical conditions include extreme air temperatures, distance to watershed divide, channel width, elevation and aspect (Sullivan et al. 1990). Accordingly, loss of streamside shade may not necessarily increase stream water temperatures due to other physical conditions that may be controlling water temperatures. Therefore, it is important to know what "natural receiving water temperatures" are so that these temperatures can be maintained where temperatures currently meet objectives. To improve the TMDL, the TMDL needs to describe the specific numeric data that describes natural receiving water temperatures in the TMDL watersheds.

Comment(s) Made By:
Farber – Timber Products Company

Response:
Extreme air temperatures, channel width, elevation, and aspect are natural factors and thus cannot cause stream temperatures to rise above natural water temperature conditions. The distance from a watershed divide is not a heating factor and does not cause stream temperatures to increase. However, distance to watershed divide is a parameter that

integrates multiple stream heating factors, such as travel time, soil temperature, and elevation. The quantification of natural temperatures requires a site- and time-specific analysis. Natural stream temperatures are the temperatures that result when the environmental factors that influence stream temperatures are unaltered by human activities. As such, natural stream temperatures will vary from place to place and time to time, and are not a set number, but rather are reflective of a condition.

P49. Comment(s):
Implementation Plan (Page 6-43): The TMDL states that certain measures in the California Forest Practice Rules will most likely meet TMDL water temperature standards, while additional measures will most likely be necessary to meet load allocations. The TMDL needs to demonstrate how historic, previous or current private forest practice measures are allowing stream water temperatures to increase? Our monitoring of stream water temperatures, presented in this letter, indicates stream water temperatures remain constant and meet water quality objectives following timber harvesting using previous and current watercourse and stream protection zones. The monitoring results of four separate tributary basins while timber harvesting was occurring provides the most powerful scientific information, cause-and-effect evidence that stream water temperatures are remaining constant during harvesting, including harvesting of Class I, II and III watercourse and lake protection zones.

Comment(s) Made By:
Farber – Timber Products Company

Response:
Regional Water Board staff acknowledge that the data presented indicates a relatively stable temperature regime, as measured by the maximum of the weekly average temperature. However, the timber harvest information provided does not indicate to what degree timber harvest activities occurred in the riparian zone, nor does it discuss the amounts of canopy reduction that occurred as result of these harvests. As a result, the information cannot be used to evaluate the effects of the Forest Practice Rules on stream temperature.

P50. Comment(s):
The TMDL needs to provide the scientific evidence and specific numeric data that describes how current timber harvesting and removal of riparian shade, at levels allowed by current forest practice rules is increasing stream water temperatures in excess of basin objectives?

Comment(s) Made By:
Farber – Timber Products Company

Response:
See response to comment P30.

P51. Comment(s):
In section 5.2.1.1 of the TMDL the assumption is made that water temperatures are controlled by the same physical and environmental controls as watersheds as far away as the Eel River, but including the Scott and Shasta river? Yet no data or scientific information is presented in the TMDL to support this assumption. In fact, information presented in this letter indicates that very cold streams located upstream of Iron Gate and Copco Reservoirs, that occur within volcanic basalt geology, may not heat or cool as streams found underlain in metamorphic or Franciscan geology types (eg. Eel River, Scott River, Shasta River). These hypothetical assumptions made in the TMDL should be reviewed against the empirical data presented in this letter. Please consider modifying the TMDL to reflect the local existing water temperature conditions found tributary streams to the Klamath River above Iron Gate and COPCO reservoirs

Comment(s) Made By:
Farber – Timber Products Company

Response:
While the magnitude of the various factors that determine stream temperatures vary from location to location, the thermodynamic processes that influence stream temperatures are the same anywhere. For instance, while groundwater inputs may be a strong temperature influence on Shovel Creek, groundwater is a factor that influences stream temperatures wherever it discharges to surface water, and must be considered. Regardless, the measures taken to prevent temperature increases are the same, and amount to preventing increased heat loads.

P52. Comment(s):
Current existing water temperature in Shovel Creek., between 12.5^{o}C and 14.1^{o}C MWAT, which is located above Iron Gate and Copco Reservoirs may actually be too cold for anadromous salmonids for optimal growth and survival (Sullivan et al., 2000). Also, the TMDL needs to acknowledge and describe these very cold stream water temperatures are occurring within an intensively managed watershed and these very cold stream water temperatures have been maintained under the standard California Watercourse and Lake Protection Zones.

Comment(s) Made By:
Farber – Timber Products Company

Response:
The conclusion of Sullivan and others is consistent with USEPA's temperature criteria guidance incorporated into the Klamath TMDL. These criteria are validated by field studies conducted in northern California that indicate coho aren't found in streams with

an MWAT above 16.8^{o} C. The information quoted by the commenter is based on 100% satiation (i.e. the fish can always eat until full), which is uncommon in actual streams. No data describing to what degree timber harvest activities occurred in the riparian zone, or the amounts of canopy reduction that occurred as result of these harvests. As a result, the information cannot be used to evaluate the effects of the Forest Practice Rules on stream temperature.

P53. Comment(s):
Water quality is sufficiently assured for timber harvesting operations through the California Forest Practice Act and the California Board of Forestry (BOF). Whatever shortcomings that could possibly have existed with regard to protecting the beneficial use of a cold water fishery (COLD), will be addressed in the BOF's new Threatened and Impaired Watershed (T/I) Rules. The Regional Water Board should defer the regulation of the forest products industry to the state agency charged by the California legislature to do so. The duplication of effort and fees is entirely too costly and inefficient to the industry as well as the State of California.

Comment(s) Made By:
Kobseff – Siskiyou County Board of Supervisors

Response:
See response to comment P30.

P54. Comment(s):
USFS and California Board of Forestry construction standards for private lands logging roads are not adequate to protect the Klamath River from sediment input. Logging roads are poorly maintained and road rules are not strict enough.

Comment(s) Made By:
Levine – Coast Action Group

Response:
Regional Water Board staff will continue to regulate forest practices through Waste Discharge Requirements (WDRs) and waivers to ensure controllable sediment discharge sites are addressed and prevented.

P55. Comment(s):
Final Report on Sediment Impairment and Effects on Beneficial Uses of The Elk River and Stitz, Bear, Jordan and Freshwater Creeks (Humboldt Watersheds Independent Scientific Review Panel); and (2) Phase II Report: Independent Scientific Review Panel on Sediment Impairment and Effects on Beneficial Uses of the Elk River and Stitz, Bear, Jordan and Freshwater Creeks (Humboldt Watersheds Independent Scientific Review Panel) - and - other studies and scientific review planels document and contain

substantial evidence that CDF's Rules and best management practices fail to protect water quality from the adverse effects of logging. These documents should be referenced in review and discussion of Implementation Planning (Implementing Programs - inclusive of Waste Discharge Requirements [WDRs] and Conditional Waivers).

Comment(s) Made By:
Levine – Coast Action Group

Response:
The Regional Water Board will continue to regulate forestry activities under its independent authority. Also, See response to comment P30.

P56. Comment(s):
The conclusion that standard FPR riparian buffer requirements fail to protect beneficial uses of waters is inaccurate. The assumptions carried forth from the two model runs contain fatal flaws. (The analysis scenario) is not a prescription that is commonplace in forested watersheds within the Klamath TMDL California region. The model being run therefore represents the exception rather than the rule and should not be used by either staff or the Board as a representation of California Forest Practice. This model run does not represent a realistic application of the forest practice rules, as applied on the ground and does not represent any temporal or spatial factors. It is obvious, that reliance on the results of this simplified model are unacceptable, considering that this Board is intending to use its findings as the basis for the protection standards used in the Klamath TMDL, currently before the Board. The consequences of blind application of this protection standard, by this Board has the potential to result in unjustified economic "take" or harm to private forest landowners.

As stated before it is obvious that staff have created a powerful tool to evaluate scenarios. Staff was asked to consider doing a sensitivity analysis on the percentage of the WLPZ network that could be operated in a given run and still be analytical demonstrated to maintain the beneficial uses of water, specific cold water habitat. I was told, no. They apparently do not have the time to use their model to answer this real questions that would lead to meaningful, science based guidance that could be applied to the Klamath TMDL, General Waiver/ GWDR and California Forest Practice Rules. Until such analysis is done a reasonable protection measure to implement within the Klamath TMDL is to utilize existing Board of Forestry passed watercourse protection rules as the default protection measure within the Klamath TMDL.

Comment(s) Made By:
Walz – Sierra Pacific Industries

Response:
See response to comment P30.

P57. Comment(s):
- Inconsistent and Conflicting Rules Governing the Same Activity.

- Duplicative rulemaking leads to administrative confusion, additional costs to the State, and worse environmental outcomes.

- There is a lack of scientific basis to establish separate watercourse protection standards.

Comment(s) Made By:
Snyder – California Department of Forestry and Fire Protection

Response:
See response to comment P30.

P58. Comment(s):
You can imagine what fun we will have trying to determine site specific tree heights for every site in Siskiyou County on Timber Harvest Plans.

Comment(s) Made By:
Costales – Siskiyou County

Response:
See response to comment P30.

P59. Comment(s):
- Commenters point to the development of new amendments to the Forest Practice Rules (FPRs), based on literature review. Request that FPRs be vehicle for implementation, and that a minimum no prescriptive requirements such as drafted are included. As drafted rules would be difficult to implement.
- Commenter asserts that compliance with the Threatened and Impaired (T/I) Rules means much more than increased riparian protections (unintended consequences), inaccurate statements regarding implementation of the T/I rules in Scott and Shasta. T/I rules are totally unnecessary above Iron Gate or Butte Creek. Data indicates that industrial timber management in Shovel Creek has been effective at keeping creek cold, using standard FPRs. T/I rules don't address nutrients/DO, no literature showing timber is a source.

Comment(s) Made By:
Quirmbach – Timber Products Company
Salvestro – Fruit Growers Supply Company

Response:
See response to comment P30.

P60. Comment(s):
It is inappropriate for the Regional Water Board to assert its jurisdiction over the conduct of timber harvest activities when it is clearly the role of the California Department of Forestry and Fire Protection (Cal Fire). This is especially problematic given that no evidence was put forward to suggest that the Forest Practice Rules as implemented by Cal Fire, do not adequately protect water quality.

Comment(s) Made By:
Rice and Oldfield – California Farm Bureau Federation and California Cattlemen's Association

Response:
See response to comment P30.

P61. Comment(s):
Our experience is that we see different measures – and we see a target width to depth ratio for streams and we're asking that that be removed.

Comment(s) Made By:
Schuyler – Klamath National Forest

Response:
The Klamath TMDL has no target for width to depth ratio.

P62. Comment(s):
We have concerns with the proposed target of width/depth changes. This is a new measurement that is difficult to measure and not included in any of the prior TMDL Action Plans.

Comment(s) Made By:
Schuyler – Klamath National Forest

Response:
The Klamath TMDL has no target for width to depth ratio.

P63. Comment(s):
There are disturbing developments within the State Water Resources Control Board (SWRCB 2009) with regard to a potential shift in oversight authority of U.S. Forest Service activities.

Comment(s) Made By:
Fetcho – Yurok Tribe
Crosby – Karuk Tribe
Bowman – Quartz Valley Indian Reservation

Response:
Comment noted.

P64. Comment(s):
There are no targets or thresholds to limit disturbance and risk of cumulative effects that have been a pervasive problem in the basin (Kier Associates 1999). Recent information provided by USFS Region 5 hydrologist Barry Hill (2009) indicates that the cumulative effects risk has actually increased on the Klamath National Forest and that there are now 50 watersheds recognized as over cumulative effects thresholds.

Comment(s) Made By:
Fetcho – Yurok Tribe
Crosby – Karuk Tribe
Bowman – Quartz Valley Indian Reservation

Response:
The current USFS waiver requires increased implementation and effectiveness monitoring in cases where projects are proposed in watersheds at threshold, or over threshold as a result of the action.

P65. Comment(s):
It is absolutely necessary that the Regional Water Board continue in its on-the-ground oversight role and that the Memorandum of Agreement (MOA) that governs timber harvest and grazing be completed in a timely manner since it is a critical link in successful TMDL implementation.

Comment(s) Made By:
Fetcho – Yurok Tribe
Crosby – Karuk Tribe
Bowman – Quartz Valley Indian Reservation

Response:
Comment noted.

P66. Comment(s):
The Memorandum of Agreement (MOA) should also increase the monitoring requirements of USFS staff and the timely provision of data for trend monitoring for adaptive management.

Comment(s) Made By:
Fetcho – Yurok Tribe
Crosby – Karuk Tribe
Bowman – Quartz Valley Indian Reservation

Response:
The Klamath National Forest is in the process of developing a master monitoring plan for sediment and temperature that will provide the necessary data for evaluating water quality trends and impairment status. Regional Water Board staff have been involved with the development of the plan from the early stages and are satisfied it provides a good framework for collecting and evaluating data.

P67. Comment(s):
In Section 6.4.6 (Salmon River) on pp. 6-22 and 6-23 of the Public Review Draft, it would be useful to briefly identify the types of activities that will be addressed through the Regional Water Board/USFS Memorandum of Agreement (MOA) and proposed Waste Discharge Requirement (WDR) or conditional waiver. For example, does the MOA explicitly discuss fire management and prevention activities within the Salmon River basin?

Comment(s) Made By:
Hashimoto and Ziegler – USEPA

Response:
Fire management is not included in the Salmon MOA, but will be included in the USFS waiver currently being developed.

P68. Comment(s):
As with the impacts to private entities within the County, the proposals within the Draft TMDL that apply to National Forests stand to have extremely serious effects. Implementation strategies and the basis upon which they rest appear similarly flawed. It is urged that the Water Board staff make every effort to address the comments of the National Forests with regard to the Klamath TMDL.

Comment(s) Made By:
Kobseff – Siskiyou County Board of Supervisors

Response:
Regional Water Board staff will continue to collaborate with the USFS to ensure that the requirements the USFS is subject to protect water quality without being overly burdensome.

P69. Comment(s):
The Regional Water Board feels that the USFS has deep pockets and anything they are doing to influence temperature, nutrients and sediment needs to be dealt with and the forest service has the funds to do it.

Comment(s) Made By:
Costales – Siskiyou County

Response:
Regional Water Board staff are often reminded by USFS staff of USFS' funding limitations, and thus, are well aware of those limitations. The Regional Water Board intends to work with the USFS to implement measures to address discharge sources and track progress in water quality improvement through the proposed USFS conditional waiver program.

P70. Comment(s):
We are concerned with the piecemeal approach and for the Klamath National Forest we're seeing duplication of the approach and regulatory requirements by different divisions of the water board – the timber doesn't talk to watershed protection division. We want a streamlined approach, one waiver for the forest.

Comment(s) Made By:
Schuyler – Klamath National Forest

Response:
Regional Water Board staff are in the process of developing a single waiver for the USFS to address non-point sources.

P71. Comment(s):
In terms of overall implementation, one thing the forest service is seeing is lack of acknowledgement. We've been doing the North West Forest Plan (NWFP) since 1994 and part of that is the Aquatic Conservation Strategy (ACS) that includes key watersheds, use of stream buffers – sediment problems on road – and there is little acknowledgement of these ongoing solutions.

Comment(s) Made By:
Schuyler – Klamath National Forest

Response:
The Klamath River TMDL Staff Report explicitly acknowledges the Northwest Forest Plan and Aquatic Conservation Strategy as means of compliance with the Klamath River TMDL. Additionally, the Staff Report acknowledges the efforts to inventory road sediment sources in the Elk, Indian, Irving, Ti, Clear, Dillon, upper Beaver, Grider, and

Horse Creeks, and the Salmon and Scott Rivers, as well as the implemented fixes on the top 10% of sources.

P72. Comment(s):
We are requesting that the Regional Water Board limit the number of waivers to one – a regional waiver until the state-wide one is completed. Thus, we feel that the draft Action Plan asks for unnecessary waivers.

Comment(s) Made By:
Schuyler – Klamath National Forest

Response:
Regional Water Board staff are in the process of developing a single waiver for the National Forest lands in the North Coast Region to address all non-point sources.

P73. Comment(s):
We are requesting that our existing range management instruments - permits and annual operating instructions - be used to minimize impacts to water quality.

Comment(s) Made By:
Schuyler – Klamath National Forest

Response:
Regional Water Board staff are supportive of the USFS management instruments as a means to meet the TMDL allocations as long as the management instruments are effective and enforceable.

P74. Comment(s):
We are looking for better acknowledgement of the past and current watershed gains being made under the Northwest Forest Plan, especially under the Aquatic Conservation Strategy (shade buffers, key watersheds, road storm proofing, etc).

Comment(s) Made By:
Schuyler – Klamath National Forest

Response:
Regional Water Board staff's incorporation of USFS plans and policies into the upcoming waiver is one acknowledgement that the Aquatic Conservation Strategy is a legitimate framework for protection of water quality. See also response to comment P71.

P75. Comment(s):
We are asking for more realistic timelines in which to conduct inventories prior to the development of a prioritized list and schedule on-the-ground treatments. The proposed timelines are too tight.

Comment(s) Made By:
Schuyler – Klamath National Forest

Response:
The timelines have been removed from the Action Plan and will be incorporated in the USFS waiver currently under development with consultation from the USFS. Public review and adoption of this waiver is anticipated to occur prior to the effective date of the Klamath River TMDLs.

P76. Comment(s):
Please be aware that the Land and Resource Management Plans (LRMPs) are not identifying the special nature of how to protect these cold-water tributaries, and their conditions will continue to degrade under the existing LRMPs. A waiver to the USFS to defer the TMDL on the federally managed lands to the LRMPs would constitute "business as usual", is against the intent of the TMDL process and would not be legal.

Comment(s) Made By:
Riggan

Response:
The TMDL works with the Land and Resource Management Plans (LRMPs) to set targets and allocations to protect beneficial uses. Where the measures specified in an LRMP are sufficient, no further measures are needed. However, the TMDL requires reporting to the Regional Water Board through the USFS lands conditional waiver to track progress on addressing sediment discharges from the road network on National Forest lands that the USFS is responsible for maintaining. Addressing these potential sediment discharge sites will assure further protection of stream temperatures. The riparian shade requirements also ensure protection of water temperatures, but allow for the flexibility to thin dense stands of short trees in order to provide older, taller fire-resistant stands of trees when it is appropriate.

P77. Comment(s):
Separate waivers for different activities on different national forests, as proposed in the Public Review Draft, would likely not be the most effective regulatory approach for the TMDL. I support the development of a single regional waiver covering all activities on all national forest system lands in the North Coast Region.

Comment(s) Made By:
Moore – U.S. Forest Service, Pacific South West Region

Response:
Regional Water Board staff will continue to develop a single regional waiver covering all activities on all national forest system lands in the North Coast Region.

P78. Comment(s):
The Klamath TMDL Action Plan does not acknowledge the past and current efforts of the national forests to improve water quality. For example, the Six Rivers National Forest used grant funds provided by the Bureau of Reclamation to decommission 89 miles of road and improve 24 miles of road. Currently, the Six Rivers National Forest is planning an additional 267 miles of road decommissioning using external grant funding.

Comment(s) Made By:
Moore – U.S. Forest Service, Pacific South West Region

Response:
Please see the response to comment P71, as well as section 6.6 of the staff report. Regional Water Board staff applaud the work by the USFS to address water quality concerns on their lands. The Action Plan is intended to identify the actions that the Regional Water Board must take to ensure water quality objectives are achieved and beneficial uses are protected.

P79. Comment(s):
Livestock management on National Forest lands is typically free range and livestock have access to stream channels. Most riparian areas cannot be excluded from grazing. Livestock grazing on national forest lands is managed through Allotment Management Plans (AMPs) or Annual Operating Instructions (AOIs). These documents outline water quality measures designed to minimize impacts to water quality associated with grazing activities. Until such a time as a grazing waiver is in place, the AMPs or AOIs should be recognized as the management tool to meeting water quality objectives.

Comment(s) Made By:
Moore – U.S. Forest Service, Pacific South West Region
Kelley – U.S. Forest Service, Six Rivers National Forest

Response:
The proposed approach to address grazing issues on federal lands is described in 6.6.3.2. That approach uses the AMPs and AOIs as the framework for addressing grazing concerns. In addition, grazing is an activity that will be covered under the USFS waiver currently in development.

P80. Comment(s):
Forest Service grazing allotments currently are not actively managed. Grazers put in their livestock in July and gather them back in October or allow them to come home on their own. Under this type of management livestock will spend large amounts of time in streams and in riparian areas where they will deposit their waste. During the winter and spring this waste becomes suspended in the water and flows downstream where it enters the Klamath River.

Comment(s) Made By:
Pace, Beck, and Gillespie – North Group-Redwood Chapter-Sierra Club and Friends of Del Norte

Response:
The USFS waiver currently being developed will address the control of livestock waste on lands managed by the USFS. The enforceable conditions of the waiver will require the USFS to implement management practices that address these discharges and include the appropriate measures as part of the Allotment Management Plans used to administer USFS grazing allotments.

P81. Comment(s):
Our roads have to be maintained if not the banks and culverts become clogged and erosion then occurs.

Comment(s) Made By:
Bennett – Siskiyou County Supervisor, District 4

Response:
If roads are being maintained so they are not discharging sediment, then the county is in compliance with the TMDL. However, if they are discharging, the county should inventory those sources and put them on a time schedule to be addressed in the future as part of the implementation of the Five Counties Salmonid Protection Program (5C Program).

P82. Comment(s):
Public Works will participate only in projects with defined and demonstrated purpose and need. Our limited road maintenance money is not currently sufficient to accomplish our fundamental goal of providing a safe and reliable road system for the traveling public 365 days of the year. Therefore we will cooperate only when additional funding is made available for the specific purposes identified.

Comment(s) Made By:
Sumner – Siskiyou County Public Works

Response:
The TMDL proposes to certify the 5 C Program through a waiver of waste discharge requirements and that counties assess their road network through that program. The sediment source inventory should include cost estimates of maintenance needs and erosion control projects. Projects should be prioritized and set on a schedule for implementation as funds become available. Periodic reports to the Regional Water Board through the 5 C Program will allow the Board to assess progress towards addressing sediment sources on roads and make a decision regarding any further action. There are public funds available for sediment source reduction projects, and projects that implement a TMDL are given priority in many grant programs. See section 10.4 of the TMDL staff report for potential funding opportunities. If the county does not participate in the 5 C Program, the Regional Board staff will consider proposing Waste Discharge Requirements for discharges associated with Siskiyou County roads.

P83. Comment(s):
We are asking for annual reporting of the reduction of road-related sediment threats, and not just the reporting of the reduction of road density.

Comment(s) Made By:
Schuyler – Klamath National Forest

Response:
The TMDL Action Plan has been revised to accommodate this request.

P84. Comment(s):
The timeline for road construction and maintenance on p. 6-22 gives the national forests 2 years to develop a prioritized list of road sediment treatment sites and a treatment schedule. The national forests will not have lists of sites until the road inventories are completed. The national forests will not be able to meet this 2-year timeframe because of the time required to complete the inventories.

Comment(s) Made By:
Moore – U.S. Forest Service, Pacific South West Region

Response:
Timeframes for developing prioritized lists of sediment source areas will be included as part of the waiver of WDRs for discharges associated with nonpoint source activities on federal lands managed by the USFS that is currently being developed by the Regional Water Board staff and interested stakeholders.

P85. Comment(s):
The timeline for road construction and maintenance on p. 6-22 requires an annual report of how the national forests are reducing road density. Most of the sediment-control work

on national forest system lands consists of storm proofing rather than decommissioning. Storm proofing roads can prevent substantial amounts of erosion, but will not decrease road density. Therefore, I request that this requirement be changed to an annual reporting requirement for reduction of road-related sediment threats.

Comment(s) Made By:
Moore – U.S. Forest Service, Pacific South West Region

Response:
The National Forest Roads Policy claims reduction in road density as one of its goals:

> Responsible officials must review the road system on each National Forest and Grassland and identify the ro ads on lands under Forest Service jurisdiction that are no lo nger needed to meet forest resource m anagement objectives and that, therefore, shou ld be decommissioned or considered for other uses, such as for trails. U.S. Forest Service, 2001.

There are roads being decommissioned in the National Forest and the Regional Water Board would like to have documentation of the progress being made in this regard. Roads that are kept in operation cost more money to maintain and since the USFS does not have enough funding for maintenance of the existing road network, it may be necessary to reduce road mileage. Regional Water Board staff understand that it may be more cost effective to storm proof roads rather than decommission them; but believes that the road network must eventually be reduced if it is to be properly maintained.

Reference used in Response P85:
U.S. Forest Service (USFS). 2001. Road Management Policy. Chapter 7712. January 12, 2001. Accessed November 17, 2009. Available at: http://www.fs.fed.us/eng/road_mgt/ policy.shtml.

P86. Comment(s):
A prohibition on road construction and reconstruction in unstable and potentially unstable terrains - including so-called "temporary roads" - is the only effective way to control deposition of landslide sediment into streams. To be effective this prohibition must include earth flows, headwall swales, debris basins and other unstable lands with potential to deliver sediment to streams.

Comment(s) Made By:
Pace, Beck, and Gillespie – North Group-Redwood Chapter-Sierra Club and Friends of Del Norte

Response:
The waiver requires the USFS to assess the sediment discharge potential of any road construction or reconstruction. The Regional Water Board staff do not believe it necessary to prohibit construction of roads in certain areas as a blanket prohibition.

P87. Comment(s):
In order to control excessive sediment delivery from unsurfaced and gravel roads, industrial forestland owners, the Forest Service and BLM must be required to maintain road systems on lands they own/control and to eliminate administrative and public use of roads which do not receive regular maintenance. We recommend the "inspect and fix" approach with inspections after major storms and after the rainy season, inspection reports submitted to the NCWQCB and a requirement that problems identified during inspections are quickly corrected. Reports on completion of corrective action to the NCWQCB should be required. A specific, written commitment by the Forest Service and industrial forest owners to keeping un-maintained roads closed to ALL use must be included in conditional waivers, Memorandum of Understanding's (MOUs) and other regulatory agreements if the Implementation Plan is to be effective in controlling sediment from forest roads.

Comment(s) Made By:
Pace, Beck, and Gillespie – North Group-Redwood Chapter-Sierra Club and Friends of Del Norte

Response:
The Regional Water Board will require the USFS to inventory and address sediment sources on their road network as part of the USFS waiver. The Regional Water Board staff do not believe it necessary to recommend that the USFS be required to prohibit use of unmaintained roads. The USFS must make this decision after considering the potential for discharge on the unmaintained roads and whether it violates water quality standards. A blanket prohibition of use is overly restrictive.

P88. Comment(s):
Removal of fish passage barriers has not been shown in the administrative record to improve water quality, increase the number or location of thermal refugia, or set any numerical limits on any pollutant impairing fish migration. Fish barriers are not pollutants and not waste. The use of a TMDL to restore the habitat is improper unless it establishes numerical limitations on the introduction of pollutants into the waters.

Comment(s) Made By:
McGowen – Caltrans

Response:
See response to comment P3.

P89. Comment(s):
Given the temperature load allocations described above, it is critical that reference streams be identified and monitored as a benchmark to compare and move towards

compliance. It is vital that reference streams are acknowledged as having natural disturbance regimes (fires, floods etc) that influence shade and hence, in stream temperatures.

Comment(s) Made By:
Kelley – U.S. Forest Service, Six Rivers National Forest

Response:
The reference stream approach to evaluating compliance with the water quality objective for temperature is problematic. Evaluating the natural temperature regime of a waterbody based on the natural temperature regime of a reference waterbody requires that the factors driving the temperatures of both streams be quite similar. Such an approach may be appropriate in some cases, but does not provide a method that is widely applicable. Evaluating compliance with the water quality objective for temperature requires the evaluation of conditions on a case-by-case basis. Regional Water Board staff and north coast temperature TMDLs acknowledge all streams as having natural disturbance regimes (fires, floods, etc.) that influence shade and hence, instream temperatures.

P90. Comment(s):
Pg. 6-3. Tables 6.1 and 6.2 address the regulatory mechanisms for implementation of the draft Klamath TMDL. The mechanisms identified to reduce sediment loads for federally managed lands appear to rely on: 1/ project level activities associated with waivers for timber harvest activities (2009 updated waiver pending), 2/ individual waivers by Forest for all activities (waiver to be developed by 2011-2013), and 3/ grazing waivers by 2013. These regulatory mechanisms are duplicative, confusing, and by the very nature of being project-driven, will not address critical watershed concerns outside of project areas at the watershed scale. Addressing pollutant sources outside of project activities at the watershed scale may make the greatest contribution towards meeting TMDL load reductions, but if the focus is always on project activities, these sources will not be addressed. A better approach would be to articulate a basin or watershed wide inventory and restoration plan that focuses on the highest priorities and that this restoration plan is independent of project activities such as vegetation management or grazing activities. Past and current watershed multi-million dollar restoration successes on the Lower Trinity and Orleans/Ukonom Ranger Districts, Six Rivers National Forest attest to the strength of watershed-wide restoration efforts independent of project driven activities (e.g. timber, fuels, grazing etc).

Comment(s) Made By:
Kelley – U.S. Forest Service, Six Rivers National Forest

Response:
The regional waiver for USFS activities currently under development is the only permitting mechanism currently proposed for USFS activities and accommodates and supports the watershed approach to reducing water quality threats. The waiver will

address all non point source discharges associated with USFS activities, including not only grazing, silviculture, and other project level activities, but also basin-scale or watershed-scale inventory and restoration plans.

P91. Comment(s):
The draft Klamath TMDL acknowledges that the Porter-Cologne Act provides flexibility to dischargers in choosing the methods they will implement to meet water quality goals. The TMDL also states that the Water Boards can formally recognize regulatory or non-regulatory actions of other entities as appropriate implementation programs when the Regional Water Boards determine those actions will result in attainment of standards. We ask that a broad waiver covering all Forest Service activities and TMDL implementation plans will be developed that will address Forest Service compliance with Basin Plan water quality objectives. An approach other than this broad one would likely be duplicative and confusing.

Comment(s) Made By:
Kelley – U.S. Forest Service, Six Rivers National Forest

Response:
Please see the response to P90.

P92. Comment(s):
The draft Klamath TMDL Action Plan serves as an action plan for the Trinity and South Fork Trinity TMDLs completed by USEPA in 2001 and1998. This section refers to the Trinity River Restoration Program and the TRRP 2000 Record of Decision and that the Regional Water Board considers the ongoing work associated with the TRRP to be early TMDL implementation of the Trinity TMDL. The USFS has completed many projects to address water quality concerns in the Trinity (details are provided in the comment letter). All of these types of actions have been identified in TMDLs as measures to reduce load allocations and meeting TMDL objectives. If BOR is to be recognized for their early restoration efforts and TMDL implementation, similar recognition of USFS efforts would also be appropriate.

Comment(s) Made By:
Kelley – U.S. Forest Service, Six Rivers National Forest

Response:
The final Klamath TMDL does not serve as an action plan for the Trinity and South Fork TMDLs as previously stated. Additionally, please see the response to comment P78.

P93. Comment(s):
The draft Klamath TMDL states that the process for assessing compliance with riparian shade allocation begins by comparing the current effective shade and the site potential effective shade. It is not clear how natural process such as floods and wildfires are accounted for in riparian shade targets. The TMDL refers to targets for effective shade

based on type of vegetation, aspect and stream width but these targets reflect only the optimal shade conditions which don't include natural disturbances. Under the NWFP Aquatic Conservation Strategy language, land managers must manage riparian reserves and their natural processes (e.g. shade) so that thermal regimes are not altered. Land management actions within riparian reserves must show that they are beneficial to riparian processes. It would be helpful if the Klamath TMDL implementation plan discusses the existing regulatory processes for the USFS and BLM that are part of the NWFP and that these regulatory processes would meet the shade targets proposed under the TMDL.

Comment(s) Made By:
Kelley – U.S. Forest Service, Six Rivers National Forest

Response:
The riparian shade allocations allow for the reduction of shade due to natural disturbances and poor site conditions. The existing regulatory processes for the USFS and BLM that are part of the NWFP are discussed in detail in section 6.6.2. The approach to ensuring temperature compliance on federal lands relies on the NWFP framework, but includes other measures necessary to assure that the water quality objective for temperature is met.

P94. Comment(s):
The draft Klamath TMDL Implementation Plan states that land managers that actively engage in implementation of measures to inventory, prioritize, schedule, implement and monitor and adapt with respect to excess sediment will be considered on a path to compliance. The Forest Service has been conducting sediment related measures as described above for many years (see table 1). What is the mechanism for the Water Board to acknowledge land managers are on the "path to compliance" and thereby waive the prohibition on sediment discharge?

Comment(s) Made By:
Kelley – U.S. Forest Service, Six Rivers National Forest

Response:
The prohibition on sediment discharge has been eliminated from the Klamath TMDL implementation plan. The issuance of a waiver of waste discharge requirements is an indication that the USFS is on a path of compliance. However, there is no mechanism to waive a prohibition.

P95. Comm ent(s):
Pg. 6-33. Existing Regulatory Structure 6.5.4.2. The draft Klamath TMDL outlines the current regulatory mechanisms in place to address TMDLs. It appears from this section that the main avenue to address discharges from roads associated with timber harvest activities is through WDRs or waivers. This project-driven approach would not address larger concerns identified under a wider basin-wide inventory approach. Please identify

regulatory mechanisms that would address basin-wide approaches that inventory, prioritize, schedule and implement such as MOUs or MAAs with land management agencies.

The statement that the Water Board does not regulate routine maintenance of existing roads appears inconsistent with a sediment prohibition and establishing road related sediment targets in the draft Klamath TMDL. These actions are regulatory by nature.

Comment(s) Made By:
Kelley – U.S. Forest Service, Six Rivers National Forest

Response:
Please see the response to comment P90. Additional text has been added to clarify that routine road maintenance is not *currently* regulated through either waivers or WDRs.

P96. Comment(s):
Pg. 10. Implementation Plan. The implementation plan describes actions in Table 4-17 by source and land use activity and states that more than one implementation action is applicable. Action items are fully independent from each other and require 100% implementation within each Source or Land Use category. This statement is confusing given the multitude of overlapping regulatory mechanisms required to meet all TMDL requirements, WDRs, and conditional waivers for vegetation management activities, roads, grazing, etc.

Comment(s) Made By:
Kelley – U.S. Forest Service, Six Rivers National Forest

Response:
Table 4-17 in the previous draft, now table 4-18, has been modified for clarity and content.

P97. Comment(s):
Pg. 20. Table 4-17 - All Activities on USFS Lands. Water Board will develop individual conditional waivers specific to each National Forest. The Forest Service is currently working with Water Board staff in developing one conditional waiver for all Forests and most land management activities within the North Coast. Given that effort, why is there the need to develop individualized conditional waivers for each National Forest? This process seems redundant and confusing. Please clarify.

Comment(s) Made By:
Kelley – U.S. Forest Service, Six Rivers National Forest

Response:
Water Board staff are currently working with the Forest Service in developing one conditional waiver for all nonpoint source discharges in national forests in the North Coast region. The text now reflects this.

P98. Comm ent(s):
It appears that the action plan will adopt the draft Timber Harvest or silvicultural conditional waiver conditions (December 2009) as a means to achieving TMDLs. This approach seems backwards. TMDLs are focused at addressing water quality concerns at the watershed scale. The draft Timber Harvest or Silvicultural Conditional Waiver addresses water quality concerns at the project level. Project level water quality priorities will not necessarily address the highest water quality concerns within the watershed. A better approach would be to adopt a watershed wide water quality improvement strategy as described on page 11 of the Draft Action Plan. If a timber harvest project occurs within a TMDL watershed for which there is a TMDL water quality improve plan, the TMDL priorities should be able to trump project specific erosion control/water quality requirements in the Timber Harvest/silvicultural waiver.

Comment(s) Made By:
Kelley – U.S. Forest Service, Six Rivers National Forest

Response:
TMDLs, waivers, and WDRs are all designed to ensure achievement of water quality standards. Therefore, implementation of properly crafted waivers and WDRs will result in achievement of TMDLs and water quality standards. See also response P90 above.

P99. Comm ent(s):
Table 4-17 - Road Construction and Maintenance on Federal Lands. Again, these actions seem to be the key element to meeting TMDL requirements and are a duplication of the statements on pg 11. The action items are reasonable measures to address water quality improvement needs. The timelines associated with the actions, however are unrealistic. Road-related watershed restoration inventory and planning can take 2-3 years to complete including NEPA process and another two years to seek funding to initiate the restoration process.

Comment(s) Made By:
Kelley – U.S. Forest Service, Six Rivers National Forest

Response:
These actions are now being addressed through the proposed USFS waiver.

P100. Comm ent(s):
TMDL pollution limits, load allocations and cleanup actions must be clearly and specifically incorporated into all permits, waste discharge requirements and waivers issued for activities that impact water quality and quantity in the Klamath basin. There

are already too many regulations that are not currently enforced, to the detriment of the river and the people who live along it. The proposed watershed-wide protections for riparian shade and class III (ephemeral) streams concerning private land timber harvest are necessary and good. The proposed approach for developing a conditional waiver of waste discharge covering all activities for each National Forest in the Klamath Basin makes sense, but we withhold judgment until more details on the proposed waivers are available.

Comment(s) Made By:
Harling – Mid Klamath Watershed Council

Response:
The general approach to implementing the Klamath TMDL is to use existing authorities and mechanisms to address water quality factors through permits, waste discharge requirements, and waivers. Please see the response to comment X1 in regards to water quantity issues. Regional Water Board staff have determined that a single waiver for all National Forests in the region comprehensively addressing nonpoint source discharges makes even more sense and are proceeding with the development and adoption of such a waiver. We look forward to receiving comments on the proposed waiver in the future.

P101. Comm ent(s):
Timely implementation will be critical to the success of the TMDL. Many of the drivers of water problems (e.g. Shasta and Scott River flow depletion, the Klamath Hydroelectric Project, and Upper Klamath Basin agricultural pollution) were identified decades ago, yet positive action has been slow in coming. We strongly encourage the Regional Water Board to fast-track implementation, to the maximum extent possible, of these key problems. Thank you for your dedication to protecting and improving conditions in the mainstem Klamath River.

Comment(s) Made By:
Harling – Mid Klamath Watershed Council

Response:
Regional Water Board staff believe the approach to implementing the Klamath TMDL addresses the three identified issues as well as can be done under the Regional Water Board's authorities. Additionally, please see the responses to comments R38, R39, Q1, O22 and X1. Thank you for the supportive statements.

FUTURE AGRICULTURAL WAIVER

Summary of Changes Since the June 2009 Public Review Draft of the Klamath River TMDL

The June 2009 draft Klamath TMDL implementation plan proposed the development of a conditional waiver of Waste Discharge Requirements for discharges associated with agricultural activities in the North Coast Region (agricultural waiver). It also proposed an interim waiver to be implemented in the time between adoption of the Klamath TMDL and the adoption of the agricultural waiver. In response to the comments received on the June 2009 draft and to public input at staff and Regional Water Board workshops, the Klamath implementation plan no longer proposes an interim waiver for agriculture. This decision was made for the following reasons, in part in response to comments and in part to simplify the process and make better use of staff resources:

1. It is inefficient to administer and enforce a separate interim waiver as part of the TMDL Basin Plan amendment when a conditional waiver of Waste Discharge Requirements is proposed for development upon adoption of the TMDL.

2. Developing an interim waiver and then the final waiver will be more confusing for stakeholders if requirements were to change.

3. There is a potential for overlapping regulatory requirements in the Klamath basin considering the existing TMDLs in the Scott and Shasta basins.

4. Removing the interim waiver and specific requirements shortens the time for the agricultural conditional waiver program to be developed.

The Regional Water Board would initiate the stakeholder process after adoption of the TMDL, which is scheduled for March 2010. It is staff's intention that this process will lead to a sensible agricultural program that has buy-in from the regulated community and all interested stakeholders. Although separate from the Klamath TMDL implementation plan, the waiver program will incorporate the load allocations and targets established by the Klamath TMDL as well as other TMDLs. The Regional Water Board staff plan to have a draft agricultural wavier ready for public review by December 2011 with a scheduled date for adoption by the Regional Water Board in December 2012. In the interim time period before the waiver is adopted, the Klamath implementation plan recommends several measures for landowners to take that will immediately address any discharges from their operations and also help to develop the waiver program:

1. Document past projects and current practices that address sources of pollution from their operations;
2. Organize into watershed groups to monitor and report to the Regional Water Board as a group as part of the future waiver program;
3. Participate in the development of the conditional waiver through a Technical Advisory Group that will convene to develop the draft waiver by December 2011;

4. Attend water quality training on implementing management practices and/or water quality management plan development.

The comments on the waiver below have been consolidated to provide a global response that addresses all the points made by the commenters. Note that the development of the future agricultural waiver will have ample opportunities for public involvement and these specific comments can be appropriately raised in that process. The first set of comments concerns the Regional Water Board staff's approach to regulating agriculture through the waiver and the second set concerns the development of the waiver and its content. More information has been added to the discussion in the staff report, section 6.5.6.

Q1. <u>General Response to comments Q2-Q12 below:</u>
Siskiyou County Supervisor Armstrong and others questioned the need for the Regional Board recommendation of a waiver program to regulate agricultural activities. "This requirement (to comply with an agricultural waiver) is way out of proportion to impacts. It proposes an alarming 'permit to farm'."

The need for a regulatory program to regulate agricultural discharges is established by the State Nonpoint Source Policy. "All dischargers are subject to regulation under the Porter-Cologne Act including both point and nonpoint source dischargers." (State Nonpoint Source Policy) The agricultural waiver program would only apply to operations that discharge waste to waters of the State, not to all agricultural activities. Not all growers and ranchers would need to apply for waiver coverage. The waiver would conditionally waive a discharger's *obligation* to apply for Waste Discharge Requirements (including submittal of a Report of Waste Discharge) and authorize the discharge(s) if the conditions of the waiver are met. The Porter-Cologne Water Quality Control Act specifically states that "all discharges of waste into the waters of the State are privileges, not rights." (Porter-Cologne)

In the Klamath River basin, and indeed throughout the state until recently, agricultural discharges have gone unregulated by the Regional Water Boards. The State Nonpoint Source Policy, adopted in 2004, requires the Regional Water Boards to adopt some combination of prohibitions, WDRs, and/or waivers to regulate all nonpoint source discharges of waste in their region. Agriculture, being one of the main sources of unregulated discharges in the state, has since been regulated in other regions with WDRs (Region 5), conditional waivers of WDRs (Regions 2, 3, 4, 8, and 9) and a conditional prohibition (Region 7). Staff of the North Coast Regional Water Board (Region 1) are recommending a waiver of WDRs to address the potentially large number of unregulated discharges associated with agricultural activities in the Klamath basin. The recommendation of a waiver as opposed to WDRs or prohibitions is based on the effectiveness of other agricultural waiver programs around the state in controlling nonpoint source pollution. In addition, implementing a waiver program is a much more proactive approach than enforcing a prohibition. Prohibitions place the Regional Water Board staff in the position of reacting to violations and penalizing landowners, while the adoption of a conditional waiver would set up a cooperative program between the Regional Water Board and the regulated community.

Some of the commenters asserted that it is only a 'handful' of dischargers that are affecting water quality, which raises the question of who will need to apply for coverage under the waiver program. The State Nonpoint Source Policy directs the State and Regional Water Boards to regulate "all activities and factors that could affect the quality of State waters to attain the highest water quality that is reasonable" (NPS Policy). The procedures for identifying those parties subject to regulation by the waiver will be determined as part of the public stakeholder process to develop the waiver.

The issues raised in the second set of comments concern the content of the waiver and any potential costs. Regional Water Board staff have not yet decided on the appropriate recommendations concerning the specific requirements of the waiver program and will base those recommendations on the outcome of the stakeholder process. All of the items mentioned by the commenters will be considered in developing the waiver. In general, the agricultural waiver would accommodate locally driven landowner efforts to control sources of pollution and include reporting requirements to demonstrate effectiveness of management practices and track progress toward meeting water quality standards and existing TMDLs. There would also be a provision to allow for de minimus discharges under the waiver program. These ideas, as well as some recommended actions for landowners to take while the waiver is being developed, are described in the TMDL staff report section 6.5.6.

Q2. <u>Comment(s):</u>

- This requirement (to comply with an agricultural waiver) is way out of proportion to impacts. It proposes an alarming "permit to farm" over the entire Klamath system as if all irrigated farming was injurious to public health and safety.
- Riparian areas are among the most fertile and productive of herbaceous forage. There is no pasture if large trees are established instead and livestock are excluded. This is, in effect, a forced land use conversion. Most farms and ranches run along side local rivers. In areas such as the Scott Valley, these operations are compressed into small slivers by hills and mountains. This makes use of riparian areas essential for continued viability of the farm.
- Although the intention of livestock exclusion may not be to prohibit beneficial use for livestock watering, it is doing exactly that. This imposes a confiscatory unconstitutional condition of a physical and regulatory taking of a water use right.

<u>Comment(s) Made By:</u>
Armstrong - Siskiyou County Supervisor, District 5

<u>Response:</u>
See General Response Q1 and response to comment O22.

Q3. Comment(s):

- One suggestion for improvement would be to speed up the timeline for the waiver/WDRs for irrigated agriculture from 2012 to an earlier date.
- It may prove more effective to simply mandate that cattle be completely excluded from stream channels, rather than to "limit" access.
- It should state more clearly if a permit or lease is given to a rancher for grazing on another private landowners property exactly who is responsible for implementing the BMP's, meeting water quality objectives, and for compliance oversight and what data will be made public.
- We request that any group compliance programs be transparent, have enforcement oversight, be open to stakeholder input during the drafting of the WDR and that results will be shared.
- The implementation plan should be strengthened by requiring on-farm treatment of all agricultural wastewater or tailwater throughout the Klamath Basin.

Comment(s) Made By:
Fetcho – Yurok Tribe
Crosby – Karuk Tribe
Bowman – Quartz Valley Indian Reservation

Response:
See General Response Q1 and response to comment O22.

Q4. Comment(s):

- As only a relative handful of activities pose even a remote possibility of contributing to the listed impairments, it is disastrous to impose such a cumbersome, expensive and litigious regulatory regime on virtually every agricultural endeavor in Siskiyou County. Waivers and WDRs should be reserved only for those operations that have a reasonable potential to contribute to impairments. A prohibition should suffice for everyone else.
- The infringement on our citizens' right to farm represented by the proposed Waiver/WDR permit regime stands in stark conflict to the consistency sought in coordination mandates. We feel such failure is a violation of the coordination required on the part of state agencies.

Comment(s) Made By:
Kobseff – Siskiyou County Board of Supervisors

Response:
See General Response Q1 and response to comment O22.

Q5. Comment(s):

- It's just a handful of people causing water quality impairments and it's just ridiculous that the entire basin has to come under this complicated permitting regime to control a few sources that may or may not be contributing. With a waiver in place, water quality violations are beside the point, everyone needs to get a permit.

- However, no analysis was done of the costs associated with the proposed Waiver/WDR regulatory scheme, which is attributable solely to the Draft TMDL. That there will be substantial likelihood of fees is assured as a result of the current budget situation in California.

Comment(s) Made By:
Costales – Siskiyou County

Response:
See General Response Q1 and response to comment O22.

Q6. Comment(s):
How is it that we have to prove we're innocent when you are (supposed to be) innocent until proven guilty? Why do I have to get a permit for something that is legally my right?

Comment(s) Made By:
Wright

Response:
See General Response Q1 and response to comment O22.

Q7. Comment(s):
This waiver program is not being done in any other place we can find.

Comment(s) Made By:
Cook

Response:
See General Response Q1 and response to comment O22.

Q8. Comment(s):
Local farmers, ranchers and timber owners are operating with utmost diligence and are enhancing the environment and habitat within the Klamath Watershed. The TMDL's assumption to the contrary is insulting and shows lack of current situation (sic).

Comment(s) Made By:
Morris- Siskiyou County Farm Bureau

Response:
See General Response Q1 and response to comment O22.

Q9. Comment(s):

- We urge the Regional Board to incorporate specific mechanisms, such as benchmarks and time-tables that will make nutrient reduction targets required of agriculture enforceable. In addition, KRK sees a tough monitoring regimen as imperative. Further, since farmers should not be expected to regulate themselves, the monitoring program should be overseen independently by a group protective of the greater public interest of clean water.
- KRK supports much stronger monitoring of the practice, and regulations that would require permits for all livestock grazing. A condition of all permits should be a riparian buffer based on best-available science to keep cows and their waste out of streams, including the mainstem Klamath River.

Comment(s) Made By:
Terence – Klamath Riverkeeper

Response:
See General Response Q1 and response to comment O22.

Q10. Comment(s):
The Boards additions to what qualifies as an acceptable Ranch Management Plan are unacceptable. Farmers and ranchers do not have the resources, or the time to meet the new criteria. The surveys, studies and monitoring described are unreasonable.

Comment(s) Made By:
Fowle

Response:
See General Response Q1 and response to comment O22.

Q11. Comment(s):

- Only a prohibition on direct deposition of livestock waste into streams, stream beds and stream banks will be effective in reducing this major source of nutrient pollution and organic matter.
- The NCWQCB should use its regulatory leverage to get Siskiyou County to repeal open range laws.
- Free range grazing should be regulated via a limited waiver. The limited waiver approach should be applied to free range grazing on public and private land.
- Free Range Grazing Limited Waiver on public and private land should require regular (weekly) range riding/herding and use of salt and other attractants to keep livestock – and their waste - out of streams and off stream banks.
- Irrigators must be required to reduce nutrients and organic matter in irrigation return flows. The only way to do this effectively is via a prohibition on direct delivery of untreated irrigation return flows to streams.

- Some form of pre-discharge treatment – settling pond, capture and reuse or capture and infiltrate - should be required for ALL irrigation return flows with a target of reducing nutrient and organic matter delivery by 50% or the amount necessary to address nutrient and organic matter impairments.

Comment(s) Made By:
Pace, Beck, Gillespie – North Group-Redwood Chapter-Sierra Club & Friends of Del Norte

Response:
See General Response Q1 and response to comment O22.

Q12. Comment(s):
In spite of the volume of information provided by the Draft TMDL, a farmer or rancher reading the Draft TMDL cannot ascertain what actions they are taking that contribute to the TMDL or the amount of that contribution. In order for a TMDL to be functional, the regulated community needs to know what they are required to do and how it contributes to the TMDL. A lack of clarity provides regulatory uncertainty for those subject to requirements of the TMDL.

Comment(s) Made By:
Rice and Oldfield – California Farm Bureau Federation and California Cattlemen's Association

Response:
See General Response Q1 and response to comment O22.

Q13. Comment(s):
- As Supervisor Kobseff pointed out, once coming under CEQA, the burden has unlimited potential to "grow like Topsy." Virtually every enterprise in California is rife with examples of how CEQA has become a budget-busting complication. Denying that this won't happen under CEQA mandates that apply to the proposed Waiver/WDR is disingenuous if not completely irresponsible. Even if the Regional Water Board were not to unilaterally initiate CEQA-related complications upon the agricultural community, which is the prime victim of the Draft TMDL Waiver/WDR proposal, numerous third parties stand ready and eager to do so. Here again, the track record is undeniable. One need look no further than the brouhaha over the California Department of Fish and Game ITP program which resulted from third party lawsuits on the CEQA mandates that were ignored on the 1600 streambed alteration agreements.
- Agricultural operator will have to analyze for impacts to endangered species as part of the waiver at additional expense.

Comment(s) Made By:
Costales – Siskiyou County

Response:
The Regional Water Board will conduct the CEQA analysis for the conditional waiver for discharges associated with agricultural activities. Individual dischargers will not be subject to CEQA suit.

MONITORING AND COMPLIANCE TRACKING

R1. Comments:
The Klamath needs a new management plan and constant monitoring.

Comment(s) Made By:
Carnam

Response:
The Klamath River TMDL Implementation Plan, Action Plan, and Monitoring Plan are comprehensive regarding achieving and tracking progress towards TMDL pollutant reduction goals. The Implementation and Action Plans will also include a wide range of BMPs that would also incorporate other ecosystem processes (e.g., riparian shading). Since the TMDL "management" plans will not be the only plans being implemented within the basin, the Regional Water Board will be coordinating with other ongoing and emerging initiatives (e.g., KBRA). In addition, the TMDL Klamath basin water quality tracking and accounting system will be actively developing projects and coordinating funding for projects basinwide. The Regional Water Board will also be working within the Klamath Basin Monitoring Program, which includes the Agreement in Principle Klamath Monitoring Program, to develop a comprehensive monitoring and data management program.

R2. Comments:
We recommend that requirements for monitoring and data sharing be made explicit.

Comment(s) Made By:
Fetcho – Yurok Tribe
Crosby – Karuk Tribe
Bowman – Quartz Valley Indian Reservation

Response:
The overall TMDL baseline monitoring program, which is not a requirement and involves the volunteer efforts of many different entities, is described in the two following documents:

1) *Review Draft Klamath Basin Water Quality Monitoring Plan*; October 4, 2009; Prepared for: Klamath Basin Monitoring Program (KBMP); editors: Chantell F. Royer & Andrew P. Stubblefield, Klamath Watershed Institute - Humboldt State University - Department of Forestry & Wildland Resources; accessible at: http://www.humboldt.edu/~kwi/?content=water_quality_workgroup&img=docs2.jpg

2) *AIP Interim Measure 12: Water Quality Monitoring Activities Monitoring Year 2009;* June 23, 2009; AIP stakeholder Group – accessible at: http://www.waterboards.ca.gov/northcoast/water_issues/programs/tmdls/klamath_river/klamath_river_aip/

Both monitoring program documents listed above include provisions for data management and data sharing to increase access and transparency to basin monitoring programs.

Responsible parties under various regulatory mechanisms in the Klamath River TMDL Action Plan have monitoring requirements that are defined under several existing and emerging permit programs and waivers. These requirements will be consistent with TMDL objectives. These program elements are not described in the material cited above.

R3.	Comment(s):
We recommend that the final Klamath TMDL should require photo monitoring points as a condition of all permits. There should be a minimum five year history of photo documentation with reports or annotation to see trends at the site and whether the project succeeded. Language should include the need to take pictures after large storm events or wet high flow years.

Comment(s) Made By:
Fetcho – Yurok Tribe
Crosby – Karuk Tribe
Bowman – Quartz Valley Indian Reservation

Response:
The Regional Water Board agrees. Photo documentation is becoming an important element of our programs. The specific requirements of nonpoint source permits will be identified as those permits are developed.

R4.	Comment(s):
Cyanotoxin monitoring and issuance of public health warnings is an appropriate step given the significance of the pollution issue in Klamath Hydroelectric Power reservoirs and in the lower Klamath River below Iron Gate Dam. The inclusion of tissue sampling of Klamath River freshwater mussels and fish is also appropriate. Findings of potentially hazardous levels of cyanotoxin on yellow perch in Copco Reservoir should prompt health advisories from the County of Siskiyou to protect its citizens.

Comment(s) Made By:
Fetcho – Yurok Tribe
Crosby – Karuk Tribe
Bowman – Quartz Valley Indian Reservation

Response:
The Regional Water Board concurs and has been actively participating in the blue-green algae monitoring program and has issued public health advisories and warnings at locations where either water column or tissue concentrations have exceeded state health

guidance levels. The TMDL monitoring plans include public health monitoring components.

R5. Comment(s):

This section (7.5) is too mainstem-centric, and should be expanded to include more monitoring of tributaries. While Chapter 5 of the TMDL includes targets and allocations regarding tributary shade and sediment, the monitoring plan does not propose any monitoring to track progress towards reaching the targets and allocations.

Comment(s) Made By:

Fetcho – Yurok Tribe
Crosby – Karuk Tribe
Bowman – Quartz Valley Indian Reservation

Response:

The Regional Water Board agrees in principle with this comment, a more comprehensive monitoring program is preferable. However, the TMDL compliance points are all on the mainstem and at the mouth of each tributary. The Regional Water Board is relying on other efforts to provide a more complete basin-wide program. That said, we are currently supporting and participating in the Klamath Basin Monitoring Program and will be combing information from that program, which includes most Klamath sub-basins, into future assessments.

R6. Comment(s):

The Draft TMDL states that "the sampling frequency and density should be of a high enough resolution and over a reasonable period of time to determine whether management actions are having the desired effect on water quality conditions." (p. 7-2). The map of locations where the Regional Water Board has a commitment for monitoring (Figure 4) shows a large number on Six Rivers National Forest (SRNF) in the lower Middle Klamath Basin, but almost none on Klamath National Forest (KNF) further upstream. Most of the data SRNF is supplying are likely from automated temperature probes and there is no reason that KNF should not be supplying similar data for Middle Klamath (e.g. Elk, Grider) and also for lower Scott River (e.g. Kelsey, Canyon) tributaries that serve as Pacific salmon refugia. Figure 6 shows water temperature data previously collected for the Middle Klamath (MKWC 2008) and all of these stations need to be added. If the USFS cannot provide staff to collect, process and submit data, then they should be required to provide funding for other entities such as the Salmon River Restoration Council (SRRC), Quartz Valley Tribe, Karuk Tribe or the Middle Klamath Watershed Council (MKWC) to do so.

The USFS must also be compelled through the MOA to supply all other trend data, such as V*, bulk gravel samples, habitat surveys, macroinvertebrate data and other standard metrics so that patterns of degradation and recovery trajectories can be developed. Such data can be used to assess aquatic habitat quality (Kier Associates and NMFS 2008).

Macroinvertebrate data are increasingly powerful for water quality analysis because of regional studies that allow understanding of communities associated with intact aquatic habitats and those associated with different levels of impairment (Rehn et al. 2007).

Comment(s) Made By:
Fetcho – Yurok Tribe
Crosby – Karuk Tribe
Bowman – Quartz Valley Indian Reservation

Response:
The Regional Water Board is currently working in several forums within the Klamath basin to develop, coordinate, and conduct monitoring activities. The most comprehensive of these forums is the Klamath Basin Monitoring Program, in which the USFS also participates. Most of this work is on a voluntary basis and tremendous strides have been made in creating an integrated comprehensive monitoring program where quality assured data is accessible through a common web site. The Regional Water Board will continue to work within this forum to achieve the TMDL monitoring objectives. In addition, the Regional Water Board is developing a Waiver of Waste Discharge Requirements for nonpoint source discharges related to certain federal land management activities on U.S. Forest Service lands in the north coast region (including Klamath basin). This waiver includes monitoring requirements that will supplement the existing monitoring information already available from the U.S. Forest Service.

R7. Comment(s):
We recognize the resources available for monitoring are always limited, but we are disappointed to see the recommended frequency for most nutrient sampling locations is monthly. For the purposes of constructing mass-balances, biweekly monitoring (every two weeks) would be far better.

Comment(s) Made By:
Fetcho – Yurok Tribe
Crosby – Karuk Tribe
Bowman – Quartz Valley Indian Reservation

Response:
The Regional Water Board agrees that a higher frequency (bi-monthly) would be preferable. The Regional Water Board will be looking for opportunities to increase the sampling frequency. However through our work with the Klamath Basin Monitoring Program we are aware of the limit to available resources and we also believe that the existing sampling frequency will provide valuable information regarding progress in achieving nutrient reduction goals.

R8. Comment(s):
The Regional Water Board might consider specifically mentioning the need to explore algal bed dynamics, water quality fluctuations and non-normative water pollution events. (p. 24)

Comment(s) Made By:
Fetcho – Yurok Tribe
Crosby – Karuk Tribe
Bowman – Quartz Valley Indian Reservation

Response:
The Regional Water Board agrees that knowledge of periphyton densities and dynamics is a key uncertainty and will work with reach monitoring entities within the KBMP to develop a program of study. Periphyton densities have been linked to fish disease dynamics. Understanding their role in providing habitat for polychaetes and in trapping feeding material through their trapping capabilities is an area of interest. The current program does not have the sampling density to capture water quality fluctuations but the existing ad hoc network of data sondes does provide insight into diurnal DO and pH patterns. The Regional Water Board is unclear what is meant by non-normative water pollution events but as a fellow member of the KBMP with the Karuk Tribe we will pursue clarification on this topic.

R9. Comment(s):
The Comprehensive Water Quality Monitoring special study includes a recommendation to collect water samples at the springs below J.C. Boyle Dam. We strongly encourage someone to do the sampling, even as a stand-alone exercise not part of the Comprehensive Water Quality Monitoring special study. (p. 25)

Comment(s) Made By:
Fetcho – Yurok Tribe
Crosby – Karuk Tribe
Bowman – Quartz Valley Indian Reservation

Response:
The Regional Water Board agrees with this comment but cannot commit to conducting the proposed study. It is well known that these springs discharge water with high concentrations of nutrients. What is less well known are the dynamics of how this water equilibrates once it is discharged from the groundwater high redox (anoxic) environment into an oxygenated water column. The Regional Water Board will continue to support this proposed study as a special study objective within the KBMP.

R10. Comment(s):
We support the proposed Periphyton Characterization in the Mainstem Klamath River special study, but think that the number of samples should be expanded to include at least one sample in July, August, and September.

Comment(s) Made By:
Fetcho – Yurok Tribe
Crosby – Karuk Tribe
Bowman – Quartz Valley Indian Reservation

Response:
The Regional Water Board agrees with this comment and will revise the text accordingly. Members of the KBMP will be consulted if / when a study plan is developed.

R11. Comment(s):
The final Klamath TMDL should include a special study recommendation to discern the length of time required for recovery of stream channels from cumulative effects from events such as the January 1997 storm. Studies on the Elk River in Oregon by the USFS showed how water temperature recovered after logging and flood damage, and we recommend that Regional Water Board staff require a similar analysis from the USFS as part of the MOA currently in development. Tools such as the shallow landslide stability model should be recommended to discern associations of land management on steep ground and sediment yield.

Comment(s) Made By:
Fetcho – Yurok Tribe
Crosby – Karuk Tribe
Bowman – Quartz Valley Indian Reservation

Response:
The USFS conducts a watershed restoration program that tracks water quality improvements that will also be coordinated with the waiver. While staff does not see these recommendations necessary for Klamath TMDL implementation, they may be considered in the development of the USFS waiver.

R12. Comment(s):
The mouths of streams that serve as refugia should also be studied using aerial photos from different eras to determine changes in channel width as an index of recovery. (p. 25)

Comment(s) Made By:
Fetcho – Yurok Tribe
Crosby – Karuk Tribe
Bowman – Quartz Valley Indian Reservation

Response:
Thank you for the suggestion. The Thermal Refugia Protection Policy provides enhanced protection of refugia. Staff agree that aerial photographs are one effective way to track thermal refugia function.

R13. Comment(s):
I have been a resident downriver from Iron Gate Dam for the last 22 years in addition to operating a small suction dredge in this river with no incidents of disease. I have observed water sampling [for algae] at various times during these years and was dismayed that they were sampling water in backwash eddies and pools. I have also heard, at a California Water Quality meeting that the samples were collected in stagnant sections of the river and samples were held for an inordinate time allowing any bacteria, flora and algae to multiply. There is no doubt that in waters that are not flowing a higher incidence of bacteria, flora and algae will propagate in summer heat.

Proposes new sampling protocols to determine the causative factor of algae in the Klamath River. An "Oversight Group" should be established to address sampling issues.

Comment(s) Made By:
Gierak

Response:
The Regional Water Board works with the USEPA, Klamath basin tribes, and other stakeholder to develop sampling protocols for the protection of human health from the microcystin toxin. The sampling is designed to develop an accurate representation of the human health risk and follows a Quality Assurance Plan approved by the EPA.

R14. Comment(s):
Identify compliance dates with milestones and monitoring – need for implementation monitoring to complement basinwide monitoring. Monitoring Plan in Chapter 7 should be included in the Action Plan.

Comment(s) Made By:
Hashimoto and Ziegler – USEPA

Response:
The discussion of timeframes and milestones has been described in greater detail in the revised draft (Chapter 7). In some cases, implementation timelines will be developed by the discharger, to account for costs and site-specific priorities, and submitted to the Regional Water Board Executive Officer for approval.

R15. Comment(s):
Statement: Chapter 7, Section 7.1.1 (Compliance and Trend Monitoring), page 7-2, states "The sampling frequency and density should be of a high enough resolution that over a **reasonable period time** to determine whether management actions are having the desired effect on water quality conditions."
Comment: This needs reworded to make sense. General statements like "reasonable period of time" are too general and need to be defined. Also, because your targets and allocations in many instances are based on monthly means, monthly means also need to be specifically defined and compliance monitoring frequency adjusted accordingly.

Comment(s) Made By:
Hicks – U.S. Bureau of Reclamation (page 11 Specific comments)

Response:
The text has been revised. The Regional Water Board is working within the Klamath Basin Monitoring Program and the Klamath Hydroelectric Settlement Agreement to develop specific monitoring regimes to address TMDL compliance measures. The Regional Water Board believes that these forums are the appropriate venue to refine the details of the program, working in collaboration with other Klamath River monitoring entities. The wording was thus left intentionally general.

R16. Comment(s):
Statement: Chapter 7, Section 7.2.2, Page 7-5. KBWQMCG goals
Comment: Make sure to review these. They have been in the process of changing them.

Comment(s) Made By:
Hicks – U.S. Bureau of Reclamation

Response:
Thank you for the comment. The text has been revised.

R17. Comment(s):
Statement: Chapter 7, Section 7.5.3, pages 7-22 and 7-23, Table 7.7
Comment: Does the frequency of monitoring at compliance points match up to the frequency used to determine numeric targets? Was the frequency used to determine the numeric targets (especially monthly means) statistically significant? These questions need to be answered to undertake valid compliance monitoring checks.

Comment(s) Made By:
Hicks – U.S. Bureau of Reclamation

Response:
The frequency of monitoring will require several years of monitoring to detect trends, which is consistent with the expectations of the implementation plan to achieve

reductions. There are other means (project based monitoring) that will also be used to evaluate progress towards TMDL targets.

R18. Comment(s):

Statement: Chapter 7, Section 7.6.1, Page 24-26. States "Link River boundary condition" and "Lost River Diversion Channel (LRDC)" and "Klamath Strait Drain (KSD)" and "Lake Ewauna/Keno Reservoir" and "Keno Reach" and "J.C. Boyle Reservoir" and "Full Flow:" and "Springs"

Comment: Previously in Ch 7, Section 7.4.1, Page 14 stated "In recent years, monitoring programs have also been conducted to evaluate cyanobacteria and cyanotoxin levels in reaches of the Klamath River upstream of the Copco reservoirs, in Oregon between Upper Klamath Lake (Link River Dam) and Copco 1 Reservoir. Those locations are not addressed in this document". If the sites in Oregon for microcystin were not included then why include proposed sites for special studies in Oregon?

Comment(s) Made By:
Hicks – U.S. Bureau of Reclamation

Response:
The TMDL is a collaborative effort involving the whole basin. Oregon Department of Environmental Quality (ODEQ) was consulted when identifying monitoring needs. The specific discussion of the results from these locations will be addressed by ODEQ in their TMDL staff report.

R19. Comment(s):

Section 6.3.2 Iron Gate Hatchery - Both DFG and PacifiCorp are permittees under the NPDES permit for IGH's discharge.

For context, this sole permitted point source within California is located approximately 190 river miles from the Pacific Ocean. DFG recommends an active effort by Regional Board staff to identify un-permitted and non-point source discharges within the intervening 190 miles of the Klamath River. DFG also recommends aerial reconnaissance, followed by ground truthing of potential pollutant sources throughout the watershed.

Comment(s) Made By:
Stacey – California Department of Fish and Game

Response:
The Klamath implementation plan is comprehensive in its coverage of nonpoint source and point source discharges in the Klamath basin. The plan proposes several measures to control sources of pollution. While aerial reconnaissance is an effective way to identify sources, it is also costly; this tool may be used from time to time and to address special situations. Dischargers are expected to comply with the Klamath implementation plan

measures and Regional Water Board staff intend to actively enforce against unpermitted discharges that violate the proposed basinwide prohibition.

R20. Comment(s):
In order to measure whether the implementation is achieving objectives, it is necessary that WDRs, Waivers and MOA requirements include comprehensive monitoring and 100% data sharing and transparency.

Comment(s) Made By:
Spain – Institute for Fisheries Resources & Pacific Coast Federation of Fishermen's Associations

Response:
Regional Water Board staff agree.

R21. Comment(s):
The TMDL must make specific requirements of all TMDL implementation cooperators to plug any identified data gaps and to provide all data and metadata, including raw data, through the proposed information sharing system.

Comment(s) Made By:
Spain – Institute for Fisheries Resources & Pacific Coast Federation of Fishermen's Associations

Response:
Regional Water Board staff agree.

R22. Comment(s):
Explicit language in the TMDL setting forth the scientific rationale for each monitoring station, and recommendations for where such monitoring stations should be located, will strengthen calls for stable funding for the placement and operation of those stations in the future.

Comment(s) Made By:
Spain – Institute for Fisheries Resources & Pacific Coast Federation of Fishermen's Associations

Response:
Regional Water Board staff agree.

R23. Comment(s):
The TMDL modeling report notes that the nutrient value used to represent the high-

volume springs below JC Boyle dam were "derived through model calibration," but it does not provide specifics. The wide range of observed variation (as noted above, this variation may or may not be real) makes it clearly evident that the concentrations of nutrients of these springs introduce an important uncertainty. Given the high volume of water produced by these springs, and the appreciable concentrations of nutrients in them, we strongly recommend that someone actually collect water samples from the springs so that the nutrient concentrations can be measured directly, yielding a more reliable value than estimates from mixing equations (as above) or model calibration (as done in the TMDL model).

Comment(s) Made By:
Spain – Institute for Fisheries Resources & Pacific Coast Federation of Fishermen's Associations

Response:
Regional Water Board staff agree and have proposed a more intense monitoring of the referenced springs as a special study within the Klamath Basin Monitoring Program.

R24. Comment(s):
We need Implementation Monitoring which focuses on the specific implementation tasks and time lines for tasks assigned in the Action Plan to staff/NCWQCB, cooperating agencies and others and which reports progress and/or lack of progress to the Board and the public on a regular basis. Implementation monitoring is also needed for the Shasta and Scott and Lost River TMDLs and since that has not been done as yet it should be completed as part of the Klamath TMDL and Action Plan.

Comment(s) Made By:
Pace, Beck, Gillespie – North Group-Redwood Chapter-Sierra Club & Friends of Del Norte

Response:
The discussion of timeframes and milestones has been described in greater detail in the revised draft (Chapter 7). In some cases, implementation timelines will be developed by the discharger, to account for costs and site-specific priorities, and submitted to the Regional Water Board Executive Officer for approval.

R25. Comment(s):
Page 7-1. Paragraph 4. Please expand on the program identified in NRC (2004) and identify similarities and differences.

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The commenter can refer to the excellent description provided in the referenced text.

R26. Comment(s):
Page 7-3. Paragraph 4. The goals outlined by the Regional Board and ODEQ are not echoed in the Preliminary Review Draft: Klamath River Basin Water Quality Monitoring Plan (KBWQMCG), but rather drawn from KBWQMCG (Royer and Stubblefield 2009). Admittedly (and contrary to the statement on Page 7-5 under section 7.2.2 that states the plan is done), the plan is still in draft form, but much of the direction for the TMDL has been drawn from the KBWQMCG. Tables 7.3, 7.4, and 7.7 are drawn directly from processes involving the KBWQMCG and not properly referenced. Many participants have worked tirelessly on KBWQMCG issues and this information should be properly referenced. Much of this chapter has been drawn from the Blue-Green Algae working group and the KBWQQMCG, but these contributions are not properly cited.

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The Public Review Draft TMDL staff report used the original deadline for the KBWQMCG Monitoring Plan, which is now the Klamath Basin Monitoring Plan (KBMP). The deadline was not revised until after the release of the public review draft. The KBMP Monitoring Plan is now final. The work is referenced and credited. In addition, the KBMP was contracted by and prepared for the Regional Water Board, which appreciates the contribution of all of the agencies, entities, and individuals that contributed to its success. The final report will reflect the final document.

R27. Comment(s):
Page 7-10, Table 7.3. Differences between the use of terms “trend monitoring” and “trend compliance monitoring” should be explained.

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
There is no difference. The term trend compliance monitoring will be used consistently in the final document.

R28. Comment(s):
Page 7-14, Paragraph 3, Lines 7-10. The statement is made “… the results should be applied to determine whether microcystin exposures are a contributing factor to

ecological impacts such as fish disease and fish health both within the reservoirs and below Iron Gate Dam". Please explain how this determination would be made.

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
Additional information is needed on the impacts of microcystin exposure on resident fish as a result of the potential disruption of liver function, which would tend to weaken fish and make them more susceptible to other disease vectors. A specific description of this special study is beyond the scope of this document. In general it would entail fish collection from these locations with an evaluation of tissue concentrations of microcystin, and an examination of liver tissue.

R29. Comment(s):
Page 7-14, First Bullet. This bullet indicates that public health monitoring in the reservoirs would occur at four shoreline sites in coves. Open water sites are not mentioned, but should be sampled also, since the open water areas are used by the public also.

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
NCRWQCB, working in cooperation with PacifiCorp and other river monitoring entities, developed a Monitoring Plan for 2009 under the AIP Measure 12. Monitoring in 2009 included sampling for cyanobacteria and associated toxins from designated reservoir shoreline areas and reservoir open water locations. Sampling was conducted at reservoir shoreline locations every two weeks during blooms, and monthly prior to and following blooms or other conditions (e.g., scums) requiring posting. Reservoir open water samples (from 0- 0.5 meters), representative of a swimmer or water skiers exposure, were also collected monthly under the baseline monitoring program. Under the KHSA Measure 15, NCRWQCB continues to work with PacifiCorp, other agencies, and the river monitoring entities to develop plans for 2010, and anticipates continuing this effort in subsequent years while the KHSA remains in effect.

R30. Comment(s):
Page 7-19, Paragraph 2, Line 3. The 26 ng/g value listed here should be specified as ng/g wet weight.

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The correction has been made to the text.

R31. Comment(s):
Page 7-24. Section 7.6.1 Comprehensive Water Quality Monitoring. This program of parcel tracking to assess water quality conditions is misleading and inappropriate for application in the Klamath River. This was tried by the Regional Board below Iron Gate dam and provided little useful information (in fact, there is no mention of this work in the draft TMDL). This is an inappropriate method to develop a system wide mass balance (which is stated as a desired outcome). The ability to track a parcel of water through the system requires a very clear understanding of travel time, which is not addressed in any way in this section. The approach does not speak to dilution and the role of tributary inputs at any sufficient level to understand the approach. A more prudent approach would be to reduce the system to a reach-by-reach basis and complete information on individual reaches multiple times per year. For example a small study of Keno reservoir over a two week period, two or three times a year, would provide dramatically more information that this proposed approach. In the Keno dam to J.C. Boyle reach, which has a short transit time, a shorter study may be required, saving time and resources. The constituents seem well represented, but the timing issue of this program will result in little useful data. Folded into this are several studies that appear to be part of this "comprehensive" parcel tracking program, but do not seem directly related. This is a confusing presentation of an important matter. For example:

- The estuary sampling does not seem related to the parcel tracking program (nor should it necessarily be related)
- The open ocean boundary condition is a very dynamic environment and trying to tie it into the parcel tracking will not provide sufficient information to form confident and robust decisions
- New flow gages and flow analyses may be useful but where is such work needed? This does not appear to tie in with the parcel tracking. How long of a record is necessary before a comprehensive understanding of the flow records can be confidently stated?
- Water monitoring for accretions is a great topic, but what defines "significant accretions" is unknown. This would vary by season, year type, and location in the system.

A bathymetric survey for the estuary is important for two reasons. The stated reason is that the initial survey may not have characterized important elements. An equally important reason is that the estuary is not static and will change, probably frequently. Thus relatively frequent surveys would be valuable to ascertain the variability in the estuary and accommodate that in modeling (sensitivity analysis) to quantify uncertainty. These tasks require considerable resources, funding, and ideally a level of cooperation and coordination. A framework, ideally developed with considerable public input, is required to identify, rank and prioritize monitoring actions to ensure effective and responsible use of funds and resources.

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The parcel tracking is mentioned in concept only and would require the development of a study plan that would be reviewed by other monitoring agencies as part of the KBMP. Therefore the estuary monitoring program proposed in the staff report is not intended as a complement to the parcel tracking special study. The recommendations included in the comment will be considered if the proposed special study moves forward. Currently there are no specific plans to implement the concept.

R32. Comment(s):
Page 7-27, Third Bullet. This bullet is titled "Below channelized section of Iron Gate Dam". Please specify what is being referred to here. What "channelized section" is this? Also, the statement is made "This station has recently been demonstrated to have the highest rate of parasite infection of fish within the Klamath system". This statement is incorrect and should be deleted. The higher rates occur downstream below the Shasta River near the confluence with Beaver Creek.

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The text has been revised to call this location the "Low Gradient Reach Between Shasta and Scott Rivers". The point being made is that the channel characteristics provide little opportunity for periphyton or polychaete colonization. The lower gradient channel below I-5 bridge is of a different and more favorable geomorphology for colonization. The reference to the higher rates of parasite infection has also been revised to more accurately reflect the subject location.

R33. Comment(s):
Page 7-29, Section 7.6.2. The second bullet point pertains to the Scott River and does not appear to be related to the Klamath River TMDL. Refugia temperatures are localized areas that probably do not have a broader affect on mainstem temperatures far from the refugia. Though groundwater in the Scott Valley may play a broader role, the valley is located well over 20 river miles upstream from the Klamath River and probably has little effect on Klamath River temperatures.

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
Yes, the referenced bullet notes that the study has been proposed as part of the Scott River TMDL. However the Klamath River TMDL includes watershed-wide allocations

for the purpose of retaining good refugia condition within the tributaries which both historically and currently function in that capacity. That is, the study is not meant to assess impact on Klamath River temperatures but to evaluate refugia status within the Scott River. The study recommendation will be retained.

R34. Comment(s):
Page 7-30, Section 7.6.5. The bullet point identifies a "Periphyton Advisory Committee." Does such a committee exist? If it does exist it is so poorly communicated in the basin that key water quality analysts are unaware of its existence.

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The Periphyton Advisory Committee is a statewide entity created by the State Water Resources Control Board SWAMP program in collaboration with the Southern California Coastal Water Research Project. The committee is made up of representatives from several agencies and universities to work on refining the protocols for sample collection, sample analysis, and data analysis to make periphyton a more useful water quality assessment tool. A draft report is available describing progress to date (SWAMP and SCCWRP. 2008. *Incorporating Bioassessment Using Freshwater Algae into California's Surface Water Ambient Monitoring Program (SWAMP).* SWAMP Report # 563.)

R35. Comment(s):
The (implementation) plan should be more explicit regarding how it will deal with those who would deliberately delay.

Comment(s) Made By:
Fetcho – Yurok Tribe
Crosby – Karuk Tribe
Bowman – Quartz Valley Indian Reservation

Response:
See response to R36.

R36. Comment(s):
Implementation and enforcement of the plan needs to be described in greater detail.

Comment(s) Made By:
Grunbaum

Response:
Dischargers will be held to the conditions of their permits and Basin Plan prohibitions. Enforcement against recalcitrant dischargers will follow the State Enforcement Policy utilizing the appropriate combination of enforcement tools.

R37. Comment(s):
We support the implementation approach described in Chapter 6.

Comment(s) Made By:
Hashimoto and Ziegler – USEPA

Response:
Support noted.

R38. Comment(s):
Chapter 6 would benefit from a more consistent structure and additional specificity. We recommend more consistent structure and more specificity – what needs to be done, by whom and when. The chapter is difficult to follow in terms of responsible parties, goals, measures and mechanisms, monitoring and ID of timeframes and milestones.

Comment(s) Made By:
Hashimoto and Ziegler – USEPA

Response:
The implementation table is clear in its designation of responsible parties and implementation mechanisms. The responsible parties are named at the beginning of each section of the implementation plan concerning the implementation measures required of the party in question. The measures and timelines associated with those measures are presented at the end of each section after a discussion of the rationale for recommending those measures. The discussion of timeframes and milestones has been described in greater detail in the revised draft (section 7.2). In some cases, implementation timelines will be developed by the discharger, to account for costs and site-specific priorities, and submitted to the Regional Board Executive Officer for approval.

R39. Comment(s):
We recommend highlighting the management system to assure accountability feedback, transparency and adaptive management – identifying who will oversee implementation and accountability. How will new information inform adaptive management? EPA's ability to determine that the TMDL provides reasonable assurance that Nonpoint Source (NPS) reductions will occur is related to two factors: (1) the degree to which the TMDL explains how both load-generating and load-reduction NPS projects will be tracked and

accounted, and (2) the success of the TMDL management framework to implement – and, over time, to improve – NPS tracking and accounting.

Comment(s) Made By:
Hashimoto and Ziegler – USEPA

Response:
Much of the nonpoint source implementation associated with the TMDL will be tracked through monitoring and reporting requirements associated with WDRs and waivers, both existing and proposed. On a larger scale, water quality trends will be tracked according to the Klamath TMDL monitoring plan described in Chapter 7 of the staff report. The Regional Board will periodically assess the success of Klamath implementation based on trends in water quality and dischargers reporting. At this time the Regional Board may decide to require additional measures in WDRs and waivers to ensure reductions in nonpoint pollutant loads. Waivers are required to be reviewed every five years.

R40. Comment(s):
TMDL should be amended to include specific mechanisms for holding individual polluters accountable for reducing pollution on set timelines.

Comment(s) Made By:
Klamath Riverkeeper - Various

Response:
Reducing pollution on set timelines is a required element of any Regional Board WDR or waiver. These regulatory mechanisms make the TMDL enforceable using the Regional Water Board's available enforcement tools as described in the State Enforcement Policy.

R41. Comment(s):
Nonetheless, requirements for transparency and a wider range of monitoring activities should be required and made part of WDRs, Waivers and the USFS MOA.

Comment(s) Made By:
Spain – Institute for Fisheries Resources & Pacific Coast Federation of Fishermen's Associations

Response:
All reporting to the Regional Water Board is 100% transparent; discharger case files are available to the public. Staff believe that the monitoring and reporting required by the Klamath implementation plan and through existing and proposed permits is sufficient to track discharger compliance with the TMDL. The USFS conditional waiver in particular will require a significant increase in monitoring requirements, many of which can be met through reporting on progress of existing USFS programs.

R42. Comment(s):
The proposed Klamath River water quality accounting and tracking program referred to as "KlamTrack" (previously described as "pollutant trading") offers promise for cost-effective water quality improvements, but only if properly implemented.

Comment(s) Made By:
Harling – Mid Klamath Watershed Council

Response:
Regional Water Board staff agree and intend to ensure that the process is implemented properly.

R43. Comm ent(s):
Lack of regulation of water use by the SWRCB Water Rights Division (WRD) and other agencies with authority over streamflow flow is a major impediment to successful TMDL implementation. Many aspects of the implementation plan look good on paper, such as requirements for farmers to develop water quality management plans. It remains to be seen how effective such efforts will actually be in practice. Overall, the implementation plan needs to be strengthened, while maintaining reasonable flexibility for those engaged in good-faith efforts to comply. However, the plan should more explicit regarding how it will deal with those who would deliberately delay.

Comment(s) Made By:
Harling – Mid Klamath Watershed Council

Response:
Regional Water Board staff will address the issue of recalcitrant responsible parties consistent with the State Board’s enforcement policy. The enforcement policy is available at: http://www.waterboards.ca.gov/plans_policies/docs/wqep.doc.

ECONOMICS and ENVIRONMENTAL ANALYSIS

S1. Comment(s):
It could prove quite costly to obtain waivers and create WQMPs for the Klamath Project as its territory encompasses land in both Oregon and California. We suggest having the same criteria required for both California waiver of WDRs (including any interim WQMPs) and Oregon's Agricultural WQMPs.

Comment(s) Made By:
Addington and Danosky – Klamath Water Users Association & Tulelake Irrigation District

Response:
The requirement to develop a WQMP has been removed from the Klamath implementation plan. The waiver requirements will be developed through a public stakeholder process that will begin after the adoption of the Klamath TMDL.

S2. Comment(s):
The implementation plan must explain in greater detail how the Regional Board or others would assist individual dischargers in locating funding sources for the proposed measures. The Regional Board must recognize obstacles outside of individual farmers' control such as regulatory limitations on algae and aquatic weed removal, power rates, and water costs.

Comment(s) Made By:
Addington and Danosky – Klamath Water Users Association & Tulelake Irrigation District

Response:
The economics chapter of the TMDL staff report (Chapter 10) provides a list of funding sources. Regional Water Board staff are available to assist landowners in locating funding for their projects and technical assistance is available from the NRCS, UCCE, as well as the local RCDs. There are several grant programs that provide funds for implementing management practices to improve water quality. The State Water Resources Control Board Department of Financial Assistance website lists some of these programs: http://www.waterboards.ca.gov/water_issues/programs/grants_loans/#funding_programs

S3. Comment(s):
Please remember that Siskiyou County is an economically depressed area and its economy is primarily agricultural. Agriculture, timber and mining all contribute to our economy and are historic factors in our cultural heritage and social fabric. Cold water fishing in the Klamath River system of Siskiyou County is only a very minor contributor to our economy.

Comment(s) Made By:
Armstrong - Siskiyou County Supervisor, District 5

Response:
The Regional Water Board staff understand the economic situation in Siskiyou County and are willing to work with landowners to implement management practices on a timeline that is practical considering their ability to fund projects and pay for implementation. However, management of wastes discharged to waters of the state is required by state law and is not an optional obligation based on the status of the local economy. In consideration of comments such as this, Regional Water Board staff have made several changes to the first public review draft that was released in June 2009. A summary of those changes may be found in section 6.5.6.2 of the staff report and general response Q1.

S4. Comment(s):

- It is quite clear that the Klamath River/watershed TMDL has significant, cumulative and disproportionate regulatory impacts on the economic activities and property use of people in Siskiyou County, particularly agricultural and timber communities, which would appear contrary to the State's Environmental Justice Policy.
- The California Resources Agency's Environmental Justice Policy identifies and protects low-income communities from the "disparate implementation of environmental regulations, requirements, practices and activities in their communities". All Departments, Boards, Commissions, Conservancies and Special Programs of the Resources Agency must consider environmental justice in their planning, decision making, development and implementation of all Resources Agency programs, policies and activities. Given the lack of an adequate analysis for environmental justice, it would appear that the Klamath River TMDL proposal is in conflict with the Resource Agency's Environmental Justice Policy. The County would urge the Board to withhold any decisions that would result in regulations that would harm the citizens of the Klamath River watershed until such a study is complete and implemented.

Comment(s) Made By:
Armstrong - Siskiyou County Supervisor, District 5
Cantrall – Modoc County Board of Supervisors

Response:
There are no new requirements for the agricultural and timber communities proposed in the Klamath implementation plan. The agricultural waiver proposed for development and adoption by the Regional Water Board by 2012 will undergo a separate CEQA process. Any new regulatory requirements of the waiver will be analyzed at that time. The Klamath implementation plan likewise does not place any new requirements on or contemplate any new permitting mechanisms for timberland managers. Timber harvest

plans are already regulated through existing permits and permitting processes and must comply with existing water quality objectives that are sufficient to implement the TMDL.

S5. Comment(s):
The monitoring cost that you are requiring could be used to do real project to help water quality.

Comment(s) Made By:
Bennett – Siskiyou County Supervisor, District 4

Response:
There are no monitoring costs associated with Klamath implementation at this time. Reporting requirements for irrigated agriculture will be developed as part of the public process to develop the agricultural waiver.

S6. Comment(s):

- Our Farmers, Ranchers, Loggers and Miners have to be able to work the land and support their families, these new TMDL requirements have not taken into consideration the Devastating consequences of the implementation of this new level of regulations will have on the economy of Siskiyou County.
- In no uncertain terms, the Draft Staff Report for the Klamath River Total Maximum Daily Loads and Action Plan (Draft TMDL) will have profound and potentially catastrophic effects on the socio-economic fabric of Siskiyou County.

Comment(s) Made By:
Bennett – Siskiyou County Supervisor, District 4
Kobseff – Siskiyou County Board of Supervisors

Response:
Staff respectfully disagree that TMDL requirements will be devastating or catastrophic. The implementation measures related to nonpoint source land use activities are focused on addressing discharges to waters of state as the Regional Water Board is required to do by the statewide Nonpoint Source Policy. Regional Water Board staff made several significant changes to the implementation plan to ensure that the measures are reasonable. The following brief discussion explains the implementation plan's approach to the various land uses referred to in the comment:

1. Miners: The limitations being recommended to protect thermal refugia from the impacts of suction dredging discharges are targeted to specific times and locations where suction dredging would have an impact on the function of the refugia. These recommended limitations on suction dredging discharges are not expected to have a significant effect on local businesses or tourism since they will most likely not reduce the number of people suction dredging recreationally.

2. Loggers: The TMDL implementation measures have been revised to work within the existing regulatory structure of the Anadromous Salmonid Protection Rules and the current Regional Water Board permitting framework.

3. Agricultural: The implementation plan proposes no new requirements on agriculture; and specifically removed requirements from the June 2009 public review draft of the TMDL based on public comments. Requirements for agricultural that meet the TMDL allocations and targets will be incorporate into a future conditional waiver for agriculture that will undergo a separate public process.

S7. Comment(s):

- The County understands the low bar that the Board must meet in analyzing the costs involved in implementing their proposed program. Consequently Chapter 10 is of little use to producers and community leaders in determining the impacts they will face if the proposed TMDLs are implemented.
- The Klamath TMDL does not address the negative economic impacts additional regulation and permits will have on the local economy.

Comment(s) Made By:
Cantrall – Modoc County Board of Supervisors
Morris- Siskiyou County Farm Bureau

Response:
The economic analysis of the TMDL implementation measures is required to give cost estimates of reasonably foreseeable compliance measures. It is not required to evaluate the costs to individuals and is not required to calculate the total cost of the TMDL, except in the case of an agricultural water quality control program. While an agricultural conditional waiver program is proposed for development in the TMDL implementation plan, it will be developed through a separate process and costs associated with complying with that program will be evaluated separately as well. The Regional Water Board gives the discharger the flexibility to select the appropriate management practices that fit their operations, once sources of pollution have been identified. The cost estimates given in Chapter 10 may prove useful in a general sense in estimating the costs of management practices. Please also note that there are many sources of grant, loan, and technical assistance available to landowners seeking to address nonpoint source discharges.

S8. No comment. This is a placeholder to retain numbering system.

S9. Comment(s):
The real issues relating to economics are the "transitional" mechanisms that might have to be funded in order to achieve the TMDLs standards as recommended by the Board's staff. They have explained that even though it may take generations, if ever, for water

quality standards to be met in the water delivered at the state line; there is no relief in the mean time for downstream producers.

<u>Comment(s) Made By:</u>
Cantrall – Modoc County Board of Supervisors

<u>Response:</u>
The requirements of the state law regarding control of waste discharges are not dependent on receiving water quality. Dischargers are individually responsible for the quality of the water in their discharge, not the quality of the receiving water. It is necessary to both control individual discharges as well as implement larger scale pollutant reduction projects to attain water quality standards in the Klamath Basin.

S10. <u>Comment(s):</u>
Consequently, where would the money come from to fund and operate a suggested water treatment plant? The staff has dismissed this concern by saying that PacifiCorp or the Bureau of Reclamation will provide the funding. The Bureau has already made it clear that they are repaid by the users for the projects they fund. So the Report has avoided analyzing or even discussing the major economic impacts of the proposal. The County is quite disappointed in the Report's lack of candor toward the issues that could severely affect the agriculture in the Project.

<u>Comment(s) Made By:</u>
Cantrall – Modoc County Board of Supervisors

<u>Response:</u>
Staff assume the commenter is referring to the proposed engineered treatment projects in the TMDL staff report, such as a wastewater treatment plant. Staff have proposed these types of projects as measures necessary to address large scale water quality impairments in addition to the Regional Water Board's more traditional regulatory approach. The exact projects have not been selected and the Klamath TMDL certainly does not require USBR or any other entity to fund a wastewater treatment plant. The treatment plant was merely an example of the types of projects that might be implemented. The commenter states that USBR must be repaid by users, however notes that PacifiCorp may provide funding. In fact, PacifiCorp has committed funding to water quality improvement projects as part of the interim measures included in the Klamath Hydroelectric Settlement Agreement (see section 6.3.1.3 of the staff report). The TMDL proposes an MAA with USBR, US Fish and Wildlife Service, and Tulelake Irrigation District which includes a study to analyze the impact of the Klamath Project and prioritize water quality improvement projects to address those impacts. The cost of those projects will be determined at that time and cannot be projected as part of the TMDL staff report.

S11. Comment(s):
A full assessment on the economic impact of the Klamath TMDL was missing. In this case, it should be a cumulative economic impact, including the effect of all TMDLs and the Department of Fish and Games ITP. This will be the third and in some cases, the fourth or fifth permit or plan than private landowners will have to endure. Especially in the current economic situation, it must be noted that agriculture and timber can not sustain any more additional cost, whether it be in capital or in time.

Comment(s) Made By:
Fowle

Response:
The TMDL requirements concerning the scope of the economic analysis are to provide an estimate of the cost of implementation of reasonably foreseeable compliance measures. There is no requirement to provide an analysis of the cumulative economic impact of the TMDL implementation plan, nor a requirement to speculate on the costs of other agencies' existing and/or proposed regulatory programs. It is expected that individual costs to meet water quality standards will vary widely depending on the costs of the specific management practices that are necessary to address any discharges to waters of the state.
The proposed agriculture waiver will be developed pursuant to a public process and the economic impact of that program will be assessed at that time. The Klamath TMDL economics analysis does, however, provide cost estimates for the types of management practices that may be implemented by dischargers to improve the water quality of their discharges.

S12. Comment(s):
Recognize the need to provide financial assistance.

Comment(s) Made By:
Hashimoto and Ziegler – USEPA

Response:
Regional Water Board staff recognize the need for various forms of assistance, including financial assistance, to enable current operations to transition to water quality compliant operations. Chapter 10 provides a list of potential funding sources. Regional Water Board staff will continue to work with local communities to match funding and technical assistance and landowners so as to improve water quality performance of agricultural operations.

S13. Comment(s):
Compliance with implementation schedules should be tracked and mandated - with additional actions to take place if the schedule is not met. There should be mile stones (or targets) for measurement of trends and efficacy of Implementing Programs - with

additional described actions if such miles stones (or targets) are not attained. The document should clearly demonstrate how all of this is to be accomplished - with described alternative actions if mile stones or targets are not attained.

Comment(s) Made By:
Levine – Coast Action Group

Response:
The monitoring chapter in the TMDL staff report (Chapter 7) has been revised in response to comments. Tracking of implementation by dischargers that are conducting land use activities pursuant to Regional Water Board WDRs or waivers will be expected to meet the timelines and monitoring requirements of their permit. The overall effectiveness of the TMDL will be periodically assessed by the Regional Water Board as described in Chapter 7.

S14. Comment(s):
Caltrans does not have the resources to address this TMDL outside of the funding allocated to applicable highway projects. Caltrans does not have the authority to impose user or utility "fees" to pay for the TMDL implementation.

Comment(s) Made By:
McGowen – Caltrans

Response:
It is Regional Water Board staff's understanding that Caltrans acknowledges its responsibility to comply with state and federal water quality law and regulation. For example, Caltrans implements management practices to address pollution sources pursuant to the terms of their statewide stormwater permit. This permit contains explicit provisions regarding TMDL requirements.

S15. Comment(s):

- We are asking for a cumulative analysis across all the TMDL Rivers - Scott, Salmon, and Shasta – in addition to the Klamath. This would put the Forest Service financial burden in better perspective.
- The costs per mile for all the required road treatments are shown on p. 10-10, but not the total cost across each national forest or the cumulative cost of the Scott, Shasta, and Salmon TMDLs. The economic analysis should consider the total cost, which could be in the hundreds of millions of dollars.

Comment(s) Made By:
Moore – U.S. Forest Service, Pacific South West Region
Schuyler – Klamath National Forest

Response:
Chapter 10 'Economics' provides an estimate of the costs of certain measures that may be used to comply with the TMDL. Specific means of compliance can be selected by the Forest Service, and implemented according to a prioritized schedule.

S16. Comment(s):

- The potential for the TMDL to greatly affect the socio-economic structure of Siskiyou County is profound. In the Chapter 10 Economic Analysis, unfortunately, the summary in sec. 10.3.8 dismisses most of the costs by alleging that, "…they cannot be attributed to the Klamath River TMDL."
- The mere identification of possible costs of compliance with the plan is not sufficient analysis of economic impacts that may result in physical changes leading to an environmental impact.

Comment(s) Made By:
Addington and Danosky – Klamath Water Users Association & Tulelake Irrigation District
Costales – Siskiyou County

Response:
Section 10.3.8 of the staff report is intended to give the reader an idea of the *total costs* of the water quality management practices that are consistent with implementing the Klamath TMDL. This is done by providing an estimate that was taken from the *Recovery Strategy for California Coho Salmon* developed by the California Department of Fish and Game. The full quote from the staff report is as follows: "…where costs are incurred as a result of the implementation/enforcement of another program, they cannot be attributed to the Klamath River TMDL and revised DO objective. However, because these costs were estimated for the whole watershed, they are included here for illustration purposes." The costs associated with implementation of the Klamath TMDL are given in the preceding sections of Chapter 10; but only the *unit costs*. For example, if the measure in question is a nutrient management plan, only the cost per plan is given as opposed to multiplying that cost by the number of plans that are needed. Or, for installing riparian fencing, the cost per mile of fence is given as opposed to the cost of all fencing that is needed in the Klamath Basin. Regional Water Board staff did not have the data to make estimates of the total cost of implementation and are not required to do so in the economic analysis for Basin Plan amendments. The total costs shown in Table 10.6 that were taken from the Recovery Strategy are provided for informational purposes only. While there is a requirement to analyze total costs of implementing an agricultural water quality control program, the Klamath TMDL implementation plan does not represent such a program. The agricultural waiver is the agricultural program, not the TMDL, and will be developed separately from the TMDL as discussed in section 6.5.6.2. Total costs will be analyzed as part of the waiver development process.

S17. Comment(s):
The development of the TMDL must comply with Porter-Cologne that requires all Regional Board actions to be reasonable and subject to consideration of economics, water quality that can reasonably be achieved, and other public interest factors.

Comment(s) Made By:
Addington and Danosky – Klamath Water Users Association & Tulelake Irrigation District

Response:
See response to comment O22.

S18. Comment(s):
The CEQA analysis is insufficient to inform the Regional Board's consideration of the implementation plan. The analysis was conducted based on an ambiguous project description that does not clearly define the geographic reach of the implementation plan or an explanation of what load and wasteload allocations will be implemented through the plan. Further, the superficial evaluation of potential environmental consequences of reasonably foreseeable future actions does not satisfy CEQA.

Comment(s) Made By:
Addington and Danosky – Klamath Water Users Association & Tulelake Irrigation District

Response:
The CEQA analysis contained in the Klamath TMDL staff report satisfies the requirements of CEQA. The staff report clearly defines the geographic scope of implementation in Chapter 6 of the staff report (section 6.1.1) and in Chapter 9 on the CEQA analysis:

The geographic source areas in the Klamath River in California can generally be grouped as follows:

- Stateline – Waters entering California from Oregon at Stateline, which includes the Williamson and Sprague River watersheds; Upper Klamath Lake; the Lost River watershed that drains the Klamath Irrigation Project area; municipal and industrial point sources to the Klamath River in Oregon; and Klamath River waters passing through Lake Ewauna, the Keno Reach, and JC Boyle Reservoir. Oregon's Klamath River TMDL source analysis evaluates the contributions from these various sources on the water quality of the Klamath River in Oregon;
- Reservoirs – The reservoirs on the Klamath River within California: Copco 1 and 2 and Iron Gate Reservoirs. Copco Reservoirs 1 and 2 are treated as a single source for the purposes of this TMDL;
- Iron Gate Hatchery; and

- Tributaries – These include the Lost, Shasta, Scott, Salmon, and Trinity Rivers, and a number of smaller tributary creeks. (Section 9.3 of the Draft Klamath TMDL Staff Report)

The analysis satisfies CEQA in that it adequately considers management practices that could be implemented to comply with the TMDL and analyzes their potential impacts to the environment.

S19. Comment(s):
The broad discussion of possible mitigation effort is not sufficient to satisfy the mitigation requirements of CEQA and does not support the staff's proposed determination that the implementation plan will not result in significant impact.

Comment(s) Made By:
Addington and Danosky – Klamath Water Users Association & Tulelake Irrigation District

Response:
The CEQA analysis for the TMDL is only required to look at possible mitigation for reasonably foreseeable compliance measures (including best management practices to control nonpoint sources). The Regional Water Board expects dischargers to implement mitigation measures when implementing their selected management practices. The requirement to mitigate any adverse effect on environment that may result from implementing best management practices is incorporated into the various Regional Water Board permitting mechanisms that implement the TMDL.

S20. Comment(s):
- There is nothing in the TMDL that analyzes what the impact of removal of the dams will be on water quality.
- From this brief local history, it appears that there is a substantial amount of Arsenic that has accumulated behind Copco dam. If the dam is removed, I would have concerns for the fish, and those that catch and eat these fish.

Comment(s) Made By:
Fowle
Simon

Response:
In response to comments, Regional Water Board staff have revised the CEQA analysis for the Klamath TMDL implementation plan to include consideration of the potential environmental impacts of dam removal. It is expected that the dam removal entity, should dam removal proceed, will complete an Environmental Impact Report to comply with CEQA. The dam removal project will be subject to a 401 water quality certification that must consider the Klamath TMDL load allocations and water quality standards.

S21. <u>Comment(s):</u>

- Arsenic should be added as a TMDL constituent. In other local reconnaissance, I discovered that (according to a resident of Copco Lake) there are not homes on the north side of the lake because the wells have too much arsenic. Other Heavy Metals (Cadmium, Chromium, etc…): … Any qualified geologist will communicate that in mining areas, not just one heavy metal will be present. These should be considered.
- At the Miner's Inn hearing, a local resident Chris Liles (Mayor of Etna) communicated that there were fisheries upstream of the Copco Dam, and that the fish died due to Arsenic. Arsenic has a history of impacting aquatic life upstream of Copco Dam.

<u>Comment(s) Made By:</u>
Simon

<u>Response:</u>
The Klamath River is not currently listed as impaired by arsenic, and arsenic impairment was not analyzed as part of the Klamath River TMDL. Any data on water quality impairments due to arsenic should be submitted as part of the 303(d) list update process. The 303(d) will be updated again in 2012 and the commenter is encouraged to submit data for consideration.

S22. <u>Comment(s):</u>
When it comes to increasing flow, the Draft TMDL must account for how increasing restrictions on timber harvest activities intended to directly protect water quality, may have the unintended consequence of increasing tree densities, which in turn will reduce flows. The Draft TMDL should address the fact that younger and denser forests are using more water than they ever have, and even more than the slower growing, less dense old growth forests ever did. This is essential to understand in order for the Regional Water Board to weigh the effects of one action - imposing greater restrictions on timber harvest activities - on other important values - maintaining streamflows.

<u>Comment(s) Made By:</u>
Rice and Oldfield – California Farm Bureau Federation and California Cattlemen's Association

<u>Response:</u>
The TMDL implementation plan does not restrict timber harvest to an extent that will reduce flows and significantly impact water quality. The implementation measures for timber harvest activities address riparian shade and slope stability and do not necessarily increase tree density. In fact, the implementation plan encourages thinning of dense timber stands to decrease the risk of catastrophic wildfires that could have an impact on water quality.

S23. Comment(s):

The CEQA analysis failed to evaluate any environmental impacts of dam removal, which the Draft TMDL indicates is the only feasible means of compliance with the otherwise unachievable load allocations. Rather, the report declares the "details associated with dam removal" to be "too speculative to consider at this time."

Additionally, the report makes no attempt to consider the economic costs for dam removal.

Comment(s) Made By:

Hemstreet - PacifiCorp

Response:

PacifiCorp alleges that the written report should have evaluated the environmental impacts of dam removal, asserting that the Draft TMDL indicates this as the only feasible means of compliance for PacifiCorps to meet waste load allocations. First, the Draft TMDL does not identify dam removal as the only feasible means of compliance with the load allocation. The language quoted by PacifiCorps on page 9-17 of the CEQA analysis is taken out of context and misunderstood and was not meant to indicate that the TMDL considers dam removal as the only means of compliance. Rather, the statement that "dam removal is understood as the measure by which final compliance with the TMDL waste load allocations will be accomplished" was made in the context of describing the terms of the Agreement in Principle (AIP). The AIP contemplates that dam removal will be how PacifiCorps meets the TMDL waste load allocations, and considers the interim measures identified in the AIP as achieving compliance with the TMDL only so long as the final outcome is dam removal. This sentence was only intended to describe how the parties to the AIP, which does not include the Regional Water Board, made dam removal a condition of considering the interim measures adequate for complying with the TMDL load allocations. Changes have been made to the text of the CEQA analysis to clarify this point.

The CEQA analysis prepared by the Regional Water Board does not consider dam removal as either a direct or reasonably foreseeable indirect effect of compliance with the TMDL. Dam removal is something that may or may not occur, and is independent of the TMDL. As explained in the Staff Report and elsewhere within the TMDL, dam removal came out of the Agreement in Principle (AIP), of which the Regional Water Board is not a party. The AIP came out of the Klamath Basin Restoration Agreement (KBRA), a negotiated settlement agreement between as many as 26 different parties designed to settle long-standing disputes in the Klamath River Basin. Under established CEQA case law, a future project must be included in an initially approved project if it is reasonably foreseeable consequence of the initial project and the future action will be significant in that it will likely change the scope or nature of the initial project or its environmental effects. (*Laurel Heights Improvement Assoc. v. Regents of the Univ. of Ca* (1988) 47 Cal. 3d 376, 396.) Here, dam removal is not a consequence of the TMDL, but rather a project independent of the TMDL with its own utility to potentially settle long-standing disputes in the Klamath River Basin.

The Regional Water Board is also required pursuant to Public Resources Code section 21159 to perform an environmental analysis on the reasonably foreseeable methods of compliance with the TMDL, including an analysis of the reasonably foreseeable environmental impacts of the methods of compliance and reasonably foreseeable mitigation measures. For similar reasons as described above as to why the Regional Water Board does not consider dam removal as either direct or reasonably foreseeable indirect effect of compliance with the TMDL, it does not view dam removal as a reasonable means of compliance with the TMDL. Dam removal, if it occurs, will occur because of agreements PacifiCorps has made with others, and will be subject to CEQA and/or NEPA compliance by the agencies involved in that decision. That it may also satisfy compliance with TMDL does not necessarily make it a "reasonably foreseeable" means of compliance, just in the way that the Air Resources Board or any other agency would not have to consider closure of a factory as a reasonable means of compliance with a new air emissions standard when that closure was prompted by financial or other reasons not completely related to the Air Resources Board's new air emissions standard.

Nonetheless, because there are analyses that have already been done to address the environmental and impacts of dam removal, the Regional Water Board will incorporate by reference that analysis into its CEQA analysis. The environmental and economic analyses were revised in the December 2009 Staff Report, Chapters 9 and 10, to include an analysis of potential environmental effects and economic costs associated with dam decommissioning activities. The environmental and economic analyses were based on the information on dam decommissioning activities readily available on the PacifiCorp FERC relicensing website: http://www.ferc.gov/industries/hydropower/enviro/eis/2007/11-16-07.asp.

S24. <u>Comment(s):</u>
The report's analysis of reasonably foreseeable alternative means of compliance with the regulation is a single paragraph that identifies alternative means of compliance "to consist of the different combinations of structural and non-structural BMPs [best management practices] that responsible parties might use" (p. 9-55). The analysis continues: "Because there are innumerable ways to combine compliance measures, all of the possible arrangements of alternative means of compliance cannot be discussed here." *Id.* The report recommends that compliance alternatives minimize structural BMPs and maximize non-structural BMPs. *Id.* This is not an analysis of alternative means of compliance. While it is true that there may be innumerable ways to combine compliance measures and therefore analysis of all of the possible arrangements of alternatives is not feasible, the failure to analyze any of the alternatives is not an option. There are numerous ways in which the Board could have met its obligation, including an analysis of example alternatives or a range of alternatives. The Board chose none of them. The analysis of alternative means of compliance is insufficient to provide particularized information about alternative means of compliance for each responsible party. Specifically, no

alternative means of compliance is identified for the Project.

<u>Comment(s) Made By:</u>
Hemstreet - PacifiCorp

<u>Response:</u>
Regional Water Board staff based the analysis of alternative means of compliance on the project scale (i.e. the TMDL implementation program) rather than at the responsible party scale (i.e. selection of individual compliance measures) as the Regional Water Board is prohibited by State law to require specific “means of compliance” (California Water Code section 13360). The selection of individual compliance measures largely in the responsible party’s control. Moreover, most compliance measures will be applied through an already existing permitting mechanism permit to be developed in the future accompanied by a more specific CEQA review. Given the vast differences in geology, land type, land use, climate conditions, timing considerations, and innumerable combinations of compliance measures, staff believes that the alternative analysis presented in the Staff Report provides the level and detail required to provide the decision makers with the potential scope of environmental impacts.

STAKEHOLDER PARTICIPATION

T1. Comment(s):
Why are these new TMDLs only being implemented in Siskiyou County?

Comment(s) Made By:
Bennett – Siskiyou County Supervisor, District 4

Response:
The Klamath TMDLs are being implemented in the Klamath basin, which includes all or portions of Siskiyou, Humboldt, Trinity, Del Norte and Modoc Counties. Some of the action measures identified in the Action Plan either already apply or are proposed to apply to the entire North Coast Region.

T2. Comment(s):
The NCWQCB needs to sit down at the table with the Siskiyou County Board of Supervisors and discuss in earnest, the entire Klamath TMDL, until the county is satisfied. (p. 2)

Comment(s) Made By:
Fowle

Response:
See response to comment T3 below.

T3. Comment(s):
The Siskiyou County Board of Supervisors formally requests an opportunity to meet "Board to Board" with the North Coast Regional Water Quality Control Board (Regional Water Board) to discuss the Draft TMDL and the process that led to its current form. Siskiyou County Board of Supervisors is formally requesting an additional 90-day formal extension of the comment period and confirmation that comments made at the September 10, 2009 meeting in Grenada, CA will be a formal part of the record. (p.1, 2)

Comment(s) Made By:
Kobseff – Siskiyou County Board of Supervisors

Response:
In response to your request, Regional Water Board Chair Mr. Anderson, Vice Chair Mr. Hales, and Mr. Noren met with you and Siskiyou County Board members Ms. Armstrong and Ms. Bennett on September 9, 2009. The comments presented at the September 10, 2009 Board meeting in Grenada are part of the formal Klamath River TMDL record. Finally, the Regional Water Board has completed a revised draft document, made public in December 2009, and provided a 47-day public comment period on the draft.

T4. Comment(s):
Objectives in State rulemaking under the CWA include assuring that the public has the opportunity to understand proposed actions and assuring that the government does not make any significant decision on any activity without consulting affected segments of the public. 40 CFR §§ 25.3(c)(1), (2). Additional objectives include encouraging public involvement, keeping the public informed, and fostering a spirit of openness and mutual trust among agencies and the public. 40 CFR §§ 25.3(c)(4)-(6).

Comment(s) Made By:
Krum – Siskiyou County Resource Conservation District

Response:
These requirements have been met during the development of the Klamath River TMDLs, as described in Chapter 11 – Stakeholder Participation of the TMDL staff report.

T5. Comment(s):
From the perspective of many of those who live in the watershed, a comprehensive water quality control scheme affecting nearly every part of the local economy was developed without the appropriate level of local participation. Because of the shortcomings inherent in the Draft TMDL due to inadequate local participation in its development, the Regional Water Board should reinitiate a more engaged process where those most impacted can help develop a better TMDL. (p. 1)

Comment(s) Made By:
Rice and Oldfield – California Farm Bureau Federation and California Cattlemen's Association

Response:
The Regional Water Board staff has met the noticing and public participation requirements in the development of this TMDL. The public process has been extensive and has occurred over an extended period of time, as documented in Chapter 11 – Stakeholder Participation in the staff report. The agricultural waiver that is being proposed as part of the Klamath implementation plan will undergo a separate public review process and will be developed with input from stakeholders and a technical advisory group to be convened by December 2011.

T6. Comment(s):
We or any remaining multi-generational families we know have yet to be asked a single unsolicited question or had any of our Klamath experience, history, or opinions given any consequential inclusion or credibility within the regulatory process. (p. 1)

Comment(s) Made By:
Cozzalio

Response:
The Regional Water Board has provided an opportunity for the public to comment on the TMDL and has responded to all comments. Staff believes the data used in the TMDL analysis was sufficient to establish the TMDL allocations.

T7. Comment(s):
I have a problem with an agency that does not recognize comments and they just do what they want and we're left fighting the battle. (p. 10)

Comment(s) Made By:
Kobseff – Siskiyou County Board of Supervisors

Response:
The public process has been well documented in the TMDL staff report. Staff have responded to comments in this public comment and response document and will also prepare another response document before the adoption hearing. In addition, the December 2009 Draft Klamath River TMDLs and Action Plan include extensive modifications in response to public comment.

T8a. Comment(s):
The North Coast Regional Water Quality Control Board ("Regional Board") made the Draft TMDL publicly available in a piecemeal manner by posting chapters and appendices to the Regional Board's website over the course of a month, from June 15 to July 13, 2009. Given the piecemeal manner in which the Draft TMDL was issued by Regional Board, and the significant delays PacifiCorp faced in receiving other requested data and information underlying the Draft TMDL, PacifiCorp reserves the right to submit additional comments in the future.

T8b. Comment(s):
The Regional Board made the Draft TMDL publicly available in a piecemeal manner by posting chapters and appendices to the Regional Board's website over the course of a month, from June 15 to July 13, 2009. The July 30 notice incorrectly states that the public comment period started June 15. The beginning of the public comment period cannot be considered to start until the complete document is actually available in the manner noticed. Therefore, the earliest the public comment period could be considered to have begun was July 30, 2009, when the Regional Board issued its notice that the last remaining chapters of the Public Review Draft TMDL were posted to the website. The public comment period was initially scheduled to close August 17 and the public comment period is in fact only 28 days.

In the alternative, if the public comment period is deemed to start on July 13, then the public comment period is now exactly 45 days, the procedural minimum. Compliance with procedural minima is not adequate in the present circumstance. The 45-day period is inadequate in this case given the complexity of the TMDL and of the underlying technical information and especially given the piecemeal release of the Draft TMDL and supporting documents. Public participation in the Draft TMDL was hindered by the significant delays in the release of documents and information as outlined above.

T8c. Comment(s):
The Regional Board provided supporting technical information and modeling files in a piecemeal fashion in response to repeated requests. PacifiCorp requested that all Draft TMDL model files used in the analytical assessment of load allocations developed as part of the Draft TMDL be released prior to or coincident with the scheduled June 15 release of the Public Review Draft TMDL. Some of this information was provided starting June 22 though it was available for release much earlier than this date. Additional requests were later made for essential data and information underlying the TMDL analyses. While requested information was provided throughout July and August, much of the requested information was not available until well into the public comment period. The most recent information request was submitted August 7. While the requested information and documentation was finally available on August 14, the continued delay in obtaining the supporting technical information and modeling files impeded PacifiCorp's review of the TMDL within the public comment period.

Comment(s) T8a, T8b, and T8c Made By:
Hemstreet – PacifiCorp

Response to Comments T8a, T8b, and T8c:
Comment noted. The Regional Water Board met all public noticing requirements and has also provided an additional 47 day comment period on the December 2009 Draft Klamath TMDL.

T9. Comment(s):
The Draft Klamath TMDL was not noticed as amending the Shasta River TMDL. Yet, that is the effect of this regulation. The notice did not contain an adequate description of the proposed project. In addition, the document itself did not clearly state what changes to the Shasta River TMDL are being imposed or additional regulations proposed. It is at times internally inconsistent and difficult to understand. (p.2)

Comment(s):
Hockaday – Montague Water Conservation District

Response:
The Klamath TMDL does not amend the Shasta TMDL. See response to comment T10 below and L7.

T10. Comment(s):
The superseding of the Shasta and Scott TMDLs by the Draft TMDL is a violation of process. The failure to provide any notice that this was going to occur caused most in the Shasta and Scott Rivers to ignore the Klamath TMDL, thinking that since they already had TMDLs, they would not be affected. This has resulted in much confusion and has been discovered too late by many people to allow adequate time to facilitate substantive comment.

Comment(s):
Kobseff – Siskiyou County Board of Supervisors

Response:
Regional Water Board staff have received several comments regarding consistency in the requirements of the Shasta and Scott TMDLs and the Klamath TMDL. After considering these comments, staff have revised the draft Klamath TMDL to continue to regulate agricultural dischargers in the Scott and Shasta Basin under their current TMDL waiver programs. New requirements for discharges in the Shasta basin have been removed from the Klamath implementation plan. Moreover, the Scott and Shasta stakeholders were included on the mailing list for the noticing of the December 2009 draft Klamath TMDL. The public process is described in Chapter 11 of the staff report.

T11. Comment(s):
Outreach failed to notify named Responsible Parties of Shasta TMDL of proposed amendments/revisions superseding Shasta TMDL proposed in Klamath TMDL.

Comment(s):
Hockaday – Montague Water Conservation District

Response:
See response to comment T10 – all noticing requirements have been met and are described in Chapter 11 of the staff report. The Shasta TMDL mailing list was used during the public process for the Klamath TMDLs. Regional Water Board staff met with the Siskiyou County Board of Supervisors and held several public meetings in Yreka and Siskiyou County concerning the development of the Klamath TMDLs.

T12. Comment(s):
The Shasta River is not listed for sediment impairment or impairments related to elevated nutrients. The Draft Klamath River TMDL cannot establish TMDLs for the Shasta River for pollutants which are not included on the State's 303(d) list as impairments to the Shasta River. If the Regional Board believes that the Shasta River is impaired by these pollutants, it must identify them as such on the State's 303(d) list and submit it to EPA for approval along with documentation to support this determination. 40 CFR §§ 130.7(b)(6),

(d). The Draft Klamath River TMDL attempts to skip the CWA Section 303(d) listing process and impose new TMDLs for sediment and nutrients in the Shasta River.

Comment(s):
Hockaday – Montague Water Conservation District

Response:
The Klamath TMDL has been revised and new requirements in the Shasta River basin have been removed. The commenter is incorrect in stating that the draft Klamath TMDL establishes a TMDL for the Shasta River. While the Klamath TMDL includes a load allocation at the mouth of the Shasta River where it enters the Klamath mainstem river, these allocation are consistent with those already established in the Shasta River TMDL. In addition, the Regional Water Board has the obligation under state law to regulate nonpoint source discharges, as described in the Nonpoint Source Policy, regardless of whether a waterbody is included on the Section 303(d) list for any particular impairment or not, and regardless of whether a TMDL has been completed for that waterbody.

T13. Comment(s):
We request that any revisions made to the implementation plan or timeline be a transparent process with input from the various stakeholders. Likewise, stakeholder input is necessary in the development of polluter MOUs, waivers (i.e. timber, grazing, irrigated agriculture), KlamTrack, nonpoint and point source control trade-offs.

Comment(s):
Fetcho – Yurok Tribe
Crosby – Karuk Tribe
Bowman – Quartz Valley Indian Reservation

Response:
Stakeholders will have the opportunity to participate in all Regional Water Board actions cited by the commenter through a transparent public process.

T14. Comment(s):
The sediment prohibition triggers additional public notice and publication requirements under Porter-Cologne (CA Water Code 13244).

Comment(s):
Addington & Danosky – Klamath Water Users Association & Tulelake Irrigation District

Response:
The sediment prohibition has been removed from the TMDL implementation plan. Regional Water Board staff are proposing a separate prohibition as part of the implementation plan that would apply to all discharges of waste and is a restatement of

existing law. The second comment period to allow for comments on revision to the June 2009 TMDL draft ran from December 23, 2009 – February 9, 2010; meeting the public notice and publication requirements cited.

T15. Comm ent(s):
The Regional Board must: (1) provide specific notice to all affected parties that the current effort includes an implementation plan for the EPA Lost River TMDL, (2) clearly explain how the implementation plan ensures attainment of the load and wasteload allocations in the EPA Lost River TMDL, (3) discuss the specific water quality standards, including applicable beneficial uses, and wasteload and load allocations assigned to the Lost River system in California, (4) conduct CEQA analysis and scoping based on a clearly defined project description that expressly includes the EPA Lost River TMDL implementation, and (5) clearly distinguish the implementation measures that apply to the specific constituents addressed by the EPA Lost River TMDL as compared to those addressed within the Klamath River TMDL, (6) comply with Porter-Cologne, including sections 1300, 13141, 13241, 13242. (p.11)

Comment(s):
Addington & Danosky – Klamath Water Users Association & Tulelake Irrigation District

Response:
(1) The public notice of the availability of the Draft Staff Report dated June 10, 2009 was mailed to all interested parties in the Lost River basin using the same mailing list that was used for the public noticing of the USEPA-developed Lost River TMDLs in California. A copy of this mailing list will be included in the administrative record and is available from the Regional Water Board.
(2) The Lost River basin is discussed in the Klamath implementation plan in section 6.4.3 and names responsible parties in the Lost River basin. The implementation plan ensures attainment of the USEPA Lost River TMDL in California by requiring management measures of the responsible parties and proposing regulatory mechanisms as needed to implement and enforce the TMDL.
(3) The Klamath TMDL is also clear regarding the load allocations assigned to the Lost River basin and provides a Table in Chapter 6 (Table 6.3) that presents the allocations as established by the USEPA for the Lost River basin in December 2008.
(4) The CEQA analysis (staff report section 9.5) clearly identifies the scope of the Klamath implementation plan. This format presents the environmental analysis for likely implementation actions from sources associated with the following:

- Stateline (Staff Report Section 6.2)
- Klamath Hydroelectric Project and Iron Gate Hatchery (Staff Report Section 6.3)
- Klamath River tributaries (Staff Report Section 6.4)
- o Lost River
- o Shasta River
- o Scott River
- o Trinity River

- Watershed-wide (Staff Report Section 6.5)
  - Road construction and maintenance
  - Grazing
  - Irrigation agricultural
  - Timber harvest
  - Measure to protect thermal refugia (Section 9.5 of Draft Klamath TMDL Staff Report)

(5) The Klamath TMDL implementation plan clearly designates responsible parties in the Lost River basin and thus serves as the implementation plan for the Lost River. The measures assigned to the responsible parties will address the constituents of concern in the Lost River basin.
(6) The Klamath implementation plan complies with Porter-Cologne in that it meets all the requirements of a TMDL implementation plan and the State Nonpoint Source Policy.

T16. Comm ent(s):
Public participation in the Draft TMDL was hindered by the significant delays in the release of documents and information as outlined above. Given these delays in addition to the heavy reliance on modeling in developing the TMDL, the regulatory and technical complexity of the Public Review Draft, and the sheer volume of information, the public comment period was inadequate.

Comment(s) Made By:
Hemstreet - PacifiCorp

Response:
See response to comments T8a, T8b, and T8c.

PEER REVIEW

U1. Comment(s):
This TMDL does not have any peer reviewed science. (p. 8)

Comment(s) Made By:
Cook

Response:
The Klamath River TMDL and the mainstem water quality model used in the TMDL were subjective to several rounds of peer review. In addition, the TMDL staff report relies on an extensive list of peer reviewed literature and widely used text books authored by national and international experts in the field.

Peer review interactions during 2005 and 2006 focused on the water quality model and its application to the Klamath River. The draft model was sent to the following parties for peer review in October 2005:

1) Ms. Cindy Williams, Bureau of Reclamation (BOR), Klamath Falls, OR
2) Mr. Merlynn Bender, Bureau of Reclamation, Denver, CO
3) Dr. Scott Wells, Portland State University
4) Mr. Michael Deas, Watercourse Engineering, Davis, CA
5) Mr. Daniel Henninger, Brown & Caldwell, consultant to City of Klamath Falls

Comments were received in November 2005, and responses to the comments were completed in February 2006.

California regulation requires an external scientific peer review of the scientific portions of regulatory actions proposed by any board, department or agency of the state. For the Klamath TMDL, this review was completed in early April 2009. Peer reviewers are listed in Section 11.5 of the staff report, and responses to comments of the peer reviewers are presented in Appendix 8 to the staff report. See also response to comment U20.

U2. Comment(s):
The Klamath TMDL was not peer reviewed in its entirety. Evidence is noted by the reviewers. Additionally, none of the "Peer Reviewers" have any practical experience in production agriculture. (p.1)

Comment(s) Made By:
Morris- Siskiyou County Farm Bureau

Response:
See response to comment U1 above. While it may or may not be true that none of the peer reviewers has experience in production agriculture, they were charged with reviewing the scientific portions of the TMDL, not the implementation plan.

U3. Comment(s):
Regional Board has chosen 'peer reviews' from those already proponents of prevailing 'conceptual theories', often unfamiliar with the intimate interactions of the Klamath and therefore commenting on the 'reasoning' and appearance of the report presented, not to the substantial support that would be demanded were the conclusions opposed. (p. 2)

Comment(s) Made By:
Cozzalio

Response:
See response to comment U1 above. The peer reviewers were selected through an independent process managed through UC Davis, and were selected because of their broad knowledge on established principles and related science relevant to Klamath River conditions.

U4. Comment(s):
In several areas, the peer review comments identified serious scientific shortcomings in the proposed TMDL, particularly regarding lack of calibration of the model and analysis of model uncertainty, and Staff failed to provide an adequate explanation in response. For example, Dr. Characklis emphasized the need to evaluate and more clearly describe the degree of uncertainty in model estimates of "natural" background levels and of current conditions. Dr. Characklis also found his concerns over lack of uncertainty analyses heightened by the lack of validation and corroboration of the model for California river segments, nutrient inputs, and tributary temperatures. Appendix 7, p. 6-7, 10, 16.

The Regional Board Staff responded with a list of reasons why formal quantitative uncertainty analyses were not feasible including the size and complexity of the system, limited resources, schedules, computational complexity, and data limitations. Appendix 7, p. 8-10. However, these factors do not show that uncertainty was adequately addressed based on sound science. Conclusive statements that the model performs reasonably well are not responsive to the comments that levels of uncertainty must be identified. Appendix 7, p. 8-10, 11, 15-16. Regional Board Staff did not respond to the main point that uncertainty must be addressed explicitly even given these practical constraints.

In another example, Dr. Tullos also commented that analysis of uncertainty in the bathymetry model is necessary and that the calibration scheme of the model to estimate "natural" conditions is particularly dubious. Appendix 7, p. 22, 24-25. The Regional Board's response again only provided the conclusive statement that the model was deemed sufficient for the purpose of this study and that the model performed reasonably well. Appendix 7, p. 22, 25. Staff also referenced the practical reasons identified in response to Dr. Characklis. Id. Similarly, Dr. Kondolf requested an indication of the uncertainty in the nutrient inputs. Appendix 7, p. 35. In response, Staff conclusively stated that the "Regional Water Board is confident that the model estimates provide an adequate basis for assigning initial allocations." Id. Again, these responses do not address the need for an explicit identification and discussion of the levels of uncertainty involved in model estimates. (final comments p. 42-43)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
See response to comments A TMDL Model for numerous responses to these issues. See in particular responses to comments A2, A51, A142, and A147. See also revised text in the staff report Section 2.8.1, and Attachment 1 detailing responses to the comments prepared by USGS on behalf of BOR.

U5. Comment(s):
Appendix 7, Page 2, Response M1, Paragraph 1, Line 3-4. The response correctly identifies that the system is "naturally eutrophic." Further, under existing conditions the margin for error may in fact be modest. However, application of these models in the natural baseline and compliance scenarios where background concentrations are reduced to extremely low levels increases the margin for error dramatically. (p. 62) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
First, the comment incorrectly quotes the peer review response, as no mention is made of "naturally eutrophic." Second, the peer reviewer's comment and the response do not speak to the point being made by PacifiCorp, but rather that under the natural conditions baseline, the assimilative capacity is small, thus leading to the need for large reductions to achieve TMDL allocation targets. The use of the term 'margin of error' may have been misleading, and has been changed in the text. As a final point, the Klamath can be eutrophic (i.e., highly productive) and still provide supporting conditions for its designated beneficial uses.

U6. Comment(s):
Appendix 7, Page 3, Comment M2, End of Paragraph 1. Is this "lens" stable and dependable? This question is really not answered in the Regional Board staff response. (p. 63) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The comment quotes the peer review response incorrectly and out of context. The peer review comment supports the compliance lens concept and then follows with the

correctly quoted concern: "One question about this approach is whether such a lens will form given the thermal and hydraulic conditions in the reservoir, and, if it does form, whether it will persist in the face of stochastic events such as strong winds." Conditions in the reservoir are dynamic and the oxygen requirements to maintain a compliance lens will vary based on changing weather conditions. Oxygen lenses have been used elsewhere in lake restoration projects. However, implementation of the lens will require an adaptive management approach to determine the best approach to ensure supporting conditions within the reservoir.

U7. Comment(s):
Appendix 7, Page 3, Response M2, Paragraph 1. With regards to the thickness of the compliance lens, setting this thickness to "depth of the river under pre-disturbance regime" seems rather arbitrary; it has no real basis in science or management. The minimum thickness should be whatever is required to maintain and assure stability. (p. 63) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The thickness of the lens is based on interviews with several federal, state, and Tribal fishery biologists regarding the minimum thickness that would provide supporting conditions. The thickness is more accurately described as based on best professional judgment of fisheries biologists familiar with the system. The alternative is to oxygenate the entire water column, which may not be necessary and may lead to destratification putting the colder waters in the hypolimnion at risk. These waters currently comprise the colder water supply to the fish hatchery and therefore this option is not recommended.

U8. Comment(s):
Appendix 7, Page 12, Response C3, Lines 4-8. How significant is this "release of dissolved inorganic nutrients into the water column"? What percentage of the total dissolved inorganic nutrients already in the water column does it represent? Also, there is no mention of settling that occurs in these reservoirs that would, in fact, trap some of these nutrients already in the water column and reduce the downstream river impacts from these nutrients. With free-flowing conditions, all the existing nutrients will simply be transported downstream, thus causing potential impairment in the lower river. (p. 65) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
See response to comment D10.

U9. Comment(s):
Appendix 7, Page 13, Response C4. The response to comment C4 ignores the question completely. Dr. Characklis' specifically voiced his concerns on how the temperature reductions in Copco and Iron Gate would be achieved. The response to the comment vaguely states the objective of getting the temperature of current condition water to natural conditions. For example, the Regional Board staff appears to ignore the practicality in the comment that temperature changes of 0.1 and 0.3 degrees C across Copco and Iron Gate reservoirs, respectively, are unachievable (let alone measurable). Instead, staff seems to assume that dams will have to be removed. These temperature targets are derived from a "natural conditions" scenario but there is little basis to convince the reader that they are really necessary to protect beneficial uses. (p. 65)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
First of all, the statement that the TMDL assumes that the dams must be removed is erroneous. The TMDL accounts for both dams in and dams out scenarios. The 0.1 °C and 0.3 ^{o}C estimated temperature increase attributed to Copco and Iron Gate reservoir are calculated values based on the best available information, and in this case represent the changes expected under a free-flowing river condition, as a depiction of natural receiving water temperatures, per the North Coast Basin Plan temperature objective. As a practical matter, temperature limits will be addressed in any regulatory action that implements the TMDL, based on the technological capabilities that exist at that time. With regard to the last part of the comment, the TMDL analysis demonstrates that natural receiving water temperatures, rather than being necessary to protect beneficial uses, are only the best condition achievable.

U10. Comment(s):
Appendix 7, Page 14, Response C5. Regional Board staff has devised a "compliance lens allocation" to protect fish. The comment is that this solution is conceptually interesting but untested and probably unsound. The Regional Board staff then responds that "how the allocation is met is ultimately the responsibility of PacifiCorp," but the definition of the compliance lens (the full length of the reservoir and the full width of the reservoir) is unattainable under a stratified condition because the thermocline is not coincident with the water surface (which defines the full length and width of the reservoir). For this novel, and potentially useful approach, considerably more thought and discussion is required prior to applying the concept as a regulatory requirement. (p. 65) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
Please see responses to comments D6 and D8.

U11. Comment(s):
Appendix 7, Page 14, Response C6. The response to climate change is inadequate. This is not a complicated analysis and is required for a TMDL with potentially long implementation timelines on the order of decades. The Upper Klamath Lake TMDL will take decades to implement and during this time notable climate changes may occur, increasing temperatures in an already compromised basin. Without a climate change assessment, realistic load allocations cannot be determined. Even a simple assessment can provide considerable insight (See Analysis F: Climate Change) (p. 65) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
C44: While climate change is mentioned in the text, there is no explicit mechanism to alter TMDL targets in response to climate change. The science of climate change is rapidly developing, and Regional Water Board staff expects an evaluation of anticipated climate change effects on the Klamath River to be completed as part of the Secretarial Determination process. The Regional Water Board will continue to closely monitor emerging climate change analysis to determine if there are any additional measures that should be incorporated into the Klamath River TMDL action plan. However, current watershed wide allocations call for no increase in temperature above natural conditions. Translated into the implementation plan this calls for protection of cold water refugia, maintaining or achieving site-potential shade conditions, and eliminating all discharges (e.g., sediment debris flows, irrigation return flows) that negatively impact temperature conditions. The Regional Water Board is also working closely with the USFS to develop a waiver of waste discharge related to certain federal land management activities on U.S. Forest Service lands in the north coast region. A monitoring program will be included as part of this waiver.

U12. Comment(s):
Appendix 7, Page 17, Comment C10. Dr. Characklis states that the TMDL needs more sufficient data before it can accurately assess allocations. He states there is insufficient data to make any informed judgments. The response restates the section on climate change, but ignores Dr. Characklis' concerns on insufficient data. (p. 66) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
It is important to include the quoted section since the paraphrase presented in the comment is not entirely adequate.

Comment C10:
"As with question (3) above, I also find myself wondering whether there have been trends toward increasing air temperatures in the Basin (i.e. climate change). This would be another area in which data certainly exists, and would seem important to explore when trying to identify potential sources of increased stream temperature. I do not want to be overly harsh here, but unless there is substantially more data and analysis of this issue than has been presented in these documents, my opinion is that there is insufficient information to make any informed judgments."

The Regional Water Board does not ignore this comment and makes a commitment to provide the available information on the topic of climate change and the current limited information on the topic. See response to comment above. However, we should also note the global warming modeling that is being done for the Secretarial Determination and that the results of that work will be used in the context of an adaptive management approach.

U13.   Comment(s):
Appendix 7, Page 22, Comment T8, Paragraph 1. The peer reviewer makes an excellent point that implementation and the condition of the river in the interim are not considered by the proposed allocations and targets. We agree with the reviewer's concerns about the use of limited data and the claim of an "implicit margin of safety." As stated "an analysis of model uncertainty is absolutely warranted." (p. 66) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The commenter is correct in noting that the TMDL allocations and targets represent a compliant condition. See response to comment below regarding interim period issues We could find no reference in the cited peer review comment regarding use of limited data, margin of safety, or analysis of model uncertainty.

U14.   Comment(s):
Appendix 7, Page 26, Response T13, Paragraph 1. Regional Board staff seem to ignore the very important point made in this comment, which is that Regional Board staff should "consider how the TMDL targets can be met during the interim period between approval of the targets and decommissioning." (p. 66) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
This is an important issue on which much progress has been made in recent months. The Klamath Hydropower Settlement Agreement incorporates conditions for TMDL compliance during the period between TMDL adoption and dam decommissioning, should decommissioning proceed. The proposed tracking and accounting program is another mechanism proposed to open opportunities for TMDL compliance during the interim period. PacifiCorp's compliance plan, to be submitted within 60 days after TMDL adoption by the Regional Board, should also provide insight on this question. In any case, Regional Water Board staff acknowledge that TMDL targets represent final compliance, and that compliance will take time to achieve.

U15. Comment(s):
Appendix 7, Page 29, Response K4, End of Paragraph 1. Are proposed DO objectives calculated from local air temperature and air pressure? We note that the Regional Board staff states that the "natural conditions baseline modeling scenario" didn't meet life-cycle and DO objectives. (p. 66) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
DO objectives account for elevation (and this barometric pressure), and are also based on achieving natural receiving water temperatures, as depicted through the modeling runs. See Appendix 1 to the staff report for additional discussion of this issue.

U16. Comment(s):
Appendix 7, Page 34, Response K13, Paragraph 1. Regional Board staff state that "excess accumulation of periphyton…appear to play an important role in high levels of parasite infection." Is this a hypothesis or does it derive from research? There is no citation associated with this statement. (p. 66)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
This comment is related to one of the questions posed to the peer reviewers – which asked them to review the water quality link to fish disease conceptual model. Each of the peer reviewers responded that the conceptual model was consistent with the state of the science. The quoted text comes from extensive interviews with the Dr. Jerri Bartholomew and Rick Stocking (among others) who have conducted the primary research on this topic in the Klamath River. For more information on this topic refer to response to comments B33, B36, B37, and B39.

U17. <u>Comment(s):</u>
Appendix 7, Page 34, Comment and Response K14. The comment is correct – that tributary contributions play a dominant role in thermal refugia form and function, with different effects in the upper reaches than in the lower reaches. Different tributary contributing watershed areas for flow and mainstem stage and flow play vital roles. Review of the draft TMDL did not reflect the basic processes at work in refugial areas near creek-main stem confluences. There is extensive exploration of these processes in Klamath River refugia completed by USBR that were ignored in the draft TMDL. (p. 67) (PacificCorp – Appendix A and B.doc)

<u>Comment(s) Made By:</u>
Hemstreet – PacifiCorp

<u>Response:</u>
Regional Water Board staff drew from thermal refugia literature specific to the Klamath River, as indicated in section 6.5.4.1. Regional Water Board staff acknowledge the Bureau of Reclamation work, and would note that the intent of the implementation plan section was not to provide a detailed description of processes at work in these areas, but to identify the importance of protecting them.

U18. <u>Comment(s):</u>
Appendix 7, Page 35, Response K19. Two citations were added to the document. Over half a dozen references on extensive thermal refugia work in the Klamath Basin were included with Chapter 4 comments. This seminal work – completed by Reclamation in cooperation with the Yurok and Karuk Tribes – was submitted the Regional Board staff in response to a request for thermal refugia information but this information was apparently not considered. (p. 67) (PacificCorp – Appendix A and B.doc)

<u>Comment(s) Made By:</u>
Hemstreet – PacifiCorp

<u>Response:</u>
Regional Water Board staff were aware of the majority of the documents submitted prior to their submission. However, the works submitted, while representing a significant level of effort and analysis, are limited in applicability to the questions under consideration as part of the TMDL temperature analysis , as they primarily address the size and extent of the refugial areas investigated in relation to changing flow and meteorological conditions. The submitted reports do not address effects of sediment delivery from tributaries and thus are not informative on this topic. Furthermore, the submitted reports focus on only three discrete thermal refugia sites, with most of the work focused on one site (Beaver Creek). The absence of these reports from our list of references does not mean they were not considered.

U19. Comment(s):

Numerous presentations before the Board of Supervisors at the August 25th Special Meeting convened to discuss the Draft TMDL by various knowledgeable interests, gives clear indication to the Board of Supervisors that the Draft TMDL is replete with flaws in science as well as the logic applied to the cited science. Agency action, particularly with regard to the massive land area and profound socio-economic effects involved, cannot be initiated without compelling, rigorous scientific justification. Peer review, as suggested in President Obama's March 9, *2009, Memorandum on Scientific Integrity,* is a good place to start. (p. 4)

Comment(s) Made By:

Kobseff – Siskiyou County Board of Supervisors

Response:

See response to comment U1 above.

U20. Comment(s):

The Regional Board Staff failed to include Chapter 6, the Implementation Plan, and Chapter 7, the Monitoring Program, in the package of materials submitted to the peer reviewers. These two chapters should have been included in the peer review package because they included scientific portions of the proposed rule as well as supporting information for the other chapters submitted. Indeed, one reviewer stated that it is "difficult" to evaluate the proposed TMDL, "impossible" to understand the impacts of the targets, and "impossible" to consider whether this TMDL is achievable without these chapters. Appendix 7, p. 21-22, 26. In response, the Regional Board staff stated that the Chapters were not completed when materials were sent to peer reviewers. The response also stated that the Regional Board did not include these chapters in the scope of technical peer review. Regardless of whether the chapters were completed at the time materials were sent to peer reviewers, the chapters contained scientific portions of the rule or supported or explained the scientific portions and they should have been submitted to peer review.

Comment(s) Made By:

Hemstreet – PacifiCorp

Response:

Section 57004 requires peer review of the scientific basis or scientific portion of any regulation adopted by the boards, including basin plan amendments. "Scientific basis" or "scientific portion" is defined as "those foundations of a rule that are premised upon, or derived from empirical data or other scientific findings, conclusions, or assumptions establishing a regulatory level, standard, or other requirement for the protection of public health or the environment." Although you did not identify what information in Chapters 6 and 7 you believe contain scientific portions of the proposed rule as well as supporting information for the other chapters submitted, it is our belief that all of the information that could be characterized as “scientific” in the Implementation Plan and Monitoring Program was also located in the chapters that were submitted for review.

Where the proposed rule is based upon issues of policy, no peer review is required. Similarly, where the scientific basis has already been peer reviewed, peer review need not be repeated. This means that the regional boards do not need to submit for peer review those items that are the result of policy decisions or that are standard regulatory practices, such as National Pollutant Discharge Elimination System (NPDES) permits, Water Quality Certifications under the Clean Water Act, Waste Discharge Requirements (WDRs), Waivers under 13269 of the Water Code, or discharge prohibitions under Water Code section 13243. Both Chapter 6, the Implementation Plan, and Chapter 7, the Monitoring Program, fall into these categories.

The Implementation Plan does not specifically set out requirements of responsible parties, but instead requires compliance with permits, waivers, prohibitions, or other regulatory requirements, or submission of a plan for implementation of the TMDL. For example, PacifiCorp is required to submit a proposal for implementation for Regional Water Board approval within 60 days of the date of TMDL adoption. Because the Implementation Plan does not set out specific actions that must be undertaken, but instead requires responsible parties to identify actions that they will take to comply with the TMDL, such as development and implementation of a water quality management plan to implement the TMDL, it would have been impossible for the reviewers to specifically comment upon the effectiveness of implementation actions. As noted in our responses to peer review, implementation issues will be subject to an ongoing adaptive management processes, and because of they are related to issues of policy, are outside the scope of the technical, scientific review. (See Response to Comment T11, p. 24.)

DATA and QAQC

V1. Comments:
Overall the technical analysis presented in the Klamath TMDL is scientifically rigorous and provides a solid foundation for remediation of the river's pollution problems. (p. 2)

Comment(s) Made By:
Fetcho – Yurok Tribe
Crosby – Karuk Tribe
Bowman – Quartz Valley Indian Reservation

Response:
Thank you – no response required.

V2. Comments:
It would provide assurance to local people that in any report, document, or decision the RWQCB is making that a licensed professional's stamp be on any and all data. A licensed professional is accountable to the state as I. I would bet that Tetra Tech is handling their own data with this professionalism. However, to better explain this need, any environmental group (Sierra Club, Klamath River Keepers), etc… that submit data without a licensed stamp – simply discard the data. (p.2)

Comment(s) Made By:
Simon

Response:
Source information is available for all of the monitoring data used by the Regional Water Board in its analyses. The Regional Water Board evaluates the available Quality Assurance / Quality Control (QA/QC) for all data obtained. Data sources include PacifiCorp, United State Geological Survey, Bureau of Reclamation, US Fish and Wildlife Service, CA Division of Water Resources, Yurok Tribal Environmental Program, Karuk Tribe Department of Natural Resources, Oregon Department of Environmental Quality, U.S. Environmental Protection Agency, the North Coast Regional Water Quality Control Board and others, all of whom operate under programs with documented QA/QC protocols. Though none of the data obtained was submitted with a "professional stamp," the QA/QC process is considered the standard of practice in water quality monitoring to assure that data are appropriately evaluated for quality before being used in analysis and decision-making. No data was submitted for use by Klamath River Keepers or Sierra Club. If data were to be submitted by them or any other organization, he same standards for review and use would be applied to them as is applied to organizations already submitting data. The intent of the comment is to probably meant to ensure that data of high quality is used in the analyses. The Regional Water Board has performed due diligence to ensure the integrity of the environmental data used in the TMDL technical studies.

V3. Comments:
There is a virtual total lack of site specific unbiased repetitive physical data to support conclusions (Chapter 2 alone has used over 270 subjectives. "We believe, it may, it could", etc, determining conclusions based upon conjecture). (p. 2)

Comment(s) Made By:
Cozzalio

Response:
The Regional Water Board disagrees with this comment. There is a large amount of quality assured data supporting the Regional Water Board analyses (please refer to response V2 for a partial list of data sources. The qualifiers relate to the lines of evidence approach used by the Regional Water Board and leave room for other interpretations or uncertainty. The analysis is technically sound and the conclusions represent a reasonable interpretation of the best available data and information.

V4. Comments:
Most estimates are based on minimal testing performed sporadically within a short timeframe involving conjecture in place of defective or non-conforming data frequently pieced from multiple party performance (e.g. Shasta River DO testing and Klamath Iron Gate periphyton 'study'). (p. 3)

Comment(s) Made By:
Cozzalio

Response:
The Regional Water Board disagrees. Many lines of evidence were assembled for the analysis, some of shorter tem duration and others much longer. The short-term results displayed were simply to illustrate a longer term trend or pattern (e.g., diurnal DO swings). Lines of evidence were consistent in illustrating severe impacts and a general lack of supporting conditions for beneficial uses.

V5. Comments:
Biased orientation of the text of text in the TMDL (e.g. selective inclusion of references that support water quality's position excluding recognition of all other studies contradicting water quality's direction such as: 2008 Columbia Sockeye Report, 2008 Columbia/Frasier tagged salmon study, 2008 Columbia salmon transport study, Rykbost Klamath created marsh evaluations, Klamath tagged salmon transport study, BOR Klamath scouring study, etc). (p. 1)

Comment(s) Made By:
Cozzalio

Response:
The Regional Water board disagrees with this comment. The best and most current information available was used in the analyses. There was no attempt to exclude information on any basis other than QA/QC concerns. Several hundred references were reviewed and cited in the analysis. For example, studies reported by Rykbost were reviewed and cited in the analysis.

V6. Comments:
Appendix B contains a list of key reports and documents that were not used or cited in the draft TMDL. Omission of these key reports and documents indicates that even a basic review of available reports and data was not completed, but rather a selective set of data were used in the TMDL analysis and development of load allocations. (final comments p.3)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The Regional Water board does not agree with this comment. No key studies were excluded, every effort was made to include relevant information and a more than adequate amount of data and studies were reviewed to make a sound assessment of conditions. As indicated by independent peer review comments the assessments represent the best available science. The TMDL project team reviewed many of the documents listed in this appendix but did not use them as a primary citation. In addition, Appendix B includes reports that have been used and cited in the TMDL staff report. The TMDL analysis includes more references, the most recent references than any previous study conducted on the Klamath River. Much of the data used in the analyses was provided by PacifiCorp.

V7. Comments:
The data used in the Draft TMDL does not include or cite many key water quality studies and data for the Klamath River Basin. Listed in the attached Appendix B to this comment document are key reports and documents that were not used or cited in the draft TMDL. Omission of these key reports and documents indicates that even a basic review of available reports and data was not completed, but rather a selective set of data were used in the TMDL analysis and development of load allocations to support a particular view of Klamath River conditions. (p. 2) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
Refer to response V7.

V8. Comments:
Page 2-16, Paragraph 1, Lines 1-3. The Draft TMDL indicates that the CA NNE boundary target is "based on a review of both regional and international studies and the recommendation of university and regional experts". Please cite the studies and provide documentation of the recommendation of experts for the target as it pertains to the Klamath River. (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The requested information is provided in the referenced document: Tetra Tech. 2006. TECHNICAL APPROACH TO DEVELOP NUTRIENT NUMERIC ENDPOINTS FOR CALIFORNIA. July 2006. Prepared for: U.S. EPA Region IX. (Contract No. 68-C-02-108-To-111). California State Water Resource Control Board; Planning and Standards Implementation Unit. Prepared by: Lafayette, CA, Research Triangle Park, NC. In addition, the technical basis for the regional and international studies was demonstrated on a site-specific basis for the PacifiCorp facilities in the TMDL staff report.

V9. Comments:
On Page 4-1 (in paragraph 3, after bullet points), the Draft TMDL notes that the analyses draw upon the most current quality assured data available from ongoing monitoring. However, the data used in the Draft TMDL does not include or cite many key water quality studies and data for the Klamath River Basin. Listed below are key reports and documents that were not used or cited in the draft TMDL. Omission of these key reports and documents indicates that even a basic review of available reports and data was not completed, but rather a selective set of data were used in the TMDL analysis and development of load allocations. All of the reports and documents cited below *(list in original comment letter)* are publicly available, and therefore should be easily accessible by Regional Board staff. If Regional Board staff have difficulty in obtaining any of these reports or documents, PacifiCorp can provide copies upon request. Otherwise, PacifiCorp assumes that the listed documents are hereby incorporated into the record. (p. 69) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The listed documents will be incorporated into the record. The documents have been obtained and reviewed by the Regional Water Board staff and they will be included in the

administrative record for this project. These materials did not support any revisions to the existing lines of evidence used in the analysis. Also refer to comment response V6.

V10. <u>Comments:</u>
The County informed the Board's staff last spring that the primary problem with water issues through the years in the Klamath Basin was the failure to use all the existing data to make decisions. The Report indicates that that trend is continuing. The County is disappointed that the citizens of the Klamath River watershed will bear the brunt of a hurried-up document because the time wasn't taken to gather and analyze all the existing information. (p.7)

<u>Comment(s) Made By:</u>
Cantrall – Modoc Co Board of Supervisors

<u>Response:</u>
The Regional Water board does not agree with this comment. The Regional Water Board used information and data from a wide-variety of sources and was able to assemble the single largest database of references and monitoring data that exists within the basin. See also responses to comments V2, V3, V4, V5, and V6.

V11. <u>Comments:</u>
In several instances, the Regional Board used information from interested parties to support its decisions without making that information publicly available or without disclosing the criteria used for such decision-making. Principles of fairness require that an agency make information available that served as the basis for its decisions. An agency may not use the public proceeding as a façade for a private decision resting upon privately acquired data. *California Optometric Ass'n v. Lackner* (1976) 60 Cal.App.3d 500, 510-511.

In evaluating solutions to achieve water quality objectives, the Regional Board can take several factors into account, including political, social, and economic factors, provided that the criteria for making decisions regarding these solutions are established. SWRCB Impaired Waters Guidance at p. 5-19. The Regional Water Boards have broad discretion in determining how to address water quality impairments. Nonetheless, public agencies must comply with fair procedures.

The modeling and technical analysis supporting load allocations assigned to the Project are designed so that compliance is not expected without dam removal. The Regional Board staff's response to one peer reviewer's comment suggesting "a discussion on how this TMDL might restrict or otherwise effect plans for removal of the 4 dams" is simply that "based on the TMDL modeling analysis, the TMDL allocations and targets would be achieved should the dams be decommissioned." Appendix 7, p. 25-26. The Public Review Draft TMDL compares the nutrient loadings for dams-out and dams-in scenarios and states that "[t]his comparison highlights the difficulty of meeting water quality objectives and supporting beneficial uses throughout the Klamath River in California with the PacifiCorp facilities in place." p. 5-22 The modeling supporting these assumptions is inaccurate. In addition to these technical flaws, the process of developing the modeling supporting this conclusion was fundamentally unfair. (final comments p.47-48)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The Regional Water Board staff complied with all required procedures, and provided extensive outreach and opportunity for stakeholder involvement as detailed in Chapter 11 and other sections of the Staff Report. Regional Water Board staff has made best efforts to promptly provide any and all documents requested by PacifiCorp and other stakeholders. Please see A168 and Attachment 2. Load allocations must be viewed in context with what is required in the implementation plan. The Klamath TMDL implementation plan provides sufficient flexibility and time to evaluate various solutions for achieving water quality standards. For a detailed discussion on the consideration of relevant factors, please see K54.

SITE SPECIFIC DISSOLVED OXYGEN OBJECTIVE

W1. Comment(s):
The superficial evaluation of the ramifications of the proposed DO objective does not satisfy the stringent requirements of these laws. (see Cal. Water Code 13000, 13241, 13242) (p. 15)

Comment(s) Made By:
Addington & Danosky – Klamath Water Users Association & Tulelake Irrigation District

Response:
The revised Staff Report for the Site Specific Objectives (SSOs) for Dissolved Oxygen (DO) (Appendix 1 of the TMDL Staff Report) includes a new Chapter 8 in which the factors listed in Section 13241 of the Porter Cologne Act are assessed with respect to the proposed Basin Plan Amendment for DO in the Klamath. In addition, Chapters 9, 10, 11, and 12 of the DO Staff Report refer the reader to the TMDL Staff Report for discussions of public participation, implementation, economics, and CEQA, respectively. The final DO Staff Report will be further revised to more directly refer the reader to the Klamath TMDL Staff Report for a discussion of monitoring, as well. Thank you for highlighting these issues.

W2. Comment(s):
USEPA Region 9 withholds comments on the Site Specific Objectives for DO at this time. But, it provides the elements necessary for inclusion in the State's water quality standards when submitted to EPA for review and approval. Further, USEPA Region 9 identifies the need for the staff report to support the simulation of "natural conditions" using the hydrodynamic model used for the Klamath TMDL and to demonstrate that the proposed Regional Board dissolved oxygen objectives are consistent with downstream objectives.

Comment(s) Made By:
Hashimoto– USEPA

Response:
Regional Board staff appreciate the assistance USEPA Region 9 staff have offered in the development and review of the SSOs for DO prior to the release of the staff report as contained in Appendix 1 of the Klamath TMDL staff report. The Staff Report for the revision of the SSOs for DO (December 2009) includes a discussion of the hydrodynamic model used for the Klamath TMDL and its application in estimating "natural conditions." It also provides a discussion of compliance with downstream objectives.

W3. Comments(s):
Chapter 2, Section 2.2.1.2, Page 6 states: "The first set of objectives included on page 3-4.00, are minimum DO levels for various beneficial uses. "Nothing on page 3-4 specifically states these objectives. Please add objectives in TMDL document.

Comment(s) Made By:
Hicks – U.S. Bureau of Reclamation

Response:
A discussion of the DO objectives is found on page 2-6 through 2-8 of the revised TMDL staff report. The statement identified by the reviewer regarding page 3.-4.00 is referring to page 3-4.00 of the Basin Plan. We apologize for the confusion.

W4. Comment(s):
Chapter 2 - Section 2.2.1.2, Page 2-6 states: "Upstream of the Iron Gate Dam, the instantaneous minimum concentration of DO required is 7.0 mg/L. Half of the monthly mean DO values for the year must also be 10.0 mg/L or greater.
Downstream of the Iron Gate Dam, the instantaneous minimum concentration of DO required is 8.0 mg/L. Half of the monthly mean DO values for the year must also be 10.0 mg/L or greater."

These dissolved oxygen concentrations are unrealistically high, since they are greater than 100% saturation at the elevations and "natural background" temperatures listed in Section 2.4.2 of this document. At a location immediately downstream of Iron Gate Dam (elevation of 2,162 feet above NAVD 1929) with a water temperature of 23.0C, 100% dissolved oxygen saturation is approximately 7.9 mg/L. The reviewer strongly recommends the revision of the numeric dissolved oxygen objectives to reflect dissolved oxygen concentrations that are appropriate for the water temperatures and the elevations within the Klamath River Watershed.

The reviewer recognizes that the Staff of the North Coast Regional Water Quality Control Board intends to propose revision to the Basin Plan to implement more reasonable dissolved oxygen objectives to be "…a minimum 85% saturation limit, as calculated based on natural water temperatures, will be proposed. Additionally, the proposed revision will state that in no case will the DO fall below 6.0 mg/L as an instantaneous minimum."

Comment(s) Made By:
Hicks – U.S. Bureau of Reclamation

Response:
Appendix 1 of the TMDL Staff Report includes Regional Water Board staff's proposal to the Regional Water Board for the revision of the existing SSOs for DO in the mainstem Klamath River. The existing DO objectives were developed from many years of data collection headed by the Department of Water Resources in the 1950s and 1960s.

Because the data were collected by grab sample during daylight hours, they represent DO saturation values sometime greater than 100% due to photosynthetic activity. Staff proposes their revision because 24-hour monitoring data can not appropriately be compared to the existing objectives.

Based on the rerun of the TMDL model, DO saturation under natural conditions in the mainstem Klamath is predicted to vary from 85% (upstream of the estuary) up to 98% depending on the location and the month. This being the case, staff has restructured the proposed revision of the SSO for DO as follows:

Waterbody/Reach	Percent DO Saturation under natural receiving water temperatures	Time period
Stateline to Scott River	90%	October 1 through March 31
	85%	April 1 through September 30
Scott River to Hoopa	90%	Year round
Hoopa to Turwar	90%	September 1 through May 31
	85%	June 1 through August 31
Turwar to Hunter Creek	85%	September 1 through July 1
	80%	August 1 through August 31
Hunter Creek to mouth	For the protection of estuary habitat (EST), the dissolved oxygen content of the lower estuary shall not be depressed to levels adversely affecting beneficial uses as a result of controllable water quality factors.	
These objectives apply throughout the length of the mainstem Klamath River except for where there is Tribal jurisdiction.		

Further, staff has removed the proposal that 6.0 mg/L be established as an absolute minimum because the TMDL model indicates that the proposed revised SSOs for DO already result in DO concentrations greater than 6.0 mg/L at all times.

W5. Comment(s):

The dissolved oxygen standard of 85% saturation is not reasonable under the varying conditions of the river when it is based upon conjectured historically non existent ‘natural background’ temperature estimates, rather than using ‘actual’ current water temperatures. By doing so, in conjunction with already exaggerated ‘safety margins’ for dissolved oxygen minimums in excess of 6 mg/l which is unjustified on a ‘blanket’ coverage, determines an inability for those conditions to ever be realistically met. (p. 4)

Comment(s) Made By:

Cozzalio

Response:
The commenter raises several issues as follows: 1) the need to account for the variability in DO, 2) the unreliability of estimated natural temperatures as representative of actual historical conditions, 3) the unreasonableness of using estimated natural temperatures rather than actual temperatures, 4) the excessive (exaggerated) safety margin as represented by the 6.0 mg/L absolute minima, 5) the poor justification for applying a single safety factor to the whole mainstem, and 6) the improbability of achieving the proposed objective.

One, a given percent DO saturation results in varying DO concentrations over the course of time, primarily as a function of the change in temperature. Regional Water Board staff account for the variability in DO by proposing a percent DO saturation criterion rather than a static concentration limit which is more typical.

Two, natural temperatures in the Klamath River were estimated considering two primary factors: unimpaired flow and riparian shade conditions. A third factor, the unimpaired volume of cold spring water, was also estimated; but, only for those locations where cold springs have a significant influence on the temperature of the surface water downstream. These factors were estimated using well-established scientific methods and represent only the most significant factors influencing stream temperature. Less significant factors and historic factors more difficult to estimate were not considered. As a result, the estimate of natural temperatures is robust and well-supported by science.

Of particular note is the importance of unimpaired flows in the mainstem to the estimate of mainstem temperatures. There is insignificant uncertainty with respect to these estimates, resulting as they do from very well studied and vetted data collection, analysis, and modeling. Greater uncertainty exists in the estimates of natural temperatures in the minor tributaries due to the limited data available there. However, the influence of minor tributaries on mainstem temperatures is insignificant.

Three, a water quality objective is established to protect the most sensitive beneficial uses of the waterbody in question. In the case of the mainstem Klamath River, the most sensitive beneficial use is the use by salmonids for migration, spawning, incubation, and rearing. The Regional Water Board can not establish life cycle-based water quality objectives for the mainstem Klamath River because the DO concentrations associated with salmonid life cycle requirements can not be met even under natural conditions—conditions in which there are no anthropogenic influences. As such, the Regional Water Board staff has proposed water quality objectives that protect natural DO conditions from further degradation.

Percent DO saturation is used as the tool for estimating natural DO conditions. But, this can only be accomplished if the corresponding concentration values are calculated based on estimates of natural temperature. Were the DO concentration values associated with the percent DO saturation criteria to be calculated based on actual receiving water temperatures, then the criteria would not represent natural conditions; but current conditions. As demonstrated by the threatened and endangered status of salmonid species in the Klamath, as well as the water quality impairment analysis as represented by the TMDL, the existing DO conditions are unsuitable for the protection of the beneficial uses of the mainstem Klamath.

Four, the 6.0 mg/L DO absolute minima was proposed as a means of ensuring that salmonids would be provided with the minimum DO necessary to make successful use of the habitat available in the mainstem. The absolute minimum has been eliminated from the draft final proposal because further analysis indicated that concentration values associated with application of the proposed percent saturation criteria always exceed 6.0 mg/L DO. Thus, the absolute minimum is unnecessary and duplicative.

Five, the justification for applying the 6.0 mg/L DO as an absolute minimum throughout the mainstem Klamath is based on the life cycle requirements of salmonids, the most sensitive of the beneficial uses in the mainstem. A DO less than 6.0 mg/L can act as a barrier to use of the habitat by salmon. Given that salmon have been barred from the use of a large portion of their historical habitat in the Klamath watershed (e.g., upstream of Iron Gate Dam), Regional Water Board staff proposed the 6.0 mg/L as protection against any further loss of access to available habitat. All of the available salmonid habitat should remain available to salmonids as one of the means of supporting their recovery.

Six, the Klamath TMDL model has been run to establish the load and waste load allocations necessary to meet the water quality objectives, including the proposed DO objective. The Klamath TMDL model indicates that the proposed DO objectives are achievable.

W6. Comment(s):
Page 4-34, Last Paragraph. There is no presentation of dissolved oxygen data. At a minimum a description of data used, methods for filling data gaps and other assumptions outlined, and graphical and tabular presentation of dissolved oxygen data along with corresponding dissolved oxygen saturation percentage should be provided. Without such information, review of assumptions is not possible.

Review of the model input files identifies that all minor tributaries to the Klamath River are placed at 90 percent of saturation under current conditions and 100 percent of saturation under natural baseline condition. This important assumption is undocumented in the TMDL. What is the basis for this assumption? Limited grab sample and water quality probe data suggest many of these tributaries are oligotrophic and, with perhaps the exception of sediment and in some cases temperature, have dissolved oxygen concentration at saturation. Why place a dissolved oxygen impairment on these tributaries where none may exist. At a minimum a sensitivity analysis should be completed and clear documentation of the conditions and results presented. (p. 42) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
Chapter 4 of the Klamath TMDL Staff Report (pages 4-1 through 4-34) is the Pollutant Source Analysis. As described in the first paragraph of this chapter, "the purpose of a TMDL pollutant source analysis is to inventory and describe all sources of pollutants that are impacting the water quality standards of the impaired waterbody." DO is not considered a pollutant source, but one of the water quality parameters affected by pollutant sources. As such, Chapter 4 does not include a discussion of DO data, data gaps, and other assumptions with respect to DO; but, focuses on organic matter, nutrient and temperature loading as pollutant sources.

Chapter 2, describing the Klamath River Problem Statement, provides a conceptual model of the relationship among stressors (e.g., pollutants), environmental conditions (e.g., DO concentrations and diurnal fluctuation), responses/outcomes (e.g., decreases spawning and reproductive success), and beneficial use impairment (e.g., loss of salmonid fishery). It also provides in tabular and graphical form the results of DO data collection in the mainstem Klamath River. With respect to the DO data used to populate the Klamath TMDL model, a summary is given in Chapter 3, Analytic Approach, and a detailed description is given in Appendix 6, Klamath River Model for TMDL Development.

Thank you for your keen observation and detailed review with respect to the question of DO saturation values assigned to tributary streams. The difference in DO saturation assigned to tributaries between the compliance and natural conditions scenarios was an artifact of the length of time over which the Klamath TMDL model was developed, reviewed, revised, and run. The last revision of the model made consistent the DO saturation values assigned to tributaries in both the compliance and natural conditions scenarios. The new assignments are based on a review of historic DO saturation data and represent unimpaired conditions. As described in the DO Staff Report (Appendix 1 of the TMDL Staff Report), the newly assigned percent saturation boundary conditions are as follows:

1. For minor tributaries, 100% saturation
2. For the Shasta, Scott and Salmon Rivers, 95% saturation
3. For the Trinity River, 100% saturation

W7. Comment(s):
Volcanic terrain drainage often results in water percolating into underground aquifers and arising as very high quality water, such as in the case of the Williamson River above Upper Klamath Lake. While phosphorous from volcanic terrain would have enriched aquatic ecosystem productivity somewhat, much of it would have been trapped before delivery to the water column by hundreds of thousands of acres of wetlands, marshes, and riparian zones that surrounded lakes and streams before disturbance.

Comments Made By:
Fetcho – Yurok Tribe

Crosby – Karuk Tribe
Bowman – Quartz Valley Indian Reservation

Response(s)
Regional Water Board staff agrees that a large proportion of the nutrients delivered to the Klamath River are a result of the loss of wetland habitat in the upper Klamath basin where nutrients were historically sequestered in the wetland vegetation and soils. Staff also acknowledges that the Klamath TMDL model does not fully take into account the buffering capacity of the extensive wetlands system of the upper Klamath basin as part of the T1BSR (natural conditions) run. However, it is not correct to say that much of the naturally produced phosphorus of the upper basin would have been *trapped* by historic wetlands. In that period of history when there were vast, functioning wetlands in the upper basin, they more likely served to *meter* the release of nutrients and organic matter downstream to the Klamath River rather than trap them. Regional Board staff asserts that the naturally high productivity of the upper Klamath basin serves to cause a diurnal fluctuation in DO downstream; but, staff acknowledges that the diurnal fluctuation has been exaggerated by the modification of upper basin wetlands.

W8. Comment(s):
Extensive marshes and wetlands surrounding Upper and Lower Klamath Lakes created slightly acidic conditions that limited some forms of blue-green algae, such as *Aphanizomenon flos aquae*. The latter was not present 100 years ago and only became well established after extensive destruction of the marshes following World War II. It now produces enormous quantities of nitrogen. When the Klamath River was nitrogen-limited and marsh buffer and filter capacity was still intact, mainstem conditions may not have had the excessive nutrients to cause periphyton blooms and associated DO variability.

Comments Made By:
Fetcho – Yurok Tribe
Crosby – Karuk Tribe
Bowman – Quartz Valley Indian Reservation

Response(s):
Regional Board staff agrees that the modification of wetland habitat in the upper basin has served to modify the nutrient dynamics and exaggerate the diurnal fluctuation in DO.

W9. Comment(s):
Water temperature conditions before mining, deforestation, dam construction and massive sedimentation were likely moderated by mainstem Klamath River hyporheic function. Thus DO would have been higher because water temperatures were likely historically lower before watershed disturbance. Due to complexities and uncertainties, hyporheic cooling is not included in the Klamath TMDL models, and thus is not reflected in model outputs for the natural condition scenario.

Comments Made By:
Fetcho – Yurok Tribe
Crosby – Karuk Tribe
Bowman – Quartz Valley Indian Reservation

Response(s):
Regional Water Board staff agrees with the commenters that hyporheic flows serve to moderate surface water temperatures in a free flowing river; though the significance of this effect on a river the size of the mainstem Klamath is unknown. Regional Water Board staff also agrees that as a general matter, water temperatures were lower in the mainstem Klamath before watershed disturbance than they are now. This is amply demonstrated by the Klamath TMDL for temperature. It is because of the availability of estimates of temperature under natural conditions as provided by the Klamath TMDL that use of percent saturation and natural temperatures as a surrogate for natural DO conditions is possible as a water quality objective.

The commenters are correct that hyporheic flow is not included in the Klamath TMDL models, the lack of which may have a minor effect on results. But, Regional Water Board staff does not believe the effect to be significant, except in localized areas of thermal refugia. And, the Klamath TMDL provides an alternate mechanism for identifying and protecting thermal refugia.

W10. Comment(s):
Standards that cannot be met are not practical, but ascribing current impairment in conditions as partially natural may be in error and does not foster a sense of urgency in what is a critical problem with DO in some reaches of the mainstem Klamath River. While one of the largest concentrations of spawning Chinook salmon in the Klamath River occurs immediately below Iron Gate Reservoir, DO problems are pervasive during the spawning season (after September 15) on the mainstem below Iron Gate Dam.

Comments Made By:
Fetcho – Yurok Tribe
Crosby – Karuk Tribe
Bowman – Quartz Valley Indian Reservation

Response(s):
Water quality standards are developed to protect the beneficial uses of the waterbody in question. In the case of DO in the mainstem Klamath River, Regional Water Board staff has determined that ensuring ambient water quality conditions do not vary substantially from natural background conditions provides the best means of protecting the beneficial uses of the waterbody, notably spawning salmonids. Regional Water Board staff believes that by establishing *natural conditions* as the basis for the proposed DO standard, we are unequivocally highlighting the critical nature of the current problem associated with DO in the mainstem Klamath.

The December 2009 proposed revised Site Specific Objectives (SSOs) for DO has been modified to provide even greater protection during the spawning season. That is, a 90% DO saturation criteria as calculated from estimates of natural temperature is proposed for application during the months of October 1 to March 31 in that portion of the mainstem from the Stateline to the Scott River, year round from the Scott to Hoopa, and September 1 through May 31 from Hoopa to Turwar.

W11. Comment(s):
We have concerns that the proposed DO standards may regard tailwater flows below Iron Gate dam as being in compliance with the TMDL and Basin Plan when in fact they reflect acute impairment. To help us assess whether we should support the proposed revisions to the DO criteria, we would like to see what the 85% saturation dissolved oxygen concentrations are under the TMDL's natural conditions scenario for various locations along the Klamath River, including Iron Gate Dam.

Comments Made By:
Fetcho – Yurok Tribe
Crosby – Karuk Tribe
Bowman – Quartz Valley Indian Reservation

Response(s):
The proposed revised SSOs for DO in the mainstem Klamath are derived from data output from the natural conditions run (T1BSR) of the Klamath TMDL model. In T1BSR, the California portion of the river is simulated as free-flowing with no impoundments from the Stateline to the Pacific Ocean. Thus, the SSOs for DO at the location now downstream of Iron Gate Dam—as throughout the river—represent natural conditions without the presence of impoundments.

The December 2009 DO Staff Report (Appendix 1 of the Klamath TMDL Staff Report) includes as Table 7.4 the concentration values associated with the percent saturation criteria as calculated using estimated natural temperatures. The concentration values are given for locations throughout the mainstem Klamath, including downstream of Iron Gate Dam.

W12. Comment(s):
Discussions of setting criteria are necessary, but non-normative water quality events in the mainstem Klamath River may be a greater concern with regard to fish health and source of juvenile salmonid mortality. The Regional Water Board needs to increase efforts to explore whether rapid changes in flow are linked to pollution events and fish mortality. If the hypothesis is upheld by patterns in data, then the Regional Water Board should join in discussions between the US Bureau of Reclamation, US Fish and Wildlife Service, National Marine Fisheries Service and the Tribes on flow releases at Iron Gate dam to minimize algae bed shedding.

Comments Made By:
Fetcho – Yurok Tribe
Crosby – Karuk Tribe
Bowman – Quartz Valley Indian Reservation

Response(s):
Regional Board staff agrees with the commenters regarding the importance of non-normative water quality events, as well as the commenters' particular concern regarding the effects of rapid changes in flow. As a result of discussion and research on the topic of flow in the Klamath basin over the last few years, Regional Board staff has developed a narrative flow objective, now contained in Region 1 and 2's draft Stream and Wetland Policy, to apply throughout both regions, including the Klamath River. The Stream and Wetlands Policy is currently being peer reviewed and will be released for public review and Regional Water Board consideration in 2010. If adopted as currently written, the narrative flow objective would require in essence that the natural pattern and range of flows be protected to ensure protection of beneficial uses and a functional ecosystem.

FLOW

X1. General Response:

The Regional Water Board received numerous comments on water quantity and flows, many focused on low flows in the Scott and Shasta tributaries. The Karuk Tribe and several environmental groups request that the Regional Water Board address flow issues in the Scott and Shasta Rivers in its Klamath TMDL. They request that the TMDL recognize the connection between groundwater and surface water particularly in the Scott watershed. They also request higher flows to offset warm temperatures, by either the TMDL, through the State Water Board's administration of water rights, or other agency action.

In contrast, Siskiyou County officials and other individuals submitted comments challenging any action by the Regional Water Board that concerns flow, and request that any reference to the issue be removed from the TMDL for being outside the scope of the Regional Water Board's jurisdiction. Siskiyou County officials specifically addressed the Klamath TMDL's suggestion that the Scott groundwater study result in certain water use management recommendations. Siskiyou County Supervisor Marcia Armstrong states that any imposition on water right holders would constitute a regulatory and physical "taking" of water use rights and should be compensated under the Fifth Amendment of the United States Constitution.

Before addressing specific comments, it is helpful to provide an overview of flow issues and agency jurisdiction, how flows were addressed in the Scott and Shasta TMDLs, and what, if any, flow provisions are in the draft Klamath TMDL. In discussing various aspects of the Scott and Shasta TMDLs, it bears emphasizing that provisions in those TMDLs are not before the Regional Water Board in the Klamath TMDL. The Klamath TMDL is not reopening the issue of flows in either of those watersheds at this time. Also, the Klamath TMDL does not promulgate any new flow objectives, and contains no requirements that in anyway purport to limit water rights in the Scott and Shasta River watersheds. The Klamath TMDL does rely on the Bureau of Reclamation to implement its ROD flows on the Trinity River.

It is entirely appropriate for the Regional Water Board to consider water quantity in its water quality planning efforts, especially when traditional controls are not adequate to achieve water quality objectives. "Water Quality Control" means the regulation of any activity or factor which may affect the quality of the waters of the state…." (Wat. Code, § 13050, subd. (i).) The Regional Water Board must consider flows in determining the assimilative capacity of the water and seasonal variation in determining the loading capacity of pollutants. The Regional Water Board has discretion to further consider flows in developing the load reductions necessary to attain standards. The goal of establishing TMDLs is to assure that water quality standards are attained and maintained. (65 Federal Register 43588.)

While the consideration of water quantity and flow for water quality is important and appropriate in the planning process, the Regional Water Board has consistently made it clear that it is not the agency that oversees water rights and does not have authority to do so. To be clear, the flow recommendation in the Shasta TMDL is just that: a recommendation. The Klamath TMDL acknowledges the importance of achieving the recommended flow measures in the Shasta TMDL for attaining Klamath water quality, and may contain guidance to help make efforts in this regard more effective. For example, water conservation grants should ensure the dedication of saved water for instream use. But this does not reset the timing requirements to challenge provisions of that TMDL. The Klamath TMDL does not alter or reopen the Scott and Shasta TMDLs.

Surface water diversions in the Shasta watershed are subject to a judgment and decree approved by the Superior Court of the State of California, in Siskiyou County in 1932. There are three adjudicated basins within the Scott River watershed, including Shackleford Creek (1950), French Creek (1958), and Scott River (excluding already adjudicated Shackleford and French Creek watersheds) (1980). The Superior Court exercises continuing authority over these adjudications, and the Department of Water Resources provides water master service for the Shasta River, Shackleford Creek, and French Creek Decrees. The State Water Board shares the authority to enforce water right laws with the state courts. In California, water rights law is administered by the Division of Water Rights under the State Water Resources Control Board.

The Shasta TMDL Implementation Plan requests water diverters to participate in, and implement applicable flow-related measures that result in dedicated cold instream surface flow in the Shasta River and tributaries. The TMDL also encourages water conservation and other flow measures on a watershed-wide scale to be the most effective, such as coordinating pulse flows as contemplated in the DFG Coho Recovery Strategy. This approach is consistent with other provisions in the plan that lends support to the on-going, proactive collaborative processes already taking place in the watershed. The Regional Water Board expects a progress report after two years, and will reassess the success of these measures after five years. While no cold water has been dedicated to the river, there is progress regarding the 45 cfs recommendation in the watershed. The Shasta Valley RCD is developing a water trust and there are landowners who have expressed interest in dedicating cold water. There are also water conservation and tailwater reduction efforts that will help meet the 45 cfs goal of reducing stream temperatures if the water saved can be formally dedicated for instream use. Participants have expressed some frustration in the water rights procedures required to dedicate flows.

The Regional Water Board staff, with help from the Division of Water Rights, is providing information to assist landowners who want to voluntarily dedicate instream flow. While the Shasta TMDL is crafted to allow for creative solutions to dedicate these flow measures, including collaborative agreements, any agreement should clearly delineate how measures ensure benefits to water quality. Water made available through the implementation of conservation measures should be dedicated to beneficial use in order to be effective under this Plan. Dedicated means that the diverter, either individually or as a group, can demonstrate that the measure contains assurances that it will result in water quality benefits. Under Water Code section 1707, any person entitled to use water, whether based on an appropriative, riparian or other water right, may petition the State Water Board to change the purpose of use to the preservation and enhancement of wetlands habitat, fish and wildlife resources, or recreation. The State Water Board may approve the petition if the change does not increase the amount of the original entitlement, does not unreasonably affect any legal user of water, and meets other requirements of the Water Code.

The Scott TMDL Implementation Plan encourages water users to develop and implement water conservation practices in order to prevent, minimize, and control elevated water temperatures in the Scott River and its tributaries. The Plan also called for a groundwater study plan, which has been completed. The Regional Water Board has provided funds to implement the initial phases of the plan. The Klamath TMDL includes an acknowledgment that the Scott River groundwater study should result in management practices with the goal of providing adequate flows in the Scott River. This does not mean that the Regional Water Board purports to require that Siskiyou County adopt a groundwater ordinance. The groundwater study is intended to be a tool for Siskiyou County and its water diverters to develop and implement its own management strategies. Regional Water Board staff encourage the approach outlined by Supervisor Armstrong. We think that a plan developed by water users is consistent with the Scott TMDL's approach supporting on-going, proactive collaborative processes already taking place in the watershed. The study will provide valuable information and hopefully lead to a coordinated effort for groundwater management that is protective of water quality and supports voluntary efforts for instream flows in the basin. (See e.g. Scott River Water Trust at http://www.scottwatertrust.org/ [for the purpose of short-term or long-term leasing of water to improve instream flows fish while protecting family farms].) We think this voluntary and proactive approach would provide protection to individual water right holders, and perhaps avoid any future call to re-adjudicate the decree. Section 6.4.5.2 of the Klamath TMDL Staff Report has been modified accordingly.

The Regional Water Board has struck the right balance in its efforts in the Scott and Shasta TMDLs as it relates to water quantity. How water quality is influenced by water diversion is recognized in the Basin Plan and could be helpful to the Division of Water Rights in processing water rights applications and petitions in these watersheds. In addition, the Regional Water Board has put in place measures to help advance voluntary progress in this area without stepping outside the scope of its jurisdiction. The Scott and Shasta measures are not subject to re-deliberation.

With respect to the comments made regarding obligations and actions by other agencies related to flow, we agree that the State Water Resources Control Board should exercise oversight to ensure against unauthorized diversions in these watersheds. It would be helpful to understand whether water shortages result from unauthorized diversions or an over-allocated system. If Regional Water Board staff encounter illegal diversions, staff will refer the matter to the Division of Water Rights Enforcement Unit. Regional Water Board staff will also assist landowners who want to dedicate flows in processing 1707 petitions before the State Water Board. The Regional Water Board will not request the State Water Board to reexamine water allocations at this time. Nor can the Regional Water Board force USFS to assert its water rights in the Scott River. The water rights on the mainstem Klamath are largely controlled by the State of Oregon, and flows released across the border are largely dictated by various Biological Opinions from federal agencies and obligations to downstream Tribes. While the Regional Water Board has concerns about changes in flows to California resulting from separate water right agreements between various parties to the KBRA, this issue is not before us. The Klamath TMDL model used flows based on measured historic flow.

X2. Comment(s):

- A certain flow -velocity and volume (or head of water) is necessary for the operation of diversion facilities and fish screens; irrigation delivery systems or facilities such as ditches, well pumps, pivot wheels, etc. Beneficial use of water for livestock and crops is not possible without water volume adequate to those needs. In addition, water velocity and volume (flow) are quality factors important to the operation of hydropower facilities; recreational use of water for white-water rafting; and the ability of suction dredge miners to operate their equipment.
- Imposing a WDR condition of the "dedication" of 45 cfs of water, when the pre-1914 right of use is secured under one of California's oldest water adjudications, would appear to be confiscatory and an unconstitutional condition. The regulatory and physical "taking" of water use rights should be compensated under the Fifth Amendment. Casitas Municipal Water District V. United States (United States Court of Appeals for the Federal Circuit 2007-5153)
- The TMDL Action Plan recommended that the County, in cooperation with other appropriate stakeholders develop a study plan to examine interconnected groundwater. That is all. Although Siskiyou County has funded several years of the static well study, the County has no funds available to pay for Dr. Harter's study. Some preliminary work was done by Dr. Harter with grant funding. When it became clear that additional funding for Dr. Harter's work would likely be contingent upon creation of a groundwater management plan, I could no longer support that work.
- Siskiyou County has jurisdiction over groundwater use, (County code, Title 3. Public Safety, Chapter 13. Groundwater.) We envision local control, with users dependent upon the resource for their living coming forward to us with a proposed groundwater management plan that meets their needs, (similar to the Glenn County model.) The NCRWQCB cannot require the Siskiyou County Board of Supervisors to pass a groundwater management ordinance. We are elected legislators and such an act is discretionary. (Bownds v. City of Glendale *113 Cal. App. 3d 875*; *170 Cal. Rptr. 342*; *1980 Cal. App. LEXIS 2597)*
- It has become obvious to water users that, under the TMDL, such a plan will be used to provide evidence to impose regulations on groundwater use in Scott Valley to increase instream flows for fish at the detriment of their livelihood and the competing use of water for livestock and crops. It is possible that they will cease to allow access to their property and wells to complete the study if they feel threatened by resultant likely regulation.

Comment(s) Made By:
Armstrong - Siskiyou County Supervisor, District 5

Response:
See General Response X1

X3. Comment(s):
Higher river flows are needed to help offset the warm river temperatures.

Comment(s) Made By:
Carnam

Response:
See General Response X1

X4. Comment(s):

- Lack of regulation of water use by the SWRCB Water Rights Division (WRD) and other agencies with authority over streamflow flow remains a huge impediment to successful TMDL implementation.
- One deficiency in the plan is that water use discussions do not mention that groundwater withdrawal can reduce surface flows.
- A sentence or a small table should be added to indicate how unimpaired flows in the Shasta River compare with current flows. This information is an important product of the TMDL analysis not previously provided, so it should be included somewhere in the TMDL document.
- The old Figures 4.21, 4.22, and 4.23 from the Agency Review Draft present some very important information regarding the consequences of Regional Water Board staff's decision not to require full restoration of flows in the Shasta and Scott Rivers as part of the Klamath TMDL. Because the CA Compliance scenario (used to set the pollutant allocations in Chapter 5) does not require restoration of full natural flows in the Shasta and Scott, maximum temperatures in the Klamath River will still be 1-2°C warmer than natural in mid-summer (Figure 1). The model results presented in old Figures 4.21, 4.22, and 4.23 show that natural flows in the Shasta and Scott are not necessary to result in near-natural (i.e. <1°C difference) temperature conditions during the fall chinook spawning (i.e. September-October); the Klamath TMDL's required mitigation of thermal impacts from the reservoirs (e.g. by dam removal) will be sufficient in that regard.
- The following point in the previous paragraph should be made clearer in the TMDL text: Restoration of natural flows in the Shasta and Scott are required to restore mainstem Klamath summer temperatures for juvenile salmon growth and survival, and the TMDL does not require such restoration of full natural flows.
- There needs to be immediate action by the SWRCB water rights division to ensure that adjudicated flow levels are met on the Scott and Shasta Rivers. There has been no effective action to restore Scott River flows.

- We strongly support the language in section 6.5.3.1 that Regional Water Board staff "will work with other state and federal agencies and tribes to identify and eliminate illegal diversions in the Klamath River basin in California".

Comment(s) Made By:
Fetcho – Yurok Tribe
Crosby – Karuk Tribe
Bowman – Quartz Valley Indian Reservation

Response:
See General Response X1

X5. Comment(s):
Lack of regulation of water use by agencies with authority over streamflow flow remains a huge impediment to successful TMDL implementation.

Comment(s) Made By:
Grunbaum

Response:
See General Response X1

X6. Comment(s):

- The State Water Board has not included all of the north coast streams (suffering from diminished flows - from over and inappropriate use, unlicensed use, and changing weather patterns) in their policy considerations for flow maintenance (and beneficial use protection). Low flow conditions exacerbate temperature and other pollutant issues. Documented in the Klamath River, and Scott and Shasta River TMDLs and Implementation Plan are pollutant effects related to diminished stream flows. The State Water Board should (under State Water Code and other regulatory authority) take action to protect beneficial uses by imposing standards and regulations to limit wasteful and illegal diversion. This issue must be addressed (in reference to conditions in the Klamath River and tributaries) in the Klamath River TMDL and Implementation Plan.
- The State Water Board has not included all of the north coast streams (suffering from diminished flows - from over and inappropriate use, unlicensed use, and changing weather patterns) in their policy considerations for flow maintenance (and beneficial use protection). Please use the notes provided relating to use of Russian River flows for frost protection and related effects (diminished flows and fish kills) as ideas for discussion and comment on the Klamath TMDL.
- Why hasn't the State Water Board imposed Water Budgets and Water Masters (with Gauges and every thing you need to monitor flow and use) in affected streams and rivers.

- These TMDLs should, and must (both under CEQA and State Water Code) address these issues.

Comment(s) Made By:
Levine – Coast Action Group

Response:
See General Response X1

X7. Comment(s):
Since time immemorial the Indigenous peoples of Northwest California, the Karuk, the Yurok, the Hupa, Chulula, and the Wiyot all belong to the "World Renewal Religion". It is a birthright and responsibility to perform the sacred dances, ritually pray, and raise children to be whole individuals. This means respecting the teachings of our elders, being clean, and to strive at knowing our place in life and meet the goals we set for ourselves in a good way.

An event like the fish kill in the Klamath River during the summer of 2002 has never been heard of in the lifetime of the elders or in the tribal mythical memory. The water given to the farmers by the US Department of Interior should have gone down river to protect the beneficial use (fish). Salmonids are a mainstay of the tribes diet and represent the connections between the physical and spiritual.

Please change the basin plan to restore and make way for the recovery of the endangered fishes.

Comment(s) Made By:
McCovey

Response:
See General Response X1

X8. Comment(s):
KRK urges the Regional Water Board to impose tough flow requirements at the mouth of both the Scott and Shasta so that temperature and dissolved oxygen targets in the mainstem Klamath River can be achieved.

Comment(s) Made By:
Terence – Klamath RiverKeeper

Response:
See General Response X1

X9. Comment(s):
The Scott River totally dries up most years in some parts of its bed, and the water quality is not good. The Shasta River is a little better but so much of its water is used in wasteful irrigation methods that are marginally productive. I understand that the Klamath basin in Oregon has the same issues. Water use needs to respond to actual precipitation in the basin not some imaginary average.

Comment(s) Made By:
Sanguinetti

Response:
See General Response X1

X10. Comment(s):
The Shasta-Scott approach has already demonstrated that it will not correct water quality impairments that are related to dewatering/flow - at least not for many many years, if ever. Is this the approach you are going to take on the Klamath TMDL?

Comment(s) Made By:
Pace

Response:
See General Response X1

X11. Comment(s):
The extent to which the Draft TMDL intrudes into water use and water rights is an example of how it goes beyond the jurisdiction of the Regional Water Board. Consequently, references to reductions in stream flows are unnecessary and should be removed.

Comment(s) Made By:
Rice and Oldfield – California Farm Bureau Federation and California Cattlemen's Association

Response:
See General Response X1

X12. Comment(s):
Imposing a WDR condition of the "dedication" of 45 c.f.s., would constitute a "take" of private property.

Comment(s) Made By:
Morris- Siskiyou County Farm Bureau

Response:
See General Response X1

X13. Comment(s):

- Flow Problems in Scott and Shasta Rivers have the potential to prevent restoration of Klamath River water quality and, therefore, must be addressed in this TMDL. This is needed to correct the failure to adequately address flow issues in the Scott and Shasta TMDLs and related Implementation Plans.
- On the Scott we recommend including in the MOU or waiver for the Forest Service a requirement that the FS take action to assert its adjudicated right to in stream flows in Scott River. That right is based on riparian ownership and under California law should be superior to appropriative rights. But in the Scott this is not the case. The Klamath TMDL Action Plan should require that the Forest Service assert the public's national forest riparian water right.

Comment(s) Made By:
Pace, Beck, Gillespie – North Group-Redwood Chapter-Sierra Club & Friends of Del Norte

Response:
See General Response X1

X14. Comment(s):
The Regional Water Board has cited against any diversions from a stream as the diversion reduces the volume and velocity, allowing faster and greater swings in temperature variations from an average, and yet later arguing against impoundments as not allowing significant variations in temperature swings allowing cooler lows.

Comment(s) Made By:
Cozzalio

Response:
See General Response X1

X15. Comment(s):
Klamath River beneficial uses have been impacted by altered flow conditions that affect habitat conditions but these alterations were due to natural causes.

Comment(s) Made By:
Gierak

Response:
The comment is incomplete and it is not possible to know what natural causes the commentor is referring to. Regional Water Board staff agree that altered flow conditions have affected habitat conditions. Flow in the Klamath River has been altered by anthropogenic means including water use for irrigation and the presence of the dams. Also, see General Response X1.

GENERAL COMMENTS

Y1. Comment(s):

- First of all, I would like to commend the Board for preparing such a thorough and insightful TMDL and say thanks for coming here to the Klamath watershed with open minds and hearts to listen to what the river and the people have to say.
- Overall, I think your plan is excellent.

Comment(s) Made By:
Grunbaum

Response:
Thank you for your support.

Y2. Comment(s):
Strongly support the draft Klamath TMDLs aggressive dissolved oxygen requirements and nutrient, temperature and toxic algae limits and load allocations. Also support the links identified in Chapter 2 between nutrients, temperature, riparian vegetation, channel morphology, toxicity, dissolved oxygen, organic matter, algae, sediment, flows, fish health, disease, and mortality as well as cultural, economic, and recreational health. Support the buffer zones proposed in Chapter 6 to protect thermal refugia used by coldwater fisheries as well as though load allocation for suction dredging and grazing practices in the basin.

Comment(s) Made By:
Klamath Riverkeeper - Various

Response:
Thank you for your support.

Y3. Comment(s):

- We are pleased with and fully supportive of Staff's efforts in these Draft Water Quality Restoration Plan ("Implementation Plan") provisions as well as in the supporting Technical TMDL portions of the Draft TMDL generally as set forth in the earlier chapters.
- We also believe the proposed zero load allocations are completely justified given the already highly degraded water quality conditions of the Klamath River today.

Comment(s) Made By:
Levine –Coast Action Group

Response:
Thank you for your support.

Y4. Comment(s):

- Section 4.2.2.1 Temperature. With regard to Copco1, Copco2 and Iron Gate reservoirs, DFG agrees with the results of the modeling analysis which states the presence of Iron Gate Reservoir significantly influences the temperature of the Klamath River.
- Section 4.2.2.2 Dissolved Oxygen. DFG agrees the presence of Copco1, Copco2 and Iron Gate reservoirs creates Dissolved Oxygen (DO) conditions that do not meet water quality standards.

Comment(s) Made By:
Stacey – California Department of Fish and Game

Response:
Thank you for your support.

Y5. Comment(s):
This TMDL processes are going to be rammed down people's throats regardless of the comments – the process is smoke and mirrors.

Comment(s) Made By:
Foley

Response:
Regional Water Board staff disagree with the commenter's assertion. Many changes to the document have been made in response to public comments.

Y6. Comment(s):
It's difficult for me to cooperate with someone who keeps changing the rules. The Regional Board needs to acknowledge that we have cooperated in the past and here we are again. This is just another far reaching, sweeping arm of power that really lacks authority.

Comment(s) Made By:
Kobseff – Siskiyou County Board of Supervisors

Response:
The Klamath TMDLs and action plan have been developed in order to achieve water quality standards, in conformance with state and federal law. In response to comments on the June 2009 first public review draft of the TMDL, Regional Water Board made several revisions that clarify the scope of the Klamath implementation plan. This was done in recognition of the potential for confusion resulting from overlapping requirements, as noted by the commenter. The implementation plan now clarifies that

there are no new regulatory requirements for individuals in tributary watersheds that have existing TMDL implementation plans, except when requirements are recommended for incorporation into a nonpoint source program that applies outside of the scope of the Klamath TMDL allocations. For example, the future regionwide waiver for activities on lands managed by the USFS will incorporate requirements that simultaneously meet the Klamath TMDL while addressing regionwide nonpoint source issues.

Y7. Comment(s):
Concerned about the water quality and algae that is in the Klamath River and is reluctant to swim or fish. The fish taste different than Salmon and trout from other rivers.

Comment(s) Made By:
Sanguinetti

Response:
Comment noted.

Y8. Comment(s):
The Regional Board's "conceptual" plan and implementation is glaringly "over simplified", conveniently excluding assets and actions improving conditions, and correlations of multiple natural inputs and cycles affecting regulatory outcomes.

Comment(s) Made By:
Cozzalio

Response:
Regional Water Board staff does not agree with this comment. The conceptual models received favorable reviews by the independent peer review panel. We believe that the conceptual model provides a comprehensive assessment framework for the TMDL staff report.

Y9. Comment(s):
Overall the technical analysis presented in the Klamath TMDL is scientifically rigorous and provides a solid foundation for remediation of the river's pollution problems. MKWC commends the Regional Board staff for their effort on the TMDL conceptual framework and technical analysis.

Comment(s) Made By:
Harling – Mid Klamath Watershed Council

Response:
Thank you for the support and recognition.

Y10. Comm ent(s):
Unfortunately, the Klamath River watershed is plagued by a legacy of poor management practices including, but not limited to, mining, ranching, agriculture, logging, road building, over-allocation of water, and pollution caused by dams. These largely unregulated practices have left us with chronic issues of temperature, nutrients, toxic algae, dissolved oxygen shortages, insufficient instream flows at critical times of the year, and a general lack of instream thermal refugia for migrating salmonids. These issues severely impair the most basic beneficial uses of the Klamath River, including swimming, drinking, fishing and boating, and continue to adversely affect Tribal Trust obligations by curtailing cultural uses of the river such as fishing, shellfish harvest, and ceremonies.

Comment(s) Made By:
Harling – Mid Klamath Watershed Council

Response:
Regional Water Board staff agree that past practices have resulted in impaired water quality conditions. The Klamath TMDL Action Plan has been crafted to address poor water quality conditions so that the beneficial uses of the Klamath River can be supported to the degree that the Klamath River is able, consistent with the Basin Plan. Also, in regards to water quantity issues, please see the response to comment X1.

EDITORIAL COMMENTS

Z1. Comment(s):
It would be of great service to the public for ODEQ, the Regional Board, and EPA to publish a simple summary of each existing and proposed TMDL, the waters it covers, the geographic areas to which it assigns allocations, the specific loads it assigns, the existing or anticipated regulatory document establishing implementation measures assigned to the TMDL, and the specific areas covered by any such implementation measures.

Comment(s) Made By:
Addington and Danosky – Klamath Water Users Association & Tulelake Irrigation District

Response:
Following adoption of the Klamath River TMDLs, staff will prepare a fact sheet with this information.

Z2. Comment(s):
The implementation plan should expressly acknowledge that the Regional Board may certify water quality management plans created to satisfy other TMDL implementation requirements within the basin as sufficient to comply with the implementation plan for the Klamath TMDL.

Comment(s) Made By:
Addington and Danosky – Klamath Water Users Association & Tulelake Irrigation District

Response:
The commenter is correct, except the Regional Water Board would not certify the implementation plan, but rather an implementation program that meets certain conditions. Text explaining this option has been included in section 6.1.4 of the TMDL staff report.

Z3. Comment(s):
The following statement on page 2-61 appears to have an erroneous citation: "The reservoirs also impact the river below Iron Gate by serving as a source of blue-green algae that continues to grow in backwater and slower sections within the river reaches below the dams (Kann and Asarian 2005)." This subject was not mentioned in the cited document. A more appropriate citation would be Kann and Corum (2009), already cited elsewhere in the Public Draft TMDL. (p. 5)

Comment(s) Made By:
Fetcho – Yurok Tribe

Crosby – Karuk Tribe
Bowman – Quartz Valley Indian Reservation

Response:
The citation has been corrected.

Z4. Comment(s):
Data in Figure 2-26 showing frequency of dissolved oxygen saturation less than 85% is credited to the U.S. Fish and Wildlife Service, but this dataset also includes data from the Karuk and Yurok Tribes, and should be cited accordingly. (p. 5)

Comment(s) Made By:
Fetcho – Yurok Tribe
Crosby – Karuk Tribe
Bowman – Quartz Valley Indian Reservation

Response:
The text has been revised.

Z5. Comment(s):
This section (4.2.2) repeatedly refers to May 2004 – May 2005 data from Kann and Asarian (2007), when in fact the data are from May 2005 – May 2006 (this appears to be due to a typographical error in the TetraTech (2008) nutrient dynamics memorandum).

Locations requiring correction in section 4.2.2.2 include the caption of Table 4.3 ("May 2004 – May 2005" should be replaced with "May 2005 – May 2006") and the contents of Table 4.5 (all instances of "2004 – 2005" should be replaced with "2005-2006 May to May").

It should be noted that the data presented from the Asarian and Kann (2009) report are preliminary results, and are subject to revision. It is our understanding that the final numbers will be only slightly different (i.e. within ±1-2%), not enough to affect any conclusions drawn from the data. Hopefully, the Asarian and Kann (2009) report will be completed soon and the final results can be included in the final version of TMDL (p. 8)

Comment(s) Made By:
Fetcho – Yurok Tribe
Crosby – Karuk Tribe
Bowman – Quartz Valley Indian Reservation

Response:
The text has been revised.

Z6. Comment(s):
The x-axis for Figure 4.17 "Comparison of estimated daily average Scott River Temperature conditions to estimated daily average Klamath River conditions." is erroneous (discussions with Regional Water Board staff on 8/6/2009 confirmed this) and needs to be corrected.

Comment(s) Made By:
Fetcho – Yurok Tribe
Crosby – Karuk Tribe
Bowman – Quartz Valley Indian Reservation

Response:
The x-axis has been revised.

Z7. Comment(s):
Reducing the number of graphs in this section would make the document shorter and clearer. We suggest that staff consider combining the two Scott River Figures 4.10 and 4.11 together into a single figure with three lines (likewise, Shasta River Figures 13 and 14 could be combined).

Comment(s) Made By:
Fetcho – Yurok Tribe
Crosby – Karuk Tribe
Bowman – Quartz Valley Indian Reservation

Response:
Regional Water Board staff disagree. The suggestion has been tried, but results in a chart with lines that are difficult to distinguish.

Z8. Comment(s):
The fall, 2008 Agency Review Draft of the Klamath TMDL included a summary section in Chapter 4 titled "Cumulative Temperature Effects of Tributary Inputs and Absence of Impoundments"; however, this section does not appear in this Public Draft TMDL. The earlier section contained very important information, and should be re-included in the final TMDL.

Comment(s) Made By:
Fetcho – Yurok Tribe
Crosby – Karuk Tribe
Bowman – Quartz Valley Indian Reservation

Response:
The analysis referred to has been revised based on refined natural flow and temperature estimates.

Z9. Comment(s):
Clarification on the thermal refugia definition: Chapter 6-28 states, "Thermal refugia are typically identified as areas of cool water created by inflowing tributaries, springs, seeps or through upwelling hyporheic flow and groundwater in an otherwise warm stream channel." Summer rearing studies in the Scott River indicate that not all cool-water inflows necessarily offer fish refuge due to site specific and ambient water quality conditions. The statement in the TMDL, Chapter 6 should read something like: "Thermal refugia are typically identified as areas of cool water created by inflowing tributaries, springs, seeps or through upwelling hyporheic flow and groundwater in an otherwise warm stream channel offering refuge habitat to cold-water fish/aquatic species."

Comment(s) Made By:
Fetcho – Yurok Tribe
Crosby – Karuk Tribe
Bowman – Quartz Valley Indian Reservation

Response:
Regional Water Board staff agree and have amended the text accordingly.

Z10. Comment(s):
Appear to be some errors in Table 7.7:
- The site "Klamath River at Shasta River at Walker Bridge (RM- 176.7)" is listed, when in fact this actually is two separate sites: Klamath River above Shasta River (river mile 176.08) and Klamath River at Walker Bridge (river mile 156.00).
- Klamath River at Brown Bear River Access is not river mile 157.5, it is 150.0 (see http://mapper.acme.com/?ll=41.82314,-122.96104 and http://www.fs.fed.us/r5/klamath/recreation/rivercenter/rivermaps/map3.shtml) (p.26)

Comment(s) Made By:
Fetcho – Yurok Tribe
Crosby – Karuk Tribe
Bowman – Quartz Valley Indian Reservation

Response:
The corrections have been made.

Z11. Comment(s):
We are disappointed to see the TMDL proposing a new 6-digit site ID system (i.e. Klamath River at Seiad Valley is "KR1285") when there is already an existing 7-digit site ID system in use. Much of the nutrient and automated probe water quality data collected in the Klamath River and its tributaries collected up through 2005 has been compiled into a single Microsoft Access database. The database was begun by PacifiCorp (2004) and

added to through other studies, such as the development of Klamath TMDL, nutrient budgets for Iron Gate and Copco Reservoirs (Kann and Asarian 2005), and nitrogen budgets for river reaches below Iron Gate Dam (Asarian and Kann 2006). That database, including lookup tables of site IDs, is available online at: http://www.krisweb.com/ftp/KlamWQdatabase\KR_TMDL_database_with_PCorp_USFWS_CDWR_data.zip

PacifiCorp has continued (mostly, but with a few exceptions) to use the same Site ID system in their 2006-2008 reports. Figure 4 and Table 2 show a sub-selection of sites and their 7- digit site ID codes.

The TMDL states that the "station ID's are per the KBWQMCG.", but we do not see any mention of them in KBWQMCG documents such as Royer and Stubblefield (2009). It would be a waste of time to re-invent the wheel unless it is absolutely necessary. (p.26)

Comment(s) Made By:
Fetcho – Yurok Tribe
Crosby – Karuk Tribe
Bowman – Quartz Valley Indian Reservation

Response:
The Regional Water Board will adopt the convention used by the Klamath Basin Monitoring Program.

Z12. No comment. This is a place holder to keep the number order correct.

Z13. Comment(s):
Please confirm that section 2.2.2, presenting tribal water quality standards, correctly distinguishes amendments to the Hoopa Valley Water Quality Control Plan from those components approved by EPA on February 14, 2008.

Comment(s) Made By:
Hashimoto and Ziegler – USEPA

Response:
The June 2009 Public Review Draft of the Klamath River TMDLs reflects the amendments made to the Hoopa Valley Water Quality Control Plan on February 14, 2008.

Z14. Comment(s):
We recommend presenting a summary, for each waterbody or reach, of impairments and parameters for which TMDL loads and allocations are generated.

Comment(s) Made By:
Hashimoto and Zigler – USEPA

Response:
A new figure has been added to Chapter 1 (Figure 1.2) which presents the 2006 Clean Water Act Section 303(d) List of Water Quality Limited Segments for the Klamath River Watershed. Additionally, Table 1.1 has been edited to include more specific information on the 303(d) listings, where that information was available.

Z15. Comment(s):
We suggest the hydrodynamic modeling scenarios be referenced primarily with narrative titles, and abbreviated references used only secondarily.

Comment(s) Made By:
Hashimoto and Ziegler – USEPA

Response:
The scenario titles have been referenced as suggested.

Z16. Comment(s):
Please clarify that natural temperatures are defined by the results of the natural conditions scenario hydrodynamic model evaluation.

Comment(s) Made By:
Hashimoto and Ziegler – USEPA

Response:
The table titles have been modified to clarify the source of the data, which is the natural conditions baseline scenario.

Z17. Comment(s):
Please consider presenting Figures 4-1, 4-2, 4-3, 5-1, 5-2, and 5-3 on an 11 x 17 inch page and clarify the significance, if any, of the light blue arrows. (p. 3)

Comment(s) Made By:
Hashimoto and Zigler – USEPA

Response:
This is not feasible given the number of reports that need to be produced for public distribution. Electronic versions of these figures will be made available by posting them to the Regional Water Board website.

Z18. Comment(s):
Page 6-2, Section 6.1.2, 1st paragraph, last sentence - This text refers to uncertainty due to settlement discussions; we suggest using explicit language that the Klamath River TMDLs and Action Plan are designed to address conditions under both dams-in and dams-out scenarios. Suggest similarly clear language on page 6-13 in last paragraph.

Comment(s) Made By:
Hashimoto and Zigler – USEPA

Response:
The Klamath TMDL already makes clear that the allocations accommodate both dams-in and dams-out scenarios. The text referred to by the commenter is discussing implementation options. Regional Water Board staff has added text to make that clear. “the Klamath River TMDL implementation plan accommodates various alternatives….”

Z19. Comment(s):
Page 6-2, last paragraph, sentence discussing AIP and possible federal legislation - suggest following edit (adding underlined language): " ... the AIP contemplates federal legislation that would allow PacifiCorp to remain on annual license from FERC thereby indefinitely delaying the 401 certification and enforcement of Clean Water Act compliance through this mechanism."

Comment(s) Made By:
Hashimoto and Zigler – USEPA

Response:
This section has been updated since June and this comment is no longer relevant.

Z20. Comment(s):
Page 6-3, Section 6.1.3, 2nd paragraph, 3rd sentence - suggest adding the following language: "…that the Regional Board adopt a general, interim conditional waiver for all parties…" to clearly identify that this waiver is an interim (or temporary) measure until a longer-term mechanism is developed.

Comment(s) Made By:
Hashimoto and Zigler – USEPA

Response:
This sentence has been removed entirely consistent with the removal of the recommendation of an interim conditional waiver for all parties.

Z21. Comment(s):
Page 6- 12, Section 6.3.1.3 - Suggest the following sentences to replace the second sentence to explain the concept of federal preemption - "Typically, the Regional Water Board would issue a permit for the operation of dams in its jurisdiction, and this permit would include regulation and enforcement of any applicable TMDLs. However, because the KHP is under the jurisdiction of the Federal Energy Regulatory Commission (FERC) and governed by a federal license, the Regional Water Board is preempted from issuing a permit for these dams. Therefore, regulation and enforcement of these TMDLs is traditionally through the State Water Board Clean Water Act Section 401 water quality certification process."

Comment(s) Made By:
Hashimoto and Zigler – USEPA

Response:
Regional Water Board staff will not make this suggested edit. In the absence of FERC jurisdiction, the Regional Water Board would have authority to request a report of waste discharge and issue waste discharge requirements, or issue clean up and abatement orders; however, this practice is not necessarily "typical." In fact water quality compliance in reservoirs is typically addressed by the State Water Board, Division of Water Rights.

Z22. Comment(s):
Page 6-15, Section 6.3.2.3, Implementation Measures – add the following (underlined) language: "Revise NPDES Permit No. CA0006688 and WDR No. R1-2000-17 to incorporate revised effluent limits to implement the TMDL wasteload allocations and to require that the responsible parties implement measures ..."

Comment(s) Made By:
Hashimoto and Zigler – USEPA

Response:
Regional Water Board staff have made the suggested edit.

Z23. Comment(s):
Page 6-17, Section 6.4.3 (Lost River), in second sentence, add the following (underlined) language - "... to accommodate the development of the U.S. Bureau of Reclamation's (USBR's) Klamath Irrigation Project…"

Comment(s) Made By:
Hashimoto and Zigler – USEPA

Response:
The staff report now refers to the irrigation project as the USBR Klamath Project as requested by USBR.

Z24. Comment(s):
Page 6-23, Section 6.4.7, last paragraph - The second and third sentences leave the reader confused. Do all of the watershed-wide measures described in Section 6.5 apply to the Trinity? The reference to "sediment and riparian control measures" in the third sentence could be interpreted to mean that there are other measures in this section that are not necessary.

Comment(s) Made By:
Hashimoto and Zigler – USEPA

Response:
This text has been removed. The watershed-wide allocations do not apply to the Trinity River basin and the implementation plan now only includes measures related to the Trinity River Restoration Program and the Record of Decision.

Z25. Comment(s):
Page 6-29, Section 6.5.3.2 - In the first paragraph, it states that there is "no regulatory mechanism in place" for suction dredging activities. This is confusing given that CDFG has authority to regulate these activities (as discussed in Section 6.5.3.3). Presumably, this statement refers to the fact that the Regional Board has no regulatory mechanism in place.

Comment(s) Made By:
Hashimoto and Zigler – USEPA

Response:
This statement has been removed entirely.

Z26. Comment(s):
Chapter 6, Section 6.2, Page 6-8 states "Nutrient loads in the Klamath River at stateline originate mainly from Upper Klamath Lake, as well as from the Lost River basin through the Klamath Straits Drain,…" The Lost River Basin releases water to the Klamath River through the Klamath Straits Drain but also through the Lost River Diversion Channel. It should read "Nutrient loads in the Klamath River at stateline originate mainly from Upper Klamath Lake, as well as from the Lost River basin through the Klamath Straits Drain and Lost River Diversion Channel,"

Comment(s) Made By:
Hicks – U.S. Bureau of Reclamation

Response:
Regional Water Board staff have made the suggested edit.

Z27. Comment(s):
Chapter 6, Section 6.4, Page 6-16 states "The Lost River traverses the Oregon/California border three times and ultimately joins the Klamath River in Oregon via the Klamath Straits Drain." The Lost River Basin releases water to the Klamath River through the Klamath Straits Drain but also through the Lost River Diversion Channel.

Comment(s) Made By:
Hicks – U.S. Bureau of Reclamation

Response:
Comment noted. The purpose of this text is merely to give the reader a context that the Lost River winds in and out of California and Oregon, ultimately joining the Klamath River in Oregon. It is not intended to describe the inputs to the Klamath River from the Lost River system.

Z28. Comment(s):
Chapter 6, Section 6.4.3, page 6-18, states "The KIP diverts water from the Klamath River at four separate locations just downstream of Upper Klamath Lake." Only three diversions are from the Klamath River. The A-canal, by far the largest diversion, originates from Upper Klamath Lake. The North Canal, Ady Canal, and Lost River Diversion Channel are the major diversions coming directly from the Klamath River.

Comment(s) Made By:
Hicks – U.S. Bureau of Reclamation

Response:
Regional Water Board staff have edited the text to reflect that three diversions are from the Klamath River and one from Upper Klamath Lake.

Z29. Comment(s):
Chapter 6, Section 6.4.3, The author references the "Klamath Irrigation Project (KIP)" which is incorrect. The correct reference would be Reclamation's Klamath Project.

Comment(s) Made By:
Hicks – U.S. Bureau of Reclamation

Response:
The text has been altered and refers to the U.S. Bureau of Reclamation's Klamath Project or Reclamation's Klamath Project.

Z30. <u>Comment(s):</u>
Chapter 6, Section 6.4.3, If the author wishes to refer to total acres farmed "200,000" it should state that it includes both the Lost River Basin and Project acreage served by Upper Klamath Lake. It would also be appropriate to mention the four National Wildlife Refuges that are served by the Klamath Project.

<u>Comment(s) Made By:</u>
Hicks – U.S. Bureau of Reclamation

<u>Response:</u>
Comment noted. Regional Water Board staff have edited the text to reflect that four National Wildlife Refuges are served by the Klamath Project.

Z31. <u>Comment(s):</u>
Chapter 6, Section 6.4.3, Water does not just "accumulate" in the Tule Lake National Wildlife Refuge, it is specifically maintained to meet biological opinion requirements for endangered suckers.

<u>Comment(s) Made By:</u>
Hicks – U.S. Bureau of Reclamation

<u>Response:</u>
The purpose of this discussion is to give the reader an idea of the complexity of the Lost River system and detail how water flows through the Klamath Project. However, Regional Water Board staff have edited the text to remove the suggestion that water "accumulates" in Tule Lake National Wildlife Refuge.

Z32. <u>Comment(s):</u>
Chapter 6, Section 6.4.3, Water is not pumped from TLNWR to LKNWR "to maintain farmland in the TLNWR" or "remove salt from the Tule Lake basin". Water is pumped for water elevation control in the wildlife refuge year round, for flood control in winter and early spring months, and for refuge water supply in the summer and fall months.

<u>Comment(s) Made By:</u>
Hicks – U.S. Bureau of Reclamation

<u>Response:</u>
The text in question was provided to the Regional Water Board by the Klamath Water Users Association as part of their comments on the Water Quality Restoration Plan released in February, 2009. The text provide by USBR has been added as a footnote to the revised draft of the staff report in section 6.4.3.1.

Z33. Comment(s):
Basin Plan Language, Section VI, Page 9. "The margin of safety, seasonal variations, and critical conditions for the Microcystin TMDL is addressed in Section V.D above." and "VI. Microcystin" Section V.D and section VI. discuss nutrients not microcystin.

Comment(s) Made By:
Hicks – U.S. Bureau of Reclamation

Response:
Thank you for the comment. The sections have been revised.

Z34. Comment(s):
The Draft Document does not contain a glossary of abbreviations or definitions of commonly used terms making the draft difficult, if not impossible, for the general public to understand.

Comment(s) Made By:
Hockaday – Montague Water Conservation District

Response:
An acronym list has been added to the Staff Report.

Z35. Comment(s):
The fact that the draft document failed to provide definitions and a table of abbreviations made the product even more difficult to follow.

Comment(s) Made By:
Krum – Siskiyou Resource Conservation District

Response:
An acronym list has been added to the Staff Report.

Z36. Comment(s):
Page 1-21, Paragraph 1, Lines 7-10. The Draft TMDL incorrectly cites PacifiCorp generation as a factor that has "altered flow timing" with respect to monthly average flows in the Klamath River (as shown in Figure 1.10 on page 1-21). PacifiCorp generation has not and does not alter timing of monthly average flows. See PacifiCorp (2004b) or the FERC Final EIS on the Project relicensing. This incorrect reference to PacifiCorp generation should be removed.

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The text has been corrected to indicate the control of flow is at Upper Klamath Lake.

Z37. Comment(s):
Page 1-22, Paragraph 3. Lines 5-6. The Draft TMDL indicates that the dams "were originally run as peak demand generation facilities but are now used in other ways". What "other ways" are being referred to here? The Copco 1 and Copco 2 facilities continue to be operated as peaking facilities.

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The text has been edited to reflect that the dams are operated as peak demand generation facilities. The reference to "other ways" has been removed.

Z38. Comment(s):
Page 2-31, Paragraph 1, Line 2: Delete "likely". The Klamath *was* (and is) a highly productive system.

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
Regional Water Board staff have made the suggested edit.

Z39. Comment(s):
Page 4-2, Paragraph 1, Lines 1-3.The fourteen geographic source areas are described in narrative fashion, but the actual locations and sources within each is vague. A simple table and accompanying figure would provide a clear definition of each. (p. 23) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The source areas are depicted on the vector diagrams – figures 4.1, 4.2, and 4.3. .

Z40. Comment(s):
Page 4-5, Footnote 2 Please correct "biological oxidation" to "biochemical oxidation."

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
Regional Water Board staff have made the suggested edit.

Z41. Comment(s):
Page 4-5, Paragraph 2, Line 6. Without the associated flow data in the Klamath River, Figures 4.1 through 4.3 lack a basis for identifying the value of tributary contribution in the form of direct dilution. That is, representing pollutant loading in terms of total annual mass is misleading. As the arrows get bigger moving downstream, it suggests that the river water quality is getting worse. However, the opposite is true. It would be useful to present the pollutant loads in terms of concentrations as well. (p. 25) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The diagrams are meant to simply convey total loads; flow data has not been added to the figures.

Z42. Comment(s):
Page 4-11, Figure 4.4 Title should specify this data as daily maximum temperature.

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The title now indicates the data are based on daily maximum temperatures.

Z43. Comment(s):
Page 4-3, Table 4.1. Are these source categories for Oregon, California, or both? Other comments include: (a) wetland conversion can affect water temperature under certain conditions, (b) if roads contribute to nutrients, then they can contribute to both organic matter and dissolved oxygen impairment (as explained in the paragraph immediately above the table), and (c) urban land use not included. (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
They are source categories for both Oregon and California and were not meant to be exhaustive. We agree with the comments, but no change is required. Urban land uses are considered to be a minor contributor to the pollutant loads.

Z44. Comment(s):
Page 4-4, Paragraph 3, Line 6. Alkalinity serves as a buffer if it is naturally in the water or introduced into the water through other means. (p. 24) (PacificCorp – Appendix A and B.doc))

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
Thank you for the information.

Z45. Comment(s):
Page 5-1, Paragraph 3, Line 2. The temperature numeric targets are based on monthly averages, but from a biological perspective this may be an insufficient averaging period. Recommend weekly or semi-monthly targets and support with literature citation.

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The monthly average temperatures were developed from a compliance perspective, not a biological perspective.

Z46. Comment(s):
Page 2-37, Paragraph 2, Lines 1-3: The Draft TMDL discusses increased organic matter loadings a nutrient "risk cofactor." The increased organic load to the Klamath River comes from upstream sources, notably Upper Klamath Lake in Oregon. The Draft TMDL asserts that compliance with the Oregon TMDLs will result in compliant conditions at Stateline. The Draft TMDL must explain how increased organic matter loading is a risk factor in the case of compliant conditions at Stateline. (p. 12) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
Organic matter has been reduced to levels such that water quality objectives are met at stateline. Organic matter contributes nutrients to the system and consumes oxygen when decomposed.

Z47. Comment(s):
Page 2-42, Bullets 1-4. All of these bullets are general statements that can be found in any limnology book. Linkage to the Klamath River is necessary.

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The linkage is made in Section 2.4.2.3 Nutrient Risk Co-Factors, Impoundments ($_N$C7) on page 2-41.

Z48. Comment(s):
Page 2-54, Paragraph 4, Lines 2-3: The Draft TMDL states "Some of the key sources [of nutrient loads] include…internal nutrient cycling from nutrient enriched sediments…." It should be made clear that this relates specifically to Upper Klamath Lake, not the Project reservoirs. There may be some internal release of nutrients from the reservoir sediments, but the resultant contribution to the load to the river is very small, if any. Because the reservoirs are a significant nutrient sink, the net result of the reservoirs is a decrease, not an increase in nutrient load to the river. (p. 14) (PacifiCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
A specific designation to UKL has been made.

Z49. Comment(s):
Page 2-49 to 2-51. The Draft TMDL discusses temperature effects attributed to the Project reservoirs, and concludes "[i]n summary, the temperature alterations…result in adverse effects to salmonids" (page 2-51). However, the Draft TMDL discussion of the effects of reservoir "thermal lag" on migrating anadromous salmonids is speculative, incorrect, or lacks balance. In fact, as discussed in detail in the cover document of PacifiCorp's comment package, the Draft TMDL's temperature allocations and targets are based on "ideal" or near-ideal temperatures for salmonids in the generally colder waters of the Pacific Northwest, not the "thermal load which cannot be exceeded in order to assure protection and propagation of a balanced, indigenous population of shellfish, fish and wildlife" in the Klamath River per 40

C.F.R. § 130.7(c)(2). The temperature effects of the Project are consistent with the protection and propagation of a BIP in the Klamath River.

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The Klamath TMDL water temperature allocations and targets are consistent with water quality standards, which are set to protect all beneficial uses of water. The protection of all beneficial uses ensures a balanced indigenous population of aquatic life. The Klamath TMDL temperature allocations and targets are based on natural temperature conditions, not temperatures that are ideal for salmonids. Additional supporting documentation has been added to the document further documenting temperature impacts caused by the thermal lag, the fact that the thermal effects of the reservoirs are not consistent with a balanced indigenous population of fish and shellfish, and that such a balanced indigenous population does not exist. See also response to comment K-40.

Z50. Comment(s):
Page 2-50, Paragraph 2, Lines 1-2: The Draft TMDL states "The temperature modeling indicates human impacts adversely affect both the rearing of juvenile salmonids and the reproductive success of adult salmonids." The temperature model is not evidence of adverse effect. It is just assumed by the authors. Statements about adverse effects must be supported by actual evidence, data or locally relevant citations.

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The text has been modified for clarity.

Z51. Comment(s):
In Figure 2.12 on page 2-50, the Draft TMDL compares modeling results for current conditions and estimated natural temperature for the 2000 simulation year. Compared to a hypothetical without-Project scenario, the thermal phase shift created by the presence of the reservoirs has warming effect on Iron Gate and Copco tailrace water temperatures during fall. However, as discussed in detail in section II.C of the cover document preceding this appendix, current temperature conditions with the reservoirs in place remain within (i.e., cooler than) MWMT chronic effects thresholds to salmonids during fall just as often, and in some cases more often, as modeled without-Project temperature conditions.

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
As discussed in the response to comments expressed in section II.C of the cover document, the analysis presented obscures the impact of the temperature changes by ignoring the time at which the temperatures occur.

Z52. Comment(s):
The Draft TMDL erroneously implies that the cooler temperature releases at Iron Gate dam during late winter than modeled “natural” temperature conditions “may reduce the growth rates of salmonids rearing in the Klamath River, and may ultimately reduce the survival rate of salmonids in the ocean” (page 2-51). The Draft TMDL provides no substantive evidence for this assertion, but only implies that the cooler temperature releases at Iron Gate dam during late winter are adverse because “the optimal temperature range for juvenile salmonids is 10-15°C, with a lower limit of 4°C“ (page 2-51). However, as discussed in detail in section II.C of the cover document preceding this appendix, both current and “natural” temperature conditions are below the optimal range for juvenile salmonids during the winter, and modeled Without Project temperature conditions are below 4°C (and therefore below the optimal range) more frequently than current conditions during the winter. (p. 13) (PacificCorp – Appendix A and B.doc)

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
Regional Water Board staff stand by the original statement, which is not definitive. The statement is justified based on the information found in the published works summarized in Appendix 4. In regards to the statement that “modeled Without Project temperature conditions are below 4°C (and therefore below the optimal range) more frequently than current conditions during the winter”, please refer to the response to comment K44.

Z53. Comment(s):
With regard to the temperature effects in the mainstem Klamath River, the Draft TMDL bases its case largely on a couple of simplistic graphical comparisons. The Draft TMDL presents a graph of “Current Conditions” and “Estimated Natural” temperatures (based on modeled results) downstream of Iron Gate dam (Figure 2.12 on page 2-50), and states that “the temperature alterations in Figure 2.12 result in adverse effects to salmonids” (page 2-51). However, the Draft TMDL provides little other model analysis, and no other specific direct analysis of biological effects.

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
Appendix 4 of the staff report contains an extensive discussion of temperature requirements of salmonids, and describes the temperatures that result in adverse effects to salmonids. Additional analysis and discussion has been added to chapter 2.

Z54. Comment(s):
Chapter 6, page 1, the Draft TMDL states that "[t]he regulatory process will accommodate for short term measures working in concert with longer-term programs to achieve full compliance over a longer time frame". The specific time frames associated with the Draft Implementation Plan's use of "short term", "longer-term", or "longer time frame" are not well defined.

Comment(s) Made By:
Hemstreet – PacifiCorp

Response:
The specific time frames were not defined because they are unknown at this time. The statement references the conceptual approach to implementation which includes engineered pollutant reduction projects that can potentially achieve results on a shorter timeframe than reduction achieved through the Regional Water Board's nonpoint source regulatory programs. Specific timelines associated with PacifiCorp's implementation measures will be identified as part of the KHSA and in PacifiCorp's implementation plan to be submitted to the Regional Water Board as required in the implementation plan.

Z55. Comment(s):
A sentence or a small table should be added to indicate how unimpaired flows in the Shasta River compare with current flows. This information is an important product of the TMDL analysis not previously provided, so it should be included somewhere in the TMDL document. (p.9)

Comment(s) Made By:
Fetcho – Yurok Tribe
Crosby – Karuk Tribe
Bowman – Quartz Valley Indian Reservation

Response:
Text has been added to section 4.2.4.1 that compares current and natural Shasta River flows.

ORAL COMMENTS ON THE JUNE 2009 PUBLIC REVIEW DRAFT

Regional Water Board staff held four public workshops in July 2009 and one Regional Water Board workshop on the June 2009 draft TMDL. The public workshops were held in Orleans, Yreka, Klamath, and Santa Rosa, California, while the Board workshop was held in Grenada, California. Many of the comments below were also addressed at the afore mentioned meetings.

ZZ1. Comment(s):
The commenters called for compliance that is enforced through Regional Water Board permits that include strong and specific monitoring requirements and implementation timelines. The commenters also called for benchmarks and contingencies so people know what to expect.

Comment(s) made by:
Malena Marvin – Klamath Riverkeeper, Aaron David, Marc Robbi, Leaf Hillman – Karuk Tribe, Petey Brucker – Klamath Forest Alliance, Erica Terence - Klamath Riverkeeper, Georgina Myers – Klamath River Coalition, Vivian Helliwell – PCFFA/IFT, David Gensaw, Zeke Grader – PCFFA, Jene McCovey, Shannon Flarity, Dana Colegrove.

Response:
See response to R1, R36, R38, R40, and Bowman - 5.

ZZ2. Comment(s):
The commenters called for shorter timeframes to meet water quality standards in the Klamath River through TMDL implementation and an adaptive management process with a written way of tracking progress over time.

Comment(s) made by:
Malena Marvin – Klamath Riverkeeper, Marc Robbi, Petey Brucker – Klamath Forest Alliance, Erica Terence – Klamath Riverkeeper, Barbara Short, Bob Goodwin.

Response:
See response to R39 and Bowman – 5.

ZZ3. Comment(s):
Commenters expressed concern about economic impacts of the TMDL implementation program, especially to the agricultural and timber harvest production. Commenters called for a more thorough economic analysis including the cumulative economic impacts of multiple regulations from various agencies.

Comment(s) made by:
Nita Still, Doug Korech, Grant Stevens, Grace Bennett – Siskiyou County Supervisor District 4, Danielle Lindler – Klamath Alliance for Resources and Environment, Mike Bryan – Mike Bryan Ranch, Rick Butler

Response:
See response to S3, S4, S6, S7, and S11.

ZZ4. Comment(s):
Commenters cited facts regarding the economic impacts of recent fishery closures along the West Coast due to low salmon counts in the Klamath River and that this impact has also affected other local businesses. The fact that there are toxic algae in the river also affects the tourism economy. Economic analysis should look at doctor's bills for people that get sick from the toxic algae in the river.

Comment(s) made by:
Mike Becker, Zeke Grader – PCFFA, Vivian Helliwell – PCFFA/IFR, David Helliwell – F. V. Corregidor, Kevin Collins – Humboldt Fisherman's Marketing Association, Michelle Berditschevsky – Mount Shasta Bioregional Ecology Center, Regina Chichizola

Response:
The economic analysis for the TMDL is only required to look at the cost of the reasonably foreseeable compliance measures. It is not within the scope of the analysis to consider the economic impact of impaired water quality. A cost/benefit analysis is not needed to justify the need for an implementation plan. The Regional Water Board is required by law to adopt measures that address the controllable water quality factors in the Klamath basin. That said, the implementation plan is designed to improve the condition of the fisheries.

ZZ5 Comment(s):
Commenters cited public health risks associated with poor water quality in the Klamath River including toxic levels in mussels and water contact through Native American ceremonial practices that caused ear infections, rashes, liver poisoning, and tumor growth. Materials are gathered from the Klamath River and if the river is not healthy, there is an effect on the spiritual quality of the basket materials and the baskets which are used for many everyday purposes.

Comment(s) made by:
Aaron David, Leaf Hillman – Karuk Tribe, Bill Tripp, Holly Hensher, Lauren Alvarado, Georgiana Myers – Klamath River Coalition, Deborah E. McConnell – California Indian Basketweavers Association, Michelle Berditschevsky – Mount Shasta Bioregional Ecology Center, Damien Scott, Jocelyn Peters, Kristen Raymond, Dana Colgrove.

Response:
Comments noted. The TMDL addresses the controllable water quality factors related to the water quality conditions identified in the comment that threaten public health.

ZZ6 Comment(s):
Need more active fire management according to tribal practices including controlled burns that will improve water quality and riparian conditions.

Comment(s) made by:
Ben Riggan and Bob Goodwin

Response:
See response to Terence – 18.

ZZ7. Comment(s):
Support for thermal refugia buffer zones and regulation of suction dredgers

Comment(s) made by:
Malena Marvin – Klamath Riverkeeper, Bob Goodwin, Kathy McCovey

Response:
Support noted.

ZZ8. Comment(s):
There is no science saying suction dredging impacts water quality and prohibiting mining is a private property takings issue. Commenters also stated that suction dredging can create cool water pools for fish.

Comment(s) made by:
Jim Foley, Dr. Richard Gierak, Grace Bennett – Siskiyou County Supervisor District 4

Response:
The TMDL staff report now includes a review of the technical literature concerning the impacts of suction dredging on fish habitat and water quality (section 4.2.4). See response to N24 that addresses private property issues.

ZZ9. Comment(s):
Fraudulent science in Chapter 2, the Klamath River has never been considered cold. Pollution comes from an extant volcano. The history of the river is that it has always been a cesspool. Upper Basin was a sick disease infested swamp and an arid desert.

Comment(s) made by:
Leo Bergeron, Mike Kobseff – Siskiyou County Board of Supervisors, Nita Still, Rick Butler

Response:
See response to Bennett – 6 and C37.

ZZ10. Comment(s):
The commenter tied the degradation of water quality and reduction in fish populations to the loss of a valuable food source for local Native American tribes that have historically relied on that food source. The commenter also noted the secondary effects on the physical health of individual tribal members as well as the adverse impact on tribal culture and practices. Environmental justice laws and policies of California must be recognized.

Comment(s) made by:
Dr. Kari Norgaard

Response:
The TMDL addresses the environmental justice issue by including implementation measures that are intended to restore water quality and support beneficial uses including the Native American cultural beneficial use (CUL) and subsistence fishing (FISH). The Regional Water Board staff met regularly with tribal staff in coordination with EPA on addressing tribal trust responsibilities.

ZZ11. Comment(s):
The TMDL adds impairments in the Scott and Shasta Rivers, circumventing the 303(d) listing process. You cannot lump impairments – each watershed has its own characteristics.

Comment(s) made by:
Gary Black

Response:
See response to L38 and Walker – 2.

ZZ12. Comment(s):
Commenters expressed support for the TMDL, in particular with regard to regulations on cattle grazing, addressing Klamath Straits Drain, the Lost River and ensuring interim conditions are followed.

Comment(s) made by:
Kathy McCovey, Regina Chichizola

Response:
Support noted. See response to Bowman – 2 for a discussion of the reasons for removing the interim requirements that were formerly proposed as part of the June 2009 draft.

ZZ13. Comment(s):
Comments expressed concern for low flows, in particular in the Scott and Shasta River and called for Regional Water Board to restore flows.

Comment(s) made by:
Dana Colgrove, Regina Chichizola.

Response:
See general response X1.

ZZ14. Comment(s):
Oregon does not regulate agriculture. Any load has to come out of a point source to be regulated. 1010 plans are not good enough. State of CA has to hold Oregon accountable.

Comment(s) made by:
Regina Chichizola.

Response:
Section 6.2 of the TMDL staff report discusses implementation to meet the load allocations at the stateline including California's role in addressing pollutant sources in Oregon. The MOA signed by the Oregon Department of Environmental Quality, the Regional Water Board, and the USEPA states that all parties agree to meet "water quality standards, water quality objectives, and TMDL allocations and targets in a timely manner." The MOA also confirms the USEPA's obligations under federal law "to address the impact of discharges in one state that may affect the attainment of water quality standards in another state."

ZZ15. Comment(s):
Counsel for Siskiyou County, Tom Guarino, raised two objections to the TMDL process, which are detailed as part of the response below.

Comment(s) made by:
Tom Guarino – Council for Siskiyou County

Response:
Below is excepted text from a letter in response dated November 24, 2009. PRA documents were produced on February 17, 2010, and have been added to the TMDL record. Additional time to comment on these documents was granted. As of the date of

printing, Regional Water Board has not received any comments. Regional Water Board staff will respond to any comments received, and the response will be made available no later than the Board hearing on the Klamath TMDL, and earlier if possible.

Counsel for Siskiyou County raised two objections relating to conflict of interest and bias in its Klamath River TMDL public comments at a North Coast Regional Water Quality Control Board (Regional Water Board) meeting on September 10, 2009. First, the County lodged a formal conflict of interest objection to Board member John Corbett's participation in the Regional Water Board's consideration of the Klamath TMDL because he is a paid representative of the Yurok Tribe and actively engaged in discussions involving the Klamath Basin Restoration Agreement (KBRA) and the Klamath Hydroelectric Project (KHP) Hydropower Agreement (HA) negotiations. Second, the County requested that any communications between Board staff and the parties involved in the HA be added to the Klamath TMDL administrative record, including communications with "various pro-dam removal environmental groups, PacifiCorp, the United States, the State of California, and the State of Oregon" (Settlement Parties). In this second request, the County states that "it appears that there has been direct communication with Board staff and [Settlement Parties] regarding the setting of TMDLs." To avoid any further confusion, I will address the latter issue first and provide the following points about the HA negotiations as it relates to the Klamath TMDL.

A TMDL has two primary components: a technical portion (technical TMDL), and an implementation plan. The technical TMDL establishes load allocations and numeric targets to implement existing water quality objectives and to protect beneficial uses. The Klamath River TMDL includes specific load allocations and numeric targets to all responsible parties in the Klamath River Basin, including the KHP. A TMDL implementation plan implements the load allocations and numeric targets and recommends implementation measures for adoption into the Regional Water Board Basin Plan. Siskiyou County suggests that HA negotiations somehow involved the establishment of load allocations or "the setting of TMDLs." This is incorrect. The technical work on Klamath TMDLs by the Regional Water Board in collaboration with Oregon Department of Environmental Quality, and US Environmental Protection Agency (EPA) Regions 9 and 10 has been ongoing since 2003 and is wholly separate from any HA negotiations. The Regional Water Board is not a party to the Agreement in Principle (AIP) or any final agreement that Settlement Parties may reach on the KHP.

Regional Water Board staff did briefly participate in the HA discussions (approximately April through mid-July, 2009) after the AIP was released by the Settlement Parties, for the limited purpose of discussing KHP implementation of the TMDL. This was necessary because it appeared that the AIP contemplated altering the process by which the load allocations and Basin Plan could be implemented. Specifically, the AIP specifies that the parties intend to pursue federal legislation that would indefinitely delay the relicensing process before the Federal Energy Regulatory Commission (FERC) and accompanying Clean Water Act section 401 permitting process before the State Water Resources Control Board (SWRCB). Because the Regional Water Board is preempted from directly issuing waste discharge requirements to the KHP so long as the project is operated under a federal license issued by FERC, the TMDL load allocations (and existing water quality objectives) as they apply to the KHP cannot be directly implemented and enforced without a relicensing decision from FERC and accompanying 401 water quality certification. Based on direction from the Regional Water Board, staff sought to participate in KHP discussions to explore the procedural and regulatory pathways for any final agreement, specifically as it relates to compliance with the Clean Water Act. Staff participated in drafting a section of the agreement which explains the regulatory pathways envisioned in the Hydropower Agreement and their relationship to Oregon and California's TMDLs. This is reflected in section 6.3 of the draft Klamath Hydroelectric Settlement Agreement released on September 30, 2009. In addition, Regional Water Board staff participated in discussions on the interim water quality measures that the Settlement Parties designed to ensure that the KHP was on a path toward compliance with water quality standards during the period when dam removal was studied and any interim period after the Secretary Determination if the decision was made to move forward with dam removal. These interim measures focus on basin-wide monitoring, nutrient reduction, temperature mitigation and a water quality conference. The interim measures are contained in section 6 of the draft Agreement and various appendices. At no time during the negotiations did Regional Water Board staff discuss, or seek input from Settlement Parties, on the characterization of sources or pollutant load allocations. How the TMDL or the Clean Water Act is implemented is a distinct and separate issue from technical TMDL development. The technical TMDL development process was not, and will never be, an appropriate topic in HA negotiations.

Regarding the formal request to include Regional Water Board staff communications with Settlement Parties in the TMDL administrative record, staff is in the process of gathering these documents and will add any relevant documents to the Klamath TMDL record as appropriate. Your October 22, 2009 letter clarified that you have requested these documents pursuant to the Public Records Act, and I had responded previously expressing the hope to have these documents by November 23, 2009. Additional time is needed for the collection and review of relevant documents, and we hope to have the documents ready in December of this year. Also, Regional Water Board staff intends to follow the procedures identified under section 3.2 of the Protocol and Confidentiality Agreement related to the KHP, which the Regional Water Board Executive Officer signed on April, 2009.[1] It is important to note that outside of the context of the HA negotiations, Regional Water Board staff has had numerous meetings with PacifiCorp, Siskiyou County, and other interested parties throughout the development of the TMDL.

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[1] Note that the protocol was signed subject to the following qualifying language:
The Executive Officer of the North Coast Regional Water Quality Control Board (Regional Water Board) intends to participate in negotiations with the limited scope and purpose of providing information to help guide parties towards a final agreement that is likely to obtain the necessary regulatory approvals on water quality issues, specifically, on adequate interim water quality measures, including possible nutrient reduction strategies upstream of the reservoirs. By signing this document, the Executive Officer of the Regional Water Board agrees to abide by the confidentiality provisions of this document; however, this shall not limit in anyway the Regional Water Board's legal authority and responsibilities. The Regional Water Board is an independent agency that has not bound itself to any Klamath agreement, and can only do so to the extent consistent with the law.

Written correspondence stemming from those conversations is already part of the TMDL record.

Regarding the request that Board member Corbett be recused, the Office of Chief Counsel has reviewed this matter. Contrary to the County of Siskiyou's claim, Mr. Corbett's participation in the KBRA and negotiations regarding the KHP, as a paid representative for the Yurok Tribe, does not give rise to a legal conflict of interest barring his ability to participate in the Regional Water Board's action on the Klamath TMDL. The Fair Political Practices Commission has established regulations to assist in this determination. (Cal. Code Regs., tit. 2, §§ 18704-18704.5.) Notwithstanding these legal analyses, Board member Corbett has announced his intention to withdraw his participation in the Regional Water Board’s consideration of the Klamath TMDL to avoid any perception of conflict.

December Comments

Addington & Danosky – Klamath Water Users Association

1. Comment(s):
KWUA's constituent districts and irrigators operate within the Klamath Project in Oregon and California. No land within the Klamath Project discharges to the Klamath River in California. As such, the Draft TMDL cannot impose requirements on the Klamath Project.

Response:
See response to comment H1.

2. Comment(s):
The Staff Report and Proposed Basin Plan Amendment continue to make vague and confusing references to "watershed-wide" measures and application to minor and/or major "tributaries." If the Regional Board is going to adopt a basin plan amendment that attempts to include new implementation measures for the Lost River segment in California, the Regional Board must clearly distinguish the implementation measures and Basin Plan requirements that apply to the Lost River segment in California. The Staff Report encourages the Regional Board to overstep its authority and create additional and conflicting requirements for Klamath Project irrigators, KWUA continues to strongly object to such action.

Response:
The staff report clearly states that the watershed-wide allocations do not apply to basins of major tributaries, such as the Lost River, that already have established TMDLs. The Lost River basin was assigned allocations in the Lost River TMDL promulgated by the EPA in December 2008. The implementation plan addresses Klamath project irrigators along with all other irrigators in the Klamath basin by proposing the development of a conditional waiver for agriculture in the Klamath basin. The waiver would cover grazing and irrigated agriculture. The only other measures that apply to the Lost River are those associated with the development of an MAA with the USBR, USFWS and TID and the incorporation of the wasteload allocations into the Tulelake Wastewater Treatment Plant NPDES permit. The implementation measures in the Lost River basin are clearly defined in the staff report section 6.4.3.

3. Comment(s):
The Staff Report contains scattered statements suggesting that the load allocations assigned to "Stateline" are intended to address discharges to the Klamath River in Oregon and to the Lost River in California. (See. e.g., Staff Report. p. 9-7 [w]aters entering California from Oregon at Stateline, which includes ... the Lost River watershed that drains the Klamath Irrigation Project area"].)

Response:
The quote referred to in the comment is out of context. The statement on p. 9-7 is describing how the Klamath TMDL approached categorization of sources in the Klamath basin as a whole, including those in Oregon. Discharges of waste to the Lost River are within the Regional Water Board's jurisdiction. The implementation plan proposes the development of an agricultural waiver which will cover dischargers to the Lost River in California. The Staff Report describes the waiver process, including the intent to dovetail requirements with Oregon to the extent possible.

4. Comment(s):
The Staff Report attempts to "implement" the EPA Lost River TMDL with only a bare reference to the load allocations set forth therein. (See Staff Report, p. 6-23.) The Proposed Implementation Plan contains no analysis of how the proposed implementation measures, designed to address various constituents including temperature (for which part of the Lost River was delisted in 2006), will address compliance with the Lost River TMDL in California.

Response:
The implementation plan does describe how the implementation measures will address Lost River TMDL compliance in section 6.4.3 of the staff report. Regional Water Board staff agree that the language is not a clear as it could be and the staff report has been revised to clearly show the elements of the Lost River implementation plan. They are:

1. MAA with USBR, USFWS, and TID;
2. Conditional waiver for agriculture to be developed through a separate stakeholder process;
3. Revision of Tulelake Wastewater Treatment Plant permit to incorporate Lost River TMDL wasteload allocations; and
4. MOA with EPA and Oregon Department of Environmental Quality.

Although the Lost River was delisted for water temperature, dischargers in the basin are still responsible for meeting the Basin Plan standards including the water temperature standard.

5. Comment(s):
The Proposed Implementation Plan does not address the inconsistency between various water quality standards applicable to the waters that the Proposed Implementation Plan attempts to address. (See. e.g., Proposed DO Objective at Staff Report, p. 1-4 of Appendix I [proposing to change the DO objective applicable at "Stateline" to a narrative objective based on saturation levels]; see also, e.g., EPA Lost River TMDL, p. 30 [explaining numeric DO objective applicable to Lost River. which is based on minimum DO levels].)

Response:
The proposed recalculated SSOs for DO in the Klamath River apply only to the Klamath River mainstem. They do not extend to the Lost River or any other tributary to the Klamath River. The Lost River TMDL is appropriately calculated to attain the concentration-based DO objectives currently contained in Table 3-1 of the Basin Plan.

Similarly, the Klamath River TMDL is appropriately calculated to attain the percent DO saturation-based objectives proposed for adoption into the Basin Plan prior to the adoption of the Klamath River TMDL.

The proposed implementation plan is designed to provide tools in both the Lost River and the Klamath River for reducing pollutant loads to a degree sufficient to attain the associated water quality objectives. Monitoring will provide the information necessary to determine when the respective objectives have been attained.

6. Comment(s):
"The Regional Board may apply any existing authorities available in a basin plan amendment, and is not necessarily constrained by the scope of the technical TMDL process." (Staff Report, p. 6-2.) If the Regional Board intends to adopt a basin plan amendment that establishes a "broad based nonpoint source approach" for the entire Klamath Basin, as suggested in the Staff Report, then the Regional Board should notice such a program and engage stakeholders in order to develop a program that takes into consideration the various water quality standards, TMDL allocations and implementation measures, and water quality levels that can be reasonably achieved in the various hydrologic areas within the basin.

Response:
The current draft includes the proposal of the stakeholder process called for in the comment. The stakeholder process will be initiated after adoption of the Klamath TMDL and is scheduled to complete a draft conditional waiver for agricultural dischargers in the Klamath basin by December 2012. Regional Water Board staff specifically removed requirements for agriculture from the June 2009 draft in part based on similar comments. This concern has already been addressed. The authority to develop a waiver program is provided under section 13269 of the Porter-Cologne Water Quality Control Act and fulfills the requirement of the State Nonpoint Source Policy for Regional Water Boards to regulate all nonpoint source discharges of waste including those associated with agriculture. The waiver program will take into consideration the various water quality standards in the Klamath basin, including the standards specific to the Lost River basin. The comment is correct that dischargers in the Lost River basin are only expected to meet the water quality standards that apply in that basin.

7. Comment(s):
In attempting to assert Regional Board authority in Oregon, the Proposed Implementation Plan puts responsibility on the Oregon Department of Environmental Quality (ODEQ) to

achieve compliance with the Draft TMDL, particularly the load allocations at Stateline. (See, e.g., Proposed Basin Plan Amendment, p. 12; see also Staff Report, p 6-10.) Though KWUA appreciates the need for interjurisdictional efforts to address Klamath Basin-wide water quality issues, such attempts to impose requirements on ODEQ are not appropriate for a Regional Board implementation plan addressing discharges to waters in California.

Response:
The Regional Water Board does not have authority over discharges in Oregon. The Staff Report details Oregon's implementation tools and suggests potential measures ODEQ could take to coordinate its existing agricultural regulatory program with TMDL implementation (see Staff Report at 6-10). These suggestions are not legally binding. The strength of Oregon's agricultural water quality management program is its focus on landowner driven efforts. By working with the KSWCD in the Lost River basin, landowners have already implemented management measures and water quality improvement projects that address the TMDL pollutants. To dovetail California's future agricultural program with Oregon in the Lost River, it would be helpful if Oregon's administrative rules developed pursuant to Senate Bill 1010, and the corresponding water quality management plans developed by ODA, would address nutrient discharges and include TMDL monitoring and reporting. The Regional Board is also recommending a few interim steps for landowners to help develop California's agricultural program, including documenting past projects and current practices that address water quality. This is intended to help bridge the gap with Oregon's program. It is Regional Water Board staff intent to continue coordinating with Oregon through the MOA to coordinate TMDL implementation to the extent possible.

8. Comment(s):
The Draft TMDL characterizes the Oregon TMDL requirements, without recognizing that Oregon has not yet adopted a Klamath River TMDL or implementation plan. (See, e.g., Staff Report. p. 5-25, 6-20).

Response:
The language on p. 5-25 is accurate and the language on p. 6-20 has been revised.

9. Comm ent(s):
Though the Staff Report suggests that the MAA would be a "voluntary and cooperative means of implementing the TMDL." It should be made clear the Regional Board cannot force any public agency to enter into an agreement that it has not seen and considered as a public decision making body. Rather, the Proposed Implementation Plan should recommend the MAA as a voluntary measure consistent with the State Water Resources Control Board Non Point Source Policy (State NPS Policy), which encourages voluntary measures to address water quality issues. (State NPS Policy, p. 56. Among the "actions" identified for a potential MAA, the draft documents refer to "Lost River and Klamath

River" TMDL allocations and targets. Again, the Regional Board has no regulatory authority related to Klamath Project discharges to the Klamath River.

Response:
Regional Water Board staff is aware that the MAA is a cooperative agreement and is proposed as such. The list of items that should be contained in the MAA is exactly what the commenter suggest as appropriate; a list of general objectives for the MAA. Regional Water Board staff view these objectives as essential to improving water quality in the Klamath Project and in the discharges to the Klamath River in Oregon. The MAA approach is recommended based on an existing MAA between USBR and the Central Valley Regional Water Board. Under the terms of the MAA, USBR and Central Valley Board have been successfully implementing a water quality improvement program to meet allocations assigned as part of the Lower San Joaquin River TMDL.

10. Comment(s):
The Proposed Basin Plan Amendment (p. 12) refers to a management plan to meet "or offset" Lost River and Klamath River TMDL allocations. While we do not oppose the general concept of offsets, it is not clear where offset opportunities may exist for Lost River or Klamath River TMDLs as structured.

Response:
The implementation plan includes the development of the Klamath basin tracking and accounting program. The purpose of this program is to provide a mechanism that would allow for collaboration among basin stakeholders on common projects while earning credit toward their regulatory requirements related to TMDLs and other mandated programs. The specifics of the program have not yet been developed. See response to comment Hashimoto and Ziegler - 8.

11. Comment(s):
The Draft TMDL inappropriately assigns responsibility to irrigation district (See. e.g,. Proposed Basin Plan Amendment, pp. 12. 18.). As an irrigation district formed and operating under California Irrigation District Law, Water Code section 20500 et seq., Tulelake Irrigation District has no authority to enforce water quality standards and cannot regulate activities of constituent irrigators.

Response:
Tulelake Irrigation District is only responsible for discharges under its control. Discharges that are the responsibility of constituent irrigators will be addressed through the proposed conditional waiver for agriculture. Nevertheless, there would seem to be important opportunities for TID to play a role in development of an agricultural waiver, and in identifying and helping implement BMPs, for example, given the institutional capacity and leadership position TID holds in the community. As such, TID is named a party responsible for participating in the development of the proposed MAA to collectively address discharges associated with the Klamath Project. As noted above,

there may be opportunities for improving management practices concerning the delivery and conveyance of water that could have a positive effect on water quality. The MAA is intended to act as a mechanism to coordinate the implementation of those practices with the goal of making progress towards meeting the Lost River and Klamath River TMDL allocations in Oregon and California and improving water quality in those basins.

12. Comm ent(s):

The Draft TMDL continues to assume immediate compliance with the Upper Klamath Lake TMDL. Despite prior comments suggesting that the baseline applied in the prior draft Klamath River TMDL was too low, the updating process appears to have resulted in further reductions to the assumed baseline. As a result, the "negative" load allocations have dropped to even lower levels, increasing the unreasonableness of the proposed load allocations. (See. e.g., Staff Report. pp. 4-14. 5-17; cf. *id.* pp 4-13, 5-16.)

Response:

The TMDL describes ultimate compliance, and does not anticipate immediate compliance. See also response to C49.

13. Comm ent(s):

The Regional Board's development of this TMDL must be reasonable and take into consideration economics, water quality levels that can be reasonably achieved, and other public interest factors. (Wat. Code, §§ 13000, 13001, 13241, 13263.) The current superficial analysis of economic factors does not satisfy this standard and completely fails to acknowledge that the assigned loads are impossible to meet in the reasonably foreseeable future. Bare references to analysis of feasibility and probability of success do not suffice to satisfy the stringent requirements of Porter-Cologne. (See. e.g., Staff Report, p. 6-6.)

Response:

See response to comment O22.

14. Comm ent(s):

The Staff Report also suggests that responsible parties may need to "improve and increase" their implementation efforts as necessary where ongoing implementation efforts are insufficient to ultimately achieve the allocations and numeric targets. (Staff Report, p. 7-1.) This statement fails to lake into account the fact that circumstances beyond the control of "responsible parties" will likely affect what can be accomplished. Further, the Proposed Implementation Plan places the burden on the regulated parties to "demonstrate that although water quality objectives are not being achieved in receiving waters, controllable sources of pollutants are not contributing to the exceedance." *(Id.* p. 7-2.) Requiring the regulated community to make such a showing is inappropriate, and contradicts the State Board's policy requiring Regional Board staff to review water quality standards during the TMDL process to "ensure that the standards are amenable to an appropriate implementation plan." *(Id.;* cf.. State TMDL Policy, p. 4.) As currently drafted, the Draft TMDL and Proposed Implementation Plan set the regulated parties up for failure, and then place the obligation on them to prove that the failure is not their fault. (See, e.g., Staff Report, p. 7-2 ["'dischargers will be required through their permits to meet the TMDL allocations and targets"].) This is unacceptable and will create unnecessary conflict that takes resources away from actual measures to improve water quality in the basin.

Response:
Thank you for pointing out this inaccuracy. Dischargers are only responsible for meeting targets and allocations that are applicable to their discharge. Individuals are not alone in their responsibility for meeting the load allocations at Stateline. Regional Water Board staff agree that dischargers are only responsible for discharges under their control and associated with their activities. The statements on page 7-1 have been revised to state: "responsible parties may be required to improve and increase their reporting, monitoring, and/or implementation efforts, as necessary to ensure any applicable allocations and numeric targets are achieved within a reasonable amount of time. Individual landowners conducting nonpoint source discharge activities are only responsible for their own discharges…" The statements on page 7-2 have been revised to state that "dischargers will periodically report to the Regional Water Board on progress. The Regional Water Board may at that time require modification of the discharger's plan and/or timelines as necessary." See also response to O17 that discusses the issue of causation between discharges and water quality impairments.

15. Comm ent(s):
KWUA appreciates the Regional Board staff's attempt to recognize recent studies showing that the Klamath Project is a "nutrient sink." However, KWUA disagrees with the Staff Report's conclusions and characterization of the concentration levels resulting from the Klamath Project. (See, e.g., Staff Report, pp. 4-20 - 4-22.) The analysis on the subject is cursory, limited, and appears end-oriented. In addition, while Klamath Straits Drain concentrations may at times be higher than Klamath River flows, there is no meaningful consideration of the effects of the Klamath Project on loads. Further, certain concentration assumptions applied to such analysis are inappropriate. *(Id.,* p. 4-21 ["[w]hen concentration data were not available for a specific canal, a nearby river concentration was used as a surrogate"].) To the extent the analysis relies on surrogate data, the Staff Report must explain the origin of the surrogate numbers, the canals to which the data was applied, and the rationale supporting such use. The Staff Report does not do so and rather makes conclusions without the requisite support.

Response:
The assumptions that went into the analysis are clearly stated. The analysis was not end oriented other than to help convey how the Klamath Project takes as inflow more nutrient mass than is discharged through KSD, yet still has a water quality impact as a result of concentrations in the KSD discharge that exceed Klamath River concentrations. See also response to C21.

16. Comment(s):
KWUA questions the use of flow assumptions explained within the Staff Report. (See, e.g., Staff Report, p. 4-22.) Flow data for one single month (August 2002) does not provide an objective or reasonable estimation of impacts. Any such analysis or conclusions about flow levels should consider varying hydrology, and further take into account the most current data available. Specifically, KWUA disagrees with the suggestion that Klamath Straits Drain discharge accounts for approximately half of the flow of the Klamath River at Keno Dam. *(Id.)* Even if this condition may have occurred on some occasion, such a single occurrence does not support the Staff Report's broad conclusions.

Response:
We believe the statement is appropriate and does not imply anything beyond August 2002. Our intent was not to evaluate typical flow conditions but to determine if KSD is a potential source of pollutants. To the best of our knowledge, there has not been a study which evaluates typical flow diversions to and returns from the irrigation project. The analysis was a sensitivity analysis of the potential impact of KSD and chose appropriate boundary conditions for the analysis.

17. Comment(s):
The legislature included prohibition provisions in Porter-Cologne to authorize Regional Boards to prohibit discharge of certain types of waste or discharge into certain areas to protect water quality. (See Wat. Code. § 13243.) General prohibitions against any unlawful discharges were not authorized and should not be used to circumvent notification requirements for bringing enforcement actions against non-compliant individuals. All persons should be afforded appropriate due process rights, including notification regarding non-compliance before being subject to enforcement.

Response:
Water Code section 13243 states the following: "A regional board, in a water quality control plan or in waste discharge requirements, may specify certain conditions or areas where the discharge of waste, or certain types of waste, will not be permitted." The prohibition proposed in the implementation plan specifies the conditions under which the discharge of waste is not permitted; namely, where that discharge of waste violates any narrative or numerical water quality objectives and is not otherwise authorized by the Regional Water Board. It is within the authority of the Regional Water Board to adopt such a prohibition. In fact, similar prohibitions have already been adopted by the Lahontan Regional Water Board (Region 6). Any enforcement action for violation of a prohibition will necessarily provide due process under procedures specified in the Water Code. Individuals who are concerned about any discharges that violate water quality standards should contact the Regional Water Board and inquire about obtaining an individual permit.

18. Comment(s):
The CEQA analysis fails to consider the environmental setting and regulatory setting associated with the Klamath Project. (See Staff Report, pp. 9-6 - 9-9.) Specifically, the CEQA analysis does not take into account the potentially conflicting water quality measures provided for in the Klamath Project through the various TMDLs, the current efforts undertaken to address these issues, and the existing water use and drainage activities within the Klamath Project. Without this important information, it is impossible to actually analyze the potentially significant impacts of the proposed actions and the reasonably foreseeable actions taken in response.

Response:
The environmental setting and land use section of Chapter 9 does contain a general description of the geographic source areas which includes the Klamath Project (page 9-7). The regulatory setting for the Klamath River watershed is described in Chapter 1 of the Staff Report and includes a description of the TMDL process, state water quality law, tribal trust responsibilities, federal and state endangered species act consultation processes, water quality certification regulations, and the pending Klamath Basin restoration and settlement agreements. In addition, Chapter 6 of the staff report contains a concise description of the geographic scope of the implementation plan.

Regional Water Board staff were unable to determine the "potentially conflicting water quality measures" cited by the commenter. Regional Water Board staff identified a suite of reasonably foreseeable compliance measures that responsible parties may use to achieve compliance with the TMDL load allocations. The selection of these measures are at the discretion of the responsible parties, not the Regional Water Board, so identification of "potentially conflicting water quality measures" would be speculative in nature. If the commenter is referring to potentially conflicting water quality measures between Oregon and California, Regional Water Board staff has identified the issue and made clear that any agricultural waiver would attempt to dovetail Oregon rules to the extent possible.

19. Comment(s):
The CEQA analysis associated with the proposed waiver program for irrigated agriculture is inadequate. (See *id.,* pp. 9-55 - 9-60.) The analysis improperly dismisses, without explanation, any potential impacts associated with pesticide and nutrient management compliance measures. With respect to other anticipated compliance measures, the analysis identifies potentially significant impacts and vague potential mitigation measures, but does not provide any explanation of how the mitigation measures will actually ensure that no significant impacts occur. (See, e.g., *id.,* pp. 9-57 - 9-58.) Despite recognition that reasonably foreseeable compliance measures could involve change in application and transport of irrigation water and use of runoff and tailwater and drainwater management (all which have the potential to alter existing water management practices), the CEQA analysis fails to meaningfully analyze the potential

impacts and necessary mitigation measures associated with changes to ongoing irrigation operations. *(Id.,* pp. 9-58 – 9-60.).

Response:
Waiver or WDR programs typically consist of actively identifying sources of pollution, implementing management practices to control those sources, documenting efforts, monitoring, and reporting to the Regional Water Board. It is generally the owner/operator's responsibility to select the management practices that are most effective at controlling pollution from their lands. The TMDL analyzes potentially significant impacts that could result from the implementation of BMPs. Any BMPs associated with pesticides and nutrients will likely *reduce* current impacts from those inputs, and the comment provides no specific impact to help further evaluate this claim. Please note that certain uses of aquatic pesticides in California require coverage under an already existing State Water Board NPDES permit (Order 2004-0009-DWQ). The precise configuration of BMPs will be developed by each individual landowner. The mitigation measures will become conditions of any agricultural waiver developed. The development of the waiver will proceed through a public stakeholder process and be considered for adoption by 2012. The regulatory permit, whether a waste discharge requirement or a waiver of waste discharge requirements, will also be subject to a formal environmental analysis as part of the development and adoption of the regulatory permit.

20. Comment(s):
The CEQA analysis fails to discuss the possible impacts to existing water supplies resulting from these water management measures. (*Id*., p. 9-105.)

Response:
The environmental analysis does address potential impacts to water supplies from the use of reasonably foreseeable compliance measures (the project). After evaluation of the potential for adverse impacts to water supplies, staff found that a "less than significant" impact would occur to existing entitlements from the use of carefully selected compliance measures.

21. Comment(s):

- The CEQA analysis inappropriately dismisses any likelihood of impacts to agricultural resources resulting from the proposed actions. Despite recognizing that "there may be incidental loss of agricultural use in lands mapped as Prime Farmland. Unique Farmland, or Farmland of Statewide Importance," the CEQA analysis concludes no significant impact to agricultural resources. (See Staff Report, p. 9-76.) Regional Board staff suggests that this loss is insignificant because there are very few lands mapped as Prime Farmland, Unique Farmland, or Farmland of Statewide Importance within the basin. *(Id.)* Even if this is true, then the loss of any such lands is all the more significant and should be avoided, or at the very least, properly mitigated. Further, any incidental loss of farmland has the potential to be a significant impact.

- CEQA requires the Regional Board to analyze economic impacts that may result in physical changes leading to an environmental impact. Despite the use of conflicting and unachievable load allocations and water quality standards as a benchmark for compliance with the Proposed Implementation Plan, the CEQA analysis fails to discuss the possibility of any economic impacts that would ultimately result in the conversion of farmland (or other associated environmental impacts). *(Id.,* p. 9-77.)

Response:
This comment fails to provide any detailed information to support the contention that a potentially significant adverse impact to agricultural resources would result from the adoption of the Klamath River TMDL. Staff did not identify any compliance measures that would result in the conversion of agricultural lands to other uses.

22. Comment(s):
The CEQA analysis must consider the potential climate change and greenhouse gas emissions resulting from the cumulative loss of agricultural lands (which offset carbon emissions) resulting from the proposed actions and other reasonably foreseeable projects affecting agricultural resources in the Klamath Basin.

Response:
The TMDL implementation plan does not include any measures that will result in the loss of agricultural lands in amounts significant enough to have an impact on climate change.

23. Comment(s):
The CEQA analysis inappropriately defers analysis of potential impacts and mitigation measures associated with compliance measures (related to TMDLs and the Proposed DO Objective) at Stateline. (Staff Report, pp. 9-17 - 9-18.) The Regional Board must analyze potential impacts associated with the proposed actions based on reasonably foreseeable circumstances. As such, the CEQA analysis should at the very least consider potential impacts associated with the suggested centralized treatment options. The Regional Board must establish mitigation measures with specific performance standards to ensure that future actions will incorporate mitigation to reduce potential impacts to less than significant.

Response:
See response to Hemstreet-238.

24. Comment(s):
The CEQA analysis concludes with a general statement that the Proposed Basin Plan Amendment and Proposed DO Objective will not have a significant effect on the environment because the identified impacts are "short-term." The duration of impacts does not bear upon their significance. Dismissing impacts as temporary in nature is inappropriate. The Regional Board must analyze potentially significant impacts to the

environment and identify feasible mitigation measures to reduce such impacts. (14 Cal. Code Regs., § 15126.2(a).)

<u>Response:</u>
Staff disagree as to the potential significance of "short term" versus "long term" impacts. By careful selection of compliance measures, "long term impacts" can be mitigated to "short term impacts". With the application of additional compliance measures such as timing considerations those short term impacts can then be mitigated to a "less than significant" level.

Bennett – Siskiyou County Supervisor, District 4

1. Comment(s):
   The farmers, ranchers, and loggers of Siskiyou County have been working to improve their practices for many years and have accomplished many of the things outlined in your regulations. They love this land and wish to continue using it to produce products that the rest of us use to make our lives better. I have always felt that there should be some reward or recognition for the 'work that has already been done and after talking with one of the EPA representatives that were at the meeting [in Yreka on January 27, 2010] it seem that there is an Early Compliance program. This should be talked about so that people are a least given a pat on the back for all of their hard work and the money that they have already spent to comply with improving water Quality.

   Response:
   Regional Water Board staff appreciate the ongoing efforts to improve water quality and recognize that there are currently a number of local programs that are effective at addressing the TMDL impairments. The regulatory approach proposed in the implementation plan builds on local programs to implement the TMDL. Examples include coordination with the Anadromous Salmonid Protection Rules, the development of an agricultural waiver program through a locally driven stakeholder process, the certification of the existing Five Counties Roads Program, and the coordination with existing USFS programs to achieve TMDL objectives.

2. Comment(s):
   There has to be an end. If we are to have a balanced use of the land and the water, all parties must compromise, it can't be completely back to wilderness and no one works.

   Response:
   The TMDL implementation plan will work with local landowners to implement appropriate management practices that fit into existing efforts to improve water quality. Regional Water Board staff have made several changes to the implementation plan in response to comments submitted on the earlier June draft, and believe the current draft of the implementation plan represents a workable approach to water quality regulation and will not result in the scenario the commenter describes.

3. Comment(s):
   The other thing that bothered me a great deal was when your board kept referring to the water in Creeks and Rivers as property of the State of California, This is not

true, 68% of Siskiyou County belongs to the Federal Government and who is the Federal Government but the People of the United States.

Response:
For the purposes of state water quality laws, "waters of the state" means "any surface water or groundwater, including saline waters, within the boundaries of the state." Water quality laws apply to both surface and groundwater and discharges to waters of the state are subject to regulation. All water within the State is the property of the people of the State, although the right to use water may be acquired in the manner provided by law. (Wat. Code, § 102.) With respect to federal lands, those lands are public lands that are managed by the federal agencies, and the waters that traverse those lands are also waters of the state (sometimes the federal government retains a "reserved right" to use water for the purpose of the federal reservation). Discharges to those waters are likewise subject to state regulatory control.

4. Comment(s):
This water shed is very diverse it change from canyon to canyon, some areas have done more restoration work than others, a basin wide approach will not work here, each area must be considered on its own merits, one size does not fit all.

Response:
Please see response to comment Bennett -1. Regional Water Board staff expect that a regulatory program will be flexible enough to reflect local conditions, at least in part by taking advantage of existing local programs, and encouraging new local programs. See also response to Walker - 2 comment on 'one size fits all' approach.

5. Comment(s):
The issues in the Klamath River basin that must be resolved in order to sustain a health fish population are: 1) pollution that comes from Oregon (there are still logs floating in Lake Euwana from the lumber mills in Klamath Falls), 2) there are two diseases that effect and kill the Fry as they try to return to the ocean, and 3) gill nets should be illegal.

Response:
1. The implementation plan contains several measures to coordinate implementation with the Oregon Department of Environmental Quality, in order to address the concern raised in the comment.
2. The Klamath TMDL includes a conceptual model which addresses fish disease in the Klamath basin. Regional Water Board staff agree that addressing fish disease is crucial to sustaining the coldwater fishery. Reducing the nutrient loading, reducing water temperatures, and protecting

cold water refugia are three ways the implementation plan addresses the fish disease problem.

3. The issue of gill nets is separate from water quality but maybe appropriate to raise before the appropriate fisheries agencies.

6. Comment(s):
The Klamath River is a warm water system and always has been; no amount of wishful thinking can change that.

Response:
The Klamath River basin has been designated as supporting the Cold Freshwater Habitat beneficial use in the Regional Water Board's Basin Plan and the TMDL is set to protect that beneficial use. It is well documented that the Klamath River supports cold water fish and the river water does not have to be 'cold' all the time to support this use. Regional Water Board staff agree that the water in the Klamath River is naturally warm during part of the year, as temperatures above 70 degrees F can certainly be considered warm. However, that doesn't mean that the Klamath River does not support a cold water fishery; in fact it does. One of the ways in which cold water fish survive in the Klamath is through the use of various thermal refugia and tributaries that do have cold water in them. The TMDL sets temperature allocations and targets in the mainstem Klamath River that are consistent with the system's natural potential as determined by the TMDL analysis.

7. Comment(s):
All Government agencies have to cooperate with one another they all have different ideas and don't work together.

Response:
The Regional Water Board is coordinating with and will continue to coordinate with other agencies to address water quality problems. Two examples, among many, of this coordination are the MOA between the Regional Water Board, USEPA, and Oregon Department of Water Quality, and the Klamath Water Quality Monitoring Group that includes a large number of government agencies in the Klamath basin.

Bowman –Quartz Valley Indian Reservation

1. Comment(s):
Overall the technical analysis presented in the Klamath TMDL is scientifically rigorous and provides a solid foundation for remediation of the river's pollution problems. The technical analysis has been further refined in recent *Revised Public Draft TMDL (December 2009)*. We commend Regional Board Staff for their effort on the TMDL conceptual framework and technical analysis.

Response:
Thank you for your comment.

2. Comment(s):
We are alarmed by Regional Water Board staff's back-sliding on important issues, such as dropping the interim requirements to develop farm and ranch water quality management plans and the removal of the conditional sediment prohibition that included requirements to control sediment discharges. The Regional Water Board is shirking its duty and abrogating its authority by not requiring farm and ranch plans similar to those required by the Garcia River TMDL (Regional Water Board 1998). We are concerned that the interim requirements to develop farm and ranch water quality management plans that were included in the June public draft is no longer contained in the December public draft.

Response:
Staff disagrees with the comment that the implementation plan is weak as a result of changes to the June draft. While the interim requirements were removed from the draft implementation plan, the requirement for the Regional Water Board to develop a basinwide agricultural waiver program remains, with tightened timelines. The Regional Water Board staff is taking this approach in order to allow more staff time for development of the waiver and allow for more stakeholder input. In addition, removing the administration of an interim program focuses staff resources on development of the waiver. While staff recognize the effectiveness of the Garcia implementation plan, the Garcia River basin and the Klamath basin are different. Mainly, that implementation strategy in the Garcia River focuses on controlling sediment, mainly from timber harvest lands. The agricultural waiver program will address all pollutants associated with agricultural activities. The Garcia River TMDL implementation plan took a number of years to develop and involved an intensive stakeholder process to come up with a program specific to conditions in the Garcia River watershed. This program cannot be simply scaled up to the Klamath basin.

While the process to develop the conditional agricultural waiver is not expected to take nearly as long as the Garcia process, with a time schedule set in the TMDL implementation plan for December 2012, Regional Water Board staff believe that this time is necessary to engage all stakeholders in the process. During the process, the Regional Water Board will consider many options with respect to developing the structure of the program and evaluate the strengths and weaknesses of different agricultural programs around the state; including the Garcia River implementation strategy. The waiver program will contain the basic elements of a nonpoint source program as required of the Regional Water Boards in the State Nonpoint Source Policy. These elements include implementation of management practices on a time schedule, monitoring and reporting to the Regional Water Board, and enforcement. The Regional Water Board staff look forward to working with the tribal governments and other stakeholders in the Klamath River basin to develop a program that is both protective of water quality, works with existing water quality protection efforts, and is tailored to the specific conditions in the Klamath basin. For more on this topic, see the staff report (section 6.5.6), response to comment Q1 and response to comment O22.

3. Comment(s):

We also find provisions with respect to timber harvest and roads left too vague, and the lack of targets and time-lines for reducing cumulative effects risks are likely to confound the plan's refugia protection policy.

Response:

The Klamath TMDL provides a specific allocation to riparian shade that applies to timber harvest and provides targets for controlling road-related sediment. The TMDL allocations and targets will be implemented through the Regional Water Board's existing and proposed nonpoint source programs. For example, the conditional waiver being developed for nonpoint source discharges on lands managed by the USFS will include conditions that address road-related sediment and protections for riparian shade from grazing and timber harvest related impacts. Timelines for addressing sediment and implementing appropriate management practices will also be incorporated into existing and proposed permits.

4. Comment(s):

Despite more than five years of recommendations from the QVIC to the Regional Board staff, the Klamath TMDL still lacks a tributary monitoring program based on trusted scientific methods (Knopp 1993, Kier Associates and NMFS 2008) with a timeline for attainment of targets. Consequently, adaptive management will remain elusive (NRC 2004) as will compliance with CEQA.

Response:

The Regional Water Board has contracted with the Klamath Watershed Institute to facilitate the development of a comprehensive basinwide monitoring program. The working group is called the Klamath Basin Monitoring Program. Participants working in collaboration have developed a draft final program document that includes shared elements (e.g, goals, monitoring sample plan, data management, QA/QC) that provide the foundation for addressing the concerns expressed in this comment. It is the intent and goal of the Regional Water Board that through the coordinated efforts of reach monitoring entities using the "Klamath Basin Monitoring Plan" (KWI 2009), sufficient information will be collected to evaluate trends and compliance for the Klamath River and other tributaries included in the plan. In addition, the Regional Water Board is developing waivers for agricultural and forest management activities that will include monitoring provisions that will provide additional trend and compliance information.

5. Comment(s):
The Revised Draft Klamath TMDL falls short of any scientific standard for the use of adaptive management (Walters, 1997). It instead falls into the pattern of "deferred action" described by the NRC (2004). The Klamath TMDL must be clearer in defining how it will enforce water quality standards, the monitoring that will be used for compliance assessment, and a timeline for abating water pollution under CEQA. These shortcomings of the Klamath TMDL, in aggregate, render it, in our view, non-compliant with the California Environmental Quality Act.

Response:
The Klamath implementation plan recommends a regulatory strategy for addressing the pollutant sources identified by the Klamath technical TMDL analysis. It also takes into account the Regional Water Board's existing and proposed nonpoint source programs that are independent of the Klamath technical analysis. The implementation plan recommends that TMDL implementation measures be incorporated into the Regional Water Board's regulatory mechanisms; i.e. waste discharge requirements and conditional waivers of waste discharge requirements. For nonpoint source discharges associated with land use activities, TMDL implementation measures will be the same or very similar as the BMPs required in a regular permit. The environmental analyses considered potentially significant impacts from the implementation of common BMPs on a programmatic level. For permits that are not developed yet, there will be an additional CEQA review. This is not a deferred CEQA action; rather, it conducts environmental review at the appropriate scale. The regular permitting mechanism, be it a WDR or waiver, will incorporate monitoring and reporting requirements and include adaptive management elements. The idea to integrate TMDLs measures into regular nonpoint source programs recognizes and responds to comments from the regulated community requesting the Regional Board to minimize overlapping requirements and duplication. Chapter 7 of the Staff Report includes basin-wide monitoring and adaptive management elements for the entire TMDL.

CEQA requires consideration of environmental impacts that result from the proposed action as compared to the baseline environmental condition. The staff report of the TMDL includes a CEQA analysis (Chapter 9) that analyzes impacts of various compliance measures that are or will be required pursuant to specific permits for given activities. Reformulating elements of a proposed plan to improve water quality does not constitute a CEQA violation.

Staff disagrees with the comment that the implementation plan is weak as a result of changes to the June draft. The implementation plan recognizes the importance of addressing sediment discharges from roads that have the potential to initiate debris flow, which have been shown to be a major source of temperature alteration in the Klamath tributaries. It also proposes the development of a comprehensive agricultural regulatory program in the Klamath basin, where many agricultural discharges have since gone unregulated. Finally, the implementation plan recognizes the importance of thermal refugia in supporting the coldwater fishery and includes a new Thermal Refugia Protection Policy that will address suction dredging discharges as well as provide heightened scrutiny in water quality and water rights permitting.

Above Iron Gate dam, the implementation plan includes a strategy to address pollution from the Klamath Hydropower Project in the context of the Klamath Hydropower Settlement Agreement as well as the FERC relicensing process. The TMDL proposes implementation to the extent of our authority and even goes beyond to set up a process that facilitates restoration projects that the Regional Water Board would not otherwise be able to order. It includes a plan to develop a program whereby dischargers could offset their allocations by implementing such projects, thus providing greater benefit to water quality. The implementation plan recommends the development of a Memorandum of Agreement with the federal agencies involved in the operation of the US Bureau of Reclamation's Klamath Project and federal wildlife refuges, and the Tulelake Irrigation District. This agreement will address pollutant loading in the Lost River basin in California by implementing the EPA's Lost River TMDL, and address pollutant loading from the Lost River basin to the Klamath River in Oregon. Finally, the plan includes a Memorandum of Understanding among the Regional Water Board, the USEPA and Oregon DEQ that coordinates implementation and supports the development of a joint reassessment strategy.

Taken as a whole, Regional Water Board staff believe that the Klamath implementation plan does an adequate job at addressing the priority water quality issues in the Klamath basin. The implementation plan must be realistic and work with the staff resources available to the Regional Water Board and within the existing regulatory structure. Regional Water Board staff look forward to working with tribal governments and the EPA to implement the measures put forward by this plan and develop effective regulatory mechanisms that will address the priority pollution sources. The plan includes provisions for adaptive management. Opportunities to revise the plan and make it more effective as necessary will present themselves during the periodic reassessments conducted by the Regional Water Board.

6. Comment(s):

We strongly support the concept of the Thermal Refugia Protection Policy outlined in the Basin Plan amendment language and section 6.5.4 of the staff report (Page 6-33). We would, however, propose two improvements: 1) update the list of thermal refugia (section 6.5.4.1) to include the locations in the Scott River submitted by the QVIR (2009), including the five-mile reach from Boulder Creek to Townsend Gulch. 2) extend the discharge restriction in and around instream buffer areas from June 15-September15 to year-round.

Response:
The time period during which the discharge restrictions would apply has been expanded to include April 15 – September 15 in order to protect thermal refugia from impacts of discharges prior to the critical June 15 – September 15 time period when their function is essential to the support of the coldwater fishery. See response to comment N4 regarding the five-mile reach.

7. Comment(s):
Additionally, the shortcomings with regard to cumulative effects from timber harvest and roads (Higgins 2010) are likely to confound attainment of the proposed thermal refugia protection, as is the lack of farm and ranch plans in tributaries like Bogus and Horse Creeks (Kier Associates 1991, 1999).

Response:
Regional Water Board staff disagree with this statement. The Policy provides support for more protective measures required for activities likely to impact thermal refugia on a site-specific basis.

8. Comment(s):
A clear timeline needs to be developed for this waiver and proper staffing needs to be allocated to ensure its success. This is a critically important process in which the Tribes must participate fully and expect Regional Board staff to engage our technical staff in the development of this waiver.

Response:
Staff intend to meet the timelines provided in the TMDL implementation plan and have a draft agricultural waiver ready for consideration by the Regional Water Board by December 2012. The development of the waiver will be a public process that will involve all interested parties in the basin and representatives of tribal governments.

9. Comment(s):
There are many well-documented Middle Klamath water quality problems related to agriculture that persist (Kier Associates 1991, 1999), including water diversion and thermal pollution in Bogus Creek. Agricultural operators in Bogus Creek need to be held accountable. The plan should incorporate "salmon safe" practices, including those related to water diversions and thermal refugia, in farm and ranch plans as soon as possible.

Response:
Thank you for the suggestion. The Regional Water Board will be retaining suggestions regarding the content of the future agricultural waiver and will consider them during the development process.

10. Comment(s):
The Klamath TMDL should clearly recommend that agriculture reduce pesticides and herbicides that are problematic for water quality restoration and push for integrated pest management (Dieckhoner and Galvin 1999). Given the extremely low flows in the Shasta and Scott River basins there is the clear potential for the concentration of pesticides to levels that could cumulatively affect salmonids. The Regional Water Board should err, if at all, on the side of caution.

Response:
Pesticides and herbicides are not addressed by the TMDL but will be addressed in the agricultural waiver.

11. Comment(s):
As noted in Section 6.5 "Nonpoint Source Control and the Watershed-Wide Allocations" of the *Revised Public Draft TMDL*, the "Prohibition on the Discharge of Excess Sediment" section of the *Public Draft TMDL* was dropped and replaced with a voluntary "Guidance for the Control of Excess Sediment".

This is another disappointing example of the weakening of the Implementation Plan. We recommend the original language be restored. Given that sediment is a well-known contributor to stream warming and that the Klamath TMDL has prohibitions on inputs to Middle Klamath tributaries to protect refugia, this new, lax language is inconsistent with the temperature refugia policy and will confound attainment of that objective.

Response:
The "Prohibition on the Discharge of Excess Sediment" proposed in the June draft changed to guidance because the prohibition caused confusion due to overlapping WDR and waiver provisions that already required sediment measures. In addition, the sediment prohibition would create overlap and confusion in every nonpoint source program to be developed in the future. It also presented difficulties for enforcement, and many parties objected to it because the Klamath is not listed as impaired for sediment. Staff agreed with comments that requested the Regional Board to consolidate and streamline water quality requirements to avoid redundant and unnecessary paper work. Sediment requirements are or will be incorporated into specific permits and waivers. Meanwhile, presenting these measures as guidance will help assist individual landowners in how to effectively manage sediment on their property.

12. Comment(s):
Wasted Discharge Requirements or Waivers for private timber are unlikely to be sufficient. The Klamath TMDL should require analysis with available landslide risk tools like SHALSTAB (Dietrich et al. 1998) and should prohibit activities on steep slopes with high or extreme landslide risk, especially those in the inner gorge where sediment may be delivered directly to streams (de la Fuente and Elder 1998).

Response:
Regional Water board staff disagree that waste discharge requirements and waivers are likely to be insufficient. Waivers are only granted for plans that represent a low risk of water quality degradation and limit practices such as even-aged management. Waste discharge requirements require the development of an erosion control plan and a time schedule for implementation of prevention and minimization management measures from all controllable sediment discharge sources within the project area. Controllable sediment discharge sites include sites that have a high risk of delivering sediment such as undersized culverts and unstable road fills. The implementation of prevention and minimization management measures must be completed during the period of coverage under General WDRs.

In regards to activities in high risk areas such as inner gorges and headwall swales, Regional Water Board staff regularly evaluate slope stability risks in the field and/or require formal evaluations by licensed geologists. Regional Water Board staff believe site-specific evaluations are an effective tool for limiting the risk of sediment delivery to streams. Additionally, we consider SHALSTAB and other risk assessment information where we have it (e.g., Scott River watershed).

13. Comm ent(s):
The Quartz Valley Indian Community and Yurok Tribe remain disappointed that there is no specific requirement to reduce road densities on USFS lands despite the fact that watershed analyses and road management plans on both Six Rivers and Klamath National Forest set such targets (SRNF 2000, 2003, KNF 2000). By simply adding their own targets to the TMDL the Forest Service would likely accelerate federal funding for bringing their lands into compliance. Absent such language the KNF will likely continue to delay such improvements indefinitely. Proactive National Forests like the Six Rivers could use the TMDL to leverage significant funds for road decommissioning projects.

Response:
Proposed targets for roads are intended to address road factors that result in decreased sediment delivery over time, and thus don't rely on specific road density as a surrogate for road design and maintenance practices that minimize sediment delivery. Regional Water Board staff expect that the efforts to address road-related sediment discharges will result in reduced road densities. However, our targets are oriented more directly towards the discharges caused by the roads. We expect targets that address road discharge risks more directly will be as persuasive to federal decision makers as road density targets. Also, please see response to comment D55.

14. Comment(s):
There is a profound need for more trend monitoring and compliance enforcement. Even when aquatic indicators are trending negatively, required corrective action, using adaptive management, has not been taken. The Regional Water Board has failed to press

for data and assessments from the Klamath National Forest. There has been a pattern of incompetence that has been tacitly allowed.

Response:
The USFS waiver will address trend monitoring and compliance enforcement. Regional Water Board staff are working with KNF on an expanded monitoring plan to assess water quality impacts from KNF activities.

15. Comment(s)
Despite the numerous requests and recommendations made by the QVIC over the past several years, the Klamath TMDL still does not acknowledge the urgent need to commence the restoration of the Klamath River basin's freshwater habitat immediately, given the imminent ocean and climate cycles, (Hare 1998, Hare et al. 1999, Collision et al. 2003) if we are not to lose coho salmon forever.

To let these fish slip through the fingers of the Regional Water Board would violate the Clean Water Act and would deliver a perpetual loss to the Klamath Basin Tribes. Given the existing water quality and fish health crisis and the onset of global warming (Van Kirk and Naman 2008), the bureaucratic backsliding represented by the devolution of the Klamath TMDL is inappropriate, unacceptable and clearly legally challengeable.

Response:
The Regional Water Board staff are aware of the urgent need to restore the Klamath River basin and the implementation plan lays out a comprehensive strategy to further this goal with respect to improving water quality through the Regional Water Board's regulatory programs. We have used state authorities on nonpoint source to regulate perhaps the most significant nonpoint sources in the Klamath basin in California, namely timber harvest on both federal and nonfederal lands, and continue to do so. The TMDL also proposes measures beyond our basic regulatory programs to set up a process that facilitates restoration projects that the Regional Water Board would not otherwise be able to order. The now optional interim actions for agriculture do not represent backsliding since they allow time for the development of a more effective regulatory program on a tighter timeline (addressing both grazing and irrigated agriculture by 2012). See also response to Bowman – 5 above.

16. Comment(s):
Page 1-27. The following text seems to be describing the old figure (now removed from the text), not the new one, and is thus obsolete and should be deleted or revised: "The estimated unimpaired flows represented in Figure ~~1.11~~ 1.12 illustrate the magnitude and pattern of flows … whereas the estimated natural Scott and Shasta River flows are reported by the U.S. Geological Survey (USGS ~~(~~2006) as monthly means."

Response:
The comment is correct; the language was inadvertently left in the document. The language has been removed from the final draft.

17. Comment(s):
Page 2-36. Richard Stocking has done excellent research on the Klamath River, but it is our understanding that he has an MS, not Ph.D., and thus the title “Dr. Richard Stocking” is incorrect.

Response:
The text has been revised.

18. Comment(s):
Page 2-39. “*Microcystis aeruginosa, Anabaena flos-aquae, Anabaena flos-aquae, and Gleotricia echinulata.*” should read, instead, “*Microcystis aeruginosa, Aphanizomenon flos-aquae, Anabaena flos-aquae, and Gleotricia echinulata*.”

Response:
The text has been revised.

19. Comment(s):
Page 2-59. Table 2.10: “Summary of fall temperature effects resulting from human alteration” is an informative table; however, the river location is nowhere mentioned. We assume it is the site of Iron Gate Dam, but this should be stated explicitly.

Response:
The table has been revised to include specific mention of the location.

20. Comment(s):
Page 2-102. Incorrect citation in the references:
“E. J. Kann, and W. Walker, 2009. Multi-year Nutrient Budget Dynamics for Iron Gate and Copco Reservoirs, California. Final Technical Report to the Karuk Tribe Department of Natural Resources, Orleans, CA. 55pp + appendices.” The names should read “Asarian, E, J. Kann, and W. Walker”

Response:
The reference has been revised.

21. Comment(s):
The changes made to the water quality model to address comments by the U.S. Geological Survey appear to be minor improvements. While we still have some concerns

regarding the model, expressed in many rounds of previous comments, it is our opinion that on the whole, the model is robust enough to serve its intended purposes in the TMDL (i.e. setting load allocations). It is abundantly clear that the current nutrient concentrations in the river are far higher than natural background and that substantial reductions are necessary to restore water quality.

Response:
Comment noted.

22. Comment(s):
Page 4-29. Erroneous dates in "Table 4.3 Hydraulic Parameters for Klamath Reservoirs (May 2004 – May 2005)" if information is based on Kann and Asarian (2007), as that report examined the period May 2005-May2006. This was noted in previous comments, please fix.

Response:
The table has been revised.

23. Comment(s):
Page 4-32. "For the purposes of this report the term retention is meant as net retention, which is the difference between influent and effluent loads. The net retention includes both permanent losses to the atmosphere and deep burial along with temporary storage and exchanges with the active sediment and gains from the atmosphere due to nitrogen fixation." We suggest the following revision to make this more explicit and accurate: "For the purposes of this report the term retention is meant as net retention, which is the difference between influent and effluent loads. The net retention includes permanent losses (denitrification to atmosphere and deep burial), temporary storage and exchanges (within reservoir water column and active sediment), and gains from the atmosphere due to nitrogen fixation. This definition of net retention is slightly different from that used by Asarian et al. (2009) because that report excluded (subtracted) changes in reservoir storage in calculating retention."

Response:
The text has been revised to more accurately and completely describe retention and loss of nutrients within the reservoirs.

24. Comment(s):
Page 4-34. "Table 4.5 Estimated Nutrient Retention and Export for Copco and Iron Gate Reservoirs". All instances of 2004-2005 in this table should in fact be 2005-2006. Also the values from Kann and Asarian (2009) should not include decimal places, as the values in that report are rounded to the nearest integer. Additionally, we suggest adding notes to clarify the sources of the literature-based empirical models. These include changing "Range of 5 methods cited by Kann and Asarian (2007)" to "Range of 5

literature-based empirical models applied by Kann and Asarian (2007)". Additionally, a note should be added to indicate that the Vollenweider (1976) and Nürnberg (1984) values were derived by TetraTech (one way to do this would be to say change "Vollenweider (1976)" to "Vollenweider (1976) empirical model applied by TetraTech (2008)", etc. In addition, the "PacifiCorp (2006)" nitrogen estimate is derived from Kann and Asarian (2005) and should be noted as such suggested revision: "PacifiCorp (2006), based on Kann and Asarian (2005).

Response:
The text has been revised.

25. Comment(s):
Page 5-3. This comment was previously submitted, but has not been resolved and is thus re-stated here. Table 5.1 in the Public Draft TMDL is generally an excellent table, nicely summarizing all of the numeric targets and allocations; however, it contains something that does not make any sense: "Microcystis aeruginosa cell density < 50% of the blue-green algae biomass, or < 20,000 cells/L (which ever is lower)" (p 5-3). We agree that the Microcystis aeruginosa cell density < 20,000 cells/L is an excellent target, but the Microcystis aeruginosa cell density <50% of the blue-green algae biomass it is unnecessary and not supported. For example, if the total blue-green algae biomass is very low, then it should not matter if Microcystis aeruginosa is 50% of the total -- because the total amount of Microcystis aeruginosa would still be very low. Public health risks are driven by the concentration of Microcystis aeruginosa cells and microcystin toxin, not the relative percent of the blue-green algae biomass that is Microcystis aeruginosa. We suggest a revised target of simply "Microcystis aeruginosa cell density < 20,000 cells/L". This is the only place in the entire TMDL that we can find any mention of a 50% target, so we suspect that its inclusion in Table 5.1 may have been unintended.

Response:
The table has been revised to provide a target based on cell density without reference to a percent biomass condition.

26. Comment(s):
We agree with staff that Alternative 3, using a percent saturation based on natural receiving water temperatures, is the most appropriate method to use for setting the criteria; however, we disagree with the values proposed in Table 7.5. It is our opinion that the values the Regional Water Board proposes in Table 7.5 are erroneous, based on artifacts of the TMDL water quality model, and should be revised. We suggest a value of 90% year-round for Stateline to above Turwar, and 85% for Turwar.

Response:
Thank you for your suggestion. We have rerun the Klamath TMDL model for that portion from Iron Gate Dam to Turwar with the revised barometric pressure assignments necessary to eliminate the artifacts associated with previous runs of the model. The results with respect to DO indicate better DO saturation under natural conditions than

was represented in previous versions of the model. However, the improvement is not as great as you've suggested. Percent DO saturation under natural conditions is still shown as less than 90% saturation from April through September from Iron Gate Dam to Shasta and from June through August from Hoopa to Turwar. We have revised our proposed SSOs for DO accordingly. Please review the final proposed Basin Plan Amendment.

27. Comment(s):
Regarding the values proposed for the various portions of the Estuary, at this time we cannot endorse setting site-specific dissolved oxygen objectives based on the TMDL water quality model for the Estuary, given: 1) the complex dynamics of the Estuary are not well understood, in part due to the lack of data, 2) the inherent difficulty of modeling a system as complex as the Estuary, 3) due to reasons 1 and 2 we regard the Estuary as the most uncertain geographic area of the TMDL water quality model, and 4) we have not closely examined model outputs for the Estuary. Furthermore, Table 6.7: "Minimum Percent DO Saturation at Locations throughout the Klamath River Mainstem under Natural Conditions (T1BSR Model Run)" does not included modeled percent saturation values for the Estuary (only displays as far downstream as Turwar).

It is our understanding that given that the Estuary is located on the Yurok Reservation, the Regional Water Board does not have authority to set a criterion anyway, as is alluded to in the text of page 7-3 "To the extent that the State lacks jurisdiction, the proposed SSO is extended as a recommendation to the applicable regulatory authority". Given the substantial uncertainty regarding the model predictions for the Estuary (even under current conditions, aside from the issue of natural conditions), and the lack of a need for the Regional Water Board to recommend a criteria due to lack of jurisdiction, we recommend that the Upper and Middle Estuary and Lower Estuary be removed from Table 7.5, and that area be left as a gap in the site-specific D.O. criteria.

Response:
We are very sensitive to the issue of jurisdiction and have no intention of asserting water quality control authority on Yurok Tribal land. To protect against any future confusion on this matter we propose updating our current DO objectives to include a phrase specifically acknowledging that the State's water quality objectives do not apply where there is Tribal jurisdiction.

Our current DO objectives are assigned for the mainstem Klamath River from the Stateline to the Pacific Ocean. The existing concentration-based objectives assigned to the estuary are numbers reflective not of estuarine conditions, but of day time freshwater conditions. The *Klamath TMDL model* provides an assessment of DO under natural conditions in the estuary which is a vast improvement over that which came before it. We feel it important to update the existing objectives to codify this improved science.

This is particularly important since the Yurok Water Quality Control Plan includes the same DO objectives for the estuary which are currently in our Basin Plan and as such represent outdated science. Our intention is to update our existing DO objectives with more scientifically-defensible DO objectives, acknowledge their application only on lands and watercourses under State jurisdiction, and offer them as potential alternative objectives to the Yurok Tribe or USEPA should a situation ever arise in which a NPDES permit or 401 certification requires consideration of DO conditions protective of the beneficial uses of the lower Klamath River.

28. Comment(s):
Barometric pressure and water temperature are key determinants of dissolved oxygen saturation, and barometric pressure is dependent on elevation (higher elevation means lower barometric pressure and hence lower dissolved oxygen). The information included in the "Table 6.6: Barometric Pressure Assignments, corrected for elevation at key locations" indicates that while representations of barometric pressure in the TMDL water quality model have been improved since previous versions of the model, the situation is still less than desirable, particularly for the portion of the Klamath River that lies within the Hoopa Valley Reservation.

Response:
We have rerun the Klamath TMDL model for that portion from Iron Gate Dam to Turwar with the revised barometric pressure assignments necessary to eliminate the artifacts associated with previous runs of the model. The results with respect to DO indicate better DO saturation under natural conditions than was represented in previous versions of the model. Percent DO saturation under natural conditions is still shown as less than 90% saturation from April through September from Iron Gate Dam to Shasta and from June through August from Hoopa to Turwar. We have revised our proposed SSOs for DO accordingly. Please review the final proposed Basin Plan Amendment.

29. Comment(s):
We object to staff's proposal of a standard that automatically weakens with climate change. The text on page 7-15 does not explicitly state whether climate change is natural or human-caused, an important distinction that should be made. It is our opinion that the majority of climate change that has occurred in the past few decades (and will continue to occur) is human-caused. Thus, climate changes are not "natural" and should not be included in "natural receiving water temperatures."

Response:
The text is intentionally vague on the question of whether or not climate change can be considered a natural phenomena or a human-caused one. In addition, the text is vague on whether or not if convincing data is developed proving climate change as the cause of water temperature rise in the Klamath, staff would recommend a revision of the temperature estimates and thereby the DO concentration requirements. This is because it is not our intention to automatically accept climate change as a natural phenomenon; but rather to closely examine any data regarding the effects of climate change as it become available.

The intention of the text as currently written is only to highlight the benefit of a percent DO saturation objective based on natural receiving water temperatures. That is, in a changing climate, a percent DO saturation objective based on natural receiving water temperatures allows for a flexibility that does not exist with concentration-based objectives. But, it requires a maintenance of conditions as close to natural as possible which does not exist with a percent DO saturation criteria based on existing receiving water temperatures. The text referred to in the comment will be changed to better describe staff's intentions.

30. Comment(s):

- Basin Plan Language, p.2: The designated beneficial uses that are not fully supported include: cold freshwater habitat (COLD); rare, threatened, and endangered species (RARE); migration of aquatic organisms (MIGR); and spawning, reproduction, and/or early development of fish (SPWN); commercial and sport fishing (COMM); Native American cultural use (CUL); subsistence fishing (FISH); and contact and non-contact water recreation (REC-1 and REC-2).
- Insert the following text: "In order to provide protection for both cultural and subsistence beneficial uses RWB must protect all lifestages of salmonids, including but not limited, to upriver habitats and thermal refugia."

Response:

The beneficial uses listed above already reference the protection of all life stages of salmonids and the Thermal Refugia Protection Policy in conjunction with the nonpoint source implementation measures are protective of cold water refugia and water quality related to up-river habitats. This statement in the Basin Plan, however, has been revised to better recognize the relationship among the beneficial uses.

31. Comment(s):

- Basin Plan Language, p.8: "…Regional Water Board, ODEQ, and USEPA are working to develop a Klamath basin water quality improvement tracking and accounting program. The cooperation and participation of PacifiCorp has been instrumental in supporting this endeavor."
- Not appropriate to effectively thank sponsors in basin plan language. PacifiCorp may be legally required to meet water quality standards set by the NCRWQCB, but were it not for the legal/regulatory nature of those requirements, PacifiCorp would not be cooperating and participating out of the goodness of its corporate heart.

Response:

The Regional Water Board frequently acknowledges efforts toward improving water quality by various stakeholders. The text has not been revised.

32. Comment(s): P.9 of Basin Plan Language in section titled "Discharge Restriction In and Around Thermal Refugia": Replace "The restriction applies June 15 – September

15 when thermal refugia are typically functioning in the mainstem Klamath River" with the following text: "A year-round prohibition of waste discharge applies protecting not only the period of time when fish density is high, but also protecting morphological alterations which can potentially diminish the carrying capacity of the refuge."

Response:
Regional Water Board staff agree with the need to protect thermal refugia from alterations to the channel structure and have expanded the time period within which suction dredging discharges would be restricted to April 15 – September 15. See revised text in the staff report (section 6.5.4.4) for the technical justification for this change. Staff did not find justification for a year-round restriction, as suggested by the commenter, in our review of the technical literature on the impacts of suction dredging discharges on water quality and stream morphology. The literature indicated only short-term impacts to channel morphology that were not found to be significant after high flows have had a chance to reshape the channel. "erosive scour holes, hand piled tailing, or downstream sediment deposits caused by suction dredge mining during the relatively low water summer conditions of California Rivers were removed following flushing flows occurring the following fall, winter, and spring"(CDFG, 2009).

California Department of Fish and Game. 2009. Suction Dredge Permitting Program: Literature Review. September 2009.

33. Comm ent(s):
Add the following tributaries to Table 4-17: "Tributaries to the Klamath River Known to Provide Thermal Refugia In and Around Their Confluence." 1) Thompkins Creek, Middle Creek, and Deep Creek (Scott River tributaries).

Response:
The Thermal Refugia Protection Policy provides a process for adding to the list of thermal refugia and the commenter is encouraged to send in technical support for the addition of these creeks to the list of thermal refugia in the Klamath basin.

34. Comm ent(s):
Alter the text on p.10 of the Basin Plan Language to add the underlined text:

A 1500 ft buffer length is required in the mainstem Klamath River downstream of the confluence with the following tributary creeks: Aubrey, Beaver, Clear, Dillon, Elk, Grider, Horse, Indian, Rock, Swillup, Thompson, and Ukonom

The lower Scott River contains a 5-mile stretch of refuge habitat from Boulder Creek to Townsend Gulch. Major tributaries that contribute are Boulder Creek, Canyon Creek, Kelsey Creek, Tompkins Creek, Middle and Deep Creeks. A 3000 ft buffer length is required in these identified tributary creeks upstream of their confluence with the Scott River and within the 5-mile stretch of thermal refuge habitat.

Response:
Please submit additional information on the need for expanding the buffer into the creeks indentified and the buffers may be added through the process provided in the policy. 3000 foot buffers into the tributaries are provided for creeks where fish have been identified using the tributaries themselves are refugia habitat. See response to comment N4 regarding the five-mile reach.

35. Comment(s):
Policy Directives and Recommendations
With in one year RWB staff will inventory and evaluate the effectiveness of the thermal refugia protection policy measures and revise regulatory recommendations as necessary.

Response:
The Klamath TMDL and implementation plan will undergo reassessments at five-year intervals and Regional Water Board staff will provide annual updates to the Regional Water Board that will include an update on the effectiveness of the policy. The Regional Water Board may decide to revise the Thermal Refugia Protection Policy at any time if it is found to need stronger protections. The list of thermal refugia locations may be revised without undergoing the Basin Plan amendment process. See section 6.5.4.3 of the TMDL staff report.

36. Comment(s):
Remove #5, p.11 of Basin Plan Language because it is predecisional in nature, and could hinder efforts to protect coldwater fisheries more fully in the future.

Response:
The status of these discharges as a point or nonpoint source has not yet been determined. Since they have not been determined to be a point source, they are currently treated as a nonpoint source and are not prohibited in the Klamath basin. Suction dredging is currently prohibited by Senate Bill 670 as the California Department of Fish and Game develops a revised permit to regulate suction dredging in coordination with the State Water Resources Control Board. There are two possible courses of action for the State Board to take at this point. They could determine suction dredging discharges to be a point source, or such discharges, by default, would continue to be regulated as nonpoint sources. If they are found to be a point source in California, the State of California would be obliged to develop an NPDES permit for suction dredging to regulate it as a point source. The Thermal Refugia Protection Policy is written to accommodate both of these scenarios. This is why the recommendation to lift the prohibition for point source discharges in certain locations for suction dredging discharges is included. It would only take effect if they are determined to be a point source; the discharges would still be prohibited within the designated buffers. The other water quality impacts of these discharges would be addressed in the NPDES permit, and the policy specifically states that it in no way limits either permitting agency (CDFG or SWRCB) from implementing

more stringent requirements. In addition, Regional Water Board staff is sensitive to the nature of mining claims in that they are viewed as private property. The Policy is better tailored to specifically address environmental concerns. See also response to comment N24.

If it is not determined to be a point source, and no NPDES permit is required, the prohibition in the Basin Plan would not apply, and suction dredging would be regulated by the CDFG permit, and perhaps a water quality certification by the State Water Board. The policy recommends that the CDFG permit exclude suction dredging discharges from the designated buffers.

37. Comm ent(s):
Basin Plan Language, P. 11 12, Klamath Irrigation Project (KIP)
Action, add underlined text:
Complete a water quality study based on best-available science to characterize the seasonal and annual nutrient and organic matter loading through the KIP and refuges.

Response:
The suggested text has been added.

38. Comm ents:
It is good to see some accountability for water quality placed at the feet of USBR. Please just ensure that the NCRWQCB retains final authority over attainment of its own standards. It's good to see explicit mention of the KIP water quality impacts to the refuges. It's important to note that the Klamath settlement gives the KIP a pass on poor water quality at refuge inflows and outflows. Expansion of wetlands, especially in Lower Klamath Lake, should stay on the table as a potentially necessary mechanism for improving water quality, despite any provisions in the settlement, and should be analyzed in the study.

Response:
Comment noted. The implementation plan supports the construction of large scale pollutant reduction projects, such as treatment wetlands, in strategic locations in the upper basin where pollutants can quickly be reduced. In order to promote the construction of such projects, the Regional Board will be co-sponsoring a workshop on treatment technology as part of Klamath implementation.

39. Comm ent(s):
Action: The Regional Water Board ~~encourages~~ requires the following actions:
3. Participate in the development of the conditional waiver through a Technical Advisory Group, comprised of all interested stakeholders, that will convene to develop the draft waiver by December 2011.

Comment: To merely encourage actions for two years would neglect the NCRWQCB's legal obligation to enforce the CWA and could leave the NCRWQCB without sufficient tools to do so. Changing the word "encourages" to "requires" on paper does not necessarily require more staff time or capacity, but does achieve consistency with the antidegradation policy in the basin plan.

Response:
Requirements will be developed as part of the planned inclusive public process, which is described in the staff report and are specifically not included in the Klamath implementation plan. The measures cited above are interim measures that landowners are encouraged to take until requirements are established through the conditional waiver. They are not intended as requirements, and may change depending on the waiver conditions that are developed. The Regional Water Board has the ability to set up a time schedule for developing a regulatory program for currently unregulated discharges as part of the TMDL implementation plan and this measure does not constitute a violation of the federal or state antidegradation policies. Other Regional Water Boards have included similar measures in TMDL implementation plans that defer the adoption of regulatory actions to a later date in order to allow time for proper development. See also response to Bowman – 2 above. While the revision suggested in the comment has not been made, the staff report has been revised to specifically state that tribal governments will be included in the development of the conditional waiver.

40. Comment(s):
It should be clear that grazing does not have to be the primary land use. For example, private timber leases land to ranchers for grazing in summer months.

Response:
Regional Water Board staff are aware of this practice and grazing on timber lands will be addressed in the future agricultural waiver program.

41. Comment(s):
Basin Plan Language, P. 19
"Evaluation of instream water quantity and quality"
Add the underlined text above. To evaluate quality, it will be necessary to evaluate instream quantity as well.

Response:
Water quality includes consideration of the effect of water quantity on quality. The text has not been changed.

42. Comment(s):
Basin Plan Language, P. 19

Please add the following underlined text: "Evaluation of the functionality of thermal refugia in the mainstem Klamath River and the lower Scott, and"

Response:
Text has been changed from mainstem Klamath River to Klamath River basin, which includes the lower Scott River.

43. Comm ent(s):
Basin Plan Language, P. 20
Add the following underlined text to "Timber Harvest". "Reporting through waivers and WDRs for timber harvest project and any other land use activities that have the potential to degrade water quality." What about other activities occurring on private timber land. In the Scott Watershed private timber companies also lease their land to ranchers for grazing. Reporting should occur for those activities as well.

Response:
Grazing on timber lands will be addressed through the future agricultural waiver program and not through the current waivers and WDRs for timber harvest projects administered by the Regional Water Board.

Cameron – U.S. Bureau of Reclamation

1. Comment(s):

Considering the significant and substantial changes to the models and associated documentation, Reclamation would like to suggest that the public comment period be extended to allow a more comprehensive review. The 45-day comment period spanned the Christmas and New Year's holidays when many staff are on vacation. As a result, Reclamation feels that the comment period was insufficient in length and did not provide enough time to conduct the comprehensive review that is warranted to adequately address the extent of modifications made to the TMDL.

Response:

The Regional Water Board met all public noticing requirements on the June 2009 draft documents. Regional Water Board staff disagree that the changes to models are significant. See responses to the USGS comments by USGS prepared on behalf of the Bureau. Regarding the review period on the December 2009 Draft Klamath TMDL, the Regional Water Board provided a 47 day comment period to account for the holidays during that period.

2. Comment(s):

The author refers to the "Klamath Irrigation Project" in several locations throughout the document. There is no such entity as the Klamath Irrigation Project. The Bureau of Reclamation (Reclamation) believes the author is referring to the Klamath Reclamation Project or Reclamation's Klamath Project. Please replace "Klamath Irrigation Project" with "Klamath Reclamation Project" or "Reclamation's Klamath Project" as appropriate.

Response:

The text has been altered to refer to the U.S. Bureau of Reclamation's Klamath Project.

3. Comment(s):

Chapter 1 states multiple times that the site specific objectives for dissolved oxygen have been recalculated. Although there is a lengthy discussion as to the reason for these recalculations in Appendix 1, there is no such discussion in Chapter 1. A brief explanation should be presented in Chapter 1 of the document to make it clear to readers why this has been done.

Response:

Thank you for this suggestion. The following text will be added to Chapter 1;

"The SSOs for DO in the mainstem Klamath River have been recalculated because conditions of barometric pressure, salinity and natural receiving water temperatures at equilibrium (e.g., 100% DO saturation) do not consistently allow for attainment of the existing SSOs for DO. Further, the *Klamath TMDL model*, as described in detail throughout the rest of this report, indicates that under natural conditions, the DO concentrations achieved in the mainstem Klamath are periodically less than the existing SSOs for DO, particularly during the summer months. For a detailed analysis of DO conditions in the mainstem Klamath River, including the recalculation of the SSOs, please see Appendix 1."

4. Comment(s):
Appendix 6 and Appendix 7 General Comments. The alteration of key boundary conditions between the previous draft TMDL model (June 2009) and the revised draft TMDL model (December 2009) is substantial. It appears that some of the changes were made in response to comments about model representation being inconsistent between reaches, while other changes have been made for reasons that are not clear. The revised TMDL model has boundary conditions and parameter values that are considerably changed from the June 2009 draft TMDL. Due to the significant changes that were made to the TMDL model, the model should be considered a "new model" and not a revision of the previous model. The extensive changes will likely cause the model to simulate significantly different water quality conditions in the Klamath River. This "new model" has not been subject to formal peer review and is untested.

Response:
The responses to comments made by USGS on behalf of BOR are detailed in Attachment 1. Changes were made to the model and to model documentation to address the comments, as described in the staff report and Appendices 6 and 7 to the staff report. After the changes to the model were made, the model was rerun. The results do not indicate substantive differences from previous model results. Regional Water Board staff do not consider the model to be 'new', but rather a minor set of revisions that confirm the its usefulness and do not requiring additional peer review.

5. Comment(s):
Statement: Chapter 1, Section 1.6.5, page 1-24, first paragraph states "It is important to recognize that the data presented in Figure 1.11 shows the pattern of flow associated with a history of consumptive use (e.g., Klamath Project in the upper basin) and altered flow timing (e.g., controlled releases from Upper Klamath Lake). However, these factors do not affect the above observations with respect to winter flows."

Comment: Based on Figure1.1, it appears that seasonal fluctuation in precipitation plays a much greater role in the observed flow pattern presented in the graph than consumptive use especially in the Upper Basin. It is misleading to generally state that the observed flow pattern shows a history of consumptive use with the Klamath Project as an example without being more specific.

Response:
The purpose of the statement is only to qualify the data as being affected by and reflecting consumptive use. The seasonal fluctuation in precipitation is made clear in

section 1.6.4, and the effects of water management on flows are presented in section 1.6.6.

6. Comment(s):
Statement: Chapter 2, Section 2.4.2.3, page 2-42, first bulleted item states "It is clear that the reservoirs spread out event-driven spikes of nutrient loads. However, this is not necessarily beneficial in regard to algal response in the lower river. Without the dams, much of the nutrient load would move in event-driven pulses and a good portion of such load would flush through the system without elevating concentrations long enough to allow full periphyton response. With the reservoirs in place, the influent load pulses are smoothed out, resulting in lower peaks, but longer periods of elevated concentrations in the river."

Comment: These statements need to be backed up with research or data. References supporting these statements should be cited.

Response:
See Asarian et al. 2009 and related discussion that has been added to the staff report (section 2.4.3).

7. Comment(s):
Statement: Chapter 2, Section 2.4.2.3, page 2-42, first bulleted item, last sentence states "The largest amount of the reservoir retention of nutrients is the particulate fraction (less bio-available) during winter and early spring high flows (not critical growth periods) (Asarian et al. 2009).

Comment: Asarian et. al., 2009 is referenced, but is not in the Chapter 2 reference section.

Response:
The reference has been added to the reference list.

8. Comment(s):
Statement: Chapter 2, Section 2.4.2.3, page 2-42, second bulleted item states "River reaches downstream of the dams (below the I-5 bridge to Seiad Valley) are saturated with nutrients with or without the reservoir nutrient retention. Therefore the nutrient retention effect probably has no positive effect on increased periphyton densities. In addition, dams can contribute to conditions that would tend to promote increased periphyton densities in the downstream reaches such as reduced scouring flows and warmer waters. This level of reduction on an annual mass loading basis is not large and the net effect on downstream water quality if this loading was to occur in the absence of the dams is not significant."

Comment: These statements need to be backed up with research or data. References supporting these statements should be cited.

Response:
The concentrations of inorganic nutrients downstream Iron Gate (Figures K-3, K-4 and K-5, page K-2) are at least 10 times greater than the half-saturation concentration controlling periphyton growth (Table 3-5, page 47) (Tetra Tech, December 2009). Therefore, slight changes in nutrients are not expected to have a significant impact on periphyton growth.

There are limiting nutrient graphs included in the model development report (Appendix 6). There are locations along the river where the model indicates that neither N nor P is limiting periphyton growth.

Also, the discussion regarding this topic has been updated in the TMDL staff report (section 2.4.3).

9. Comment(s):
Statement: Chapter 4, Section 4.2.1.1, page 4-18 states "To assess the effects of altered flows due to diversions on water temperatures, model scenarios for current flows and natural flows, with all other factors assigned as natural conditions, were compared."

Comment: What flows were used for natural flows? Additional information and justification needs to be provided for the flow values used for the "natural flows" scenario.

Response:
Please refer to Appendix 6 for the requested information. The text has been clarified.

10. Comment(s):
Statement: Chapter 4, Section 4.2.1.2, page 4-20 states "The movement of water from Upper Klamath Lake is regulated, with much of the flow diverted from the Klamath River into the Lost River basin to support irrigated agriculture, with some portion of these flows eventually transferred back to the Klamath River."

Comment: This statement is incorrect. This statement implies that most of the water from Upper Klamath Lake and the Klamath River is diverted to the Lost River watershed. Much of the water diverted from Upper Klamath Lake and the Klamath River is used within the Klamath River watershed and only a portion of the water is moved to the Lost River watershed. Consider revising this statement.

Response:
The text has been revised: The movement of water from Upper Klamath Lake is regulated and at times much of the flow is diverted to support irrigated agriculture. Some portion of these flows eventually transferred back to the Klamath River.

11. Comment(s):
Statement: Chapter 4, Section 4.2.1.2, page 4-20 states "These facilities, along with water withdrawal canals, hydrologically connect the Klamath River to the Link River system (for this document the "Lost River system" refers to the hydrologically connected natural and constructed portions of the Lost River, Tule Lake, Lower Klamath Lake, Klamath Straits Drain and other associated canals and drains)."

Comment: This statement is incorrect. There are no Reclamation facilities that connect the Link River to the Klamath River. The reviewer believes that the author means to state that facilities connect the Lost River to the Klamath River.

Response:
Comment noted. The reference to the "Link River" has been altered to read "Lost River".

12. Comment(s):
Statement: Chapter 4, Section 4.2.1.2, page 4-22 states "Even though USBR's Klamath Project appears to be a net sink of nutrients, it also appears to have detrimental impacts to the water quality of Klamath River."

Comment: This sentence makes a strong statement about the Klamath Project having "detrimental impacts to the water quality in the Klamath River", but provides no data to support this statement. There is no existing data showing degraded water quality conditions in the Klamath River downstream of the Klamath Straits Drain, due to discharges from the Klamath Straits Drain.

Response:
See response to C21.

13. Comment(s):
Statement: Chapter 4, Section 4.2.1.2, page 4-22 states "Based on mean August 2002 flows, approximately 1255 cfs was diverted out of the Upper Klamath Lake and the Klamath River, leaving approximately 182 cfs in Keno Reservoir just upstream of Klamath Straits Drain (Figure 4.8). Klamath Straits Drain discharge then accounts for approximately half the flow of the Klamath River at Keno Dam. Therefore, its higher concentration of nutrients relative to the Klamath River increases the nutrient concentration which in turn contributes to water quality degradation in the Keno impoundment (Figure 4.9)."

Comment: This statement implies that the specific example provided of Klamath River and Klamath Straits Drain flows is representative of typical conditions. The 2002 water year was far from average and represents a statistical anomaly for the month of August. The percentage of Klamath Straits Drain flows to Keno flows in August 2002 (52%) was the highest ever recorded since complete records began in 1961. When a similar comparison is made using all August flows from 1961-2009, the mean value is 18%. It would be more appropriate to evaluate for the entire year and present as a table. To present discussion on just one month is not appropriate. This statement is also misleading in that it leads the reader to believe that if diversions did not take place, all of the water would contribute to increased flows in the river. Another important point for consideration is that there is no flow measurement point "just upstream of Klamath Straits Drain". There are dozens of ungauged non-Project diversions and returns, accretions and evaporation that take place along the 21 miles of river between Link River and Keno. It appears that the author is trying to paint an overly simplistic picture of a complex system in order make an unjustifiable conclusion. For the comparison in Figure 4.9, the "constituent concentrations" should have been set at concentrations consistent with the nutrient increase due to internal nutrient loading processes that exist in the Klamath River, and not to Link River where concentrations are lower.

Response:
We believe the statement is appropriate and does not imply anything beyond August 2002. Our intent was not to evaluate typical flow conditions but to determine if KSD is a potential source of pollutants. To the best of our knowledge, there has not been a study which evaluates typical flow diversions to and returns from the irrigation project. The analysis was a sensitivity analysis of the potential impact of KSD and chose appropriate boundary conditions for the analysis.

14. Comment(s):
Statement: Chapter 5, Section 5.2.2.2, page 5-15 states "The model takes advantage of available data collected over multiple years, and deterministically represents the cause-effect relationship between discrete sources and water quality conditions throughout the Klamath's riverine, reservoir, and estuarine portions."

Comment: Reclamation's experience with model development has shown that two years of data, the most recent being 2002, is insufficient to develop a water quality model of this complexity. In addition, there is considerable additional existing water quality data that was not utilized for guiding the most recent revisions of the models.

Response:
When the TMDL model analysis is updated as part of TMDL reassessment water quality monitoring data collected since 2002 will be incorporated into the analysis. Regional Water Board staff believe that the existing TMDL model analysis adequately supports the TMDL development process.

15. <u>Comment(s):</u>

Statement: Chapter 5, Section 5.2.2.2, page 5-15 states" It was determined that the largest source of uncertainty in this system is the highly variable and dominant loading from Upper Klamath Lake rather than the numeric water quality model", "Predicted conditions in the Klamath River are strongly influenced by the predicted variable conditions of the Upper Klamath Lake TMDL", and "The magnitudes of the allocations are based on median loading conditions from Upper Klamath Lake."

Comment: Despite the author's acknowledgment that Upper Klamath Lake is the largest source of uncertainty, the modelers chose just one year (1995), the median of six years, to represent the "natural background conditions" from which to compare all current loadings and assign TMDL load allocations. This type of an arbitrary selection as a "natural background condition" establishes a very low level of confidence when comparing model results to current conditions for purposes of assigning TMDL load allocations. Also, the process used to select 1995 should be discussed. Why was the median selected for use? Is 1995 in fact the median year? Please provide additional information (i.e. table or graph) showing the range of nutrient concentrations for other years of data. Additional discussion justifying the selection of the 1995 data set should be provided. Also, quantification of the error associated with the Upper Klamath Lake TMDL model outputs should be provided to provide insight on the accuracy of these values.

<u>Response:</u>

See responses to comments A2, A3 and A4. See also discussion in the draft Upper Klamath River TMDL recently released by Oregon DEQ.

16. <u>Comment(s):</u>

Statement: Chapter 5, page 5-32, Table 5.8.

Comment: The document discussion should address why TP, TN, and CBOD concentration levels at stateline have been reduced since the original draft. This reduction in concentration levels decreases the loading allocations to meet compliance as evidenced in previous figures and tables in the document (Figures 5.1, 5.2, 5.5, and Table 5.2). Based on 2002 monitoring at Link Dam, the mean concentration for the year was 0.21 mg/L for TP (ODEQ believes TP to be the limiting factor for Upper Klamath Lake (UKL)). This would require a greater than 86 percent reduction in phosphorus levels from UKL (the primary source for Klamath River) based on stateline concentration allocations. It is unreasonable to think that this is attainable. EPA sets a reference level of 0.03mg/L for total phosphorus for Ecoregion III, Subregion 9 which is above all monthly concentration allocation levels being proposed in this document. Although the 0.03 mg/L level is not likely attainable either.

Response:
Please refer to Appendix 6 for model updates since the previous draft. The implementation plan includes strong but reasonable provisions that will greatly improve water quality conditions in the Klamath River. The Regional Water Board will have the opportunity to reassess the TMDLs progress toward attaining water quality standards at various times as detailed in Chapter 7 of the Staff Report.

17. Comment(s):
Statement: Chapter 6, Section 6.2.3.2, page 6-10 states, paragraph 1 states "For the USBR and USFWS, the implementation plan measures include an evaluation and implementation of methods to reduce the water quality impacts of the operation of the Klamath Irrigation Project and the Klamath River basin Wildlife Refuges and implementation of an effective pollutant reduction strategy."

Comment: It needs to be made clear that Oregon Department of Agriculture is responsible for implementation and oversight in Oregon to reduce nonpoint pollution from agricultural lands operated within the Klamath Project and that the irrigation districts are responsible for canals and drains within the project boundaries.

Response:
The implementation discusses the regulatory structure in Oregon (section 6.2.3.1) and section 6.4.2 has been revised to specifically recognize that the Tulelake Irrigation District is responsible for discharges associated with the conveyance and delivery of water with its boundaries. The content of the agriculture waiver is yet to be developed; but for discharges of waste in California, Regional Water Board staff intent is to dovetail Oregon requirements and California requirements to the extent possible.

18. Comment(s):
Statement: Chapter 7, Section 7.1, paragraph 1, states "….as the Klamath Basin Water Quality Monitoring Coordination Group (KBWQMCG), and the Statewide and Klamath Blue-Green Algae Work Groups….."

Comment: The Klamath Basin Water Quality Monitoring Coordination Group recently changed their name to: Klamath Basin Monitoring Program (KBMP). Additionally, there are numerous references to the group within this chapter that need corrected.

Response:
Comment Noted. The document has been edited to reflect this name change.

19. Comment(s):
Statement: Figure 7.1, page 7-11.

Comment: The monitoring sites presented as USGS sites on the Klamath River stretch between Link Dam and Keno Dam are actually Reclamation sites.

Response:
A new figure is not available at this time. A note has been added to the text to notify the reader of the needed correction.

20. Comment(s):
Statement: Appendix 6, Section 1, page 1, paragraph 3, states "Impairments include dissolved oxygen (DO), chlorophyll *a*, temperature, pH, and ammonia for various portions of the Klamath River and its tributaries in Oregon and nutrients, temperature, and organic enrichment/low DO for segments of the river and its tributaries in California.

Comment: The State of California has also listed portions of the Klamath River below the confluence of the Trinity River for sedimentation/siltation impairments.

Response:
The text has been corrected.

21. Comment(s):
Statement: Appendix 6, Figure 1-1, page 2.

Comment: The figure map incorrectly identifies the locations of Lake Ewauna and the Lost River Diversion Channel. The diversion channel is downstream from Lake Ewauna.

Response:
The map has been updated.

22. Comment(s):
Statement: Appendix 6, Figure 2-2, page 15.

Comment: The figure map incorrectly identifies the location of Lake Ewauna.

Response:
The map has been updated.

23. Comment(s):
Statement: Appendix 6, Section 2.2.1, page 7 states "Concentration boundary condition files were modified using a labile particulate OM (LPOM) to labile dissolved OM (LDOM) ratio of 4.0 (LPOM:LDOM = 0.8:0.2), which is same as for the Link River boundary condition. Labile OM refers to the portion that is decomposed relatively quickly."

Comment: The model lumps all organic matter into the labile form and ignores refractory organic matter. This is inconsistent with existing data for outflows from Upper Klamath Lake and the Klamath River from the Link River to Keno Dam, where refractory organic matter can be a significant fraction of the total organic matter. This inappropriate fractionation of organic matter ignores a considerable load of refractory organic matter and will likely have significant model accuracy implications.

Response:
This is clarified on page 19 of Appendix 6.

24. Comment(s):
Statement: Appendix 6, Section 2.3.2, page 18, paragraph one states "For this study, state variables were selected to most accurately predict TMDL impairments and related physical, chemical, and biological processes." Later on the same page, TDS is listed as one of the state variables for the Klamath River where the CE-QUAL-W2 model was applied.

Comment: In the draft comments (dated December 15, 2009) provided to USGS titled "Klamath River TMDL Development Team Draft Response to USGS Review of the Klamath River TMDL Models from Link Dam to Keno Dam, your response to the **TDS inputs** comments states "TDS is not a parameter of concern or relevance to the TMDL. In the model, it is simply a dummy constituent that has no affect on the modeling results. These statements seem to be very contradictory to one another. What importance does Tetra Tech and the TMDL Development Team put on TDS values from the Klamath Straits Drain? These statements need to be clarified and documented as to which statement is true and which statement is false.

Response:
The report has been updated.

25. Comment(s):
Statement: Appendix 6, Section 2.3.3.2, page 23 states that "Link River's flow was determined by using the observed flows at USGS flow gage 11507500 minus the flow from the PacifiCorp West Turbine (powerhouse) gage, which is downstream of the USGS gage."

Comment: Flows exiting the Link River are the sum of the observed flows at the USGS gage 11507500 and the PacifiCorp West Turbine gage. This sentence should read "Link River's flow was determined by using the observed flows at USGS flow gage 11507500 **plus** the flow from the PacifiCorp West Turbine (powerhouse) gage, which is downstream of the USGS gage.

Response:
The report has been updated.

26. Comment(s):
Statement: Appendix 6, Section 2.3.3.2, page 23 states that “There are 18 tributary discharges in the Lake Ewauna to Keno Dam river segment.”

Comment: The text should also state that these are only the definable or observed tributary discharges, and that there are many other undefined discharge locations in this reach of the river.

Response:
The report has been updated.

27. Comment(s):
Statement: Appendix 6, Section 2.4.1, page 36 states “The OM in the boundary conditions is lumped (and thus not partitioned between labile and refractory components) due to lack of sufficient data for accurate OM partitioning.”

Comment: This statement is incorrect. Existing data shows that much of the organic matter in the outflow from Upper Klamath Lake is refractory. This incorrect model setting should have been changed as part of the December 2009 model revision. This incorrect assumption will likely have significant consequences for simulated water quality downstream of Keno Dam.

Response:
The commenter’s understanding about water quality modeling of OM is incorrect in that the difference between “lumped” approach and “differentiated approach” was not taken into account when this claim was made. Actually, in a lumped approach, while no data is sufficient to derive an accurate partitioning between labile and refractory OM, the partitioning is implicitly represented using the lumped decay rate, which is estimated through the calibration process. In most water quality modeling studies, organic matters are lumped without differentiating labile and refractory, which doesn’t invalidate such approach and TMDL was developed using such a lumped approach. Also please see response to Cameron - 23.

28. Comment(s):
Statement: Appendix 7, page 1 states that “UKL flow was set to be the same as the calibrated Klamath River Model (Tetra Tech, Inc. 2009), but the water quality and temperature were based on 1995 UKL TMDL model conditions. 1995 represents the median condition occurring in UKL (based on implementation of the UKL TMDL).”

Comment: The process that was used to select 1995 should be discussed. Why was the median selected for use? Please provide additional information (i.e. table or graph) showing the range of nutrient concentrations for other years of data. Additional discussion justifying the selection of the 1995 data set should be provided. Also, quantification of the error associated with the Upper Klamath Lake TMDL model outputs should be provided to provide insight on the accuracy of these values.

Response:
For additional information related to this comment. refer to Hemstreet 8, A4, A18, and A25.

Chapman – Campbell Timber Management

1. Comment(s):

The footnote in section 1.1, page 1-1, defines the terms "watershed" and "basin" stating that in this report that they " ... are synonymous and will be used to refer to the area that drains flows to the Pacific Ocean at Requa.". Neither waters from Antelope Creek nor Butte Creek ever flow to the Pacific Ocean or the Klamath River. Antelope Creek flows into Antelope Sink while Butte Creek Flows into Butte Valley where they both either disappear into the ground or evaporate. In fact, the whole Butte Subbasin does not naturally flow into the Pacific Ocean or the Klamath River. Therefore, these watersheds should not be encumbered with the restrictions and requirements of the Klamath River TMDL plan. These watersheds should be removed completely from the plan in order that they are not inadvertently included in any future revisions or restrictions that are specifically for the Klamath system and not for watersheds that are hydrologically disconnected.

Response:

The Butte Valley subbasin is not subject to the Klamath TMDL allocations and targets. However, the implementation actions to control non-point sources basin-wide apply to the entire basin, including the Butte Valley subbasin. The Regional Water Board is not limited to the confines of the TMDL exercise when it promulgates a Basin Plan Amendment. In response to numerous comments, Regional Water Board staff eliminated interim requirements for agriculture and grazing dischargers, and instead recommend that they participate in the development of a Basin-wide waiver for Regional Board adoption in 2012. The Staff Report explains that the Regional Water Board has responsibility to regulate waste discharges independent of the TMDL process, and it would be more efficient and less duplicative to incorporate TMDL requirements into the broader nonpoint source programs. Often TMDL measures are the same or similar to normal nonpoint source measures designed to comply with the existing Basin Plan. As described in the State Water Board's Nonpoint Source Policy (May 2004), state law requires the development of non-point source controls for all sources, regardless of listing status or TMDL development. Thus, even in Butte or Antelope, agricultural landowners are encouraged to participate in the development of the waiver. Additionally, please see the response to comments L1 and P31.

2. Comment(s):

In section 6.1.1, page 6-2, there is a statement that "technical analysis does not include the Butte Valley Hydrologic Area." However, there are also contradictory statements throughout the plan that indicate that the goals, targets, and restrictions are for all areas within the plan through the use of phrases such as "... target in the TMDL". "The TMDL provides", and "WDRs and waiver contain a requirement that all provisions of the Basin Plan must be met to qualify ...." These phrases imply that the Butte Valley Hydrologic Area is not exempt from following the Klamath TMDL targets and restrictions.

Response:
See response to Chapman-1.

3 Comment(s):

- At the January 27, 2010 workshop meeting in Yreka, I asked a NCRWQCB staff why the Butte Creek and Antelope Creek Watershed are included in the Plan, the answer I finally received was that it was the policy of the NCRWQCB. What specific policy is it that the Board has to include watersheds not hydrologically connected to a major watershed in which a TMDL Plan is being developed?
- If the above watershed areas are not removed from the plan, what is the legal authority that allows them to be included in this Plan?

Response:
Please refer to the response to comment L3 and Chapman-2.

4. Comment(s):
The water in Antelope and Butte Creeks do not flow outside of state boundaries; are not navigable or tributary to navigable waters; or are not involved in interstate commerce, and therefore, are not under federal jurisdiction as they are not "Waters of the United States" and federal rules like the Clean Water Act do not apply. The impairments being addressed by the Klamath River TMDL is under the federal law; however, both Antelope Creek and Butte Creek do not fall within the definition of "Waters of the United States". Therefore, these watersheds should not be encumbered with the restrictions and requirements of the Klamath River TMDL plan, should not be associated with the Plan, and should be removed.

Response:
Please see the responses to comments L1 and P31.

5. Comment(s):

- Section 1.1, page I-I, 3rd paragraph, last sentence, states that" ... watershed continues to support what were once historically significant mining and timber industries." “Were once" and "historically" are repetitive.
- The timber industry in the basin is less of an employer in the basin than in the past, but it is still quite significant. This is apparent in that the vast majority of the private forest lands in the basin are managed primarily for the production of wood products. Combine these lands with tribal lands that also have a wood products component and it is evident that the timber industry in the basin is still significant.

Response:
The identified language has been modified.

6. Comment(s):
Throughout the document, there is a consistent goal of the CA Klamath TMDL being coordinated with that of Oregon. I have searched the web and have also tried to contact Steve Kirk, Oregon DEQ (left message) but I have been unable to find any information on additional restrictions beyond the standard Oregon Forest
Practice rules that will be placed on forestry within the Oregon Klamath River Watershed. Therefore, with current California forestry regulations exceeding that of Oregon regulations, there should be no need to have additional forest management restrictions beyond that of current regulations.

Response:
Please see the response to comment P36.

7. Comment(s):
Section 6.5.7.5, page 6-52, states"...FPRs may not always be protective enough to meet the water quality standards" and "…to comply with the TMDL, responsible parties will be required to implement additional riparian shade protections where Regional Water Board staff determines that the ASP Rules are insufficient…." Additional or the possibility of additional regulations/restrictions places the California timber industry at an increasing competitive disadvantage to Oregon especially within this basin where logs from this region are sold to local forest product manufacturing facilities in both states. If this is the case, then the economic impact needs to be addressed in that section of the TMDL. Also, a statement needs to be included that California is exceeding those required by Oregon along with the explanation for it.

Response:
Please see the response to comment P36.

8. Comment(s):
Finally, like California's rules, there is nothing in the current Oregon Forest Practice rules that explicitly prevents a "five degree increase in water temperature" though in both cases if the current rules are [sic]

Response:
This is an incomplete sentence and thus it is not possible to determine the intent of the comment and give a response.

9. Comment(s):
Section II, Watershed Restoration Efforts, of the Klamath River TMDL Action Plan and Lost River Implementation Plan lists specific government agencies, tribes, and environmental groups. However it fails to specifically list major private landowners or their groups that have been involved in restoration or enhancement and instead just states "local Resource Conservation Districts", "local irrigation districts", and "private timber

companies". Unfortunately, these are the same entities that have sacrificed the most, putting in their own money, and have done it without grant money (that can be an income producer for government agencies and non-profits) when it has come to enhancement and restoration. A minimum of recognition equal to that of the government agencies, tribes, and environmental groups is fair and deserved for the major private landowner" that have been part of the restoration/enhancement efforts.

Response:
The Regional Water Board appreciates the work that has been done to improve water quality on private timberlands and encourages and supports continuation of those efforts. The text referred to in the comment has been modified based on the comment and the specific mention of environmental and watershed groups has been removed. There are simply too many entities to list individually.

Costales – Siskiyou County

1. Comment(s):
The last zonal flow pattern was around the 1940's thru 1970's which was a typically moderate cool/wet period. My understanding, though I cannot find the specific records, is that sufficiently accurate temperature data collection for the Klamath began around 1940. If so, and if this data has been incorporated into the "natural receiving temperature" in the Basin Plan and/or temperature guidelines sought for the cold water fisheries (COLD) beneficial use, the periodicity of the zonal/meridional influence may be unaccounted for in more than one key area related to the temperature analysis of the TMDL.

Response:
The temperature analysis does not rely directly on temperature measurements, but rather on achieving conditions, primarily related to riparian vegetation and flow, that would result in natural receiving water temperatures. The natural temperature estimates were used in this analysis to evaluate water temperatures in the absence of human alteration, and to determine whether an increase in temperatures is allowable, given the water quality objective for temperature. The natural receiving water temperatures estimates evaluated in this TMDL are based on the 2000 meteorological conditions. The biological temperature thresholds based on the physiology of the species are not used to define natural receiving water temperatures, but as information to interpret temperature conditions.

2. Comment(s):
A shift to extreme weather events characteristic of a meridional flow pattern, especially one that is forecast to be extremely and perhaps historically prolonged, manifests itself in a number of ways such as the increasing frequency and severity of catastrophic wildfire. This in turn affects such hydrologically important factors as evapotranspiration and soil stability. This presents TMDL effects associated not only with "natural receiving temperatures," but also with sediment-related temperature guidelines associated with the COLD beneficial use. Granted, the TMDL process accommodates periodic reevaluation allowing response to changing knowledge and experience. However, there appears to be no analysis or discussion of this acknowledged climatologic effect on riverine systems. Given the current emphasis on climate change within the CEQA process and other statutes that have caused Timber Harvest Plans and development projects within the County to be returned for climate-related analysis, (including one at the personal direction of the California Attorney General) it would seem reasonable to assume that there are legal mandates in the area of climate change that must be addressed within the TMDL that may be lacking.

Response:
Regional Water Board staff recognize the wisdom in accounting for expected changes in climate. The approach to preventing and addressing elevated water temperatures outlined in the Klamath TMDL are the same actions that prudence dictates be taken in an

increasingly warmer climate: prevent excess solar insulation, eliminate other causes of temperature increases, and protect and maintain unique cold water environments.

3. Comment(s):
Another climate-related presentation that the Water Board staff missed at the Klamath Science Conference was the effect of temperature on fish disease. Different diseases have different temperature ranges within which fish are affected. Many diseases share the characteristic that a very minimal change in temperature (commonly as little as $3^{o}C$) has considerable effect on the mortality of cold-blooded organisms such as fish. A $3^{o}C$ upward change in summer and late fall water temperature is conceivable in climate change models. This is further evidence of the need to incorporate climate change into setting TMDLs and developing an action plan to implement them.

Response:
Regional Water Board staff agree that increasing water temperatures resulting from climate change are likely to add to the adverse effects to beneficial uses posed by high temperatures. Please see response to comment 2 above.

4. Comment(s):
TMDL action plan mandates should be created such that they do not pose inadvertent and difficult-to-alter obstacles to climate change response. Road density mandates that might prompt road decommissioning that might in turn render aggressive thinning cost-prohibitive is an example of unintended consequence to hydrologically beneficial climate-related action.

Response:
The Klamath TMDL contains no road density mandates. However, Regional Water Board staff encourage land owners to decommission unnecessary road segments. This is a key element to the Green Diamond Roads WDR and the USFS waiver.

5. Comment(s):
One of the critical complaints the County has heard consistently from citizens and businesses with regard to management and restoration has been the degree to which regulatory frameworks appear to be trying to "fit a square peg into a round hole. Aside from whether it is anthropogenic, very real evidence of climate change and its associated hydrological and biological responses highlight this baseline/endpoint conflict in neon letters. Though it may be a lot of work at this late date, even to the point of threatening the mandated deadline, the need to examine the degree to which climate change is affecting our ability to set and meet temperature and other TMDL goals must be addressed to a far greater degree in the TMDL document.

Response:
The temperature TMDL does not set a compliance temperature. Rather, the temperature goal is a temperature regime that is determined by nature. The question of whether climate change is an expression of nature is beyond the scope of the TMDL analysis. That said, the TMDL implementation plan provides sufficient flexibility to evaluate climate change impacts on water quality moving forward.

6. Comment(s):
In the case of the Klamath TMDL, the actions proposed affect every natural resource industry in Siskiyou County. Within the document, the necessarily speculative nature of the impact of individualized economic effects results in the typical short shrift given in these analytical sections of decision documents. Completely lacking is the cumulative effect of the TMDL's proposed actions as well as consideration in conjunction with the Water Board's past regulatory creations. Also missing is the evaluation of these impacts in the cumulative context of other state mandates that now exist or can reasonably be foreseen on the regulatory horizon. Please conduct this analysis.

Response:
The TMDL requirements concerning the scope of the economic analysis are to provide an estimate of the cost of implementation of reasonably foreseeable compliance measures. There is no requirement to provide an analysis of the cumulative economic impact of the TMDL implementation plan, nor a requirement to speculate on the future costs of other agencies' proposed regulatory programs. It is expected that individual costs to meet water quality standards will vary widely depending on the costs of the specific management practices that are necessary to address any discharges to waters of the state. That said, Regional Water Board staff did propose several substantive changes in response to the County's concerns regarding duplicative requirements.

7. Comment(s):
Apparently, since other areas outside these thermal refugia will still be open to suction dredge mining under the TMDL, Water Board staff views "takings" implications and other issues as insignificant. There is a very significant economic impact to declaring such areas off limits to mineral exploration.

Response:
See response to comments N15 and N24.

8. Comment(s):
While noise, movement and other non-discharge activities associated with suction dredging may affect the role of refugia in supporting the COLD beneficial use of water, I think such impacts are under the purview of the Department of Fish and Game and are why they are charged with updating their Permit for suction dredging. This leaves the Regional Board to consider the potential for spilled fuel and lubricants or the extremely

temporary and spatially limited discharge plume behind the dredge to affect thermal refugia. It is hard to imagine that any significant impact can be attributed to these discharges. It is beyond any reasonable credulity whatsoever that reasonable mitigations could not have been incorporated. Please reconsider mitigating practices for suction dredging in thermal refugia.

Response:
The Regional Water Board primarily considered the impacts associated with the discharge from the suction dredge but also considered the overall effects on the use of refugia by coldwater fish based on a review of the scientific literature. A summary of the findings from the literature review has been added to the TMDL staff report (section 4.2.4). See also response to comment N20. Regional Water Boards staff will coordinate with the State Water Board to have the TMDL recommendation incorporated into the CDFG permit, and/or a possible future state NPDES permit. The recommendation to exclude suction dredging from thermal refugia areas is necessary to protect those refugia from the documented short term impacts of suction dredging that can compromise their function in supporting the coldwater fishery.

9. Comment(s):
Given that mining is a beneficial use of the water that must be preserved along with other beneficial uses, a ban in these critical areas does not strike the required balance.

Response:
See response to comment O23b.

Davis

1. <u>Comment(s):</u>
I have seen test results that indicated TMDL contamination, caused by Dam removal, that will cause a major long term stream damage (sic). What are your best estimates?

<u>Response:</u>
The CEQA Analysis chapter of the staff report (Chapter 9) presents a programmatic environmental analysis of dam removal. Whether the dams are ultimately removed is a decision before several federal and state agencies in consideration of other factors in addition to water quality, including water allocations, species protection and power needs. These decisions will necessarily be informed by detailed environmental review that goes beyond the required scope of the TMDL CEQA analysis.

2. <u>Comment(s):</u>
Information supplied by aquatic personnel from the Klamath area must be confirmed or disputed by impartial, qualified, sources to be accepted.

<u>Response:</u>
Data utilized for the development of the Klamath River TMDL has been through a Quality Assurance/Quality Control process to determine data quality and usability for TMDL purposes.

3. <u>Comment(s):</u>
What is the progress report to date on the cleanup of the stream above California state line?

<u>Response:</u>
Please contact the Oregon Department of Environmental Quality for information on the Klamath River in Oregon. The ODEQ contact person is Steve Kirk at 541-388-6146.

4. <u>Comment(s):</u>
EPA reports this past year indicated water was cleaner below Iron Gate Dam than above Copco Lake. Evidently the lakes are not adding to the contamination bringing to question the reason for the clean water permit to be withheld.

<u>Response:</u>
The TMDL found through its technical analysis that the project is contributing to the degradation of water quality in the Klamath basin and assigns pollutant load allocations accordingly in Chapter 5 of the TMDL staff report. Regional Water Board staff are not withholding permits relating to the project as suggested by the commenter.

Epp

1. Comment(s):
Tributaries should not be deleted from consideration in the Klamath TMDL (e.g. the revision in Sec 1.4 p1-10); they can easily be the largest contributors to problems at times, overwhelming the ability to regulate if regulation is only applied to the mainstem.

Response:
Regional Water Board staff could not locate the revision identified by the commenter. Tributaries were not deleted from consideration. Tributaries are given nutrient and organic matter load allocations at their mouths to ensure mainstem Klamath River water quality standards are met.

2. Comment(s):
The failures of the Scott River and Shasta River TMDL waivers must be remedied in this TMDL, with targets and enforcement, including implementing remedies to improve conditions in time for the 2010 spawning season.

Response:
Scott and Shasta River implementation is addressed through a process separate from the Klamath TMDL process. The effectiveness of the conditional waivers associated with the Scott and Shasta TMDLs will be reviewed by the Regional Water Board when they come up for renewal in 2011 and 2012.

3. Comment(s):
Throughout every aspect of the plan, there must be penalties strong enough to actually bring about changes for the better in actual conditions on the ground and in the waters, triggered by monitoring that's comprehensive enough to assure catching problems before they get out of hand, based on specific and enforceable actions, targets, and timetables. This must also apply to the MOU between Oregon and California.

Response:
The implementation plan does this and supports enforcement according to the Statewide Enforcement Policy that guides the approach to the use of the Regional Water Board's considerable enforcement tools granted by the Porter-Cologne Water Quality Control Act. The Klamath TMDL and implementation plan includes timetables, monitoring, and targets as suggested by the commenter.

4. Comment(s):
Parties can be encouraged to engage in voluntary methods to divide the work among themselves or go beyond what's called for, but the cumulative actions, targets, and timetables impacting the waters must be mandatory, including interim measures and waivers.

Response:
The TMDL will be implemented through the Regional Water Board's regulatory programs. Nonpoint sources of pollution will be addressed pursuant to the State Nonpoint Source Policy described in section 6.1.4 of the TMDL staff report. This policy makes the State Nonpoint Source Program enforceable and does not rely on voluntary compliance.

5. Comment(s):
Nobody should be given an unrestricted waiver, not even public agencies like the Forest Service. In the real world it's not possible to predict all eventualities. Waivers must be subject to tightening or revocation if conditions deteriorate, so the Water Board will not be stuck in the predicament of being left with no effective options to address unexpected situations. The goal is to provide as much certainty as possible to attaining the target conditions in the waters, not to provide certainty to individuals or organizations no matter how damaging their actions or inactions, even if entirely unintentional.

Response:
Existing Regional Water Board waivers and waivers proposed as part of the Klamath implementation plan are all conditional and contain terms and conditions that the discharger must meet to qualify for the waiver. The Regional Water Board does not adopt 'unrestricted waivers'. Further, all conditional waivers must be renewed every five years at which point the Regional Water Board considers their effectiveness at attaining target conditions and can make necessary adjustments and improvements as suggested by the commenter.

6. Comment(s):
Do not weaken any of the strengthening revisions that were made, including those restricting grazing, dredging, and logging, as well as those applying to PacifiCorp's reservoirs and dams.

Response:
Comment noted.

7. Comment(s):
- Need to provide a large margin of precautionary safety beyond what science currently thinks is necessary, to compensate for its profound ignorance about the ecological vitamins needed for long-term watershed health in general, and anadromous health in particular.

Response:
The TMDL provides a margin of safety, which is discussed in section 5.1.2 of the TMDL staff report.

8. Comment(s):

- In the Klamath TMDL the criteria for flow regimes and water quality parameters now and in the future must be contingent on the current and future health of the watershed in general, and its at-risk and keystone species in particular. If fish or other critical species decline in health (not just numbers), whether due to drought or habitat degradation elsewhere or due to reasons completely unknown, then water quality parameters must be adjusted. There should be a process in place for people to petition for such adjustments at any time the need arises. Only opening the door at decade intervals could mean action only happens after it's too late.

Response:

Implementation of the Klamath TMDL will be adaptively managed and reviewed for effectiveness every five years. There will also be periodic reports from staff to the Regional Water Board to update the Board on progress towards meeting the TMDL allocations and targets. The reassessment plan for the TMDL is described in Chapter 7 of the staff report.

Garayalde – Shasta Valley RCD

1. Comment(s):

While language in the Shasta River TMDL calls for an increase in flow, we worked very hard to incorporate some flexibility in achieving temperature reductions by adding language that addressed alternative flow regime as another way temperature reduction might be achieved. Language in the Klamath River TMDL only states that there will be a 45 cfs dedicated cold water instream flow goal and that attainment of the Klamath River temperature TMDL requires achieving the Shasta River flow goal.

Suggests editing the text in Section 6.4.4 of the Klamath River TMDL by adding the underlined text below so the text reads as follows: "The Shasta River TMDL Action Plan includes a goal to increase dedicated instream cold water flows by 45 cubic feet per second (cfs) or alternative flow regime that achieves the same temperature reductions from May 15 to October 15. Attainment of the Klamath River temperature TMDL, and associated temperature standards, may require achieving the Shasta River TMDL goal. Water made available through the implementation of conservation measures should be dedicated to beneficial use in order to be effective under this Plan."

Response:

The text has been changed to add the language regarding alternative flow regimes. The linkage of the Klamath River TMDL to the Shasta River TMDL should have been described as 'necessary' as opposed to 'required', in the sense that the Shasta conditions represented in the Klamath River TMDL model are consistent with the Shasta TMDL, including the flow recommendation. The text has been changed to clarify this point.

Gierak

GIERAK COMMENTS FROM JANUARY 2010 SUBMITTALS:

1) "KBRA and Dam Removal on the Klamath River in Siskiyou County in Northern California" Letter - this letter offers comments in opposition to the removal of the Klamath Hydropower Project dams, and does not pertain to the Klamath TMDL. Regional Water Board staff will forward these comments to the Secretarial Determination Team led by Dave Gore of the Bureau of Reclamation.
2) From: "Recommendations for Klamath River protocols and toxicity studies" Letter - Most of the text of this letter is directed at getting a better idea of the toxicity of sediments before the dams should be considered for removal or removed. Again, this is not a Klamath TMDL issue. This letter will be forwarded to the Secretarial Determination Team led by Dave Gore of the Bureau of Reclamation.
3) From: "Sediment Analysis at Dams along the Klamath River" Letter -There are no comments in this letter pertaining to the TMDL document. These comments contain suggestions regarding sampling protocol to better assess toxicity in sediments behind the dams. This is not a Klamath TMDL issue. This letter will be forwarded to the Secretarial Determination Team led by Dave Gore of the Bureau of Reclamation.
4) From: "Biological Survey of the Klamath River" Letter -These comments offer concerns and suggestions regarding protocols for sampling microcystin. This letter will be forwarded to the State Blue-Green Algae Work Group, who are responsible for proposing BGA monitoring protocols.
5) From: "KBRA and Hydroelectric Agreement" Letter -These comments address the sustainable fisheries position of the KBRA and the removal of the dams. This letter will be forwarded to the Secretarial Determination Team led by Dave Gore of the Bureau of Reclamation. See also response to comment B30 on the June 2009 draft.

Comments that are germane to the Klamath TMDL analysis and implementation plan are presented below, along with responses.

1. Comment(s):

"Historically the largest recorded run of Salmon on the Klamath River occurred in 1928, 10 years after dams were in place. The primary scientific explanation for the reduced runs of Salmon can be attributed to the warming of the Pacific Ocean by over three degrees driving Salmon North into cooler waters. Secondly the Endangered Species Act, which protects seals, now has river estuaries filled with seals which devour salmon as they attempt to reach their spawning grounds. Thirdly the indiscriminate use of gill nets by the Indian Tribes which have been photographed stretching across the entire river. Finally a change in the mitigation protocols at Iron Gate Hatchery has seriously reduced future runs of Salmon."

Response:

Please see response to Comment B 30.

2. Comment(s):
"At several meetings located in Siskiyou County by the North Coast Board openly admitted that sampling done by the tribes and environmentalists were taken from backwashes and held for several days prior to laboratory analysis. Even non technical individuals would understand that samples of algae, bacteria, fungi, viruses or parasites that are kept for days in warm weather will result in a large increase in the result indicating toxic levels. How can the Board seriously consider these results when formulating edicts upon the waters involved. Another case of faulty data being utilized to make a point."

Response:
See response to comment R 13.

3. Comment(s):
"Several years ago the Water Board determined that there were exceedingly large levels of algae blooms which were determined to be toxic. Since that time samples from multiple locations were sent to the CDC and their report was issued recently which stated clearly that no significant toxins were present. There was some concern for individuals who may have compromised immune systems."

Response:
The TMDL staff report provides information concerning toxicity levels in the Klamath River and the hydroelectric project reservoirs that contributed to the basis for the impaired waters listing (section 2.5.4). The comment misstates the conclusions of the CDC study, which documented inhalation as a complete pathways for exposure to microcystin for recreational users of the reservoirs. The study was not designed to address the question as to whether actual exposure had occurred, and therefore did not draw any conclusions on this question.

4. Comment(s):
"Another case of faulty data utilized by the Board to warrant the posting of lakes as unsafe to be utilized for recreational purposes. I would suggest that immediately all such postings be removed and this argument removed from your assessment of the safety of the Klamath River and its associated reservoirs."

Response:
The criteria regarding postings of the reservoirs is not a part of the TMDL and is available here:
http://www.swrcb.ca.gov/water_issues/programs/bluegreen_algae/docs/bga_volguidance.pdf

5. Comment(s):
"As to the States of California and Oregon imposing TMDL regulatory action on this river they do not have any regulatory power over rivers that fall under the Dormant Commerce Clause of the Constitution."

Response:
See response to comment O21.

Hashimoto – USEPA

1. <u>Comment(s):</u>

In reviewing the draft proposed DO SSO, EPA notes that it is of paramount importance that RB 1 provide clear language describing how the proposed DO SSO will be protective of the Beneficial Uses on the RB1 jurisdiction of the Klamath River. Additionally, EPA notes that clarification is required to satisfy 40 CFR section 131.10(b), the protection of downstream uses. Specifically, we request that explicit information be provided that describes how the draft DO SSO protects the spawning and incubation beneficial uses of the Hoopa Valley Tribal Reservation water quality standards, and meets the 90% saturation standard at the boundary of the Hoopa Reservation.

<u>Response:</u>

New text has been added to Chapter 6 of the DO Staff Report saying "The *Klamath TMDL model* indicates that under natural conditions, daily minimum and monthly mean DO concentrations ensure no production impairment and no more than slight production impairment, respectively, of other (non-embryo and non-larval) life stages of salmonid. It also indicates that under natural conditions, daily minimum and monthly mean DO concentrations essentially meet National criteria for the protection of all early (embryo and larval) life stages if the primary spawning and incubation season in the mainstem Klamath River is understood to occur from about October 1 through April 30."

With respect to compliance with Hoopa Valley Tribal standards, a rerun of the *Klamath TMDL model*, improving the application of barometric pressure to the calculation of percent DO saturation, allows for the revision of the proposed SSO for DO from the Scott River to the Hoopa boundary as "90% DO saturation under natural receiving water temperatures year round." This is consistent with the Hoopa Valley Tribe's percent DO saturation objective.

2. <u>Comment(s):</u>

The draft DO SSO, in the paragraph at the bottom of page one of the Executive Summary, refers to EPA guidance suggesting "two pathways" for the development of DO criteria for the protection of beneficial uses. We would like to clarify that an existing use (applicable in the current case) is required to be protected. Life cycle requirements *in conjunction* with natural conditions must be applied to achieve this protection. They are not "alternative pathways".

<u>Response:</u>

Thank you for your interpretation of the guidance on this point. The DO Staff Report text has been revised to compare natural DO concentration to National Criteria for the protection of cold water aquatic life indicating essential consistency between the two.

To elaborate on the confusion, however, USEPA's DO guidance says: "Where natural conditions alone create dissolved oxygen concentrations less than 110 percent of the applicable criteria means of minima or both, the minimum acceptable concentration is 90 percent of the natural concentration." (USEPA 1986). In addition, Tudor Davies, USEPA Director of Office of Science and Technology states in a memorandum dated November 5, 1997 that "For aquatic life uses, where the natural background concentration for a specific parameter is documented, by definition that concentration is sufficient to support the level of aquatic life expected to occur naturally at the site absent any interference by humans." These two statements in combination suggest that establishing DO criteria based on life cycle requirements is one method for establishing standards sufficient to protect aquatic life; but, establishing DO criteria based on natural background conditions is another method by which to achieve the same goal, regardless of the relationship between the two.

3. Comment(s):
In the Executive Summary (first full paragraph on page 2), the draft SSO compares the proposed DO standards to EPA guidance. In the last line, a daily minimum of 9.0 mg/L is cited. The appropriate EPA number to be cited is 8.0 mg/L.

Response:
Thank you for this correction. The 9.0 mg/L was cited as the criteria ensuring no production impairment. The DO Staff Report has been revised to compare the recalculated SSOs for DO to the National Criteria of 8.0 mg/L.

4. Comment(s):
The second full paragraph, on page two of the Executive Summary, cites 11.0 mg/L as the EPA recommended spawning criterion. 11.0 mg/L is the EPA recommended water column number for "no production impairment" and assumed to attain an 8.0 mg/L intergravel DO level. In the same EPA guidance, for "slight production impairment", a criterion of 9.0 mg/L in the water column is required. According to the model results (shown in Figures 6.5 and 6.6 of the Staff Report), 9.0 mg/L is met under natural conditions at nearly all times and locations in the late April to early June and September-October portions of the spawning season. The last sentence in the paragraph ("Thus, the first pathway towards developing DO criteria is unavailable to the North Coast Regional Water Quality Control Board [Regional Water Board] in the mainstem Klamath River".) indicates that spawning cannot be protected in the Klamath River. We believe that your Staff Report shows that spawning will be protected (at 9.0 mg/L), and we would like clarification regarding this.

Response:
This clarification has been made.

5. Comment(s):
Where staff proposes DO criteria based on natural conditions (in the 3rd full paragraph of page 2 of the Executive Summary), EPA requests some clarification. Staff should include a clear statement indicating that the proposed applicable water quality objectives are not

solely those in the draft amended Basin Plan Table 3-1. Also applicable are the existing narrative objectives as defined by and implemented through the natural conditions generated by the TMDL model (see also Table 7.4 of the Staff Report). These objectives together are protective of the existing aquatic life and spawning and incubation uses in the Klamath River. Further, there should be clear indication that the Hoopa Valley Tribal standards which have been adopted by the Tribe and approved by EPA will also be met by means of adopting the draft amended Basin Plan Table 3 - 1 along with the proposed TMDL.

Response:
Thank you for this suggestion. The text will be revised to include this explanation.

6. Comment(s):
In the statement concerning monitoring, EPA recommends that monitoring not only occur at key locations, but also at key times to verify that sufficient intergravel DO levels are being maintained.

Response:
Thank you for this suggestion. The text will be revised to include this modification.

Hashimoto & Ziegler – USEPA

1. Comment(s):
As indicated in EPA's August 27, 2009 letter regarding the June 2009 Public Review Draft, EPA fully supports the TMDL development approach utilizing a set of hydrodynamic water quality models to characterize current conditions, define natural background conditions, and calculate reductions in pollutants necessary to achieve instream water quality objectives for identified impairments: temperature, DO, nutrients and microcystin toxins. The modeling work has been conducted by Tetra Tech, Inc., under contract to EPA, with input from a technical team consisting of staff from the Regional Board, the Oregon Department of Environmental Quality, and EPA Regions 9 and 10.

Additional modeling refinements were conducted for this December 2009 Public Review draft of the California Klamath River TMDLs, in response to comments on the June 2009 Public Review draft. These refinements include rerunning of the model to support scenario reanalyses for TMDL development, and increasing documentation for the model (presented in TMDL Appendix 6 – Modeling Configuration and Results, and Appendix 7 – Modeling Scenarios: Klamath River Model for TMDL Development). The December 2009 Public Review Draft TMDLs reflects the revised model output and updated allocations needed to meet identified water quality criteria and targets.

EPA is confident that these TMDLs, including the revised allocations as calculated by the Regional Board following modeling refinements, form an appropriate and fully adequate scientific basis for the TMDL calculations.

Response:
Comment noted.

2. Comment(s):
Dissolved oxygen targets refer to those values representing attainment of water quality standards. Appendix 1 to this TMDL Staff Report presents the proposed Site-Specific Dissolved Oxygen Objectives for the Klamath River in California. The DO targets correspond to the reach- and seasonally-specific designated percent saturation under natural temperature conditions, and are expressed as monthly average and monthly minimum concentrations. However, the target values presented in Table 5.9 as concentrations (Dissolved Oxygen Numeric Targets for Copco 2 and Iron Gate Tailraces) appear to reflect 100% saturation (modeled natural condition values as presented in the DO SSO, Appendix 1 to this TMDL Staff Report, Table 6.3 and 6.4). Please confirm that the DO targets shown in Chapter 5 reflect those values corresponding to the proposed DO concentrations resulting from Alternative 3 – Percent DO Saturation Criteria (e.g., Table 7.4) of the DO SSO (Appendix 1 to the TMDL Staff Report).

Response:
The DO numeric targets are based on the CA compliance run of the Klamath TMDL model. The compliance scenario models the water quality conditions that will be achieved as a result of implementation of the TMDL both in Oregon and California. Further, the compliance scenario is modeled as if the dams are removed. According to the model, the result in California is water quality that exceeds the water quality objectives in some months. For this reason, the DO targets at various locations also exceed the water quality objectives in some months.

3. Comment(s):
Please verify that this table correctly identifies and addresses all relevant portions of the Klamath River mainstem, including the mainstem below Iron Gate Dam and tributaries.

Response:
The tributary allocations are specifically mentioned in the table. The mainstem locations receiving numeric allocations are at Stateline, within the Klamath Hydroelectric Project reach, and at a location below the Salmon River. Watershed-wide allocations and targets are assigned to the mainstem Klamath and minor tributaries, and do not apply to the Butte Valley Hydrologic Area. Major tributaries are not assigned temperature allocations because the Scott, Shasta and Salmon River watershed already have assigned allocations, and the Lost and Trinity are not listed as impaired for temperature. Text explaining what is meant by watershed-wide has been added to table 5.1.

4. Comment(s):
As expressed in our prior comments, we endorse the approach described in the implementation plan in Chapter 6. In particular, we wish to acknowledge and reinforce the following:

- the comprehensive approach to addressing both point and nonpoint sources that uses California's regulatory tools to promote water quality improvements in the Klamath basin, consistent with the TMDL technical analysis;
- the inclusion of actions to implement the federal TMDLs for the Lost River for Nitrogen and Biochemical Oxygen Demand, as well as the early implementation measures for the South Fork and mainstem Trinity River sediment TMDLs;
- the intent to carry out and promote implementation activities on a basinwide level, in coordination with Oregon Department of Environmental Quality, with the assistance of both EPA regional offices (as embodied in the Implementation MOA);
- your efforts to work with interested parties on developing a basinwide water quality improvement Tracking and Accounting Program that will establish a framework for tracking progress towards mutual water quality goals, facilitate coordinated and accelerated implementation efforts across jurisdictional boundaries, and allow credits towards meeting TMDL allocations;
- the acknowledgement of the role of watershed planning and local stakeholders in developing reach-specific or subbasin tailored implementation plans.

Response:
Comment noted.

5. Comment(s):
In Chapter 6, we encourage discussion on how a basinwide regulatory process (conditional waiver) for agricultural activities (pp. 6-46 – 6-47, Section 6.5.6.3 – Content of the Future Agricultural Waiver) can be structured to allow for localized identification of appropriate measures to meet specific water quality goals.

Response:
The text has been updated in section 6.5.6.3 to provide this description.

6. Comment(s):
In Chapter 6, we encourage more discussion on providing individual landowners and land managers with technical and financial assistance to achieve load allocations and targets.

Response:
Financial assistance is discussed in Chapter 10 and the staff report cites technical resources related to the control of agricultural nonpoint sources (section 6.5.6.3) and road-related nonpoint sources (section 6.5.5.3).

7. Comment(s):
In Chapter 6, we suggest you clarify that individuals will determine the specific practices to be implemented to achieve water quality goals, rather than being dictated by the agricultural regulatory program.

Response:
Thank you for the suggestion. Text has been added to section 6.5.6.3 to clarify this point.

8. Comment(s):
Suggested further discussion for Chapter 6. The Klamath Basin Water Quality Improvement Tracking and Accounting Program (Klamath TAP) should provide the framework for establishing specific water quality goals for different sectors within the basin. These goals can then be integrated into future regulatory mechanisms governing point and nonpoint sources in the basin (such as the proposed conditional waiver for agricultural activities). Progress toward these water quality goals can then be tracked, both via the basinwide monitoring program, as well as entity-specific or project-specific compliance monitoring. Further, the goals can provide benchmarks for a bi-state adaptive management program and the proposed 5-year TMDL review.

Response:
Regional Water Board staff agree with this comment.

9. Comment(s):
In Chapter 6, we would like to see more direct discussion of specific requirements for compliance monitoring by responsible entities, and how individual monitoring will be integrated with the basinwide monitoring program described in Chapter 7.

For example, on pp. 6-53 – 6-61, Section 6.6. – TMDL Implementation on Federally Managed Lands – This section could more explicitly identify and describe monitoring requirements that will be incorporated into the revised USFS waiver. There is some reference to monitoring being required for certain watersheds whose cumulative effects analysis exceeds a certain threshold (on p. 6-56 in Section 6.6.3). There is also a general statement on p. 6-57 that Board staff "will work with the USFS to track progress towards meeting the watershed-wide targets and allocations." However, there doesn't appear to be a specific discussion on how the USFS should monitor the effectiveness of its actions in improving water quality and, ultimately, determine progress towards meeting the watershed targets and allocations.

Response:
The USFS waiver is under development and will address TMDL targets and allocations. The implementation plan does not include specific measures at this time, because these measures are still being worked out between Regional Water Board staff and the USFS staff. In general, the USFS will meet the TMDL requirements through their existing programs. Riparian shade allocations will be achieved by following the policy direction from the Northwest Forest Plan and the forest-specific Land and Resource Management Plans. The allocations and targets related to roads will be met through the USFS ongoing road analysis process and watershed assessments that identify road maintenance issues. The conditional waiver requires the USFS to submit sediment source inventories and track progress towards compliance with the TMDL.

10. Comment(s):
Suggested further discussion for Chapter 6. We encourage coordination of California's adaptive management program with that of Oregon DEQ's, particularly with regard to conducting monitoring programs to determine effectiveness of actions, establishment of interim milestones and water quality targets, and identification of joint timeframes for monitoring progress and for periodic review of TMDL targets and allocations.

Response:
The Regional Water Board is committed to working with ODEQ and USEPA to track TMDL implementation. The MOA among USEPA, DEQ, and the Regional Water Board establishes a framework for joint implementation of the Klamath River and Lost River TMDLs. It includes the following agreements concerning monitoring and tracking of progress towards meeting the TMDL (section 6.2.3.3):

1. Work to develop and implement a joint adaptive management program, including joint timeframes for reviewing progress and considering adjustments to TMDLs and
2. Work with the Klamath Basin Water Quality Monitoring Coordination Group and other appropriate entities to develop and implement basinwide monitoring programs designed to track progress, fill data gaps, and provide a feedback loop for management action s on both sides of the common state border.

11. Comment(s):

In Chapter 6, in addition to those actions identified on page 6-46 (Section 6.5.6.2) that will be encouraged in the interim period until an agricultural waiver is adopted, we encourage the Board to consider inclusion of activities that will start to identify the potential growers and ranchers who would be included in the agriculture regulatory program. This could occur through a future Notice of Intent (NOI) process (such as that undertaken by Regions 2 and 3 and described on p. 6-49), some inventory process undertaken by Regional Board staff or third party, or some other means.

Response:

The specifics of the agricultural waiver program, including the enrollment process, will be developed as part of a stakeholder process that will be initiated after adoption of the Klamath TMDL. However, the Regional Water Board staff plan on initiating an initial screening process to get an idea of the universe of potential participants in the waiver program. This may be done based on county land ownership records.

Hemstreet – PacifiCorp

Presented here are Regional Water Board staff responses to comments presented by PacifiCorp on the December 2009 Draft Staff Report submitted on February 9, 2010. Responses to comments on the June 2009 Draft Staff Report previously submitted by PacifiCorp on August 27, 2009 are presented in preceding sections of this response to comments document. Many of PacifiCorp's comments relate to modeling analysis conducted on reaches of the Klamath River located in Oregon. In addition, other PacifiCorp comments relate to Oregon water quality standards, Oregon TMDL implementation activities, among other topics. Regional Water Board staff closely coordinated with ODEQ on responses to Oregon related comments submitted on August 27, 2009. For Oregon related comments submitted on February 9, 2009, ODEQ provided less input on the responses presented below, due to time constraints. Comments related to modeling and other issues in Oregon should be submitted to ODEQ. ODEQ's Upper Klamath and Lost River Subbasins TMDL is available at:
http://www.deq.state.or.us/WQ/TMDLs/TMDLs.htm

Many of the PaicifiCorp comments submitted on February 9, 2009 are duplicates of comments submitted on August 27, 2009. Responses to duplicate comments are provided below by alphanumeric reference to responses on the August 27, 2009 comments and are presented . Generally the duplicate comments are not repeated below, but are referenced to the page number from the February 9, 2009 comment letter.

Comment 1:

1. The Revised Draft TMDL continues to repeat the error of the original Draft TMDL in assigning water quality targets and load allocations that are inappropriate and unachievable because they do not reflect the Klamath River Basin's nutrient-enriched characteristics. The Revised Draft TMDL points out that Upper Klamath Lake's (UKL) hypereutrophic status "has had profound water quality implications and has resulted in impairment of beneficial uses … in downstream waters" of the Klamath River. However, the Revised Draft TMDL does not acknowledge the impossibility of the huge nutrient reductions in the Klamath River downstream of UKL that would be required to achieve its water quality goals, which are based on returning to "pre-disturbance" conditions that, as defined by the Revised Draft TMDL, would require reductions even below natural pollutant loadings. Indeed, the Revised Draft TMDL's "natural conditions" scenario reflects its unnecessarily stringent water quality objectives and targets rather than any plausible scenario of actual natural conditions.

Response 1:

Regional Water Board staff disagrees with this comment. The targets and allocations are achievable and the implementation plan provides a strong framework to develop the necessary management actions required to achieve the proposed nutrient reductions. The water quality goals are not, as stated in the comment, to return to pre-disturbance conditions. Rather the goals are to provide supporting conditions for beneficial uses that the Klamath River supported prior to its current impaired state. The proposed nutrient reductions are not impossible. The TMDL nutrient limits for the reservoirs do require nutrient reductions below background to control nuisance toxic blue-green algal blooms that occur each summer. However, if PacifiCorp is able to meet the in-reservoir target for the nuisance algal bloom impairment (i.e., chlorophyll a µg/L) through means other than nutrient reductions, then the nutrient reductions are not required. See also responses to K39, K53, and K54.

Comment 2:

2. The Revised Draft TMDL would require nutrient load allocations that are not achievable, practicable, or enforceable. The Revised Draft TMDL assigns nutrient allocations that call for reductions in total phosphorus (TP) of up to 98 percent and total nitrogen (TN) of up to 75 percent at Stateline (and other downstream locations by extension). The Revised Draft TMDL's resulting targets would require in-water nutrient concentrations that are impossibly low – so low, in fact, as to be substantially less than naturally-occurring groundwater concentrations that discharge to the Klamath River.

Response 2:

Regional Water Board staff also disagrees with this comment. The required nutrient concentrations are not impossibly low. PacifiCorp's analysis of the impact of groundwater on background nutrient concentrations is incomplete and flawed. The issue of groundwater contributions ignores the fact that nutrients are not a conservative parameter and that substantial dilution from other sources also occurs. The TMDL model is a far better peer reviewed tool to make this determination than the unfounded assertions found in the PacifiCorp comments. This is not to say that there is not some uncertainty regarding the ultimate reductions that can or should be achieved, and these targets and allocations will be continually assessed as more information becomes available. However, any uncertainty regarding the proposed reductions and concentrations at TMDL compliance does not in any way alter the management actions that should begin immediately to restore beneficial uses to this threatened water body. See also response to comment K54.

Comment 3:

3. The nutrient reductions identified in the natural conditions simulations of the Revised Draft TMDL create dramatically unrealistic conditions in the upper reaches of the Klamath River that have profound effects on downstream reaches. The Revised Draft TMDL model assumes nutrient concentrations (including organic matter sources) between Keno Dam and the large springs complex below J.C. Boyle Dam that are so low that modeled benthic algae do not grow in the natural conditions simulation. If these unrealistic modeled conditions are assumed to be accurate, the implications of such conditions on aquatic system function are profound. Food webs would be significantly altered, possibly having profound adverse impacts on native fisheries and other aquatic flora and fauna. Discussion of the potential implications of massive nutrient reduction as a strategy to achieve numerical targets and objectives are not presented in the Revised Draft TMDL.

Response 3:

PacifiCorp's own analysis in its FERC documents cites the conditions other than nutrients that limit the growth of periphyton in this reach. The TMDL model parameter that was used to evaluate required nutrient reductions was dissolved oxygen, which the model is well calibrated to simulate. There are many complex factors that affect food web dynamics, none of which were provided in PacifiCorp's comments. The Klamath River has historically been a very productive river under pre-disturbance and much lower nutrient conditions. Excess nutrients from all of the source categories identified in the TMDL staff report are driving many of the impairments seen in the Klamath River today. To suggest that the river is possibly threatened due to a lack of nutrients at some in the future is highly speculative. A reasonable assessment of expected conditions under TMDL compliance is provided in the TMDL staff report.

Comment 4:

4. The Revised Draft TMDL's load allocations are improper because they have not been demonstrated to be reasonably achievable and are not achievable. Under the Clean Water Act's implementing regulations, load allocations must be "attributed" to nonpoint sources, including natural sources. Moreover, the regulations require such an attribution to be based on a reasonable estimate of the pollutant loadings from the source. An estimated loading is not reasonable if it cannot be shown to be reasonably achievable (*e.g.*, because the source's pollutant loadings are not regulated or because the loading is technically or economically impracticable). The Revised Draft TMDL is based on load allocations that are improper because they have not been demonstrated to be reasonably achievable and are not achievable. These include load allocations that would require reductions from natural loadings; reductions that cannot be enforced because the source is not regulated or, in some cases, such as sources in Oregon, cannot be regulated by California; and reductions that are not technically or economically practicable. The CWA anticipated situations where water quality standards (WQS) or a TMDL would not be achievable by including processes such as Use Attainability Analyses (UAA) or development of site-specific criteria. In fact, use of the UAA process is the first recommendation by the National Research Council (NRC 2001) on improving the TMDL program, whereby "States should develop appropriate use designations for waterbodies in advance of assessment and refine these use designations prior to TMDL development".

Response 4:

The TMDL staff report clearly identifies the estimated background loads. The TMDL then proceeds to allow loads to the point where water quality objectives (e.g., dissolved oxygen) are no longer achieved. The proposed implementation plan identifies a wide range of traditional nonpoint source best management practices to address many of the nonpoint source loads. The implementation plan also includes a discussion of other more innovative tools that could be used to help achieve the required reductions of nutrients and organic matter. These tools include wetland treatment systems, low-level wastewater treatment systems strategically placed to capture the most polluted return flows, and a water quality tracking and accounting system that will facilitate the purchase of nutrient reduction credits to fund the innovative treatments. PacifiCorp is participating in the work group to develop the Klamath Basin water quality tracking and accounting system. They have also undertaken pilot studies for wetland treatment systems. One of the interim measures funded through the Klamath Hydroelectric Settlement Agreement (KHSA) is a basin-wide workshop which will bring together experts on innovative treatment systems as a major step forward in developing a landscape engineering plan that, in a feasible manner, can be implemented to achieve the necessary nutrient reductions. A UAA would be premature prior to the development of a landscape engineering restoration plan since the objective is to preserve existing and restore prior beneficial uses. The TMDL in combination with the Klamath Basin Restoration Agreement (KBRA) dramatically increases the potential for restoration of existing and historical beneficial uses in the Klamath River basin. See also responses to comments K39, K53, and K54.

Comment 5:

5. The Revised Draft TMDL's load allocations to PacifiCorp are improper to the extent that they are not addressed to pollutant loadings from PacifiCorp. TMDL load allocations must be addressed to a source's pollutant loadings. Improper allocations to PacifiCorp include (1) the requirement to achieve a "compliance lens" of simultaneously achieved temperature and dissolved oxygen criteria in portions of Copco and Iron Gate Reservoirs and (2) negative nutrient "load allocations" upstream of Copco Reservoir. Neither of these allocations is addressed to pollutant loadings to the Klamath River from PacifiCorp or that PacifiCorp can control.

Response 5:

PacifiCorp's TMDL targets and allocations are directly related to impairments caused by its facilities that are related to controllable water quality factors. The compliance lens allocations require PacifiCorp to address oxygen deficiency and temperature impairment within the reservoirs that in combination create non-supporting conditions for cold-water fish. See also responses to comments K39 and K53.

Comment 6:

6. The Revised Draft TMDL analysis of annual nutrient loadings from source areas contains significant discrepancies in the accounting of loads. The magnitude of unaccounted loads that can be calculated from information provided in the Revised Draft TMDL is troublesome and suggests serious shortcomings in the TMDL analysis.

Response 6:

Regional Water Board staff believe that this comment comes from an oversight in updating the loading analysis figures (4.1, 4.2, and 4.3) from the June draft with figures using the revised model run in the December draft. In addition, PacifiCorp (in a later comment) attempted to sum the reaches in a manner that was not intended. Clarifying text and updated figures should address this concern. Regional Water Board staff also note that though there remain opportunities for refinement of the model, its representation of the river, and the presentation of results, overall the model has been demonstrated to reasonably depict the dynamics of the system, and is sufficient and appropriate for setting load allocations.

Comment 7:

7. The thermal TMDL presented in the Revised Draft TMDL is inconsistent with the Clean Water Act (CWA) because it does not determine, and would not establish, the thermal load limits *required* to ensure a balanced indigenous population of aquatic life (BIP). The thermal effects associated with the Klamath Hydroelectric Project (Project) are consistent with a BIP.

Response 7:

Please see response to comment K40.

Comment 8:

8. The Revised Draft TMDL model – the analytical tool relied upon to develop the TMDL's allocations and targets – includes inappropriate boundary condition values. The Revised Draft TMDL states that nutrient concentrations used in assigning upstream boundary conditions in the TMDL model reflect median conditions expected upon attainment of Oregon's UKL TMDL. However, the selected values used in the model are not consistent

with the median values predicted by the UKL TMDL model, but instead are too low and do not properly account for inter-annual variability. As such, the allocations and targets set using the Revised Draft TMDL model are biased.

Response 8:

The PacifiCorp analysis in a later comment focuses on a load-based analysis of UKL conditions (1995 flows times concentration). However, the UKL boundary conditions were concentration based, not load based. The UKL boundary condition was based on the median condition. The following rationale is provided in the draft Oregon Klamath TMDL:
http://www.deq.state.or.us/wq/TMDLs/docs/
klamathbasin/uklost/KlamathLostTMDLWQMP.pdf

Page 2-41 of that document states:
"The Upper Klamath Lake boundary condition for the natural conditions baseline model was based on the existing Upper Klamath Lake TMDL (DEQ 2002, also see Section 2.6.2 for the source assessment, Section 2.8.1 for discussion of uncertainty and Chapter 1 for discussion of policy). The Upper Klamath Lake TMDL model is predicting a bi-modal distribution of summer phosphorus concentrations with 2 of the 8 years experiencing high phosphorus concentrations (> 200 ìg/L) associated with large algae blooms (Figure 2-29). For the purpose of the Klamath River TMDL, one of the moderate years was chosen because it would provide for more conservative allocations (see Section 2.8.2). Specifically, concentrations for water quality constituents were based on 1995 Upper Klamath Lake model output which represents a median year (Figure 2-29). Choosing a specific year, rather than averaging the eight years of model results, allowed for the removal of the influence of the two extreme years and their lingering impact in the following winters. The year 1995 had the sixth highest spring phosphorus concentrations and the fourth highest summer concentrations (out of eight years). Since the year 1995 was not influenced by the two extreme years, the total phosphorus concentrations are lower than the multiple year, average targets presented in the Upper Klamath Lake TMDL of 30 ìg/L (March – May) and 110 ug/L (annual) (DEQ 2002). For 1995, the average March – May total phosphorus concentration was 27 ug/L and the annual average was 23 ug/L. "

In summary, the UKL boundary conditions are based on a number of years of data, and thus account for interannual variability, and reflect median values of the available data.

For additional information related to this comment, see also responses to comments A4, A18, and A25.

Comment 9:

9. The TMDL temperature model includes inappropriate and biased reductions in solar radiation of 20 percent in certain modeled river reaches and scenarios. The reservoir reaches are modeled with 100 percent of solar radiation (no reduction). For example, where Iron Gate and Copco reservoirs are included in an analysis, 100 percent solar radiation is applied. For the same reach under a no-dams analysis, 80 percent solar radiation is applied. This results in a bias in which the downstream temperature effects of the reservoirs are overstated in excess of 1°C. As such, the temperature allocations and targets set using the Revised Draft TMDL model are biased. Other significant changes have been made to parameter values in the TMDL model used for the Revised Draft TMDL compared to the original Draft

TMDL. These changes result in predicted water quality conditions that are substantially different in the Revised Draft TMDL than the original Draft TMDL. Because of this, the model is essentially a new model and not just a minor revision of the previously-released model as the Regional Board staff suggested to Regional Board members and the public prior to release of the Revised Draft TMDL.

Response 9:
The Regional Water Board does not agree with this comment. The TMDL model(s) used for the December draft are essentially the same model(s) used in the June draft. Also refer to Appendix 6 and response to comment A10.

Comment 10:
Despite these concerns, PacifiCorp remains committed to working with the Regional Board and other stakeholders to enhance the water quality conditions in the Klamath River. As the Regional Board is aware, PacifiCorp has been active in supporting strong science and prudent actions related to water quality in the Klamath River. Even as the TMDL is still under development, PacifiCorp is already proactively implementing important water quality measures and activities designed to bring about substantial water quality improvements in the Klamath River basin. PacifiCorp has and will continue to implement these measures and activities under a number of separate but related commitments, including elements of the Agreement in Principle (AIP), Klamath Hydroelectric Settlement Agreement (KHSA), the Interim Conservation Plan (ICP), Reservoir Management Plans (RMP), as well as other planned activities.

Response 10:
Regional Water Board staff remain committed to working with PacifiCorp on the Klamath basin water quality tracking and accounting program, Klamath Basin Monitoring Program, review of their Reservoir Management Plans, development of the AIP Monitoring Plans, and other areas. We look forward to working with PacifiCorp in the development of their TMDL implementation plan.

Comment 11:
Based on our numerous conversations with Regional Board staff, we understand that nutrient and algae reduction measures are the primary focus of TMDL efforts. The measures that have been identified by PacifiCorp in the AIP, KHSA, ICP and RMP will directly address the water quality problems in the Klamath River related to nutrients and organic matter. These efforts also will address dissolved oxygen (DO) and water temperature conditions in the Klamath River basin below Iron Gate dam and within the Project area. For example, PacifiCorp is pursuing or evaluating wetlands treatment in the upper basin (a critical nexus of water quality for lower river conditions), in-reservoir treatments, and other management actions above, within and below the Project area. In addition, comprehensive water quality monitoring will be continued and expanded to extend baseline monitoring at a basin scale and address public health monitoring needs. The baseline program will be valuable in assessing long-term trends, assessing the efficacy of actions associated with implementation of water quality measures, including but not limited to TMDL actions, and tracking progress toward TMDL goals and objectives. The public health monitoring elements of the plan utilize the latest information and approaches to blue-green algae ("BGA") monitoring and assessment through continued input from the Klamath BGA working group. The program will provide the necessary public health information and will identify inter-annual variability and long-term trends.

Response 11:
The Regional Water Board agrees that PacifiCorp has identified measures that will be useful in working towards restoring water quality conditions within their Klamath River facilities. However, it is not clear that the measures identified to date will fully address PacifiCorp's responsibilities related to the targets and allocations assigned to their facilities in the Klamath River TMDL. The next step in answering that question will be when PacifiCorp submits their TMDL implementation plan. The Regional Water Board looks forward to continuing to work with PacifiCorp in developing an implementation program that fully addresses their allocations. In addition, PacifiCorp's commitment to helping to develop and fund monitoring programs in the Klamath River mainstem and their collaboration with the Regional Water Board on the development of the Klamath Basin Water Quality Tracking and Accounting Program is to be applauded. However, we note that our evaluation of the measures identified by PacifiCorp in their Reservoir Management Plans found several measures of uncertain value to addressing water quality issues in the Project area and are not recommended by the Regional Water Board for inclusion in the TMDL implementation program. In addition, the wetland treatment needs to be considered within the context of a basin-wide program that will be developed as part of KHSA Interim Water Quality Measures. For more detail on KHP implementation, including interim water quality measures, please see response to comment K39.

CHAPTER 1. INTRODUCTION

Comment 12:
Page 1-1, Paragraph 1, Lines 4-5 and Lines 9-11. The Revised Draft TMDL introduces a new term: "recalculated Site Specific Objectives". This term is then used throughout the Revised Draft TMDL with regard to dissolved oxygen (DO) targets and allocations. This term should be defined for the reader, and an explanation given as to the reason, purpose, and rationale for "recalculated Site Specific Objectives" for DO.
Response 12:
Thank you for this suggestion. The following text will be added to Chapter 1;

> "The SSOs for DO in the mainstem Klamath River have been recalculated because conditions of barometric pressure, salinity and natural receiving water temperatures at equilibrium (e.g., 100% DO saturation) do not consistently allow for attainment of the existing SSOs for DO. Further, the *Klamath TMDL model*, as described in detail throughout the rest of this report, indicates that under natural conditions, the DO concentrations achieved in the mainstem Klamath are periodically less than the existing SSOs for DO, particularly during the summer months. For a detailed analysis of DO conditions in the mainstem Klamath River, including the recalculation of the SSOs, please see Appendix 1."

<u>1.5 Other Ongoing Processes in the Klamath River Basin</u>

Comment 13:
This section is missing important specific and updated information on the KHSA, ICP, RMP, and Klamath Basin Restoration Agreement (KBRA) that are directly relevant to the TMDL and its eventual implementation.

Response 13:
Comment noted. The discussion is meant as a general recognition that other processes are ongoing. The text was not revised.

Comment 14:
Page 2-2, under *2.1.1 Non-TMDL Factors and other Regulatory Processes*. The naturally-eutrophic nature, and currently hypereutrophic status, of Upper Klamath Lake (UKL) has been and remains an overwhelmingly important factor to Klamath River water quality. Yet it is not mentioned as a factor impacting beneficial uses in the bullets listed under this section of the Revised Draft TMDL

Response 14:
The title of the referenced subsection is non-TMDL factors. The comment incorrectly identifies UKL as a non-TMDL factor. UKL has an approved TMDL and the excess nutrients and organic matter that originate from UKL are discussed at several locations throughout the TMDL staff report. There are several instances where existing conditions within UKL are identified as a source of nutrients and organic matter that contribute to impaired water quality conditions in the Klamath River downstream.

Comment 15:
[T]he data used in the Revised Draft TMDL does not include or cite many key water quality studies and data for the Klamath River Basin. See the list provided in the attached Appendix A in PacifiCorp's August 2009 comments on the original Draft TMDL. Omission of these key reports and documents indicates that a thorough review of available reports and data was not completed, but rather a selective set of data were used in the TMDL analysis and development of load allocations.

Response 15:
This comment is incorrect. The datasets and information compiled to support the TMDL technical analyses are among the most complete compilation of information and monitoring data ever undertaken in the public arena for the Klamath River. As part of these efforts data was obtained from multiple sources for several years of record for every indicator assessed; hundreds of technical references were reviewed; and hundreds of interviews with regional experts and stakeholders were conducted. The information from these sources has been compiled for public review. The Regional Water Board did not omit any observation from any of the monitoring data acquired from any of the agencies or other monitoring entities. The TMDL technical analyses provide a robust and accurate assessment of existing conditions within the Klamath River. The law does not require the inclusion of every reference of every possible data source possibly available. The TMDL must include or reference data and information that supports the Regional Water Board's action. The TMDL staff report meets and far exceeds this standard. The Staff Report includes or references data sources relied upon to support the TMDL.

Comment 16:
Page 2-4, Paragraph 1. The Revised Draft TMDL notes all of the existing beneficial uses for the Klamath River and makes particular note of uses "that are currently not fully supported due in part to degraded water quality," including aquaculture. The Revised Draft TMDL did not address, however, the potentially significant negative effect to the hatchery and its aquaculture beneficial uses should the dams be eliminated. Aquaculture at the hatchery is made possible by

Iron Gate reservoir, which provides a cold water supply for the hatchery (especially certain hatchery programs, such as a yearling program which requires sufficient cold water flow during the summer months). Iron Gate reservoir supports the aquaculture beneficial use since the cold water supply to the hatchery is free of disease parasites. This is due to the fact that the reservoir does not provide suitable habitat for spore survival. Fish from the hatchery are thus free of fish disease - which is significant in a river in which fish disease is a major concern. As a result, the removal of Project dams may have the effect of impacting or possibly eliminating at least portions of the existing hatchery operations whereas there are water quality conditions that could reasonably be achieved through the coordinated control of all factors which affect water quality.

Response 16:

It is not the purpose or intent of the TMDL to remove the dams, or to take a position on whether or not the dams should be removed. For the last several years, PacifiCorp has been participating in negotiations with many parties within the Klamath basin to remove the dams. The Regional Water Board was not included as a party to these settlement discussions. However, the Klamath Hydroelectric Settlement Agreement (KHSA) includes provisions for moving and reengineering the fish hatchery if the dams are eventually removed. If KHSA parties determine that removing the dams is an option they want to pursue, the Regional Water Board would welcome the opportunity to discuss fish hatchery alternatives similar to those developed for the KHSA.

Comment 17:

PacifiCorp argues that the temperature TMDLs are inconsistent with the Clean Water Act because they do not determine, and would not establish, the thermal load limits necessary to ensure the protection and propagation of a balanced, indigenous population of shellfish, fish, and wildlife.

Response 17:

This comment was previously submitted. See response to comment K40.

Comment 18:

Page 2-8, under Nutrient-Related Water Quality Objectives. The Revised Draft TMDL states: "[T]he cycling of nutrients in an aquatic environment is strongly influenced by several factors." However, the Revised Draft TMDL does not tackle this problem in any quantitative manner. The specific cycling of nutrients in the aquatic system is stated several times throughout the document, but no analysis on nutrient cycling (Kaplan and Newbold, 2003), spiraling, spiraling rates or velocities (Elwood et al,1983; Kalff, 2002) or other similar analysis is included. The role of the benthic environment, in eutrophic systems in particular, is critical to these discussions, yet these important attributes are unquantified and not discussed in the Revised Draft TMDL

Response 18:

We have revised this wording to read, …"nutrient dynamics within aquatic environments….." This is an introductory section. A more detailed discussion of key factors that affect nutrient dynamics is included later in Section 2.4.

Comment 19:

Pages 2-16 and 2-17. The Revised Draft TMDL contains new text on these pages that describe current trophic conditions in Upper Klamath Lake and the Klamath River. By this statement, and elsewhere on these pages, the Revised Draft TMDL is much more clear than the original Draft

TMDL that the headwaters of the Klamath River (that is, the outflow from UKL) is hypereutrophic (and has been for about the last 100 years), and prior to that was eutrophic.

Response 19:

No response necessary.

Comment 20:

Page 2-16, Paragraph 2 through Page 2-17, Paragraph 1. The Revised Draft TMDL states: "Another consideration is ensuring that the target values for the selected indicator(s) are consistent with the desired trophic status of the waterbody, and that the desired trophic status is appropriate for the waterbody." Subsequently, there is discussion of "trophic classification." Such classification scheme is undefined in the TMDL, although a wide range of basic limnology texts provide guidance on trophic status for both rivers and lakes (e.g., Kalff, 2002; Wetzel, 2001; Horne and Goldman, 1994).

Response 20:

A general definition of trophic classification is provided in the referenced section – since the point is one of general trends over time not a specific classification. However, two tables from Welch and Jacoby (2004) have been inserted as examples to more specifically illustrate the general trophic classification definition. Please note that the trophic boundaries from this highly regarded text are inconsistent with those recommended by PacifiCorp elsewhere in these comments. The ranges and qualitative characteristics included in the added tables are consistent with the targets and characteristics used in the Klamath River TMDL for lentic portions of the Klamath River.

Comment 21:

On page 2-16, Paragraph 4, the Revised Draft TMDL included new text indicating that the fact that UKL has always been a eutrophic system "…should not be used as an excuse for inaction…or the argument that it useless to reduce nutrient loading because the lake will still be eutrophic…".

To be clear, PacifiCorp has no interest in inaction, nor do we believe it is useless to reduce nutrient loading from UKL. In fact, PacifiCorp believes that actions to reduce nutrient loading are essential to achieve future water quality improvements in the Klamath River downstream of UKL. As discussed above, PacifiCorp is already proactively implementing important water quality measures and activities designed to bring about water quality improvements in the Klamath River basin.

Rather, PacifiCorp is concerned that the Revised Draft TMDL, as with the original Draft TMDL, is based on a huge nutrient reduction goal that is simply unrealistic and unachievable. *** As a result, the Revised Draft TMDL fails to provide proposed nutrient load allocations that are achievable, practicable, or enforceable. As PacifiCorp made clear in our August 2009 comments on the original Draft TMDL…. *** The federal Clean Water Act (CWA) anticipated situations where water quality standards (WQS) or a TMDL would not be achievable by including processes such as Use Attainability Analyses (UAA) or development of site-specific criteria. (Duplicate text omitted to save space.)

Response 21:

- The wording referenced in the comment was not directed at PacifiCorp. Rather it was intended because of a generally expressed sentiment stated by stakeholders at several meetings within the basin.

- The Regional Water Board is encouraged by PacifiCorp's proactive program of water quality improvements. However, we caution that compliance and implementation measures are best agreed upon collaboratively as outlined in the interim conditions of the KHSA.
- The Regional Water Board disagrees that the allocations and targets are unachievable. For more response to these previously submitted comments, see also K39 and K53. Both allocations and targets will be continually reassessed as part of the TMDL adaptive management program. What is absolutely clear is that all measures must be taken to reduce the pollutant load and address factors negatively affecting water quality conditions to reverse what has been a declining trend for many years. Many existing beneficial uses are critically threatened.
- The Regional Water Board within the TMDL staff report has provided a technical justification for the allocations to the reservoirs. The allocations are required to address controllable water quality factors within the reservoirs relative to chlorophyll-a concentrations during critical summer growth periods. The chlorophyll-a targets are well within reasonable limits for the reservoirs and are necessary to eliminate impairments.

Comment 22 (condensed):

The Revised Draft TMDL model simulation results indicate that there are insufficient nutrients (neither inorganic nor organic forms) to support a standing crop of benthic algae. This nearly complete lack of primary production (phytoplankton are moving through this reach, but concentrations are low, ranging from 1 to 2 mg/l) simulated by the model is unrealistic and infeasible. If these unrealistic modeled conditions are assumed as accurate, then the Revised Draft TMDL is based on nutrient reductions that would have profound implications on the food web within the aquatic system (and possible terrestrial implications as well).

Further, these simulation results indicate that mean benthic algae conditions (represented as chlorophyll *a* with a conversion of 67 mg of algae per mg of chlorophyll *a* (APHA et al, 2005), which is consistent with Appendix 6 of the Revised Draft TMDL) are ultra-oligotrophic below Keno Dam and mesotrophic below the large springs complex. The mesotrophic status in summer is presumably due to benthic algae growth as a result of naturally elevated nutrient concentrations in the springs complex. When examining maximum benthic algae conditions (represented as chlorophyll *a*) in these simulations, the system is always oligotrophic. The implications of the basic assumptions used in modeling natural baseline conditions – those assumptions that resulted in what is essentially an oligotrophic system between Keno Dam and the large springs complex – on food webs and productivity are critical to anadromous fish and are not presented in the TMDL.

Thus, there is a fine balance required when managing nutrients in thermally challenged streams to ensure that overall productivity is not sacrificed to meet targets or objectives for other uses. The Revised Draft TMDL has failed to identify these critical processes and does not provide discussion or detailed assessment of the potential implications of dramatic nutrient reductions on food web dynamics and how beneficial uses are affected.

Response 22:

First, nutrient reductions in-line with historic natural conditions cannot cause a situation in which production is too low to support a healthy fish population. Historically, the Klamath had a major salmon spawning run; thus, natural conditions are clearly sufficient to support a healthy fish population. It is unlikely that achievement of nutrient load allocations set to represent "natural conditions" will disrupt food webs or alter overall productivity, and PacifiCorp's evidence is unpersuasive.

Regional Water Board staff agrees with PacifiCorp that fish need food to grow, especially in thermally challenged system. However, as the system slowly returns to more natural nutrient conditions, ecosystem function will provide sufficient food resources for fish from primary production supporting aquatic macroinvertebrates, and from terrestrial sources. Nutrient concentrations under TMDL compliance conditions will support primary production sufficient to contribute energy for in situ production of macroinvertebrates. In situ production will also be enhanced by allocthonous input as well as marine derived nutrients from returning anadromous salmon (if PacifiCorp moves forward with dam removal).. These ecosystem functions providing for production and food availability were intact historically, and will be furthered under the TMDL.

Second, the comment focuses on a comparison of model simulated benthic algal densities above JC Boyle reservoir, comparing the Natural Conditions simulation at this site to Natural Conditions simulation at Stateline and showing minimal algal growth above JC Boyle reservoir. This comparison is uninformative, as benthic algal growth may be restricted by a variety of factors. In documents submitted in support of its FERC application, PacifiCorp provided a description of several factors other than nutrients that limit benthic algae in the reach just below the reach referenced in the comment. (See e.g. Section 4.2.6 Bypass Reach—J.C. Boyle Dam to J.C. Boyle Powerhouse [The general physical aspects of this reach are not conducive to phytoplankton growth and limit attached algae forms. These features include bedrock or large substrate channel forms; steep, high velocity reaches; and topographic shading.] and Section 4.2.7 Peaking Reach—J.C. Boyle Powerhouse to Copco Reservoir [Conditions within the peaking reach probably lead to only a limited capacity for algal biomass to utilize available nutrients due to scour, light limitations due to colored water and suspended matter, the inability of phytoplankton to persist in the riverine environment, and short residence time] (internal citations omitted).) Nonetheless, aquatic organisms exist and thrive in certain reaches now with little to no benthic algae. It is not appropriate to apply one standard of productivity to the entire basin when the Klamath Basin encompasses many different complex ecosystems with differing levels of productivity. (See PacifiCorp Oregon 401 Application, pp. 4-18.) A more informative comparison would be between benthic algal densities in this reach under Natural Conditions and under current conditions.

Third, analogies to the Shasta River Big Springs area are not appropriate to the Klamath basin in general. Although the geology is similar, the springs provide conditions that are unique and are widely recognized as historically well above productivity of other reaches within the basin. Also refer to responses 2, 8, 22, and 76, and C76.

Finally, the scenario described in this comment does not take into account the structure of the implementation plan. The implementation plan does not require PacifiCorp to meet its load allocations immediately. Nor can the implementation plan require Oregon to meet load allocations at Stateline immediately. In fact, many other comments from PacifiCorp insist that the load reductions can never be met. While staff does not agree that load allocations can never be met, we acknowledge that full compliance with load allocations at Stateline and for the KHP is likely to take time. The implementation plan allows PacifiCorp to submit a proposed plan that provides a process and time for investigating various infrastructure improvements and modifications. The implementation plan requires Regional Water Board review and approval prior to moving forward with any major project for TMDL compliance. Meanwhile, the Staff Report identifies a trigger point at the tail race of Iron Gate Dam so the Regional Water Board can review and respond to this issue if and when nutrients are reduced to the level that may alter downstream productivity and food availability.

Comment 23:

Page 2-17, Paragraph 1, Lines 1-2. The TMDL neither presents nor cites any data to support the assertion that the Klamath River downstream of UKL "historically has ranged from eutrophic to mesotrophic". Assertions such as this must be supported with data or citations to relevant studies or reports. This statement is also in conflict with statements on the previous page (2-16) in which it was acknowledged that Upper Klamath Lake, the headwaters of the Klamath River, has "a natural background condition of eutrophic ". Estimates of the background concentration of phosphorus in Klamath Basin groundwater range from 0.06 mg/L (NRC 2004) to 0.08 mg/L (based on PacifiCorp water quality monitoring data). Thus, it is unlikely that the Klamath River just downstream of UKL was ever mesotrophic – a status typically defined by phosphorus concentrations ranging between 0.01 to 0.20 mg/L (Chapra 1997).

Further, the application of trophic state language to rivers in the same way it is applied to lakes leads to confusion and analytical error. For example, trophic state in a lake can be defined based on planktonic chlorophyll concentration or Secchi depth, which would be clearly inappropriate in a river where most of the chlorophyll is in the form of attached vegetation, and Secchi depth measurements are not possible.

Response 23:

The mesotrophic status is not unrealistic for several reaches within the Klamath system. Ward and Armstrong (2009) have recently released for peer review the results of a study conducted for the U.S. Fish and Wildlife Service (Arcata) to assess the community metabolism and associated parameters in the Klamath River below Iron Gate Dam. The study findings, which are consistent with the findings of Regional Water Board staff, are that under existing conditions the Klamath River below Iron Gate indicates a mesotrophic system. Therefore if the Klamath River is currently classified as mesotrophic under current loading conditions, which are well above background, then it is reasonable to assume that under lower loading conditions that reaches of the Klamath River below UKL also could be mesotrophic. The Regional Water Board estimates are consistent with the most current science. We do agree with the portion of the comment suggesting that reaches of the Klamath River immediately below UKL were most likely eutrophic. However the associated nutrient concentrations cited in PacifiCorp's comment are higher than the TMDL natural baseline condition estimates.

Comment 24:

The Revised Draft TMDL's statement that restoring conditions in Upper Klamath Lake is critical to restoring conditions in the Klamath River is an important finding and statement in the Revised Draft TMDL that was unclear in the original Draft TMDL. However, Upper Klamath Lake's hypereutrophic state and its affect on the river downstream are not realistically dealt with in the Revised Draft TMDL with regard to assessing the attainability of designated beneficial uses, setting realistic water quality objectives and targets, attaining TMDL compliance, and maintaining that compliance into the future. The above statement from page 2-17 of the Revised Draft TMDL clearly states that TMDL's de facto goal with respect to nutrient targets and allocations (as described later in Chapter 4), which calls not just for a shift in trophic status, but an unrealistic and unachievable reduction to the trophic state assumed under "pre-disturbance" conditions (that is, conditions without and before human development and disturbance activities over at least the last century).

Response 24:

PacifiCorp's conclusion from the cited text is erroneous. The supplemental discussion of trophic state was added to underscore the shift in productivity and conditions within UKL to conditions that are causing serious impacts on beneficial uses. This concept is strongly supported by the research cited in the TMDL staff report. The allocations address the assimilative capacity of the system remaining above natural background levels. The TMDL staff report provides an implementation framework for achieving the goals and objectives of the TMDL. Regional Water Board staff welcome the opportunity to continue working with PacifiCorp on the Klamath basin water quality tracking and accounting program, which is one of the key elements making the TMDL goals achievable. See also response to comment K53.

Comment 25:

Page 2-17, Paragraph 1, Lines 10-12. The TMDL presents no evidence that the mere existence of the Project dams has "shifted the trophic status" of the portion of the river between Stateline and Iron Gate Dam. The TMDL provides no metric by which the trophic status of the river was measured historically or presently, no indication that such a metric, should it exist, is equally applicable to both free-flowing rivers and impounded reservoirs, and no evidence that such a metric, should it exist, is altered by the mere presence of the reservoir, rather than by the influx of excessive nutrients from upstream.

Response 25:

The language in this section has been revised somewhat to place the focus on the role of the dams in creating undesirable conditions for phytoplankton concentrations and nuisance blue-green algal blooms. Welch and Jacoby (2004) provides a description of quantitative and qualitative characteristics to evaluate the trophic status of lakes. For each of these, the PacifiCorp reservoirs fall into the eutrophic to hypereutrophic condition. Since in the pre-disturbance period there were no dams, we must evaluate the river based upon a different set of metrics. The Ward and Armstrong (2009) report evaluates the trophic status of the Klamath River below Iron Gate and suggests that its condition is consistent with a mesotrophic system. Therefore, the project has taken what under lower loading conditions in the past what would have been at least a mesotrophic river to what is currently a eutrophic to hypereutrophic system. The TMDL staff report identifies targets that are appropriate for the varied conditions found within the Klamath system. The reservoirs have their set of targets and the river reaches have their own set of targets. No attempt was made to apply one metric to all conditions.

Comment 26:

If the TMDL targets are intended to re-establish a formerly existing mesotrophic status, the TMDL must present some evidence to support the assertion that such a former status actually existed, and at what former time that occurred. The TMDL provides no evidence to support its claims. In any case, the Revised Draft TMDL's nutrient targets (identified in Chapter 5) are unrealistic in that they represent nutrient targets for oligotrophic-to-mesotrophic conditions (e.g., see Wetzel 2001) that are far below the Klamath River's naturally-eutrophic condition. Although a "natural conditions" simulation is presented in the TMDL, the supporting information formulating the basis for this state, e.g., "pre-disturbance conditions", is not presented. Thus, the "natural conditions" scenario cannot be evaluated to determine if it is realistic. Load allocations developed in the TMDL to achieve these "natural conditions" therefore cannot be adequately reviewed to determine their appropriateness. This lack of transparency in how "natural conditions" were arrived at impedes the public review process.

Response 26:

The goal is not to establish a particular trophic status; the goal is to restore water quality conditions to their formerly beneficial use-supporting status. The TMDL staff report provides sound scientific evidence of a shift in productivity, species composition, and nutrient concentrations, all associated with the current degraded water quality conditions. There are many different trophic classification systems. Dr. Eugene Welch, a long time researcher in the Klamath basin, provides the trophic classification system most relevant to Klamath lakes and reservoirs. Regional Water Board staff has cited that text as its reference for trophic classification: Welch, E.B. and J. M. Jacoby. 2004. Pollutant Effects in Freshwater: Applied Limnology, Third edition. Spon Press. London, UK. 504 pp. (pages 187 through 192).

The TMDL staff report and supporting documentation provides a transparent presentation of the assumptions associated with the natural condition baseline scenario, the condition the commenter refers to as "pre-disturbance" (a characterization not provided by the Regional Water Board). Therefore, the information has been made available to the commenter to evaluate the natural condition scenario. The Regional Water Board staff has met the noticing and public participation requirements in the development of this TMDL. The public process has been extensive and has occurred over an extended period of time, as documented in Chapter 11 – Stakeholder Participation in the staff report.

Comment 27:

Page 2-17, under *2.3.1 Temperature*. The Revised Draft TMDL states, "Establishing load allocations and targets based on natural conditions is the best possible means of achieving a balanced indigenous population . . . . The protection of all beneficial uses ensures a balanced indigenous population of aquatic life." This misunderstands the CWA's thermal TMDL requirement, which is that TMDL must establish "the *maximum* daily thermal load *required* to assure" a BIP. 33 U.S.C. § 1313(d)(1)(D) (emphasis added).

Response 27:

Please see response to comment K40.

Comment 28:

Page 2-18, Paragraph 3, Lines 6-8. The Revised Draft TMDL indicates that the California nutrient numeric endpoint (NNE) boundary target is "based on a review of both regional and international studies and the recommendation of university and regional experts". Please cite the studies and provide documentation of the recommendation of experts for the target as it pertains to the Klamath River.

Response 28:

The references are provided in the cited text: Tetra Tech. 2006. Technical Approach to Develop Nutrient Numeric Endpoints for California. Prepared for U.S. Environmental Protection Agency

(Contract No. 68-C-02-108-TO-111), and CA State Water Resources Control Board – Planning and Standards Implementation Unit. Lafayette, CA. 120 pp.

Comment 29:
Page 2-18, first bullet, Lines 10-13. The Revised Draft TMDL incorrectly indicates that the Klamath headwaters are eutrophic. Upper Klamath Lake, which is the headwaters of the Klamath River, is well known to be hypereutrophic (e.g., Kann and Smith 1993, Eilers et al. 2001, Walker 2001, ODEQ 2002, Kann and Welch 2005, Wee and Herrick 2005, PacifiCorp 2006). Hypereutrophic lakes are very nutrient-rich lakes characterized by frequent and severe nuisance algal blooms and low transparency; they typically have greater than 40 micrograms/liter total chlorophyll *a* and greater than 100 micrograms/liter phosphorus (Welch 1992, Cooke et al. 2005). Upper Klamath Lake often exceeds these chlorophyll *a* and phosphorus concentrations.
Response 29:
The reference to Upper Klamath Lake as eutrophic relates to its unimpaired condition, not its current impaired status – thus the appropriateness of the targets downstream.

Comment 30:
Page 2-18, Paragraph 4, Lines 1-6. The Revised Draft TMDL cites "Ward and Armstrong 2009 in press". The Regional Board should make this document available immediately for public review. The use of documents still "in press" or otherwise unavailable to the public does not allow a thorough review of this TMDL by the public and affected parties. For example, the "Ward and Armstrong 2009 in press" citation is used to support the target of 150 mg/m^2 of benthic chlorophyll *a* as consistent with mesotrophic conditions. However, while trophic classifications in rivers can be difficult to pin down, many researchers have reported that nuisance conditions occur in rivers when periphyton exceeds about 100 mg/m^2 of benthic chlorophyll *a* (e.g., Welch and Jacoby 2004).
Response 30:
Regional Water Board staff determination of the Klamath River as a mesotrophic system was made long before the draft final Ward and Armstrong (2009) publication was released. The primary citation for setting Klamath River periphyton targets is: *Tetra Tech. 2008. Nutrient Numeric Endpoint Analysis for the Klamath River, CA. Prepared for U.S. EPA Region 9 and North Coast Regional Water Quality Control Board. May 29, 2008. Tetra Tech, Inc., Research Triangle Park, NC.* PacifiCorp commented on the Tetra Tech 2008 technical memorandum as part of their review comments on both the June 2009 TMDL staff report and the December 2009 TMDL staff report. The USFWS draft final study has been publically available since August 2009. The peer reviewed final report by Ward and Armstrong is expected in March 2010. The purpose of citing this research is that it simply provides the latest scientific information on this topic.

Comment 31:
Page 2-18, Paragraph 5. The Revised Draft TMDL indicates that "the scoping tool" used for the TMDL estimated benthic chlorophyll *a* levels of 109 to 157 mg/m^2, with a mean of 141 mg/m^2 under natural conditions (which the Revised Draft TMDL indicates is "consistent with pre-disturbance conditions"). Therefore, the Revised Draft TMDL's own estimates indicate that benthic chlorophyll *a* consistently exceeded nuisance conditions (of 100 mg/m^2) and on

occasions exceeded the TMDL's target (of 150 mg/m^2) under natural (pre-disturbance) conditions.

Response 31:

The target is a summer growing season average (reach average). The portion of the discussion not included in the cited text in PacifiCorp's comment goes on to explain that because of the naturally productive characteristics of the Klamath River, the target should be adjusted to the level of 150 mg/m^2. This target was presented to the peer review team for their evaluation. The target was strongly supported in peer review comments. Estimated densities would be a vast improvement upon conditions existing today. The TMDL adaptive management mechanism would allow a review to determine what flexibility would be allowed in the target once the cited density range had been achieved. If beneficial uses are supported under these conditions a minor correction can be made to the target.

Comment 32:

Page 2-19, Paragraph 2. Line 1-2. In addition to the above comment, the benthic chlorophyll *a* target of 150 mg/L is also questionable because the methodology to measure it is undefined. Other than stating that it is a "reach average" (undefined) value, there is no information about how this target will be measured. Any benthic biomass value is quite susceptible to measurement methodology. Without precisely defining how the target is to be measured, there is no way to establish if it has been met. In addition, the target makes no mention of attached macrophytes, which are a major portion of the aquatic plant biomass in the Klamath River, especially where suitable habitat exists.

Response 32:

See response to comment 33 below.

Comment 33:

Page 2-19, Paragraph 2. Line 2-3. The Revised Draft TMDL states "this is a reach-average benthic algae biomass target". There is limited data on benthic biomass in the Klamath River, and that which is available indicate a wide range of conditions present in the river, i.e., high spatial and temporal variability. In fact, data from different years and sites are combined into a single metric, different sample sizes are treated equally, the duration of the sampling programs in any one year do not exceed two months, except 2007, and in that year there are no samples above Weitchpec.

Response 33:

Periphyton densities along the Klamath River require additional monitoring. Recently, new protocols have been established for more consistently measuring this key indicator. The citation to the recently developed SWAMP guidance is: Fetscher, A.E., L. Busse, and P. R. Ode. 2009. Standard Operating Procedures for Collecting Stream Algae Samples and Associated Physical Habitat and Chemical Data for Ambient Bioassessments in California. California State Water Resources Control Board Surface Water Ambient Monitoring Program (SWAMP) Bioassessment SOP 002.

Additional data collection has been included as a recommendation of the monitoring plan in Chapter 7 of the TMDL staff report. A simple visual inspection of the river channel during the summer season would confirm the presence of excessively high densities of periphyton for many reaches. This is confirmed through an examination of diurnal water chemistry patterns for DO and pH available from several locations along the Klamath River that demonstrate extreme variation associated with impacted systems.

Comment 34:

Species counts are available for periphyton for limited reaches of the river and completely absent in other reaches; macroalgae, macrophytes, filamentous algae and other non periphyton forms have not been quantified; associated chlorophyll *a* data to estimate biomass of periphyton are lacking; spatial variability in species has not been quantified. Thus, predictions of algal biomass (using any of the methods identified) are unsubstantiated, and extending these results to future conditions is thus tenuous. These sparse data sets with an analysis that does not detail assumptions and uncertainty are used to arrive at the 150 mg/L target (consistent with a eutrophic stream) that is inconsistent with the Revised Draft TMDL nutrient targets (consistent with oligotrophic-to-mesotrophic conditions). As mentioned in previous comments, the Revised Draft TMDL should include a sensitivity analysis to bracket the range of potential conditions and to compensate for data gaps and shortfalls in understanding.

Response 34:

Comment noted – the impacts from excessive periphyton densities have been clearly demonstrated. When additional information is available using the most current protocol (cited above), additional data analysis will be undertaken.

Comment 35:

Page 2-19, Paragraph 4, first bullet. The Revised Draft TMDL's chlorophyll *a* target of 10 µg/L is inconsistent with Oregon's guideline chlorophyll *a* criterion of 15 µg/L, which is itself used only as a conservative screening level to identify waterbodies that may be impaired. The Revised Draft TMDL does not explain this inconsistency or why a more stringent target is needed in California. The Oregon guideline criterion also has a defined methodology for data collection to determine if it has been met. The Revised Draft TMDL lacks a defined methodology.

Response 35:

The comment is comparing two different targets that have two different purposes. There is no inconsistency for the following reasons: (1) different beneficial uses are being addressed between Oregon and California, (2) ODEQ's target is an "action level" whereas California's is a compliance target that is meant to protect beneficial uses before impairment occurs, and (3) the impairment is not due to the algae produced in Oregon (most of the floating algae in Oregon is not transported downstream), whereas the California phytoplankton is grown in the California reservoirs. As explained in the staff report, Regional Water Board staff relied on statewide guidance in developing the target, which is appropriate for the conditions in California reservoirs.

Comment 36:

Page 2-19, Paragraph 4, second and third bullets. The Revised Draft TMDL's targets for *Microcystis* and microcystin targets are not necessary for the protection of the beneficial use (REC1). Both the Oregon Department of Health and the California Office of Environmental Health and Hazard Assessment have set 40,000 cells/mL (of *Microcystis* or *Planktothrix*) and 8 µg/L microcystin as the criteria that are protective of public health. The TMDL should present data or citations to relevant sources to justify the necessity of a 50 percent reduction in the guideline.

Response 36:
The ODEQ target is a nuisance target. The California target is set prior to nuisance conditions occurring (i.e., low health effects threshold). Also, ODEQ supports the California target. Refer to response b6 for additional information on this topic.

Comment 37:
Page 2-19, Paragraph 5, last sentence of the paragraph. Prolonged high levels of chlorophyll *a* are typical of eutrophic *and* hypereutrophic water bodies.
Response 37:
Comment noted.

Comment 38:
Page 2-20, Paragraph 2. The Revised Draft TMDL includes new text here that attempts to explain that the 10 µg/L chlorophyll *a* target is appropriate for the reservoirs and other "quiescent waters" in the Klamath River "…because it marks the boundary between eutrophic and hypereutrophic". However, a 10 µg/L chlorophyll *a* concentration more approximately marks the boundary between mesotrophic and eutrophic (Chapra 1997, Wetzel 2001, Welch 1992, Lampert and Sommer 1997). Additionally, the chlorophyll *a* target is meaningless because there is no information about how this target will be measured. Any chlorophyll *a* value is susceptible to measurement methodology. Without precisely defining how the target is to be measured, there is no way to establish if it has been met.
Response 38:
The TMDL target condition is consistent with the CA NNE framework and is also consistent with Welch and Jacoby (2004) trophic classification system. Text has been included on the target measurement in both Chapter 2 and Chapter 7.

Comment 39:
Page 2-20, Paragraph 2. The Revised Draft TMDL includes new text stating, "The river upstream rarely exceeds 10 µg/L of chlorophyll- a, despite the currently eutrophic condition of the system". As in the original Draft TMDL, the Revised Draft TMDL continues to make inappropriate and misleading comparisons between river and reservoir conditions using the 10 µg/L chlorophyll *a* target, which the Revised Draft TMDL clearly states is applicable only to the reservoirs as a "surrogate measure of suspended algae (phytoplankton) biomass…for the Klamath River reservoirs" (page 2-19, paragraph 4). The Revised Draft TMDL has developed and applied a different chlorophyll *a* target for the river – that is, the benthic algae biomass target of 150 mg/m^2 of chlorophyll *a*.
Response 39:
The purpose of the comparison is to evaluate the impact of impoundment conditions on phytoplankton productivity and the development of nuisance algal conditions.

Comment 40:
Page 2-22, Paragraph 1. The Revised Draft TMDL includes new text discussing relationships of chlorophyll *a* and algal biomass related to potential health effects. The Revised Draft TMDL cites Graham (2009) to the effect that 10 µg/L would equate to a moderate probability of acute health effects from microcystin. The table referenced in Graham (2009), cited by the Revised Draft TMDL to support its unnecessarily low target misrepresents the World Health

Organization (WHO) guidelines for recreational water. In fact, the WHO (2003) guidelines equate a moderate probability of adverse health effects to the presence of 100,000 cyanobacterial cells/mL or 50 µg/L of chlorophyll *a*, with no mention of "acute" effects. This is five times greater than the proposed TMDL target. The TMDL must present data or citations to relevant sources to justify this extreme reduction.

The 10 µg/L chlorophyll *a* target in the reservoirs was not chosen to protect the beneficial use, but because it correlates to a relatively low probability of exceedence of 20,000 Microcystis cells/mL or 4 ppb microcystin/L. The values of 20,000 cells/mL and 4 ppb microcystin are not necessary for the protection of beneficial uses (water contact recreation), as demonstrated by the WHO guidelines for recreational water (WHO 2003), which identifies a "moderate probability of adverse health effects" at 50 µg/L chlorophyll *a* and 100,000 cyanobacterial cells/mL. The Oregon Department of Health and the California Office of Environmental Health and Hazard Assessment both use criteria of 40,000 cells/mL (of *Microcystis* or *Planktothrix*) and 8 ppb of microcystin for posting water bodies to protect public health. As such, 40,000 cells/mL (of *Microcystis* or *Planktothrix*) and 8 ppb of microcystin are protective of the beneficial use. It is unreasonable to use a target that is half the established public health criterion, and the Revised Draft TMDL needs to provide evidence to justify this choice

Response 40:

The TMDL staff report is consistent with state guidance on this issue and the TMDL target is appropriately set to a low threshold consistent with the purpose of water quality objectives.

Comment 41:

Based on Figure 2.3 in the Revised Draft TMDL, using the same probability of exceedence acceptable to the TMDL (approximately 24 percent) for a public health-protective 40,000 cells/mL, the corresponding chlorophyll *a* value is approximately 18 µg/L. Likewise, the same operation on Figure 2-4 for 8 ppb microcystin gives a corresponding chlorophyll *a* value of approximately 17 µg/L.

Given the above, 15 µg/L chlorophyll *a* (as a growing season average) would be a reasonable chlorophyll *a* target that would be protective of the beneficial use (water contact recreation).

Response 41:

See response to comment 40 above.

Comment 42:

Page 2-22 to 2-30. On these pages, the Revised Draft TMDL cites at length an analysis (in Draft form) by Kann and Corum (2009) that purports to show that increasing chlorophyll-a concentration leads to increasing likelihood of exceeding the WHO guidelines for *Microcystis aeruginosa* abundance or microcystin concentration. This Revised Draft TMDL analysis misstates the situation. The threshold analysis shows some correlation between the targets chosen, but it does not show that the targets are necessary or appropriate for protecting beneficial uses. These targets must be supported by data that demonstrates the targets are protective of beneficial uses.

The Revised Draft TMDL has selected target levels of 20,000 cells/mL for *Microcystis* and 4 µg/L for microcystin, and set the chlorophyll-a target at 10 µg/L based on a simplistic correlation to *Microcystis* and microcystin. However, this correlation shows that, at the proposed target level of 20,000 cells *Microcystis*/L, it is more likely than not (53 percent) that the microcystin concentration would be less than 4 µg/L (see Revised Draft TMDL, page 2-28), a value that

WHO has determined has a low probability of causing adverse health effects, when in drinking water, during a lifetime (75 years) of consumption. The Revised Draft TMDL's targets for *Microcystis* and microsystin are substantially lower than the current guidelines used by both Oregon and California (i.e., 40,000 cells/mL and 8 µg/L, respectively), but the Revised Draft TMDL provides no justification for choosing such low targets. Without such justification, based on data or citations to relevant reports, the selected targets are arbitrary.

Response 42:

See response to comment 40 above.

Comment 43:

The 10 µg/L chlorophyll *a* target is not achievable. Extensive research over decades (e.g., Vollenweider and Kerekes 1982) has established a clear relationship between total phosphorus and chlorophyll *a* concentration. Because of the permeable nature of the volcanic rocks prevalent throughout the upper Klamath basin, groundwater forms a major portion of the flow of upper Klamath Basin streams including the Klamath River. A total phosphorus concentration of 0.07 to 0.08 mg/L (or 70 to 80 µg/L) – the natural background concentration of groundwater entering the Klamath River – puts the Klamath reservoirs clearly in the naturally-eutrophic range. Based on empirical relationships between phosphorus and chlorophyll *a* (OECD 1982), the baseline chlorophyll *a* concentration in the reservoirs under natural conditions would likely be greater than 20 µg/L with short-term maximums exceeding 70 µg/L (Wetzel 2001). As discussed elsewhere in these comments (see comments on Page 2-66, Figures 2.16 and 2.17), the phosphorus concentration necessary to meet the 10 µg/L chlorophyll *a* target cannot be achieved.

Response 43:

The TMDL analysis has demonstrated that the chlorophyll-a target of 10 µg/L is achievable. Also refer to Response B6.

Comment 44:

Page 2-36 to 2-39. The Revised Draft TMDL discusses a hypothesized linkage between increased nutrient loading and increased incidence of fish disease. On page 2-36, the Revised Draft TMDL states "The pathways that have resulted in major documented fish mortalities in the Klamath River in the last several years are illustrated as follows: increased nutrient loading (NA1) → elevated periphyton/macrophyte growth (NB1) and elevated suspended algae and blue-green algal growth (NB2) → increased polychaete habitat (NB4) → increased polychaete population and *Ceratomyxa shasta* (*C. shasta*) population and dosing (NB9)". However, the Revised Draft TMDL presents no evidence or citations to evidence that such pathways "have resulted in major documented fish mortalities in the Klamath River." In the absence of such evidence, the hypothesized causal relationship between nutrient loads and fish disease in the Klamath River is unsubstantiated and speculative. Moreover, the Revised Draft TMDL does not describe or consider important uncertainties in the hypothesized causal connections between nutrient loads and fish disease.

Response 44:

The TMDL staff report discusses fish disease as a contributing factor to documented fish kills. The conceptual model identifies a series of hypotheses that the TMDL staff report then provides supporting information for many if not all of the identified linkages. TMDL peer reviewers were asked to specifically review and comment on the conceptual model. Peer reviewers stated that the model represents the state of the science understanding of these processes. In addition, many of the leading fish disease research scientists on the Klamath River have been closely consulted on the development of the fish disease conceptual model and in the analysis of data regarding the linkages. Science requires interpretation and Regional Board staff have ensured that this aspect of the TMDL is consistent with the best available science.

Comment 45:

Page 2-36 and 2-37. The Revised Draft TMDL includes new text describing anecdotal information obtained from personal communications with Richard Stocking. These personal communications are used to support the Revised Draft TMDL's "conceptual model" assumption that "…high levels of FPOM [fine particulate organic matter] exported from the reservoirs during the summer months….appear to be a critical factor determining distribution and abundance of M. speciosa". There is no definition of what constitutes "high" levels of fine particulate organic matter (FPOM). There is no evidence to support the Revised Draft TMDL's assumption that there is increased deposition of organic matter below the dams in the river channel below the dams or that, if there were, it increases polychaete habitat. This assumption is purely speculative. In fact, from the available data, it is clear that if the Project reservoirs have altered the distribution of organic matter in the lower Klamath River, it has reduced it. Actual empirical information on organic matter in the river is and has been available to the Regional Board that is not presented in the Revised Draft TMDL (e.g., see Deas 2008). The available empirical data show that average values for dissolved organic carbon (DOC) are significantly lower at the hatchery bridge below Iron Gate Dam compared to above J.C. Boyle reservoir ($P < 0.01$) and that total suspended solids (TSS) and volatile suspended solids (VSS) are not significantly different ($P > 0.05$)[1]. The values at the hatchery bridge tend to be slightly higher, but not significantly different than, those measured in Iron Gate reservoir. However, there are several hundred meters of prime habitat for benthic algal species – a potential source of increased organic matter and diatoms - between the tailrace of Iron Gate dam and the hatchery bridge where measurements were made. DOC measured at the hatchery bridge and Iron Gate tailrace is the same.

Response 45:

A personal communication from a leading researcher on the Klamath River is not anecdotal. PacifiCorp has offered an interpretation of Mr. Stocking's studies and Regional Water Board staff chose to speak directly with Mr. Stocking regarding his findings and observations.

Deas (2008) compares TSS, DOC, and volatile organic matter above JC Boyle Reservoir to concentrations below Iron Gate Dam, concluding that these concentrations are similar, based on a limited number of samples from a single year of data. These data are not sufficient to establish that the intervening reservoirs are not a source of organic matter load. Indeed, it would be expected that the organic matter load would decline downstream without additional inputs. The fact that concentrations do not decline would suggest that the intervening reservoirs are producing organic matter load that compensates for the losses of organic matter from upstream.

The Regional Water Board stands by the analysis provided in the TMDL staff report.

[1] Data for DOC, TSS, and VSS from Deas (2008).

Comment 46:
Page 2-38, Paragraph 1. The Revised Draft TMDL disregards some key findings from Stocking and Bartholomew (2007) on the distribution and relative abundance of polychaetes and their habitats throughout the Klamath River to the estuary. Stocking and Bartholomew (2007) found the highest densities of polychaetes in the reservoir *inflow* areas compared with the river samples. This contradicts the Revised Draft TMDL's assumption that reservoirs are contributing to higher polychaete densities. Stocking and Bartholomew (2007) indicated that it was the capacity for a habitat to buffer against disturbances that was the critical factor in determining the distribution and abundance of the polychaetes in riverine environments and did not mention nutrients as a potential factor.
Stocking and Bartholomew (2007) examined live specimens of the polychaete and found that their diet consisted of very fine detritus and diatoms. There is no evidence that FPOM increases in a downstream direction from Link River dam, and diatoms are found throughout the river. There are no data presented or cited to support the assertion that suspended algae and cyanobacteria growth in Iron Gate reservoir contribute to increased polychaete populations, particularly in the identified "hot spot" of disease infection located downstream of the Beaver Creek confluence, which is approximately 16 miles below Iron Gate dam.
Response 46:
The cited studies did not find that the polychaetes densities are higher at the reservoir inflows. The studies found that there is a lot more fine sediment habitat at these locations. Sampling by Dr. Bartholomew's team showed higher densities in river samples (personal communication Dr. Jeri Bartholomew February 2010). The report states that the polychaetes are food limited.

Comment 47:
The available data do not support the Revised Draft TMDL's assertion that large quantities of phytoplankton (specifically diatoms) grow in and are released from Iron Gate reservoir. Conversely, the data show that very few diatoms are released from the reservoir compared to the quantity that grows in the river between the dam and the sampling point at the hatchery bridge. Removal of the reservoirs would provide considerably more riverine habitat to grow extensive quantities of diatoms and increase that fraction of the food source for the polychaetes that would colonize the new habitat, thus exacerbating the potential for disease transmission.
Response 47:
Refer to responses to comments 80 -85 below.

Comment 48:
Page 2-38, Figure 2.10. It is not clear how the diagram in Figure 2.10 illustrates anything about the balance between parasite, host and environment or what relevance that has to the Project reservoirs. Elevated nutrient concentration is not a function of the Project reservoirs, but of Upper Klamath Lake and other upstream sources. Increased habitat is not a function of the Project reservoirs – if anything the Project reservoirs act to decrease polychaete habitat since the reservoirs do not provide suitable polychaete habitat. No data are presented to support the assertion that elevated phytoplankton growth in Iron Gate reservoir increases downstream polychaete populations.

Response 48:
The diagram and text cited in the comment was the subject of focused peer review question. The peer review response was that the diagram and discussion represented the state of the science regarding understanding of these issues.

Comment 49:
Page 2-39, Paragraph 1. The Revised Draft TMDL asserts that reduced peak flows are a factor in the proliferation of *C. shasta*, but it provides no data or citations to support this assertion. However, there are ample data and reports to the contrary that have been and are available to the Regional Board (e.g., see PacifiCorp's March 2004 Exhibit E Environmental Report and the 2007 FERC EIS on the Klamath Hydroelectric Project Proposed Relicensing). PacifiCorp's Project reservoirs do not change Klamath River peak flow conditions. This is because the reservoirs have minimal active storage, and elevated flows are simply passed over the spillways. Thus, the magnitude and frequency of peak flows or "scouring" flows are not affected by the Project as asserted.
Response 49:
The effect of the reservoirs, as discussed in the TMDL staff report, is more complex than change in peak flows alone. For extreme high flows the reservoirs will pass the incoming flow downstream, with only a small amount of attenuation. However, it is not just the extreme flows that determine the benthic algal response in the river reaches. Instead, it is the time interval between flows sufficient to cause scour and sloughing that is important. The extreme spring flows would cause sloughing regardless of whether the dams are present or not. However, the dams likely eliminate sporadic thunderstorm-induced scouring flows during the summer, with the result that the time between scouring flows during the growing season is likely increased.

It is not simply the magnitude of high flows that determines their ability to scour benthic algae but rather the rate of change in flows. Attenuation caused by the dams changes the rate of rise of the hydrograph, reducing the likelihood of removing algal mats.

More important than the magnitude of flows themselves, the dams are effective traps of coarse sediment. The coarse sediment concentration during high/energetic flows is an important component in their ability to remove benthic algal growths. Because the dams impede the downstream transport of coarse sediment, they effectively reduce the rate at which benthic algae are removed in the river below Iron Gate.

The project dams also cause important effects at lower flows. The natural river had flows in which the volume and wetted perimeter varied continuously. The regulated flows cause a situation in which the wetted perimeter remains much more constant. Under natural conditions, periphyton biomass would be limited to areas that remained continuously wetted, while growth in areas temporarily wetted would be mitigated by exposure and desiccation.

Comment 50:
Further, on page 2-39, the Revised Draft TMDL needs to clarify that the "hotspot" of *C. shasta* density is actually located in the reach extending from the Shasta River to the Scott River, and that the reach just below Iron Gate dam has a relatively low *C. shasta* density (see Figure A2

below). The Revised Draft TMDL states that among the "…parasite promoting factors included in the conceptual model… is that high densities of salmonids trapped in the reach below Iron Gate lead to increase[d] shedding of the myxosporean spore…" (page 2-39). However, the Revised Draft TMDL needs to discuss that a major source of myxospores is salmon spawners in Bogus Creek downstream of Iron Gate Hatchery. Bogus Creek fall Chinook escapement has averaged 9,000 fish since 2002. This constitutes about 30 percent of the total fall Chinook production for the Klamath River (Trinity River excluded). In fact, the number of fall Chinook that spawn in the mainstem Klamath River is a relatively small proportion of the total basin-wide escapement (see the FERC Final EIS on the Project relicensing).

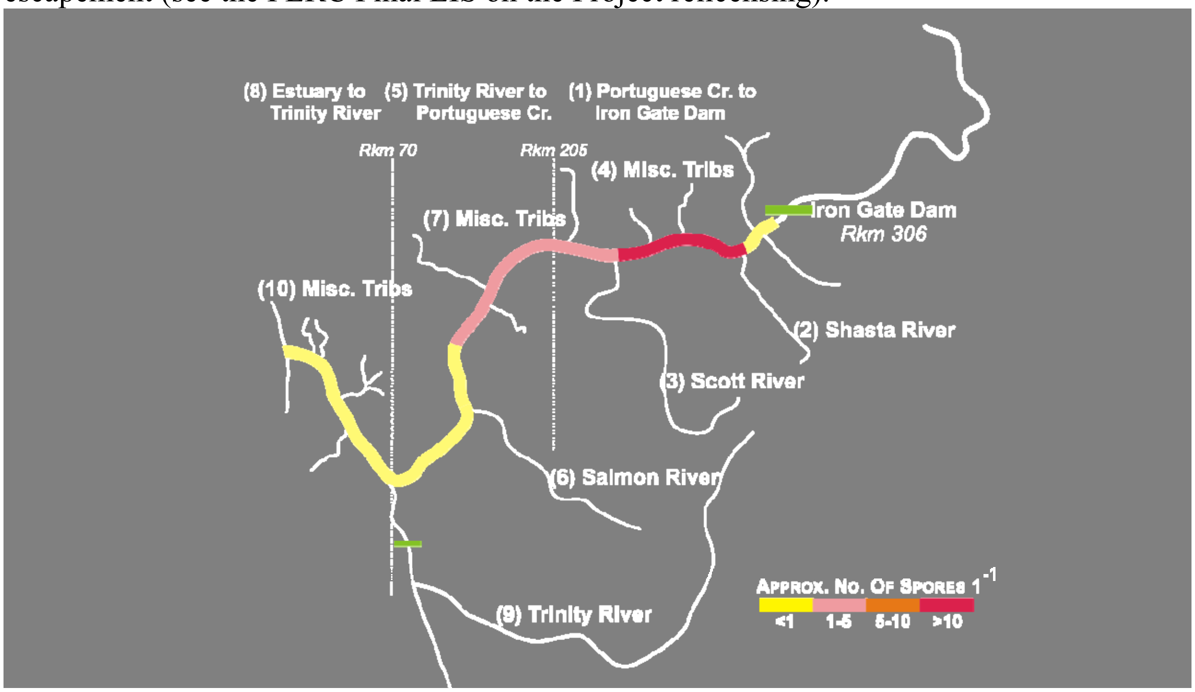


Figure A2. Density of C. shasta in the Klamath River below Iron Gate dam (Scott Foott, pers. comm.. 2008).

In addition, Stocking's (2006) data indicates that mortality due to *C. shasta* infection was both greatly reduced and delayed in rainbow trout groups exposed in the Upper Klamath River (from Link to Iron Gate dam) when compared to groups exposed in the Lower Klamath River (Iron Gate dam downstream). In general, mortality was reduced and delayed in the reservoir groups when compared to groups exposed in the free-flowing stretches of the river.

Stocking (2006) states that the presence of the four reservoirs in the upper basin likely significantly reduces the abundance and distribution of the *C. shasta* actinospore. The infectious stage (actinospore) is viable for less than 10 days under laboratory conditions. Because of their higher capacity and longer retention time relative to the free-flowing stretches, the reservoirs may serve to dilute incoming spore densities and impede passage of the fragile actinospore by means of spore sedimentation. Stocking (2006) states that, if high spore densities resulted in the high mortality documented in exposure groups held in the Lower Klamath River, then it seems likely that continuity of water flow (absence of obstructions) is an important factor in explaining the differences between the Upper Klamath River and the Lower Klamath River results.

Response 50:

Elements of this comment are currently the topic of ongoing research by Dr. Batholomew and her colleagues. Dr. Bartholomew supports the analysis presented in the TMDL staff report and further states that she believes that spores released from fish spawning in the mainstem are much more likely to be available for polychaete consumption than those released in the tributaries. The research tem is currently monitoring this situation, but they are not seeing a lot of tributary contribution (Bartholomew, personal communication, February 2010).

Comment 51:
Page 2-40 to 2-44, under 2.4.2.3 Nutrient Risk Cofactors. The Revised Draft TMDL does not discuss the variation in these nutrient risk cofactors with regard to space or time, but implies that such conditions are prevalent at all times in all places. In fact, many of the "cofactors" are not consistently applicable in the basin, and certain of these processes are not naturally amenable to implementation actions described in the Revised Draft TMDL. For example, the "reduced riparian habitat" description (page 2-40) suggests that riparian vegetation restoration serves as a panacea for restoring DO and pH, slowing down SOD and BOD processes, and cleansing pollutant runoff. However, the Revised Draft TMDL includes no discussion of where such habitat exists or where such habitat is lacking (naturally or unnaturally). The Revised Draft TMDL identifies no measures of quantifiable benefit, or the limitations that may exist for such restoration or management. The Revised Draft TMDL provides only general statements that do not support the selection and relevance of "cofactors" for the Klamath River, except in a conceptual or theoretical manner.
Response 51:
The TMDL staff report does not imply anything regarding the temporal or spatial variation of the nutrient risk co-factors on the Klamath River. The discussion provides a general background to help understand the discussion that follows. Many of the risk co-factors do apply to the Klamath River. Nothing in the comment is offered to dispute this relevant point.

Comment 52:
Page 2-41, First Bullet, Altered flow conditions. As discussed above, PacifiCorp's Project reservoirs do not change Klamath River peak flow conditions. The reservoirs have minimal active storage and elevated flows are simply passed over the spillways. Thus, the magnitude and frequency of peak flows or "scouring" flows are not affected by the Project as asserted. There are ample data and reports on this matter that have been and are available to the Regional Board (e.g., see PacifiCorp's March 2004 Exhibit E Environmental Report or the 2007 FERC EIS on the Klamath Hydroelectric Project Proposed Relicensing). In addition, PacifiCorp's March 2004 Water Resources Final Technical Report includes a detailed geomorphology analysis showing that peak flows regularly exceed flow levels capable of mobilizing and transporting gravels.
Page 2-41, First Bullet, Altered flow conditions. The Revised Draft TMDL needs to specifically define "periphyton accrual time".
Page 2-41, Paragraph 4, first bullet under "Impoundments". The Revised Draft TMDL cites analysis and results from "Asarian et al. (2009)". This citation is not included in the References (page 2-102), and has not been made available for public review. This is another example of the TMDL's use of documents still "in press" or otherwise unavailable to the public, preventing a thorough review of this TMDL by the public and affected parties. The Regional Board may not base its analysis and TMDL upon evidence outside the record and not made publicly available.
Page 2-41, Paragraph 4, under "Impoundments ($_N$C7)". The Revised Draft TMDL includes new text on the matter of net annual retention of nutrients in Copco and Iron Gate reservoirs. The Revised Draft TMDL states that the results of the publically-unavailable study by "Asarian et al.

(2009)" determined that the net annual retentions of nutrients in Copco and Iron Gate reservoirs includes "[a} reduction of 15% Total Nitrogen and 10% Total Phosphorus delivered downstream", and "[d}uring the summer critical growth months (May – September) the reservoirs had a combined retention for TP of 8% and 31% for TN." The Revised Draft TMDL states that "This level of reduction on an annual mass loading basis is not large and the net effect on downstream water quality if this loading was to occur in the absence of the dams is not significant" (page 2-42, paragraph 2, under second bullet). Retention of the inflowing load of TP at a rate of 10 percent annually equates to a reduction of about 71,000 pounds of total phosphorus, and retention of the inflowing load of total nitrogen at a rate of 15 percent annually equates to a reduction of about 453,000 pounds of TN. The Revised Draft TMDL's characterization of these reductions as "not large" and "not significant" is misleading and discounts the very reduction in nutrients levels that the TMDL seeks to achieve.

Response 52:

See responses above and in addition refer to comment responses K1 and A40 for additional information on the issues raised in this comment.

Comment 53:

In addition to downplaying reservoir retention of nutrients, the Revised Draft TMDL also does not recognize the beneficial role of the reservoirs in shifting the timing of inflowing nutrient "peaks" from upstream sources, notably Upper Klamath Lake. (Duplicate text omitted to save space.)

Response 53:

This previously submitted comment has been addressed in K1 and A40.

Comment 54:

Page 2-42, Paragraph 2, under first bullet. The Revised Draft TMDL should define what is meant by "event-driven pulses", and what upstream conditions cause or create them. The Revised Draft TMDL states "Without the dams, much of the nutrient load would move in event-driven pulses and a good portion of such load would flush through the system without elevating concentrations long enough to allow full periphyton response". This statement is incorrect and misleading. First, pulses of nutrients in the Klamath River originating from Upper Klamath Lake and other upstream sources are on the order of weeks, not hours or days, so there is ample time for periphyton "response". Second, benthic algae (periphyton) have a natural capability to respond to available nutrient. They are highly effective at carbon, nitrogen, and phosphorus uptake across a wide range of nutrient concentrations. Benthic algae can dramatically deplete carbon dioxide, the principal carbon source in the water column, on an hourly basis (Horne and Goldman, 1994). Third, the statement in the TMDL that the reservoirs "spread out" peak nutrient events is not supported by the model results presented in Figure A3. The overall duration of all the peaks is nearly identical, the only difference is in the magnitude. In sum, to state that nutrients can "flush" through the system is counter to basic understanding of algal uptake and storage dynamics, neglects the naturally-enriched background levels of nutrients, ignores the actual duration of nutrient pulses in this system, and misrepresents the effect of the reservoirs on the duration of nutrient pulses.

Response 54:

The text in this section (2.4.3) has been revised to more clearly convey the issues identified by Regional Water Board staff.

Comment 55:
Page 2-42, Paragraph 2, under second bullet. The Revised Draft TMDL includes new text on the effect of nutrient retention on downstream river reaches. The Revised Draft TMDL states, "River reaches downstream of the dams (below the I-5 bridge to Seiad Valley) are saturated with nutrients with or without the reservoir nutrient retention". There is no basis or reference provided for this statement. Available field data (USFWS, PacifiCorp) show that nitrate concentrations steadily decrease in the downstream direction (with increasing distance from Iron Gate dam) to levels that suggest potential nutrient limitation in the lower river. Regional Board staff has selected total nitrogen (TN) and total phosphorus (TP) as metrics throughout the Revised Draft TMDL. However, what is critical in identifying any level of nutrient for benthic algae requirements are the bioavailable forms (i.e., the inorganic forms), such as ammonia, nitrate, and orthophosphate. To state that the system is saturated based on TN and TP is invalid, particularly when field data suggest otherwise.
Response 55:
The concentrations of inorganic nutrients downstream of Iron Gate (Figures K-3, K-4 and K-5, page K-2) are at least 10 times greater than the half-saturation concentration controlling periphyton growth (Table 3-5, page 47) (Tetra Tech, December 2009). Therefore, slight changes in nutrients are not expected to have a significant impact on periphyton growth.

There are limiting nutrient graphs included in the model development report (Appendix 6). There are locations along the river where the model indicates that neither N nor P is limiting periphyton growth.

The text in this section has been revised to more clearly convey the issues identified by Regional Water Board staff.

Comment 56:
Additional data on benthic algae densities (i.e., standing crop) and available substrate would be required to identify if algae had completely occupied the bed to the extent that no additional growth could be accommodated (i.e., no additional nutrient uptake). With continuous grazing, algae senescence, and sloughing/erosion, it is difficult for benthic algae to attain bed densities that would preclude additional growth and associated nutrient uptake.
Response 56:
The Regional Water Board staff agrees that periphyton densities and growth dynamics is an area of uncertainty requiring additional research. However, the comment offers no basis for its assertion. There is no doubt at present densities the algal biomass is having a negative impact on water chemistry (pH, and DO) in the Klamath River

Comment 57:
Page 2-42. The Revised Draft TMDL is self contradictory when it attempts to argue that a slight increase in nutrients over a longer time (PacifiCorp's comment above points out that the reservoirs do not in fact increase the duration of upstream nutrient pulses passing through the reservoirs) resulting from the time shift of upstream nutrient pulses is an impairment (bullet 1) while at the same time claiming that the significant retention of nutrients within the reservoirs is of no benefit (bullet 2). If, as stated in bullet 2, the Klamath River is saturated in nutrients, so

that the significant retention of nutrients by the reservoir has no effect, then a slight increase in nutrients resulting from a pulse from upstream would also have no effect. Conversely, if a slight increase in nutrients from upstream would have a noticeable detrimental effect on the lower river, as argued in bullet 1, then the significant reduction as a result of retention in the reservoirs should also have a noticeable beneficial effect. Saying that any effect the reservoirs have on nutrient abundance, either to increase or decrease, has a negative effect is biased.

Response 57:

The text in this section has been revised to more clearly convey the issues identified by Regional Water Board staff.

Comment 58:

Page 2-42, Paragraph 2, under second bullet. The Revised Draft TMDL states that "dams can contribute to conditions that would tend to promote increased periphyton densities in the downstream reaches such as reduced scouring flows and warmer waters". As discussed above, PacifiCorp's Project reservoirs do not change Klamath River peak flow conditions. The reservoirs have minimal active storage, and elevated flows are simply passed over the spillways. Thus, the magnitude and frequency of peak flows or "scouring" flows are not affected by the Project as asserted. There are ample data and reports on this matter that have been and are available to the Regional Board (e.g., see PacifiCorp's March 2004 Exhibit E Environmental Report, PacifiCorp's March 2004 Water Resources Final Technical Report, the 2007 FERC EIS on the Klamath Hydroelectric Project Proposed Relicensing). Peak flows regularly exceed flow levels capable of mobilizing and transporting gravels.

Page 2-42, Paragraph 2, under second bullet. The Revised Draft TMDL states, "This level of reduction on an annual mass loading basis is not large and the net effect on downstream water quality if this loading was to occur in the absence of the dams is not significant." This statement misleads the reader by stating that the annual loading is not appreciably reduced, but the seasonal load – during the growth season - is the important element. Annual loading reductions provided by the Project reservoirs are significant. More importantly, the reduction in seasonal load during the growth season is highly significant and important. A seasonal (May-September) reduction of 31 percent in total nitrogen in a system that is nitrogen-limited is considerable. To divert the reader to the annual number, and to term this seasonal reduction insignificant without specific analysis or supporting information is misleading. Additionally, during the late spring through fall water quality conditions vary considerably due to dynamics at Upper Klamath Lake. These variable conditions result in weeks-long deviations where water quality is considerably degraded. The reservoirs tend to dramatically reduce these "peak" periods. As evidenced by the Revised Draft TMDL numbers: if the May to September reduction is 31 percent, the short term peak loads moving through the reservoir are notably higher. These increases are supported by model simulations using the TMDL models supplied by the Regional Board.

Page 2-42, Paragraph 2, under third bullet. What are the green algae species that the Revised Draft TMDL is referring to under this bullet? What are the species, time of year, densities, duration of bloom, locations, and methods that the Revised Draft TMDL is assuming to define and quantify a "nuisance bloom"?

Page 2-42 to 2-43, under fourth bullet. Under this bullet, the Revised Draft TMDL restates text presented at pages 2-36 to 2-39 on the Regional Board's "hypothesis" or "conceptual model" that "…high levels of FPOM exported from the reservoirs during the summer months….appear to be a critical factor determining distribution and abundance of *M. speciosa*". As discussed in comments above on pages 2-36 to 2-39, there is no empirical evidence to support the Revised Draft TMDL's "hypothesis" or "conceptual model". In fact, from the available data, it is clear that if the Project reservoirs have altered the distribution of organic matter in the lower Klamath River, they have reduced it. As discussed in comments above on pages 2-36 to 2-39, actual empirical information on organic matter in the river is and has been available for the Regional Board that is not presented in the Revised Draft TMDL. In addition, the very studies that the Revised Draft TMDL references to support its conceptual model do not consider nutrients to be a factor related to the distribution and abundance of *M. speciosa* in the Klamath River (Stocking and Bartholomew 2007).

Further, under this bullet, the Revised Draft TMDL indicates that "dams acting as barriers may also be contributing to the high levels of infection" under the assumption that without the dams (i.e., in "a free flowing river system") "salmon would be widely dispersed". To support this assumption, the Revised Draft TMDL states that "below Iron Gate Dam, dense spawning redds…and salmon carcasses can be found on top of, or very near, dense populations of the polychaete host". Again, the Revised Draft TMDL provides absolutely no empirical evidence to support this claim. In addition, the data that is available on spawning escapement and redds in the river below Iron Gate dam is not presented or discussed in the Revised Draft TMDL. The available spawning data shows that the situation is different from that suggested in the Revised Draft TMDL. For example, available spawning data show that the maximum number of spawning Chinook salmon in the mainstem Klamath River between Iron Gate dam and the mouth of the Shasta River is on the order 5,000 fish, with average numbers around 3,000 fish. However, in Bogus Creek next to the Iron Gate Hatchery, the number of spawning Chinook salmon is about 9,000 on average, with a maximum of 42,000 fish (FERC 2007). This data shows that dense spawning redds below Iron Gate dam are not a barrier issue, but an issue with management of hatchery-returning fish. Moreover, even if dams were a barrier, the establishment of fish passage above Iron Gate Dam, as would be required by a new FERC license for the Project, would eliminate the barrier.

Also, the Revised Draft TMDL does not point out that the Iron Gate Hatchery produces fish that are uninfected until they are released to the Klamath River. The Iron Gate Hatchery obtains its water from Iron Gate reservoir, indicating the source waters from the reservoirs are either clear of actinospores or counts are sufficiently low that the hatchery has no infection rate. This shows the benefits of the reservoir, particularly given that the disease otherwise occurs in the Klamath River basin upstream of Copco reservoir. In fact, Stocking and Bartholomew(2007) found the densities of polychaetes to be higher at the reservoir inflow areas compared to the river samples.

Response 58:

See responses to comments 44 – 57 above.

Comment 59:

Page 2-44, Paragraph 1, Lines 1-3: The Revised Draft TMDL asserts that the reservoirs increase organic matter loading and describes this as a nutrient "risk cofactor." The increased organic load to the Klamath River comes from upstream sources, notably Upper Klamath Lake in Oregon, not the Project reservoirs. The Revised Draft TMDL asserts that compliance with the Oregon TMDLs will result in compliant conditions at Stateline. The Revised Draft TMDL must explain how increased organic matter loading, or the failure to achieve reductions in Oregon, is a risk factor in achieving compliant conditions at Stateline.

Response 59:
The text in this section has been revised to more accurately reflect the contribution of the reservoirs to describe the seasonal increase of algal biovolume that has its source within the reservoirs.

Comment 60:
Page 2-47, Paragraph 4, Lines 7-8. The Revised Draft TMDL states "In the Klamath River, these effects [delays in seasonal temperature changes] may extend downstream to the Pacific Ocean under certain conditions (Bartholow et al. 2005)". This statement is so general and caveated as to be essentially meaningless.
Response 60:
The statement is not "meaningless". It is a true statement, albeit general, meant to define the downstream extent of the reservoirs' influence on Klamath River temperatures. The fact that the temperature influences persist so far downstream is an important consideration.

Comment 61:
Pages 2-48 and 2-49, bullets under Temperature Risk Cofactors. All of these bullets are general statements that can be found in any limnology book. Linkage to the Klamath River is necessary. For example, Bullet 1, Line 3: The Revised Draft TMDL states, "In waterbodies that have high concentrations of ionized ammonia and frequent excursions of high pH such as the Klamath River…." There is no evidence, data, or locally relevant citations presented to support the statement that the Klamath River has high concentrations of ionized ammonia, or to support a conclusion that NH_4^+ is a problem in the Klamath River. This assertion must be supported by locally relevant data or citation. Also, to properly assess the temperature co-factors as listed, the TMDL model must be a robust tool. However, as discussed with regard to our comments in Appendix 7, the river models used in the Revised Draft TMDL have included a factor that reduces solar radiation assumed in the model by 20 percent, leading to erroneously low predicted water temperatures.
Response 61:
The text describing the risk of ammonia toxicity has been edited for clarity. The conceptual model really is conceptual, and presents hypotheses regarding the way the Klamath River system works. We believe they are solid hypotheses in line with current science, as evidenced by their discussion in limnology text books. Please refer to the response to comment A10 regarding the solar radiation calibration. Note also that this comment was not previously submitted and does not appear to address issues relating to the revisions in the December Draft.

Comment 62:
Page 2-49 to 2-51. The Revised Draft TMDL discusses temperature effects asserted to be due to the Project reservoirs, and concludes, "[i]n summary, the temperature alterations…result in adverse effects to salmonids" (page 2-51). However, the Revised Draft TMDL discussion of the effects of reservoir "thermal lag" on migrating anadromous salmonids is speculative, incorrect, and lacks balance. In fact, as discussed in PacifiCorp's comment package on the original Draft TMDL, the Revised Draft TMDL's temperature allocations and targets continue to be based on "ideal" or near-ideal temperatures for salmonids in the generally colder waters of the Pacific Northwest, not the "thermal load which cannot be exceeded in order to assure protection and

propagation of a balanced, indigenous population of shellfish, fish and wildlife [BIP]" in the Klamath River per 40 C.F.R. § 130.7(c)(2).

Response 62:

The Klamath TMDL water temperature allocations and targets are consistent with water quality standards, which are set to protect all beneficial uses of water. The protection of all beneficial uses ensures a balanced indigenous population of aquatic life. The Klamath TMDL temperature allocations and targets are based on natural temperature conditions, not temperatures that are ideal for salmonids. The comment mischaracterizes the Administrative Law Judge's findings. See also response to previously submitted comment K39.

Comment 63:

The Revised Draft TMDL erroneously implies that the cooler temperature releases at Iron Gate dam during late winter (as compared to modeled "natural" temperature conditions) "may reduce the growth rates of salmonids rearing in the Klamath River, and may ultimately reduce the survival rate of salmonids in the ocean" (page 2-60). The Revised Draft TMDL provides no substantive evidence for this assertion, but only assumes that the cooler temperature releases at Iron Gate dam during late winter are adverse because "the optimal temperature range for juvenile salmonids is 10-15°C, with a lower limit of 4°C" (page 2-60). However, both current and "natural" temperature conditions are below the optimal range for juvenile salmonids during the winter, and modeled Without-Project temperature conditions are below 4°C (and therefore below the optimal range) more frequently than current conditions during the winter.

Response 63:

Please see response to comment AA52 and K44

Comment 64:

Page 2-54, Paragraph 2, Lines 2-3: The Revised Draft TMDL states, "Some of the key sources [of nutrient loads] include…internal nutrient cycling from nutrient enriched sediments…." It should be made clear that this relates specifically to Upper Klamath Lake, not the Project reservoirs.

Response 64:

Comment noted, and text clarified.

Comment 65:

Page 2-54, Last Paragraph. Page 2-54. The Revised Draft TMDL uses EPA (2003) Pacific Northwest guideline criteria to evaluate chronic temperature effects on Klamath River salmonids without considering site specific conditions in the Klamath River. In Appendix 5 of the Revised Draft TMDL, the applicable species are identified as occupying the mainstem Klamath River during every month of the year. However, available temperature data show that conditions in the middle and lower Klamath River in the vicinity of Happy Camp downstream to the Trinity River – a reach that is influenced little, if any, by upstream reservoirs – chronically exceed these temperature guidelines. For example, daily maximum and minimum water temperatures in the vicinity of Happy Camp can be up to 30°C and 25°C, respectively, for over a week at a time in late July and early August. The maximum weekly mean temperature (MWMT) exceeds the guideline temperature by over 10°C for juvenile rearing, and exceeds the guideline temperature for lethal effects by several degrees C in portions of the river below Seiad Valley. During summer periods, the flows are much lower, leaving the river in a large bedrock or alluvial channel that has appreciable exposure. Topographic shading has a modest effect when solar altitude is at an annual maximum (Deas et al. 2006). In summary, the river is naturally warm, and the EPA (2003) guideline criteria for the colder waters of the Pacific Northwest are inconsistent with local conditions (see also Bartholow 2005). The Revised Draft TMDL discussion also neglects to mention climate change, which will also present considerable challenges to meeting the Revised Draft TMDL's temperature targets in the Klamath River. Climate change is expected to result in 2°C to 6°C warmer water temperatures (above current conditions) under a range of climate change conditions (Barr et al. 2009).

Response 65:

Regional Water Board staff agrees that the Klamath River is naturally warm during the summer months. However, the fact that the river is warm does not change the biological temperature requirements of salmonids, nor does it mean that the biological requirements of Klamath River fish are different from those that live in the greater Pacific Northwest. While climate change is mentioned in the text, there is no explicit mechanism to alter the TMDL targets in response to climate change. However, the Klamath TMDL is a living document that can be revised as new information and understanding warrants. The science of climate change is rapidly developing, and Regional Water Board staff expect an evaluation of anticipated climate change effects on the Klamath River to be completed as part of the Secretarial Determination process. The TMDL targets can be revised in the future, if information warrants it.

Comment 66:

Page 2-55, Second to last paragraph. The Revised Draft TMDL states, regarding a longitudinal temperature distribution in the Klamath River from Stateline to the estuary, that "these data clearly demonstrate that the river has no capacity to assimilate increased heat loads during the hottest critical periods without adversely affecting the beneficial uses COLD, SPWN, RARE, and MIGR." The Revised Draft TMDL provides no assessment of whether or not these temperatures under pre-development conditions would meet the criteria presented in Tables 2.8 and 2.9, nor under a pre-development condition with warmer temperatures caused by climate change.

Response 66:

The commenter is correct. These comparisons were not made. However, these comparisons are not necessary. The comment reflects a misunderstanding of the water quality objective for temperature. Nonetheless, the statement that "the river has no capacity to assimilate increased heat loads during the hottest critical periods without adversely affecting the beneficial uses" is true.

Comment 67:

Page 2-55, Last paragraph (and on to page 2-56). This paragraph is misleading. NRC (2004) does not state explicitly that the thermal changes caused by the dams are adverse to coho salmon, rather that the mainstem Klamath River resides in an environment that is not going to provide thermal conditions for coho salmon rearing in the warm parts of the year. NRC (2004) does state that reduced diurnal variation can be adverse to coho, but it does not state that the dams create thermal conditions that are adverse to coho rearing. This is misleading and mischaracterizes NRC (2004).

Response 67:
The text has been clarified. However, the NRC report clearly discusses the adverse impacts that reduced diurnal variation has on coho salmon, and the reduced diurnal variation caused by the impoundments is clearly shown in Figure 2.12.

Comment 68:
Page 2-59, Table 2.10. The Revised Draft TMDL's modeling results presented in Table 2.10 (for both the existing conditions and natural conditions based on Year 2000) are not reliable and should not be used because they include a 20 percent reduction in solar radiation. This reduction has a direct, negative bias (i.e., it produces lower water temperatures) of over 1°C during the warmer parts of the year. In the runs completed by PacifiCorp and subsequently used by Dunsmoor and Huntington (2006), the solar radiation is not reduced, so the comparison of results in Table 2.10 is not valid.
Response 68:
Please refer to the response to comment A10 regarding the solar radiation calibration. The fact that two alternate formulations of the Klamath water quality model produce remarkably consistent temperature results speaks to the lack of uncertainty that exists regarding temperature impacts of the reservoirs.

Comment 69:
Page 2-61. Second to last paragraph. The Revised Draft TMDL states, "These data clearly demonstrate that these tributaries have no capacity to assimilate increased heat loads during the hottest critical periods without adversely affecting beneficial uses." It is overly-simplistic for the Revised Draft TMDL to dismiss the entire tributary based on temperatures at the mouth. This statement lacks important context in that there are fish that rear in thermal refugia at the mouths of tributaries when conditions are appropriate. In addition, many of these tributaries have considerable rearing habitat in upstream reaches. There may be some lower reaches of these tributaries that are: (1) naturally warm due to the geologic and alluvial processes present; (2) have been affected by anthropogenic activities; or (3) been affected by other conditions (e.g., wildfire).
Response 69:
The point of the discussion in the cited paragraph is that the tributaries are quite warm in the summer months in relation to the biological needs of salmonids, so temperature increases are not allowable, given the water quality objective for temperature. Note also that this comment was not previously submitted and does not appear to address issues relating to the revisions in the December Draft.

Comment 70:
The Revised Draft TMDL should state that much of this vegetation has recovered, and water temperatures have dropped in response to vegetation recovery. Flood impacts on natural streams occur and recovery can be rapid. This is a natural process in many systems. An assessment of current conditions is required to ascertain current conditions, and the Revised Draft TMDL should account for the frequency of floods, fires, disease, and other factors that can periodically affect conditions along a tributary or tributaries.

Response 70:
See response to comment C83.

Comment 71:
Page 2-62. Section 2.5.2.3 Reservoirs. The Revised Draft TMDL states, "The available Iron Gate and Copco Reservoir temperature and DO profile data indicate that during summer stratified conditions, temperatures are only suitable for cold water species, including salmonids, rearing at depths where the DO concentrations are near lethal levels." This is contrary to the testimony of USFWS and NMFS agency experts, and the findings of fact of the administrative law judge which concluded that anadromous fish stocks possess the biological and behavior traits needed to successfully spawn, rear and migrate in the Project reaches upstream of Iron Gate dam (assuming passage facilities at the dams).
Response 71:
This comment was not previously submitted and does not appear to address issues relating to the revisions in the December Draft. However, the nature of the comments requires a response. The ALJ makes two findings that specifically refer to water temperatures and migration and two general findings about migration past Iron Gate dam:

- Although water temperatures in the summer above IGD are an issue, they will not preclude coho salmon from utilizing the habitat within the Project area (ALJ, 7-12, p.36);
- Summer water temperatures are likely to block the migration of adult spring-run Chinook salmon before they reach suitable holding or natal areas (ALJ, p.19, 2A-39);
- If access was provided, anadromous fish would migrate past Iron Gate Dam (ALJ, p. 14, 2A-12);
- Coho salmon below IGD would migrate above the dam if access was provided through fishways (ALJ, 7-15, P.36).

The ALJ makes no findings that water temperatures above Iron Gate dam are suitable for salmonids, and on the contrary states that summer water temperatures in the summer are an issue for both spring-run chinook and coho. The statement that fish will migrate above the dam if access is provided is not equivalent to a statement that water temperatures above the dam are suitable and fully protective of salmonid migration, spawning and rearing.

Comment 72:
It is apparent from examining the modeling used in the Revised Draft TMDL that the "natural conditions" scenario has been developed to support the water quality targets that are asserted to be protective of the designated beneficial uses, regardless of their attainability and regardless of what actual pre-disturbance natural conditions really were.
Response 72:
The comment offers a misinterpretation of the TMDL development strategy which is clearly provided in the TMDL staff report and was closely adhered to during TMDL development. Therefore the conclusions offered in the comment are erroneous.

Comment 73:

- Much of the discussion in Chapter 2 is based on the Revised Draft TMDL's "conceptual model", wherein many processes have little or no supporting data. Where is the analysis of what natural conditions would be like?

Response 73:
TMDL peer review responses supported the TMDL conceptual model as reflecting the best available science. In addition, many of the conceptual model indicators and endpoints were evaluated as part of the impairment assessment in Chapter 2. The comment is incorrect.

Comment 74:
The California NNE relied upon in the Revised Draft TMDL was developed at a state wide level and does not consider the site specific, unique attributes of the Klamath River basin that are pertinent to an appropriate analysis of this issue. For example, the Klamath River: (1) is one of only two rivers which cross the Cascades Range in California and Oregon, and thereby is subject to very different climates and other conditions as it flows from its source to the ocean; (2) the river has naturally-eutrophic and currently-hypereutrophic Upper Klamath Lake as its source; and (3) the extensive marsh and wetland systems in the upper basin and around Upper Klamath Lake also cause much higher background levels of dissolved organic matter than occurs in other systems.

Response 74:
Regional Water Board staff supplemented the lines of evidence presented in the NNE framework with site-specific analysis. The final TMDL targets are appropriate to the Klamath system; this conclusion was supported through the TMDL peer review process

Comment 75:
Page 2-66, Figures 2.16 and 2.17. The natural conditions background values for total phosphorus and total nitrogen (approximately 0.025 - 0.03 mg/L for total P, and 0.25 mg/L for total N) assumed in these figures are unrealistically low (somewhere between oligotrophy and mesotrophy). These assumed values in no way correspond to the documented historical evidence of the Klamath system, which has been nutrient enriched throughout recorded history. Examples of historic information from Upper Klamath Lake include (citations omitted):

Response 75:
Several previous responses have addressed the question of natural conditions background. Please refer to in order of relevance to this comment A25, B1, A4, A6, A30, C2, and C49. Regional Water Board staff evaluated the paleolimnological work in Snyder (1997), and Eilers (2004) which provides more relevant insight into historical background conditions.

Comment 76:
The NRC (2004) determined that the natural baseline phosphorus concentration in water flowing to Upper Klamath Lake was approximately 0.06 mg/L. Several years of data collected at the bottom of the bypass reach above the J. C. Boyle powerhouse and available on PacifiCorp's website[2] show that the natural total phosphorus concentration of baseline groundwater flow from springs to be 0.07 – 0.08 mg/L. The TMDL presents no evidence to demonstrate how this

[2] See Water Quality Reports & Data available at http://www.pacificorp.com/es/hydro/hl/kr.html.

natural background concentration in the Klamath River at approximately River Mile (RM) 221 could be reduced to 0.025 mg/L (a factor of more than three-fold) by RM 209 in a pre-disturbance "natural conditions" scenario. A simple mass balance suggests that to attain such a concentration at Stateline, that total phosphorus concentrations above the large springs complex below J.C. Boyle dam would have to be on the order of 0.01 mg/L or less - approximately an order of magnitude less than natural groundwater contributions that dominate the Upper Basin hydrology. Given:

- the description of Upper Klamath Lake as naturally eutrophic (e.g., NAS, 2004; Eilers et al, 2004; Walker, 2001),
- that background levels of phosphorus for springs in the upper basin (Boyd et al, 2001) are similar to those springs below the J.C. Boyle,
- that groundwater dominates inflow the Upper Klamath Lake (Gannett, 2007), thus providing considerable phosphorus loading, and
- that surrogates, such as Big Springs Creek in the Shasta River basin, indicate that naturally nutrient rich springs produce extensive aquatic growth which can deplete inorganic forms to low levels, but in turn contribute to total forms (Jeffres et al, 2009). In the case of the Shasta River, total phosphorus concentrations are five to eight times greater than the Klamath River mainstem target value (total P of 0.025 mg/L) identified in the draft TMDL - below the Big Springs Creek confluence, and above all major diversions.

In sum, the draft TMDL identifies natural background phosphorus levels that are clearly in conflict with 1) previous literature, 2) existing conditions in the basin (background spring phosphorus concentrations and groundwater dominated upper basin hydrology), and 3) surrogate basins, such as the Shasta River, where the implications of nutrient rich groundwater are clearly documented. Because the target phosphorus concentrations in the Revised Draft TMDL are lower than established natural background levels in the Klamath River basin the Revised Draft TMDL is not achievable.

The natural conditions background values for total phosphorus and total nitrogen shown on the graphs also display unrealistically small variability. A comparison of Figures 2.16 and 2.17 between the original Draft TMDL and the Revised Draft TMDL shows these nutrient concentration assumptions to be even further detached from physical and historical reality. The previous versions of these figures showed greater variability and recognized that water quality in the Klamath River improves as the river flows downstream. This improvement in water quality results from accretions from tributaries in the lower basin that are less impacted by nutrients. An examination of these figures shows that the Revised Draft TMDL assumes that, under "natural conditions", the nutrient concentrations at Stateline imposed from Upper Klamath Lake were identical to concentrations found throughout the river on down to the estuary. This assumption is contrary to physical reality and ignores the naturally higher nutrient concentrations that are present in the upper basin as a result of the volcanic geology of that area. These values in no way correspond to the conditions in the Klamath River caused by its naturally-eutrophic and currently-hypereutrophic source water from Upper Klamath Lake, which as recognized in the Revised Draft TMDL earlier on page 2-42, can produce "event driven spikes" of nutrient loading as a result of algal bloom dynamics that impart significant water quality variability.

Response 76:

Dissolved inorganic phosphorus is not a conservative constituent but can be removed from the water column by periphyton and phosphorus bound to solids can settle. Therefore, comparison between the concentrations of springs and the concentration of the river to determine a 'realistic' concentration is not appropriate.

The model accounts for all of the boundary inputs, source inputs, and instream processes affecting the fate and transport of phosphorus in the river. The annual average upstream boundary input at the UKL outlet is 0.022 mg/l under the natural condition baseline (the commenter cites a different value from the UKL TMDL (0.041 mg/l) that is not applicable to this analysis). Using the correct upstream boundary condition, the predicted downstream TP concentrations in the TMDL scenario (0.030-0.039 mg/l) are higher, not lower, than the assumed phosphorus concentration at the upstream UKL boundary (0.022 mg/l). Therefore, the statement that "the Draft TMDL requires TP concentrations at Stateline (and at other downstream locations by extension) that are lower than upstream concentrations from Upper Klamath Lake under future compliant TMDL conditions and naturally-occurring groundwater base flows" is incorrect.

Comment 77:
As discussed in detail in PacifiCorp's August 2009 comments on the original Draft TMDL, the Revised Draft TMDL's chlorophyll *a* analysis and recommended target of 10 µg/L for the reservoirs is inappropriate, particularly in light of the naturally eutrophic nature of the upper Klamath River system, and the unrealistically large nutrient reductions that would be required for the target to be achieved. (Text omitted.)
Response 77:
See responses to comments B10, B12, B13, B14, and B15. Additionally, see responses to comments 80 through 85 below.

Comment 78:
Page 2-71, Paragraph 1, Line 4. The Revised Draft TMDL states that similarity between the median and the mean indicates a normal distribution. This is incorrect. Close similarity between the median and the mean indicates only that the distribution is nearly symmetrical. Any symmetrical distribution (including a normal distribution, uniform distribution, bimodal distribution, etc.) would have similar median and mean values.
Response 78:
Comment noted.

Comment 79:
.Page 2-72, Paragraph 1, Lines 1-2. The Revised Draft TMDL states that "Figures 2.22 and 2.23 demonstrates the effect of quiescent waters…". However, Figures 2.22 and 2.23 do not show the effect of quiescent waters, but rather show the effect of the inappropriate comparison of the reservoir chlorophyll *a* target applied to the river. Attributing the algal blooms to quiescent waters in the reservoirs because the chlorophyll *a* numbers are lower in the river upstream is based on the inappropriate and misleading application of the unachievable reservoir target to the flowing river. The chlorophyll *a* target of 10 µg/L as drawn on Figures 2.22 and 2.23 is not applicable or relevant to the river reaches. The tendency for the Revised Draft TMDL to examine river data in light of this target for the reservoirs recurs elsewhere in the document (e.g., see page 4-35), and indicates a fundamental misunderstanding of the applicability of the target.

This is an inappropriate comparison, just as it is inappropriate to apply the river-related benthic chlorophyll *a* target of 150 mg/m^2 to the reservoirs.

Response 79:

Regional Water Board staff have proposed targets appropriate for the impounded sections of the Klamath River (chlorophyll *a* target of 10 µg/L) and another set of targets for the free-flowing sections of the Klamath River (benthic chlorophyll *a* target of 150 mg/m^2). The comparison referred to in the comment demonstrates that it is the impoundment behind the dams that creates the environmental conditions that promote nuisance algal (phytoplankton) blooms.

Comments 80 - 85:

80: Page 2-72, Paragraph 3, Lines 2-6. The Revised Draft TMDL states, "Elevated levels of fine organic material including suspended algae in the Iron Gate Reservoir outlet waters are then available as a food source for polychaetes in the river", and "fine particulate organic matter discharged from the outlet of Iron Gate reservoir is deposited in the river bottom sediments below the reservoir". As previously discussed in these comments, the Revised Draft TMDL presents no data and cites no report to support the assertion that elevated levels of fine particulate organic matter occur in the river below Iron Gate dam as compared to the river above Copco reservoir. These statements are assertions with no supporting data. In fact, the available empirical data (Deas 2008) indicates that organic matter concentrations are usually significantly less below Iron Gate dam as compared to above Copco reservoir. Also, as discussed earlier in these comments, the Revised Draft TMDL misinterprets cited study results and does not acknowledge that the "hot spot" of infection is not directly below Iron Gate dam, but in the Beaver Creek area downstream of the Shasta River (Bartholomew et al. 2007). .

81: Page 2-73, Paragraph 1, Lines 8-10. The Revised Draft TMDL claims that Iron Gate reservoir is "the source of blue-green algae that continues to grow in backwater and slower sections within the river reaches below the dams", and that "[t]he Iron Gate/Copco Reservoir complex greatly increases the quantity of algal biomass supplied to the river below Iron Gate Dam; this export is considered to be an innoculant which would contribute to downstream blooms". Even in the absence of Project reservoirs, however, cyanobacteria would be abundant in the Klamath River, because the system is nutrient-enriched and cyanobacteria are abundant in Upper Klamath Lake, which is the source of the Klamath River. Moreover, cyanobacteria are ubiquitous in the environment and will grow wherever suitable conditions exist. Removing the Project reservoirs will not preclude the growth of cyanobacteria in the Klamath River. Indeed, cyanobacteria have also been documented in area rivers such as the Eel and Van Duzen rivers. Thus, the absence of Iron Gate and Copco reservoirs is not likely to eliminate cyanobacteria in the Klamath River. .

82: Page 2-73, Paragraph 1, Lines 8-10. The Revised Draft TMDL's statement that "the Iron Gate/Copco Reservoir complex greatly increases the quantity of algal biomass supplied to the river below Iron Gate Dam" is not supported by the data. In using Figures 13 and 15 from Raymond (2009), the Revised Draft TMDL misrepresents the facts. The Revised Draft TMDL uses figures that show only *Microcystis* as though that were the total algal biomass, when in fact *Microcystis* is merely a fraction of the total algal biomass. When the correct data from 2009 are used, it is clear that there is no significant difference in biomass measured at any site below Link River dam. Analysis of variance of biovolume vs. site followed by Tukey's HSD test for all pairwise comparisons shows that algal biovolume at the mouth of Link River is significantly higher than the other sites ($P < 0.05$) and that all other sites form a homogenous group not significantly different from one another. Additional analysis shows there is no significant increase in algal biovolume below Iron Gate dam compared to above Copco reservoir. A two-sided Dunnett's multiple comparison with site KR20642 (Klamath River near Shovel Creek) as a control showed no significant difference from any site, except KR25312 (the mouth of Link River). Similar results are obtained when the analysis is done considering algal abundance (count data). It is clear from this analysis that algal abundance is not increased below Iron Gate dam as a result of the reservoirs. The results are similar when considering data from all years. As shown in Figure A5 below, algal biomass in the tailrace of Iron Gate dam (site KR19000) is dramatically lower than at a site above J.C. Boyle reservoir (site KR22822). Algal biomass only begins to increase below the Iron Gate Hatchery bridge (site KR18973), a likely consequence of abundant benthic algal growth between Iron Gate dam and the hatchery bridge.

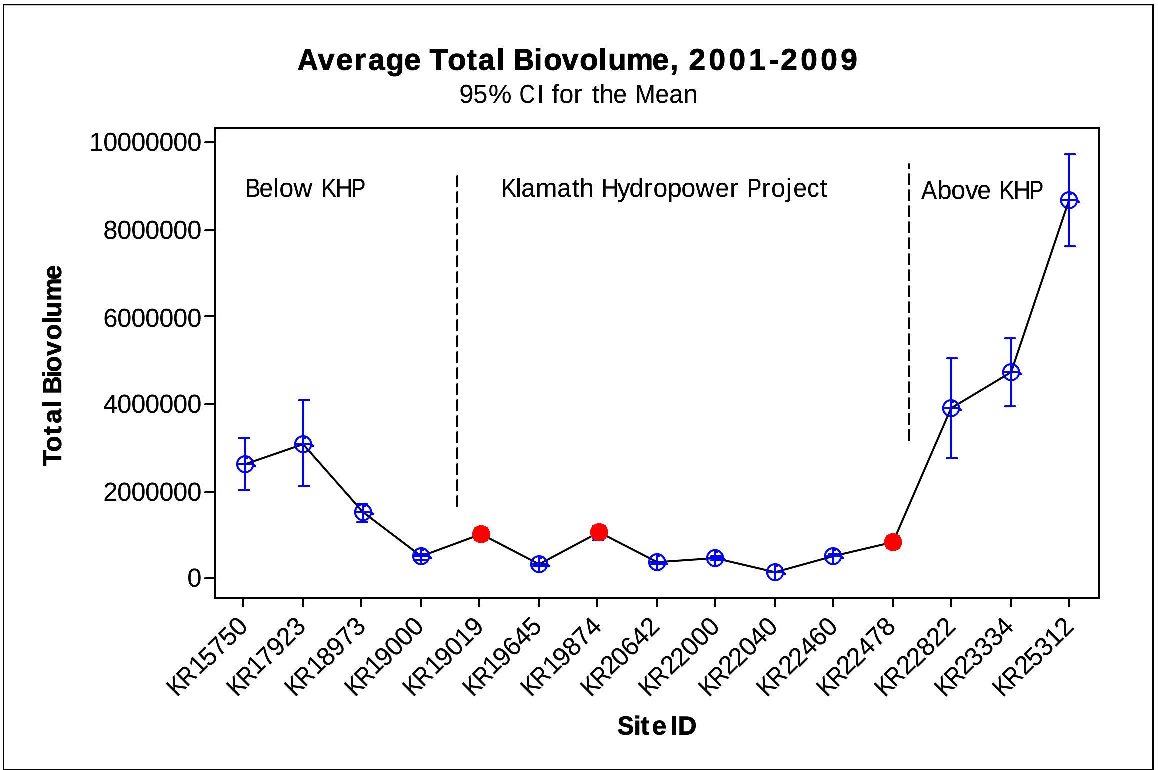


Figure A5. Average total biovolume (µm3/cm3) at various sites in the Klamath River measured in 2001-2009. Red symbols denote project reservoirs, J.C. Boyle (KR22478), Copco (KR19874), and Iron Gate (KR19019)

83: Page 2-73, Paragraph 2, Line 3. The Revised Draft TMDL states, "The consistent presence of high concentrations of *Microcystis aeruginosa*…." (MSAE). The assumption of a "consistent presence of high concentrations" of MSAE is not supported by data. MSAE is highly variable in both time and space and is not consistently high (or even consistently present) throughout the Klamath River and within Project reservoirs. Results of monitoring since 2005 have shown *Microcystis* to be present at high abundance at some sites in some years, and absent or present at different sites in other years. The Revised Draft TMDL must clarify its use of "consistent" with regard to the summertime presence of *Microcystis* in the Klamath River. From a year-to-year perspective, *Microcystis* blooms have been documented only during the last 4 or 5 years, with no evidence that supports the assumption of the existence of consistent *Microcystis* blooms before that. Data collected in the Klamath River and reservoirs prior to approximately 2003 (EPA 1978, City of Klamath Falls 1986, PacifiCorp website) do not indicate that *Microcystis* blooms were occurring, although *Microcystis* has been reported in Upper Klamath Lake since at least 1999 (Gilroy et al. 2000). Blooms of potentially harmful cyanobacteria, such as *Microcystis,* are known to be increasing worldwide (Hudnell 2009). Because the Project reservoirs have been in place for 50 years, it is reasonable to infer that recent increases in *Microcystis* are a part of the worldwide trend and may have some cause other than the mere presence of the Project reservoirs. Assertions to the contrary are not supported by data.

84: Page 2-73, Paragraph 4, Line 1. The first sentence, "Every year since 2004 *Microcystis aeruginosa* counts have exceeded…" is incorrect and clearly contradicts Table 2.11. Such contradiction notwithstanding, it is not possible to assess the severity of the supposed problem because Table 2.11 provides no information about the total number of samples for microcystin collected in each reach.

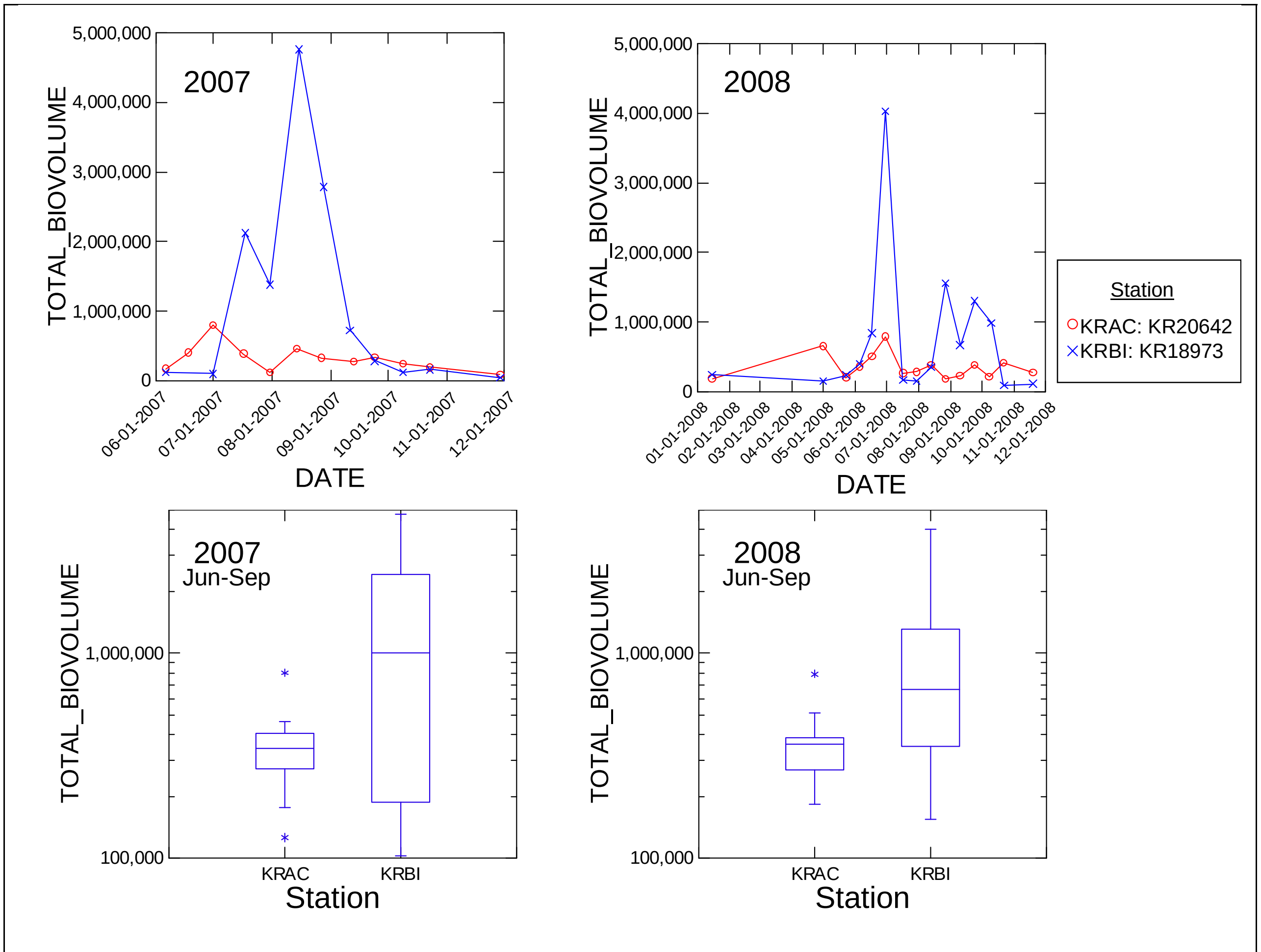
85: Page 2-92, Paragraph 2. The Revised Draft TMDL presents an incomplete and unbalanced discussion of the available data and information on the presence of microcystin in tissues and fish and mussels from the Klamath River. Key sources of available data and information on the topic, including from PacifiCorp, are absent (e.g., PacifiCorp 2008c, CH2M HILL 2009a, CH2M HILL 2009b). Until such data are presented, this section of the Revised Draft TMDL is inadequate and misleading. For example, during three years (2006-2008) of bi-weekly sampling between the Trinity River and the estuary, there has been only one instance when a water sample exceeded the threshold value for microcystin (see Table 2.11 on page 2-75). During the same three years of biweekly sampling at multiple sites from Iron Gate dam to the mouth, there have been only seven samples, or less than two percent, that exceeded the threshold value for microcystin. There is no evidence that the Project was the cause of the microcystin observed downstream of the Trinity River.

Responses 80 -85:

There are insufficient data to determine how the reservoirs affect fine particulate organic matter. Data regarding several partially useful parameters are available but none adequately measures particulate organic matter. These include: 1) particulate phosphorus (calculated as total phosphorus minus soluble reactive phosphorus) also includes inorganic phosphorus, 2) organic nitrogen (calculated as total nitrogen minus nitrate/nitrite) also includes dissolved organic nitrogen, 3) biological oxygen demand also includes dissolved organic matter and many samples are below laboratory detection limits, 4) the difference between total organic carbon (TOC) and dissolved organic carbon (DOC) should represent particulate organic carbon but Raymond (2008) reported analytical problems with that technique, 5) chlorophyll-*a* and algal biomass only account for living algal biomass, not dead and decaying organic material, 6) volatile suspended solids is a measure of particulate organic matter, but most samples are near or below laboratory reporting limits rending the data of limited utility, 7) total suspended solids also includes inorganic particulates.

Karuk Tribe data from 2005-2007 generally show that chlorophyll-a concentrations during the low-flow season are higher below Iron Gate than above Copco, but the particulate phosphorus, total organic carbon, total nitrogen are generally lower (Asarian et al. 2009). Total phosphorus follows a seasonal pattern with higher concentrations below the Iron Gate than above Copco in June through August or September, but then the opposite (higher at Iron Gate) through December (Asarian et al. 2009). Organic nitrogen concentration were generally lower below Iron Gate than above Copco (Asarian et al. 2009).

Summer algal biomass concentrations were generally higher below Iron Gate than above Copco in 2007-2008 . See data analysis of summer season of 2007-2008 PacifiCorp data below.
The Deas 2008 volatile suspended solids (VSS) data is not relevant to the commentor's point because the Deas 2008 study does not present any data collected directly above Copco Reservoir; the sites in the river upstream in the Deas 2008 study are all located between Keno Dam and J.C. Boyle Reservoir (both above the J.C. Boyle springs), so the reductions in organic matter could be due to dilution from the springs, not anything related to the reservoirs. Raymond (2008 and 2009) presents PacifiCorp's 2007-2008 data regarding VSS above and below the reservoirs; however, most sample results are estimated values below the method reporting limit (MRL) of 2 mg/L and making it difficult to draw robust conclusions from the data. Tables in Raymond (2008) indicate that 2007 mean and median VSS concentrations below Iron Gate Dam are several times higher than above Copco Reservoir (despite the apparently erroneous statement in the report that "The lowest median value for TSS was observed below Iron Gate dam"). Raymond (2008) notes that "No significant trends with distance or season were noted" regarding VSS and examination of the data indicates VSS values were similar above Copco and below Iron Gate (though peak values were higher below Iron Gate).
The Regional Water Board obtained the original spreadsheet used by PacifiCorp's consultant and conducted the following analysis (without any modification to the data included in the spreadsheet). The Regional Water Board staff conducted the analysis on the critical summer season, which is the time period that the original comment referred to.
Regional Water Board staff conducted a seasonal analysis of PacifiCorp data which clearly shows an increase in total phytoplankton biomass below the reservoirs. In addition, parametric tests of significance shown above imply data were normally distributed (or needed to be transformed if they were not); normality tests performed on the data shows they are not normally distributed. Normality notwithstanding, the time series graphs and boxplots below show a distinct seasonal (June -September) increase in total algal biomass (biovolume) below the reservoirs. In, fact two nonparametric tests of the Jun-Sep 2007-2008 data show that the distribution of total algal biovolume is significantly greater below the reservoirs than above (Kolmogorov-Smirnov Two-Sample Test [p=0.034] and Kruskal-Wallis Mann-Whitney U Test [p=0.08]).
In summary, the available data suggest that the reservoirs are likely net sources of live algae during the blue-green algae growing season (based on chlorophyll-a and biomass data), but their effect on dead and decaying particulate organic matter is unknown due to insufficient data.
Regarding *Microcystis* presence in the reservoirs, the text has been revised to clarify that the reservoirs consistently experience severe nuisance blooms on more than one occasion each summer. The intent is to communicate the regularity that severe nuisance blooms occur in the reservoir as an indicator of their current hypereutrophic status – a condition the reservoirs clearly meet.



Comparison of above Copco Reservoir (Station KRAC; KR20642) and below Iron Gate Dam (Station KRBI; KR18973) biovolume for the summer 2007 and 2008. Data collected by PacifiCorp (http://www.pacificorp.com/es/hydro/hl/kr.html#).

For additional information on these comments, refer to response B18.
PacifiCorp's comment addressing Page 2-92, Paragraph 2, does not address text revised since the June 2009 Public Draft. Nevertheless, the Regional Water Board offers the following. Chapter 2, Section 2.6.2.2, discusses evidence of impairments to Beneficial Uses (BUs), specifically Native American Culture (CUL) and Subsistence Fishing (FISH) BUs. Criteria for toxicity states "All waters shall be maintained free of toxic substances in concentrations that are toxic to, or that produce detrimental physiological responses in human, plant, animal, or aquatic life. Compliance with this objective will be determined by use of indicator organisms ..." This section of Chapter 2 demonstrates the impairment for CUL and FISH BUs; it is not intended to present all available data regarding microcystin levels in river waters.

Comment 86:

Page 3-1, Paragraph 1. In the Revised Draft TMDL, the language on "model calibration and corroboration" from the original Draft TMDL has been removed, and replaced with the term "testing". This is inappropriate if by "testing" the Revised Draft TMDL means something less than the necessary level of calibration and corroboration. Calibration is an essential model step for evaluation and discussion. EPA (2009) clearly identifies the need to calibrate models:

> "the Office of Water's standard practice is to calibrate well-established model frameworks such as CE-QUAL-W2 (a model for predicting temperature fluctuations in rivers) to a specific system (e.g., the Snake River). This calibration generates a site-specific tool (e.g., the "Snake River Temperature" model)."

The Revised Draft TMDL needs to explain here what is meant by "testing". If the model is neither calibrated nor corroborated, the model would not provide a reasonable basis for the TMDL.

Response 86:

The terminology in the report was changed; however, the approach to calibration and corroboration has not changed. The model has been calibrated and corroborated as described in Appendix 6. See also response to comment A9.

Comment 87:

Page 3-1, Paragraph 2. The PacifiCorp models used to support studies for the Federal Energy Regulatory Commission hydropower relicensing process are documented in PacifiCorp (2005), and reflect incorporation of comments from Wells et al (2004) with respect to the Watercourse (2004) document. Leading up to the 2005 document, collaboration on model updates between Tetra Tech and Watercourse was fairly continuous, and the models were quite comparable at that time.

Response 87:

Differences between the original PacifiCorp model and the model used for TMDL development are identified in Appendix 6.

Comment 88:

Page 3-2, Paragraph 2. PacifiCorp did not have sufficient time to review the estuary application of EFDC, and reserves the right to submit comments at a later date.

Response 88:

Comment noted. The Regional Water Board staff has met the noticing and public participation requirements in the development of this TMDL.

Comment 89:

3-5, Paragraph 3, Line 10. The Revised Draft TMDL needs to explain the "corroboration" process and the results of the process. Greater transparency in this regard is needed to ensure confidence in the TMDL model. Corroboration is not a formal modeling term and does not replace validation of the model for an independent time period. If the Revised Draft TMDL is using corroboration as a replacement for validation, then the applicability of the model and confidence in model results are in doubt for this TMDL.

Response 89:

The process is adequately described in Appendix 6 of the TMDL staff report. See also response to comment A9.

Comment 90:

Paragraph 2, Line 1 and elsewhere. The Klamath River TMDL model above the estuary is divided into eight parts or reaches, which includes river and reservoir reaches. To call these reaches “segments” is confusing and misleading. Further, modeled reservoirs are divided into “segments” in the language of CE-QUAL-W2.

Response 90:

Comment noted. Not all models refer to segments and elements consistently. Also see comment response A48.

Comment 91:

Page 3-7, Second paragraph. In this paragraph, the Revised Draft TMSL suggests that modifications were made on the modeling grid and framework. If so, the Revised Draft TMDL needs to document the reasons for the changes, and what changes were made. If changes have been made to the grid, then the hydrodynamic calibration noted in the last paragraph on this page is no longer valid.

Response 91:

No changes were made to the model grid and framework.

Comment 92:

Page 3-7, Bullets. Why were the terms “boundary conditions” removed from these bullets?

Response 92:

This was an editorial change – the bullets are described as boundary conditions in the paragraph above introducing the bullets, the use of the term boundary in the bullets was considered redundant.

Comment 93:

Page 3-7, Paragraph following bullets. The Revised Draft TMDL includes a brief discussion of calibration, but the terminology regarding calibration was removed on page 3-1. Also, if the TMDL model parameters are changed to provide a “best fit”, then summary statistics have to be identified and a “best fit” defined for the purposes of calibration.

Response 93:

The process is adequately described in Appendix 6 of the TMDL staff report. Calibration statistics have been included in Appendix 6.

Comment 94:

The last sentence states that calibrated model parameters were tested against field parameters. This cannot be correct for all parameters. Many model parameters used in calibration (e.g., Manning’s roughness, rate constants, temperature coefficients, oxygen demands, reaeration rates) were not tested against field measurements. The model must compare simulations with field observations of state variables (e.g., nitrate concentration) or derived constituents (e.g., pH).

Response 94:

The text has been revised to correctly describe the model calibration and corroboration process. The model calibration and corroboration process involved comparing simulation results to field observations.

Comment 95:

Page 3-8, Paragraph 2. Testing the model for the single year, 2000, does not test the model for a wide range of hydrologic conditions and water quality. The Revised Draft TMDL is clear that water quality conditions in the Klamath River vary seasonally. Coupled with highly variable meteorological conditions (intra-annually and inter-annually), variable hydrology from one summer (or spring, or fall) to another has considerable implications for water quality. Assessment of inter-annual variability is critical.

Response 95:

Refer to responses to comments A3 and A47.

Comment 96:

Page 3-8, Paragraph 2. The Revised Draft TMDL includes the following sentence: "The model was not run downstream (Segments 6 through 9) for 2002 primarily due to limited boundary data." The previous draft stated that the model was not run downstream in 2002 due to costs. In addition, there were meetings between PacifiCorp and the Regional Board and ODEQ regarding TMDL activities. Through these meetings the specific issue of not extending the model through segments 6 through 9 was raised. The TMDL team stated clearly that this was a resource and cost limitation. It is disappointing to see this transparency being removed from the Revised Draft TMDL. Further, review of data indicates that 2002 had a comparable set of data for downstream reaches, as USFWS had commenced a detailed sampling program below Iron Gate dam.

Response 96:

The text has been revised to explain that the model was not run downstream (Segments 6 through 9) for 2002 due to limited boundary data and limited funding.

Comment 97:

Page 3-8, Paragraph 2. Considering the availability of data and models from 2000 through 2004 that were provided to the Regional Board Staff early in the TMDL process, it is unfortunate that only data from one year are used to calibrate the TMDL model. As such, the TMDL model does not have a formal validation period. Thus, there is no reasonable assurance that the TMDL model downstream of the Bypass-Peaking Reach is reliable for setting TMDL load allocations or other purposes. As it stands, one can only have confidence for model applicability for 2000, and yet the TMDL model is relied upon to set load criteria for many years to come. Specifically, using only a single year on which to base the TMDL analysis provides no information on inter-annual variability – a considerable omission in a system with the size, complexity, and degree of inter-annual variability of the Klamath River.

Response 97:

Refer to responses to comments A3 and A47.

Comment 98:

Page 3-8, Paragraph 3. Review of Appendix 6 of the Revised Draft TMDL indicates that sensitivity analyses were limited and only applied to areas where problems were perceived. No systematic approach assessing individual parameters was completed. No uncertainty analysis is included in Appendix 6.

Response 98:

Refer to comment responses A2, A3, A51, and A150. Also calibration error statistics are presented in Appendix 6.

Comment 99:
Page 3-8, Paragraph 3. The peer reviews of the TMDL modeling brought up a host of comments regarding uncertainty, lack of calibration, and sensitivity analysis, yet little of this critical review is reflected in the Revised Draft TMDL. Uncertainty analyses or even model performance metrics that allow model uncertainty to be quantified are absent from this analyses. Models are only representations of physical systems and, although powerful and useful, are by their nature imperfect. Without a quantification and incorporation of model uncertainty into analyses, the models are insufficient to develop the TMDL, including TMDL load allocations. EPA (1997) states, "[T]he question of model accuracy is often crucial in situations where a given allocation is being negotiated or contested" (page 4-27). Further, "uncertainty analysis should be included as an integral component of water quality modeling. One of the primary purposes is to quantify the error in predicting water quality and evaluate the effect of input parameters on model output. Better management decisions can be made by quantifying this error. Such quantification also facilitates subsequent studies, such as risk assessments, to evaluate alternative allocations." (page 4-29) EPA (1997) identifies sensitivity analysis as a valid approach to defining uncertainty and dedicates a portion of an appendix (Appendix D) to this topic. The fact that sensitivity analysis is presented with reference to the EPA water quality model QUAL2E shows that, even in complex systems, quantification of uncertainty is feasible and necessary. As stated in the Revised Draft TMDL, "models are suitable tools for establishing Klamath River TMDL allocations and targets," but the tools must be appropriately developed, tested, and applied to carry out this task. The model used to develop this TMDL has not been.
Response 99:
Refer to comment responses A2, A3, A51, and A150. Also calibration error statistics are presented in Appendix 6.

Comment 100:
Page 3-9, Paragraph 2, Lines 2-7. The Revised Draft TMDL notes that the "NNE approach is a risk based approach," but without identification and clear quantification of uncertainty, risk-based assessments are at best a challenge and at worst infeasible. Specifically, without sensitivity analysis, assessing interannual variability, defining uncertainty associated with field data, and quantifying model uncertainty (as well as other sources of uncertainty), the approach of developing multiple lines of evidence for response variables is infeasible.
Response 100:
The comment overstates the intent of the description of the NNE. The framework includes several but not all of the elements of a risk analysis. The description is taken from the introduction of the document.

Comment 101:
Page 4-1, Footnote. The calculation for conversion of organic matter to CBOD, and to CBOD ultimate is not presented in the analyses. Basic stoichiometric considerations and decay rates are not provided to convert among these parameters. As such the reader of the technical TMDL cannot interpret what has been used to calculate load allocations for CBOD.
Response: 101
This information is included in Appendix 6.

Comment 102:
Page 4-1, Paragraph 4, Bullet 1. Please show how the UKL TMDL compliance target for TP of 0.11 mg/L was converted to nutrient boundary conditions used in scenarios.
Response:102
Refer to comment response A27. The description is also included on page 21 of Appendix 6.

Comment 103:
Page 4-2, Paragraph 2, Bullet point 2. It is not valid to treat Copco No. 1 and Copco No. 2 "as a single source" simply because there is no data for Copco No. 2. Copco No. 2 has fundamentally different water quality response than Copco No. 1. For example, because the reservoir is small, it does not stratify and does not have hypolimnetic anoxia (because it does not stratify). The TMDL is silent on whether processes and water quality impairments identified for Copco No. 1 are automatically applied to Copco No. 2, where they may not be applicable.
Response: 103
This simplifying assumption was deemed appropriate for TMDL development purposes. Sufficient data were not available to separate the reservoirs for modeling and TMDL purposes. Indeed, Copco 1 and 2 were combined in the original PacifiCorp model. The same configuration was used for the TMDL model.

Comment 104:
Page 4-3, Paragraph 2. The Revised Draft TMDL does not specify the relative magnitudes of the point and non-point sources or the current nutrient contributions from UKL. Such specifics are needed to quantify UKL contributions, so that water quality improvement actions can be determined and prioritized.
Response: 104
The California Klamath River TMDL specifies the loads at Stateline, leaving the more detailed assessment of loads (including breakout of point and nonpoint sources) to the Oregon Klamath River TMDL. UKL TMDL is an approved TMDL which provides a framework for achieving TMDL compliant conditions. The vast majority of the pollutant load in the Klamath basin is from nonpoint sources, such as the sources identified in Table 4.1. The CA Klamath TMDL does provide source area load estimates and priority has been placed on assisting with reducing loads within Oregon. Thus the development of the Klamath basin water quality tracking and accounting system, on which PacifiCorp is currently collaborating, is intended to promote collaboration on priority pollutant sources.

. **Comment 105:**
Page 4-4, Table 4.1. Are these source categories for Oregon, California, or both? Other comments include: (a) wetland conversion can affect water temperature under certain conditions, (b) if roads contribute to nutrients, then they can contribute to both organic matter and dissolved oxygen impairment (as explained in the paragraph immediately above the table), and (c) urban land use not included.
.**Response: 105**
The source categories apply to both Oregon and California.

Comment 106:
Page 4-4, Paragraph 1, Line 1. Regarding the Upper Klamath Lake TMDL, the National Research Council (2004) recognized that "[c]urrent proposals for improvement of water quality in Upper Klamath Lake, even if implemented fully, cannot be counted on to achieve the desired improvements in water quality." Thus, the Revised Draft TMDL's use of natural, "pre-disturbance" conditions as the "starting point" for the Klamath River TMDL is unrealistic. The TMDL should provide justification for this position based on actual data, and needs to discuss the uncertainties inherent with such a starting point.
Response:106
The NRC comment is on proposals that were current in 2004 and is not relevant to a very different set of options that are potentially available today. To our knowledge, the model used to determine the TMDL for Upper Klamath Lake is the best predictive tool available. The PacifiCorp comment does not provide an alternative.

Comment 107:
Page 4-4, Paragraph 3, Line 1. Volcanic geology is identified as a source of natural phosphorus and may suggest the Upper Klamath Lake is nitrogen limited, which may also explain why *Aphanizomenon flos aquae*, a nitrogen fixer, dominates in UKL. Regardless of the limiting nutrient, there is no discussion in the TMDL of what nutrient management strategies are available to implement reductions in nutrient loads from UKL. The lack of a clear nutrient management strategy (e.g., N:P ratios and seeking a limiting nutrient to manage) provides little direction for successfully attaining water quality improvements within a TMDL framework or for demonstrating that the assumed nutrient reductions are achievable or otherwise a reasonable basis for the TMDL.
Response: 107
Oregon Department of Environmental Quality Klamath River TMDL (2010 page 2-42 - link provided earlier) presents a limiting nutrients discussion for the Klamath River. The UKL TMDL (DEQ 2002) creates the framework for restoring UKL. The phosphorus and nitrogen allocations in the Klamath River TMDL and the management actions identified in Chapter 6 (TMDL Implementation) provide a clear strategy and guidance for restoring supporting conditions and achieving TMDL compliance.

Comment 108:
Page 4-4, Paragraph 3, Lines 6-7. The Revised Draft TMDL states that "the upper Klamath basin was characterized by high levels of nitrogen and phosphorus demonstrating the high natural background loading of nutrients." Here the Revised Draft TMDL clearly acknowledges that the upper Klamath Basin and Upper Klamath Lake have long been known for natural eutrophic conditions and high levels of organic matter. Upper Klamath Lake is the source of the Klamath River and provides those eutrophic conditions and high loads to the Klamath River. Therefore, the Revised Draft TMDL's recognition of this high natural background loading of nutrients fundamentally contradicts the Revised Draft TMDL's allocations that assume and set "natural" conditions in the Klamath River for nutrient concentrations that are in the oligotrophic to mesotrophic range. See section 5.3.

Response: 108
Regional Water Board staff does not agree with this comment. A range of trophic conditions existed naturally throughout the Klamath River. There is a substantial amount of scientific justification that supports the targets and allocations used in the Klamath River TMDL. There are no targets or allocations that are consistent with oligotrophic conditions. Where appropriate there are targets and allocations that could be identified as mesotrophic. As discussed previously Ward and Armstrong (2009) classify existing conditions in the Klamath River below Iron Gate Dam as mesotrophic. Simple logic dictates that if under the existing loading conditions that are clearly above natural baseline a mesotrophic condition exists, then it is certainly possible to have at worst similar conditions under lower loading scenarios reflect of past conditions.

Comment 109:
Page 4-4, Paragraph 4, bottom of page. The Revised Draft TMDL includes new text that "Eilers et al. (2004) have identified a clear shift in UKL productivity and species composition in the past 100 years, consistent with large scale land disturbance activities, which can be strongly implicated as the cause of the lake's current hypereutrophic character". The Revised Draft TMDL goes on to state, "These changes also include increased export of nutrients and organic matter from UKL to the downstream waters of Klamath River, contributing to the pollutant loading and water quality conditions that are present today". The inclusion of these statements is a much stronger recognition than in the original Draft TMDL of the naturally-eutrophic and currently-hypereutrophic conditions of the source waters to the Klamath River. However, the Revised Draft TMDL continues to repeat the error of the original Draft TMDL in assigning water quality targets and load allocations that would require huge nutrient reductions that are unachievable, unenforceable, or both.
Response: 109
Regional Water Board staff have used well accepted science to determine targets and allocations that are both achievable and enforceable. See also response to comment K53.

Comment 110:
Page 4-5, Paragraph 4. The Revised Draft TMDL states that:

> "Further exacerbating the effect of the naturally productive and weakly buffered system is the presence of regionally high ambient summer air temperatures, and the resulting high heat load to the shallow and predominantly un-shaded Upper Klamath Lake. These naturally warm waters are the source of the Klamath River. In addition, the east-west aspect of much of the Klamath River also makes it prone to heating, even within the steep gorges of some reaches of the river."

This paragraph suggests that heat loading at Upper Klamath Lake is a source for heat in downstream reaches. First, the temperature of Upper Klamath Lake is in dynamic equilibrium with meteorological conditions, i.e., at equilibrium temperature, much of the year (ice cover is a deviation from this condition). Much of the Klamath River is at or near equilibrium temperature (this is not a static value in space or time). To suggest that warm waters are a source of elevated temperatures in downstream reaches (i.e., in California) would be erroneous.

Response: 110
This comment was not previously submitted and does not appear to address issues relating to the revisions in the December Draft. The text is making the point that the Klamath River is naturally warm and its source is naturally warm.

Comment 111:
Page 4-5, Paragraph 5, and 4-6, Paragraph 1. The Revised Draft TMDL correctly identifies that natural background water quality:

- is naturally productive/biologically productive
- produces large seasonal volumes of organic matter
- results in subsaturated dissolved oxygen
- is weakly buffered (prone to elevated pH)
- includes high seasonal water temperatures

However, these statements are largely in conflict with the defined natural baseline conditions outlined in Chapter 2 of the Revised Draft TMDL. The natural conditions baseline total N and total P concentrations presented in Chapter 2, Figures 2.16 and 2.17 would occur in a system with low natural productivity (low nutrients), with low volumes of inorganic nutrients, and with high concentrations of dissolved oxygen.
Further, the last sentence, "These natural background heat, nutrient, and organic matter loads to the Klamath River underscore the very limited capacity of the river to assimilate anthropogenic pollutant sources, and ***the necessity for establishing load allocations that will result in attainment of water quality standards***" (emphasis added), shows that the load allocations in the Revised Draft TMDL are based on desired water quality outcomes rather than on an assessment of what load allocations are reasonably achievable and enforceable.
Response: 111
The comment is incorrect, the TMDL allocation strategy is discussed in the TMDL saff report and decisions regarding allocations followed the described protocol. The natural conditions baseline is not inconsistent with the characteristics of a productive system (provided in PacifiCorp's comment). For example, please note that the SSO for dissolved oxygen is in recognition that the Klamath River under natural conditions could not achieve fully saturated or existing water quality objectives. In summary the allocation strategy for the TMDL is that after establishing background conditions, load allocations were added in using the remaining assimilative capacity to a point just prior to violation of water quality standards.

Comment 112:
Page 4-6, Paragraph 2, Lines 12-17. Please include the flows at Stateline and the Mouth, or at minimum approximate flow volumes. At Iron Gate Dam the mean annual flow is on the order of 1.4 million acre-feet (MAF), while for the Klamath River near Turwar, the flow is on the order of 11 MAF – nearly 8 times greater (in drier years mean annual flows at Iron Gate and Turwar are on the order of 1 MAF and 6 MAF, respectively). So, in normal years when flow at Stateline is about 10-12 percent of the flow at the mouth, the total load (as identified in the draft TMDL) is approximately 40 percent of the load at the mouth. This clearly identifies the disproportionate load from the upper basin and the challenges that face both California and Oregon in improving water quality conditions.

Response: 112
This point, without the use of specific flow volumes which vary annually, was made in Section 4.1.3 of the Staff Report.

Comment 113:
Pages 4-10 to 4-12, Figures 4.1 to 4.3. The derivation and calculation of the loadings presented in these figures are not explained. It is therefore difficult to review these loadings to determine if they are appropriate.
Response: 113
The comment is incorrect. The first sentence of the section explains that the estimates were developed using the TMDL model and conditions for the year 2000. Additional detail on model scenarios and specific model applications are available in Appendices 6 and 7.

Comment 114:
Pages 4-10 to 4-12, Figures 4.1 to 4.3. Only loads from 2000 are taken into consideration, while loads change from year to year. The lack of assessment of inter-annual variability in the Revised Draft TMDL precludes it from addressing more than a narrow range of potential conditions. The Revised Draft TMDL lacks the technical rigor in the categories of inter-annual variability, sensitivity analysis of numerical tools, and overall uncertainty analysis to establish a reasonable TMDL and load allocations.
Response: 114
Please see the response to comment A28.

. **Comment 115:**
Pages 4-10 to 4-12, Figures 4.1 to 4.3. Without the associated flow data in the Klamath River, Figures 4.1 through 4.3 lack a basis for identifying the value of tributary contributions in the form of direct dilution. That is, representing pollutant loading in terms of total annual mass is misleading. As the arrows get bigger moving downstream, it suggests that the river water quality is getting worse. However, the opposite is true. It would be useful to present the pollutant loads in terms of concentrations, as well.
Response: 115
The TMDL staff report discusses the unusual nature of the Klamath River where the upper basin contributes a smaller fraction of the flows but a much larger fraction of the pollutant load. The diagram is intended as a simple illustration of loads at various points in the river and has received very favorable comment from Klamath stakeholders. The role of tributaries and their effect on pollutant concentrations is represented in the model analyses and discussed elsewhere in the TMDL staff report. The figures will be retained as they are.

Comment 116:
Pages 4-10 to 4-12, Figures 4.1 to 4.3. The figures report data to single pounds and single kilograms. This is misleading to the reader that the analysis is accurate to this level. Because there is no uncertainty analysis in the draft TMDL, there is no method for determining the appropriate significant figures in these figures or in Table 4.2

Response: 116
Regional Water board staff believes that it is important to report the actual model output rather than use an arbitrary rule for rounding. The intent is not to imply greater accuracy; rather it is to accurately report model output.

Comment 117:
Pages 4-10 to 4-16, Figures 4.1 to 4.3 and Table 4.2. The load values shown in Figure 4.1 through Figure 4.3 and Table 4.2, respectively, do not balance along the river. Annual nutrient and CBOD loads in the Klamath River TMDL do not add up, and significant losses and sources are unaccounted for. Because of discrepancies in loads along the river, the Revised Draft TMDL fails to put in-river sources and sinks in proper perspective, and thereby improperly considers appropriate load allocations. In every reach of the river, there are significant, unaccounted losses or gains, indicating that processes at work in the river and reservoirs are not properly addressed. These unaccounted losses and gains should be fully identified, and the processes that produce these significant losses or gains should be discussed in detail, especially with respect to the relative magnitude of regulated sources.
Also, load balances could not be checked for the “natural” baseline condition because load diagrams are presented only for current conditions, and in-stream loadings for “natural” baseline conditions are not listed. Because TMDL “natural” conditions load diagrams are not listed, and the supporting table does not list instream loads below Iron Gate dam, the relative magnitude of unaccounted “natural” sources and sinks along the river cannot be determined. Therefore, the analysis leaves the reader unable to compare TMDL “natural” baseline and estimated current conditions nutrient and CBOD sources along the river or to understand the relative importance of sources and sinks in these two scenarios. These omissions frustrate meaningful public review and result in an incomplete and misleading presentation of constituent loading in the Klamath River and need to be corrected. Furthermore, the magnitude of unaccounted loads that can be calculated from information that is provided in the Revised Draft TMDL represents a flawed analysis and a serious shortcoming of the Revised Draft TMDL.
As presented in the Revised Draft TMDL load diagrams, nutrient and CBOD loads do not balance in any reach of the river. A simple mass balance on any reach of the river follows the form:
Where:

$Load_{in}$ = total constituent load at the upstream boundary of a reach
$Load_{out}$ = total constituent load at the downstream boundary of the reach
$Load_{internal}$ = total constituent load added to the reach by tributaries or riverine processes

This relationship does not hold for the loads listed for any reach in the Revised Draft TMDL load diagrams. The sum of loads is never zero; there are unaccounted loads in every reach. These unaccounted loads are significant and often far greater than, for example, the upward benthic flux attributed to either Copco or Iron Gate reservoirs.
Unaccounted loads of total phosphorus, total nitrogen and carbonaceous biochemical oxygen demand (CBOD) in the Revised Draft TMDL load diagrams are listed by river reach in Table A1 through Table A6 below. A negative value indicates that a loss has been neglected, and a positive value indicates that a source has not been taken into account in the listed reach.
Significant digits are always a concern when presenting modeling or field data. Because of uncertainties associated with modeling processes and the data underlying them, only as many

significant digits should be used as would give the results meaning. Following this well-accepted guideline, annual loads from the modeling effort undertaken for the Revised Draft TMDL should reasonably be rounded to the nearest hundred pounds. Instead, for consistency with the TMDL, load values appear here as they are listed in the Revised Draft TMDL, to the nearest pound.

Table A1. Klamath River Revised Draft TMDL phosphorus load balance, "current conditions"

Reach	Current Conditions Phosphorus Load (lbs/yr)			
	Load$_{in}$	**Load$_{out}$**	**Load$_{internal}$**	**Unaccounted Load**
Stateline to Iron Gate	717,523	772,016	94,675	-40,182
Iron Gate to Shasta River	772,016	Not given	18,055	Unknown
Shasta River to Scott River	Not given	Not given	104,846	Unknown
Scott River to Salmon River	Not given	Not given	206,780	Unknown
Salmon River to Trinity River	Not given	Not given	103,015	Unknown
Trinity River to Estuary	Not given	Not given	367,401	Unknown

Table A2. Klamath River Revised Draft TMDL phosphorus load balance, "natural" baseline

Reach	"Natural" Baseline Phosphorus Load (lbs/yr)			
	Load$_{in}$	**Load$_{out}$**	**Load$_{internal}$**	**Unaccounted Load**
Stateline to Iron Gate	86,737	95,493	10,157	-1,401
Iron Gate to Shasta River	95,493	Not given	17,690	Unknown
Shasta River to Scott River	Not given	Not given	58,653	Unknown
Scott River to Salmon River	Not given	Not given	206,780	Unknown
Salmon River to Trinity River	Not given	Not given	103015	Unknown
Trinity River to Estuary	Not given	Not given	425,410	Unknown

Table A3. Klamath River Revised Draft TMDL nitrogen load balance, "current conditions"

Reach	Current Conditions Nitrogen Load (lbs/yr)			
	Load$_{in}$	**Load$_{out}$**	**Load$_{internal}$**	**Unaccounted Load**
Stateline to Iron Gate	3,020,913	2,819,510	381,647	-583,050
Iron Gate to Shasta River	2,819,510	3,084,413	116,978	147,925
Shasta River to Scott River	3,084,413	3,258,247	231,080	-57,246
Scott River to Salmon River	3,258,247	4,522,128	1,113,982	149,899
Salmon River to Trinity River	4,522,128	5,463,502	761,780	179,594
Trinity River to Estuary	5,463,502	8,072,118	2,641,224	-32,608

Table A4. Klamath River Revised Draft TMDL nitrogen load balance, "natural" baseline

Reach	"Natural" Baseline Nitrogen Load (lbs/yr)			
	Load$_{in}$	**Load$_{out}$**	**Load$_{internal}$**	**Unaccounted Load**
Stateline to Iron Gate	866,423	950,527	94,355	-10,251
Iron Gate to Shasta River	950,527	Not given	115,617	Unknown
Shasta River to Scott River	Not given	Not given	189,820	Unknown
Scott River to Salmon River	Not given	Not given	1,113,982	Unknown
Salmon River to Trinity River	Not given	Not given	761,780	Unknown
Trinity River to Estuary	Not given	Not given	3,086,366	Unknown

Table A5. Klamath River Revised Draft TMDL CBOD load balance, "current conditions"

Reach	Current Conditions CBOD Load (lbs/yr)			
	Load$_{in}$	**Load$_{out}$**	**Load$_{internal}$**	**Unaccounted Load**
Stateline to Iron Gate	17,492,704	11,295,995	1,807,322	-8,004,031
Iron Gate to Shasta River	11,295,995	12,879,105	1,109,290	473,820
Shasta River to Scott River	12,879,105	13,812,364	1,387,237	-453,978
Scott River to Salmon River	13,812,364	19,212,688	4,785,678	614,646
Salmon River to Trinity River	19,212,688	29,908,129	8,375,798	2,319,643
Trinity River to Estuary	29,908,129	55,969,233	29,820,283	-3,759,179

Table A6. Klamath River Revised Draft TMDL CBOD load balance, "natural" baseline

Reach	"Natural" Baseline CBOD Load (lbs/yr)			
	$Load_{in}$	**$Load_{out}$**	**$Load_{internal}$**	**Unaccounted Load**
Stateline to Iron Gate	6,498,082	7,077,933	690,994	-111,143
Iron Gate to Shasta River	7,077,933	Not given	1,109,290	Unknown
Shasta River to Scott River	Not given	Not given	2,008,839	Unknown
Scott River to Salmon River	Not given	Not given	4,785,678	Unknown
Salmon River to Trinity River	Not given	Not given	8,375,798	Unknown
Trinity River to Estuary	Not given	Not given	34,915,178	Unknown

Calculations to balance loads, as illustrated in these tables, show unaccounted losses in the Revised Draft TMDL that range as high as -40,000 lbs/yr phosphorus, -583,000 lbs/yr nitrogen, and -8 million lbs/yr CBOD. Unaccounted loads range as high as 179,000 lbs/yr nitrogen, and 2.3 million lbs/yr CBOD. Most of these unaccounted loads, and all of the highest values, occur in the Stateline to Iron Gate reach. Copco and Iron Gate reservoirs lie within this reach and represent loss due to deposition and nutrient processing, but this loss is not specifically accounted. Reaches upstream of Scott River always show unaccounted load loss. The Scott River to Salmon River reach and the Salmon River to Trinity River reach always show unaccounted load gain. The Trinity River to Estuary reach shows a gain in phosphorus and loss of nitrogen and CBOD.

Even though insufficient information is provided in the Revised Draft TMDL load diagrams and table to calculate load balances for "natural" baseline conditions along most reaches of the river, large losses are apparent under this scenario in the Stateline to Iron Gate reach, where sufficient information is provided. All of these unaccounted loads suggest processes that are poorly documented in the Revised Draft TMDL.

In sum, the Revised Draft TMDL leaves significant nutrient and CBOD loads unaccounted for in its presentation of loading in support of numerical targets and load allocations. Much load information for "natural" baseline conditions is missing, so load balances could not be completed for most reaches under this scenario. But, given the data presented in the TMDL, significant unaccounted loads must exist for the "natural" baseline conditions as they do for the current conditions scenario. Unaccounted loads are significantly greater than loads that are accounted for. The failure to include data describing "natural" baseline loads needs to be addressed. Without these data, "natural" baseline and current condition loads cannot be evaluated. The magnitude of unaccounted loads that can be calculated from information provided in the Revised Draft TMDL represents an incomplete analysis and is a serious shortcoming.

<u>Response: 117</u>

The table is a listing of individual source loads and is not the same concept as the vector diagrams which do account for system processes (e.g., losses and retention). The text in 4.1.3 notes this. The table does provide an accurate summary of individual source areas.

The comments presentation of the balance equation is not entirely correct.

The actual balance equation should be:

$$Load_{in} + Load_{internal} + Load_{kinetics} - Load_{out} = 0$$

where $Load_{kinetics}$ represents the source or sink due to model kinetics. For example, OM decay would result in additional loss of CBOD, and periphyton and phytoplankton mortality would result in additional CBOD, etc. The same concept applies to TN and TP.
$Load_{in} + Load_{internal} - Load_{out} = 0$ is insufficient.

Table 4.2 does provide current and natural baseline loading estimates for comparison. In addition there are bar charts elsewhere in the chapter (e.g., Figure 4.6) that provides the same comparison graphically. The source analysis for the purposes of the TMDL is adequate in its current form.

Comment 118:
Page 4-14, Table 4.2. This table suffers from the same problem as the previous figures. The numbers don't add up. It is not possible to get the total phosphorus load shown on the table by summing any logical combination of values from the table rows above. It also has mysterious disappearing phosphorus between Stateline and Copco. See the Table A7 below for examples (using values for Table 4.2 of the Revised Draft TMDL).

Table A7. Klamath River Revised Draft TMDL load balance by sources

Source	PT load	% of calculated total	% of table total
Klamath River	717,523	47	45
Copco Reservoir Outlet	703,047	46	44
Copco Reservoirs sed flux	3,331	0	0
Stateline to Iron Gate	90,979	6	6
Iron Gate Reservoir outlet	772,016	50	48
Iron Gate Reservoir sed flux	365	0	0
Iron Gate Fish Hatchery	365	0	0
Iron Gate to Shasta	17,690	1	1
Shasta River	98,544	6	6
Shasta to Scott	6,302	0	0
Scott River	13,856	1	1
Scott to Salmon	68,217	4	4
Salmon River	70,302	5	4
Salmon to Trinity	32,713	2	2
Trinity River	302,196	20	19
Trinity River to Turwar	65,205	4	4
Total calculated	1,542,081	100	96
Total from table	1,612,295		100

Response: 118
Refer to responses 116 and 117 above.

Comment 119:
Page 4-14, Table 4.2. The annual source loads of phosphorus for Iron Gate to Shasta Tributaries, Scott River, Scott to Salmon tributaries, Salmon River, Salmon to Trinity tributaries, and Trinity River to Turwar tributaries are all set equal to the natural background, and the Trinity River is set below natural background. This is unrealistic given the anthropogenic alterations that have occurred in these watersheds. This needs to be explained and justified using actual data or citations to relevant reports. Similar comments apply with respect to the numbers for nitrogen and CBOD.
Response: 119
The Trinity River loads are subject to lower flows under the ROD, which include diversions to the Sacramento River. Natural background used a higher flow volume – thus the difference.

Comment 120:
Page 4-14 to 4-16, Table 4.2. As noted above, the data presented in Table 4.2 (and Figures 4.1-4.3) suggests accuracy to single pounds, which is greater accuracy in the analysis than can possibly exist. As with Figures 4.1 to 4.3, the Revised Draft TMDL also is missing any discussion of how the values in Table 4.2 were derived. Such discussion is necessary in the TMDL documentation to effectively interpret these figures and table.
Response: 120
The numbers reported represent model output. Regional Water board staff do not support the use of an arbitrary rounding protocol to report model output. Refer to response 116.

Comment 121:
Page 4-17 Section 4.2.1.1 Temperature. The Revised Draft TMDL states "The results, summarized in Figure 4.4, indicate that the sum of all sources upstream of California leads to significant temperature increases, possibly as much as 6.9°F (3.35°C), from approximately April to December." This statement is erroneous, and neglects the fundamental fact that this is an open system, and the aquatic environment can readily gain or lose heat across the surface (as well as the bed). Thus, all sources of heat energy cannot be simply summed, because heat energy can enter and leave the system, and the system is always seeking equilibrium with meteorological conditions. Further, in the Revised Draft TMDL modeling, J.C. Boyle reservoir receives 100 percent solar radiation input in the "existing conditions" scenario, while the solar radiation is reduced by some 20 percent in the "natural conditions" (no dam) riverine reach model (as discussed further below in comments on Appendix 7).
Response: 121
The use of the word "sum" was not meant in a mathematical sense. The language has been revised for clarity. Please refer to the response to comment A10 regarding the solar radiation calibration.

4.2 Pollutant Source Area Loads

Comment 122:
Page 4-17 and 4-18, discussion under 4.2.1.1 Temperature. Water temperature is one of the least conservative constituents because of the constant heat exchange across the air-water interface. There is no discussion of whether the river is at or near equilibrium temperature for this assessment (i.e., Figure 4.4), although presumably it is. There is no discussion of whether the

return flows from irrigation are at or near equilibrium, although presumably they are. There also is no discussion of the volume of irrigation return flows compared to the receiving water, and the notable distance from Stateline to these return flow points. The river will seek equilibrium temperature and may make any difference in irrigation return flow negligible. A more complete and accurate discussion is necessary to interpret these results.

Response 122:

The purpose of this discussion is to disclose the possible sources of heating upstream of California. The relative contribution of those sources and their load allocations will be addressed in the State of Oregon's Klamath River TMDL.

Comment 123:

Page 4-18 and 4-19, Figures 4.4 and 4.5. These graphs show only the difference between two model runs, with no reference to the actual temperatures. Without knowing the actual temperatures, it is impossible to adequately evaluate the statements in the text. Secondly, these are comparisons of the output of two model runs. If the expected accuracy of the models is +/- 2 ºC, then a difference of 4 ºC might be due to fluctuations in the model only. This error and associated uncertainty should be provided to the reader.

Response 123:

Please see the responses to comments A2 and C68.

Comment 124:

Page 4-18 and 4-19, Figures 4.4 and 4.5. An exceedance curve of deviations would be a valuable addition to assess these data. For example, in Figure 4.5, although positive differences of as much as 1.5°C occur, this is only one day in 365. All other differences are less than 1°C. Further, an exceedance plot would also illustrate the number of days when deviations were positive (warmer) and negative (cooler). However, without a quantification of uncertainty, data interpretation is challenging. Using information from Watercourse (2006) for temperature model simulations on the Klamath River below Iron Gate Dam, model uncertainty is probably on the order of 1°C (a function of time of year and location).

Response 124:

See response to comment C89.

Comment 125:

Page 4-19, Paragraph 1, Line 2. The Revised Draft TMDL should explain whether or not TP and TN loads include algae-bound, and particulate organic-matter bound P and N.

Response 125:

TP and TN include both living and non-living organic components.

Comment 126:

Page 4-20, Figure 4.6. There is no supporting data or detailed documentation in the Revised Draft TMDL document for the derivation of "natural conditions" baseline presented in these graphs. What are the flows and concentrations that make up these loads? It is especially confusing that the total phosphorus load is presumed to have increased nearly six-fold when the difference between "current" conditions (based on actual data) and "natural" conditions (based on groundwater and tributary streams) is only about two-fold. For example, the current average total phosphorus concentration in the Klamath River in the vicinity of the Project is about 0.18

mg/L. Assuming 0.18 mg/L is six-fold greater than "natural" conditions would require a "natural" concentration of 0.03 mg/L (assuming the same flows). A total phosphorus concentration of 0.03 mg/L is unrealistically low for the Klamath River, even substantially lower than the current total phosphorus concentration in "natural" groundwater (at the J.C. Boyle bypass reach) of 0.07 to 0.08 mg/L as well as the natural baseline phosphorus concentration in water flowing to Upper Klamath Lake of approximately 0.06 mg/L (NRC 2004). See comments above related to Page 2-66, Figures 2.16 and 2.17.
A range of years would provide considerable insight into the potential variability and ranges of loads. Also, should a simulation from 2000 be used for a TMDL that will be completed a decade later? Have UKL TMDL implementation actions improved water quality in the six years since adoption of that TMDL? At a minimum, an assessment of available data should be carried out to assess current conditions at UKL and determine if indeed improvements have been observed. Such information would be useful to include in the Klamath River TMDL because if loads have been reduced (or increased, or stayed the same…or simply experienced a range of conditions) at Link River Dam this would provide some evidence regarding the reasonableness of the Revised Draft TMDL's assumptions about the loading from UKL to the Klamath River.

Response 126:

The natural baseline conditions documentation is provided in Appendices 6 and 7 of the TMDL staff report. Refer to response number 107 for a discussion related to baseline nutrient concentrations. The TMDL allocations were based on a single year using conservative assumptions. The conservative assumptions should protect water quality in the variety of expected flows. The ODEQ Klamath River TMDL (2010 – page 2-27 - link provided earlier) found no statistically significant trends in total phosphorus concentrations in UKL from 1990 to 2008.

Comment 127:

Page 4-22, Paragraph 1, last sentence. Mayer (2002) found that in 1999-2000 the Klamath Straits Drain contributed 25-75 percent of the nitrogen and 25-50 percent of the soluble reactive phosphorus load to the river below the Klamath Straits Drain.

Response 127:

Comment noted – no response necessary. This information has been provided to Oregon Department of Environmental Quality for their consideration.

Comment 128:

Page 4-25, Paragraph 3, Lines 5-6. The Revised Draft TMDL states that "the presence of Copco Reservoir can increase Klamath River water temperatures as much as 6.8°F". This is a misstatement of the facts. There is no "increase" in temperature; there is a change (of a week or two) in the time of year that a given temperature occurs in the river. The TMDL must be clear about this because an actual increase in temperature of 6.8°F could have a substantially different effect than a change in the timing of existing temperatures. The Revised Draft TMDL presents no empirical evidence that a shift in the timing of certain temperatures has had an adverse effect on beneficial uses.

Response 128:

Please see response to comment C90.

Comment 129:
Page 4-25, Paragraph 3, Lines 6-8. Same comment as the previous comment. The maximum temperature does not increase. Instead, the timing of the maximum temperature shifts.
Response 129:
Please see response to comment C90.

Comment 130:
Page 4-25 to 4-28, Section 4.2.2.1 Temperature. Throughout the section of the Revised Draft TMDL, only temperature *differences* are shown. This is the case for the entire chapter for all applicable graphs – only the differences in constituent concentrations are shown. Thus, the actual concentration or temperature is not available to the reader. The Revised Draft TMDL needs to include the actual concentrations and temperatures. Although conditions may deviate from natural conditions, such a deviation is not inherently harmful to beneficial uses.
Response 130:
See response to comment C92.

Comment 131:
Page 4-25, Paragraph 2, Lines 3-4. The draft TMDL states that the analysis isolated the effects of each reservoir. However, the difference calculations do not isolate the reservoirs but include the effects of the reservoir and any upstream reservoirs. Thus, the results for Copco reservoir (Figure 4.10) include those for J.C. Boyle reservoir, and the results for Iron Gate Reservoir include those for Copco reservoir and J.C. Boyle reservoir. This makes it difficult to assess if the effects presented are correct.
Response 131:
See the response to comment A31.

Comment 132:
Page 4-26, Figure 4.10 and elsewhere. Presenting only differences and not actual model simulated temperatures (or other constituents presented in this manner in Chapter 4) provides limited insight into the relative impact of the difference given the actual temperature or concentrations in the aquatic system. With no knowledge of the actual temperature range involved it is not possible to make properly informed decisions about the "significance" of the temperature differences. The Revised Draft TMDL needs to include the actual temperature plots of the two scenarios in addition to the differences between scenarios.
Response 132:
See response to comment C92.

Comment 133:
Page 4-28, discussion under Dissolved Oxygen. Providing a chart of the dissolved oxygen conditions in Copco 1 and 2 and Iron Gate reservoirs throughout the year with associated volumes is needed. Labeled on the chart should also be the applicable water quality standards. This discussion should be supported by field data to supplement the model results, which are limited to the year 2000. Such data would also illustrate the inter-annual variability in volumes of water where dissolved oxygen conditions are undesirable.
Response 133:

The Regional Water Board staff believes that adequate documentation has been provided to demonstrate that non-supporting conditions exist. Additional quantification of the zone of noncompliance will need to be addressed as part of the PacifiCorp TMDL implementation plan.

Comment 134:
Temperature and dissolved oxygen conditions under existing and natural conditions scenarios are not presented for critical summer periods in the Copco and Iron Gate dam reaches, nor are associated standards. Presentation of this information is required to support the statement that co-occurring dissolved oxygen and temperatures would meet targets under natural conditions. It should be made clear whether or not the reference to a "natural free flowing condition" is the same as the TMDL's assumed natural conditions baseline.
Response 134:
The proposed DO objective would require 90% saturation under natural temperatures for October 1 through March 31, and 85% from April 1 through September. This objective corresponds to a daily minimum DO concentration ranging from 6.3 mg/L in June to 10.6 mg/L in December from Stateline to Iron Gate Dam. The DO proposed objective is based on the natural conditions baseline TMDL model scenario, which is without dams (i.e., free flowing river). A comparison can be made to Figure 2.15 (Dissolved oxygen and temperature depth profiles in Iron Gate Reservoir – average for July and August 2000 – 2005) where for the period dissolved oxygen concentrations are well below the proposed objective in the water column where temperatures are below 18.8 ^{0} C. The natural conditions baseline modeling scenario output files have been provided to PacifiCorp which provide the requested information.

Comment 135:
Page 4-28, Paragraph 2, last sentence. It is not clear what aspects of the reservoirs the Revised Draft TMDL is referring to that "require" that the reservoirs be considered a contributing source and assigned allocations and numeric targets. Earlier in Chapter 4 (see page 4-3), the Revised Draft TMDL states, "Precise quantification of individual source categories within source areas is not critical because the primary mitigation for nonpoint source loads is not a specific permit limit; rather mitigation is generally based on the use of best management practices that have demonstrated effectiveness to reduce pollutant loads through their application." Since the reservoirs are a net sink for nutrients from upstream, thus protecting the lower river from even higher loading than currently exists, the Revised Draft TMDL needs to support and justify (with data or reference to relevant reports) why it is "required" that the reservoirs be considered a contributing source.
Response 135:
Regional Water board staff believe that they have adequately demonstrated within Section 2 and Section 4 of the TMDL staff report that the reservoirs are a source of nuisance algal blooms, disruption of the natural temperature regimen downstream, and have oxygen deficits during the summer season. The fact that the reservoirs also provide some level of nutrient retention does not remove the need for these facilities to address the targets and allocations related to their impairments. See also response to comment K53.

Comment 136:
. Page 4-28, discussion under Dissolved Oxygen, Paragraph 3 of page, Lines 1-4. Internal nutrient loading in stratified reservoirs does little to exacerbate dissolved oxygen conditions

because for internal loading to occur, anoxia must be present. Anoxia occurs primarily because of seasonal stratification and is largely driven by organic matter loading and sediment oxygen demand. Resulting loading from the sediments is generally limited to the hypolimnion. When the reservoir attains an isothermal condition in the fall, dissolved oxygen conditions are typically no longer of concern. Likewise, any available nutrients that were contributed from the hypolimnetic volume during turnover are of minimal consequence because the shorter days and cooler temperatures limit algal growth. Copco and Iron Gate reservoirs have very short residence times in the winter due to the relatively small storage, large inflows, and isothermal condition, so carryover of hypolimnetic nutrients from one season to the next is most likely insignificant.

Response 136:

Please see the response to comment C10.

Comment 137:

Page 4-28, Paragraph 3, Line 12. The 18.7°C maximum weekly maximum temperature under natural conditions referenced in the Revised Draft TMDL is not valid due to the inappropriate 20 percent reduction in solar radiation in the TMDL's river models.

Response 137:

Please refer to the response to comment A10 regarding the solar radiation calibration.

Comment 138:

Page 4-29, Table 4.3. The table refers to the period from May 2004 - May 2005, while the text refers to May 2005 - May 2006. Likewise, annual values in the table do not correspond to annual values in the text, and it would be helpful to present all data in days or years, or both. Please clarify that these are "compromise" values (Appendix 2, section 3.2) used in analysis. How any of these values for residence time were determined is not described here or in Appendix 2. Residence time information is readily available from the CE-QUAL-W2 models of the reservoirs in model output.

Response 138:

The text has been revised.

Comment 139:

Page 4-29, Paragraph 4, Lines 1-4. The Revised Draft TMDL accurately states that Copco and Iron Gate reservoirs "promote the settling of particulate material, including nutrient-bearing organic material and algae, and nutrient sorbed to inorganic sediment". This statement contradicts conclusions made elsewhere in the Revised Draft TMDL that the reservoirs export "high levels" of organic matter (for example, see page 2-37), and that the level of nutrient retention by the reservoirs is small and insignificant (for example, see page 2-42).

Response 139:

The text has been amended in the later sections to clarify that the reservoirs export live algal biomass as demonstrated in Figure 2.25 and in other analyses elsewhere in the TMDL staff report.

Comment 140:
Pages 4-29 and 4-30, five bullet points on these pages. The listed bullet points are a description of processes that largely are not applicable to Iron Gate and Copco reservoirs. They are not significant processes that drive water quality conditions in Copco and Iron Gate reservoirs.

- Bullet 1 – Resuspension of sediments is unlikely to be a source of nutrients to Copco and Iron Gate reservoirs. The fact that both Iron Gate and Copco reservoirs experience stable stratification in the summer with a thermal gradient developing as shallow as 5 m indicates that there is relatively little wind generated turbulence and little likelihood of resuspension of anoxic sediment. It is theoretically possible that sediments shallower than 5 m could be resuspended, but no evidence of it has been observed during frequent visits over 10 years. Copco and Iron Gate reservoirs are impoundments located in steep canyon areas and thus are deep with sloping sides. Because they are maintained at stable levels for hydropower purposes, macrophytes tend to ring these reservoirs, dissipating wind energy and minimizing resuspension of sediment. This process (along with degassing and bioturbation) is probably small in the reservoirs. Bubbles rising to the surface of the reservoirs, suggesting degassing, have been observed on at least one occasion (Eilers pers. comm.). There was no evidence to suggest that the gasses came from the sediment. In any event, even if degassing were a regular phenomenon it would have little effect on the nutrient budget of the reservoir because it happens during the fall when stratification breaks down and biological activity is low. Any nutrients that might be released would be quickly washed out of the system during the winter.
- Bullet 2 – Low redox potential is not likely to be a source of phosphorus to the Klamath River. Available data does not show phosphorus releases from the sediment in Iron Gate reservoir (see extensive water quality data for Iron Gate reservoir posted on PacifiCorp's website, and previously available to the Regional Board). Available data shows that phosphorus can increase in Copco reservoir during the summer below about 24 m (see extensive water quality data for Copco reservoir posted on PacifiCorp's website). However, the volume of Copco reservoir contained below 24 m is less than 5 percent of the volume of the reservoir (Eilers and Gubala 2003). An increase in such a small volume of the reservoir would be undetectable when mixed into the total volume. A similar situation exists with respect to ammonia. Figures 4.1 to 4.3 in the Revised Draft TMDL show that loading from the Iron Gate and Copco reservoir sediments is less than one percent of influent loads.
- Bullet 3 – "High" pH is not defined. Elevated pH near the bulk of the sediments (in deeper waters) is atypical during summer when anoxia is present (and pH is actually quite low near the sediments under these conditions where fermentation is occurring). Both Copco and Iron Gate bottom waters during summer have pH values typically below 7.5 and sometimes below 6.0. This may occur in shallow margin areas of the reservoir, but likely is not a dominant process.
- Bullet 4 – The Revised Draft TMDL claims that Figure 4.13 demonstrates the transport of phosphorus from "below the thermocline" to the surface via migrating cyanobacteria. This is a misrepresentation of the data found in Figure 4.13, which illustrates vertical migration of *Microcystis* in Copco reservoir, but it in no way demonstrates that there is translocation of phosphorus from deeper water "below the thermocline" to the surface. Figure 4.13 shows that *Microcystis* migrates between approximately 7 m to the surface, but it does not reach as deep as 10 m. This is well above the thermocline. The summertime concentration of phosphorus in Copco reservoir does not change until depths greater than 20 m. The migrating cyanobacteria never move below the thermocline, and there is no greater concentration of

phosphorus at 7 m than there is near the surface, so there can be no translocation of phosphorus from an area of higher concentration to an area of lower concentration. The Revised Draft TMDL needs to be modified to accurately represent the facts.

- Bullet 5 – Nitrogen fixation does require energy, and there has been no analysis to date if this process is occurring. The mere presence of heterocysts is not conclusive of actual nitrogen fixation. In addition, both Copco and Iron Gate reservoirs experience the presence of both non-nitrogen fixing BGA (e.g., *Microcystis*) and nitrogen fixing BGA (e.g., *Aphanizomenon*), and the presence of ample soluble nitrogen in the water indicates that nitrogen fixation is not a substantive process in the Project reservoirs. There is no empirical evidence that nitrogen fixation is occurring in Iron Gate or Copco reservoir, and the Revised Draft TMDL presents none. The empirical information that is available using nitrogen isotopes (Moisander 2009, Deas pers. comm.) suggests that the nitrogen in the reservoirs comes from sources other than nitrogen fixation.
- **Response 140:**

Refer to comment response C11.

Comment 141:

Page 4-30, Paragraph 2. The Revised Draft TMDL hypothesizes several mechanisms by which nutrients might move from the reservoirs and constitute an additional load to the downstream reaches. However, the Revised Draft TMDL provides no actual empirical evidence, and cites no studies that demonstrate that such movement occurs. In fact, the evidence that does exist (based on PacifiCorp's extensive water quality monitoring data from 2001- 2008 , available on its website) suggests that the mechanisms hypothesized by the Revised Draft TMDL do not occur, and that no such loading from the reservoirs occurs (PacifiCorp 2006). The Revised Draft TMDL explicitly recognizes that the reservoirs are a net nutrient sink

Response 141:

The Revised draft presents empirical analysis that shows during certain periods the reservoirs can export both TN and TP. It is true, as acknowledged in the TMDL staff report, that the reservoirs are a net annual sink for nutrients.

Comment 142:

Page 4-30, Paragraph 2, last sentence. The Revised Draft TMDL expresses concern about export of nutrients "when occurring within the window of the critical growth period for periphyton", but the Revised Draft TMDL provides no empirical evidence that such export occurs. The Revised Draft TMDL also provides no empirical evidence that periphyton growth in the river is the result of anything other than nutrients transported from upstream. In fact, on page 2-42, the Revised Draft TMDL asserts that the river is saturated with nutrients so that small changes in nutrients caused by the reservoirs would have no effect on periphyton growth.

Response 142:

The report does include information regarding the export of nutrients during the growth season for periphyton. The point is, as stated in the TMDL staff report, that without the dams it is unclear what the effect on periphyton densities would be below the dams because of several offsetting factors that are described in the staff report.

Comment 143:
Page 4-32, Paragraph 1. The Revised Draft TMDL cites analysis and results from "Asarian et al. 2009". This citation is not available for public review. The use of documents still "in press" or otherwise unavailable does not allow a thorough review of this TMDL by the public. The Revised Draft TMDL should delete reference to this information unless and until a report has been made available for public review. There have been substantial flaws with previous nutrient loading analyses by these authors (i.e., Kann and Asarian 2005, Asarian and Kann 2006, Kann and Asarian 2007) as described in PacifiCorp (2006), PacifiCorp (2008b), and Butcher (2008).
Response 143:
This paper has been made available to PacifiCorp and is available to the public. It can be downloaded from the following website:
main text of report is at:
http://www.riverbendsci.com/reports-and-publications-1/Cop_IG_Budget_may05dec07_report_final.pdf?attredirects=0&d=1
report appendices at:
http://www.riverbendsci.com/reports-and-publications-1/Cop_IG_Budget_may05dec07_appendices_final.pdf?attredirects=0&d=1
See also response to Comment 244a.

Comment 144:
Page 4-32, Paragraph 2, under Role of Copco and Iron Gate Reservoirs in Klamath River Nutrient Dynamics. To reiterate earlier comments, the Revised Draft TMDL definition of the critical growth period from May through October masks critical intra-seasonal dynamics in the Klamath River. Discussions in the Revised Draft TMDL focus on annual or six-month loading assessments and miss critical within-season dynamics during which reservoir nutrient retention is even more important. The fundamental flaw in this analysis is the failure to carefully examine TMDL model outputs, which show that the reservoirs dramatically reduce large nutrient pulses emanating from Oregon (in response to bloom conditions in UKL) and provide substantial reductions during the critical summer season.
Response 144:
The targets and allocations address controllable water quality conditions within PacifiCorp facilities, and that result from the presence of the facilities. The rationale for these targets were specifically reviewed as part of the TMDL peer review and received strong support form each of the four peer reviewers. The one exception was from Dr Tulos who recommended more stringent targets than those adopted by Regional Water Board staff. See also responses to comments K1 and K53.

Comment 145:
PacifiCorp's water quality modeling consultant (Watercourse Engineering) performed model runs (using the Revised Draft TMDL models recently obtained from Tetra Tech for review) that show that TP and TN loads at Iron Gate dam are substantially lower under current conditions than under conditions assuming the dams are absent. This is due to the significant retention and loss of inflowing organic matter in the reservoirs that would not occur without the reservoirs. The peak nutrient loads coming from upstream sources are also shifted later into the fall than would occur without the reservoirs. This shift into the fall is important because, with dams in

place, nutrients tend to leave the reservoirs later in the season after the benthic algae standing crop in the river has started to diminish.

Response 145:

Regional Water Board staff have not had the opportunity to review the new model runs by PacifiCorp's consultant referenced in the comment, therefore we are unable to provide meaningful response to these specific model runs. With this said, section 4.2.2.2 of the staff report provides a detailed discussion of nutrient retention provided by the reservoirs in California, and the annual and seasonal effects of the reservoirs on nutrient dynamics of the Klamath River.

Comment 146:

Page 4-33, Paragraph 1, under Table 4.4. The Revised Draft TMDL includes new text on the matter of net annual retention of nutrients in Copco and Iron Gate reservoirs. The Revised Draft TMDL states, "Within the critical summer growth period (May – October), the TMDL model estimates a combined reservoir retention of TP of 7.6% annually and 6.0% during the period May to October. For nitrogen the annual retention is 14.9% and 30% during the summer growing period (May to October)." The Revised Draft TMDL goes on to state, "Asarian and Kann have estimated the combined effect of the reservoirs to be 15% retention of TN and 10% retention for TP on an annual basis and seasonally TP 8% and TN 31%". Despite these appreciable levels of nutrient retention, the Revised Draft TMDL consistently downplays these levels as "small" (see page 4-35, second bullet), "not large" (see page 2-42, under second bullet), and "not significant" (see page 2-42, under second bullet). Retention of the inflowing load of TP at a rate of 10 percent annually equates to a reduction of about 71,000 pounds of total phosphorus, and retention of the inflowing load of total nitrogen at a rate of 15 percent annually equates to a reduction of about 453,000 pounds of TN. The Revised Draft TMDL's characterization of these reductions as "small", "not large", and "not significant" is misleading and discounts the very reduction in nutrients levels that the TMDL seeks to achieve.

Response 146:

The language in this section has been revised. However, Regional Water Board staff have provided, both in previous drafts and in the current draft, a balanced discussion of the positive (e.g., retention) and negative water quality impacts of the reservoirs.

Comment 147:

Page 4-34. The net retention values presented in the Revised Draft TMDL are actually considerable – especially the critical May-September period: 31 percent for total N and 8 percent for total P (Table 4.5). Table 4.4 in the Revised Draft TMDL is misleading. It only states Klamath River inflows and outflows from reservoirs, underestimates retention for the reservoirs, and even suggests that Iron Gate reservoir is a source of TN and TP. Tributary inflows and associated loads to the reservoirs need to be listed. The retention estimated by the TMDL model appears to under-predict estimated annual and seasonal TP retention compared to Asarian et al (2009) by some 24 percent and 25 percent, respectively (acknowledging that the averaging periods on seasonal values are slightly different). This significant deviation needs to be explained.

Response 147:

The discussion accurately portrays the variability seen in both the data and in the various methods to estimate reservoir retention. There are periods when the reservoirs export nutrients.

All lines of evidence were provided and they have helped to inform TMDL development. The staff report includes references to papers that provide more information related to the information requested in the comment.

Comment 148:
Page 4-35, first half of page. The net retention benefits of Copco and Iron Gate reservoirs are clearly presented in Table 4.5 (page 4-34). Nevertheless, on page 4-35, the Revised Draft TMDL tries to argue that such retention is unimportant and perhaps even undesirable. The fact is that, if the reservoirs were absent, there would be considerably more nutrients in the Klamath River below Iron Gate dam. Again, the downplaying of reservoir retention in the Revised Draft TMDL puts the Regional Board in the position of discounting the reduction in nutrient levels that the TMDL seeks to achieve.
Response 148:
The cited discussion (which has been revised) presents a balanced evaluation of both the positive and negative water quality impacts of the reservoirs.

Comment 149:
Page 4-35, first bullet. Retention within the reservoirs is largely the result of settling to the bottom, where the nutrients do not participate in biological activity within the reservoir. Retention therefore has little to do with the algal conditions in the reservoirs, which are driven by the concentration of nutrients imported from upstream.
Response 149:
This comment reflects an overly simplified description of reservoir nutrient dynamics. The TMDL staff report provides a much more complete description of the processes that drive nutrient dynamics within the reservoirs. For example, the retention within the reservoir is what in part drives the development of high concentrations of phytoplankton during the summer months.

Comment 150:
Page 4-35, second bullet. The Revised Draft TMDL states that "net retention amounts are small relative to the nutrient-rich conditions downstream of Iron Gate dam". Given that retention involves the very biostimulatory constituents (i.e., nutrient and organic matter) that the TMDL is aimed at reducing, the Revised Draft TMDL should explain why it considers these substantial reductions in nutrients to be unimportant.
Response 150:
The revised TMDL staff report provides a more complete treatment of this issue. The staff report provides a balanced discussion of the impact that the dams have on water quality conditions.

Comment 151:
Page 4-35, fourth bullet. The Revised Draft TMDL provides no data concerning particulate and dissolved partitioning. This Revised Draft TMDL needs to provide the supporting information on particulate and dissolved forms of inorganic and organic phosphorus, including the stoichiometry of the particulate forms (i.e., C, N, and P fractions). In fact, available data shows that most of the phosphorus in the system is in the dissolved fraction (see data posted on PacifiCorp's website, and as previously available to the Regional Board)

Response 151:
The stoichiometric ratio is provided in Appendix 6. All the inorganic P and N are assumed to be dissolved in the model due to a lack of data to support further partitioning. The partitioning of OM between particulate and dissolved forms changes temporally and spatially. As such, a significant amount of data is required to accurately represent these features. Therefore, in the TMDL model, the particulate and dissolved partitioning of OM at the upstream boundary condition (at UKL) was assumed to be 0.8:0.2 based on the original PacifiCorp model. This was set using CE-QUAL-W2's default value for algal-related OM. For downstream sections, the particulate and dissolved OM partitioning was determined dynamically using simulated results in the W2 models. This demonstrated that dissolved OM becomes dominant in a downstream manner, particularly in Copco and Irongate Reservoirs.

Comment 152:
Page 4-35, fourth bullet. The Revised Draft TMDL includes new text that states, "For phosphorus, it is inappropriate to assess retention only at an annual time step, as the majority of the retention occurs in Winter-Spring, when more of the phosphorus is in particulate form and water quality conditions (i.e., flow, light, temperature) are not subject to biostimulatory conditions". Such a conclusion fundamentally contradicts the *year-round* or *annual* nutrient targets and allocations required in the Revised Draft TMDL (see Chapter 5).
Response 152:
It does not contradict critical period analysis, which is also a part of the Klamath River TMDL. The point is that the nutrients would under free flowing conditions pass through the system into the ocean during the winter and early spring with little to no biological impact. The retention period of interest is the critical summer growth period. The TMDL provides monthly mean targets for all pollutants to address seasonal concerns and provides annual and daily pollutant loading allocations to satisfy the TMDL policy requirements.

Comment 153:
Page 4-35, fifth bullet. The section addresses nutrients, but this fifth bullet discusses oxygen allocations and implications for fisheries. This point is out of place or needs additional information to make it relevant to this section. Further, the draft TMDL is vague about where and when oxygen depletion occurs and which fishery (COLD or WARM) is affected.
Response 153:
Please see the response to C17.

Comment 154:
Page 4-35, sixth bullet. The Revised Draft TMDL states that "Chlorophyll-a and blue-green algal related targets are achieved above the reservoir but not within the reservoirs." This statement is irrelevant and should be deleted. These chlorophyll *a* and blue-green algal related targets are not applicable or relevant to the river reaches. The tendency for the Revised Draft TMDL to examine river data in light of these targets recurs elsewhere in the document (e.g., see pages 2-70 and 2-71), and indicates a fundamental misunderstanding of the applicability of these particular targets. It is an inappropriate comparison. It is as inappropriate as it would be to apply the river-related benthic chlorophyll *a* target to the reservoirs.

Response 154:
The statement is not irrelevant; it demonstrates that the reservoir provides an environment that promotes the growth of phytoplankton. This has been clearly demonstrated with the supporting analyses. The chlorophyll *a* target is also appropriate for back water environments of the Klamath River. In addition, targets have also been provided for river reaches as well.

Comment 155:
Page 4-35, seventh bullet. The Revised Draft TMDL has deleted text here from the original Draft TMDL that reservoir nutrient "retention plays an important…role". The Revised Draft TMDL replaces the deleted text with text indicating that "negative water quality affects [*sic*] associated with changes in nutrient dynamics". These edits indicate the Revised Draft TMDL's bias toward making interpretations that emphasize reservoir detriments and downplay reservoir benefits, such as with regard to nutrient and organic matter loading. The Revised Draft TMDL's own analysis indicates that the reservoirs provide substantial levels of nutrient retention (e.g., 6-10% retention of TP and 15-31% retention of TN as shown in Table 4.5). The Revised Draft TMDL discounts and downplays the very reduction in nutrients levels that the TMDL seeks to achieve. The implications of increased nutrient loads under the "without dams" condition on river reaches and the estuary needs to be more comprehensively and accurately assessed to determine implications on implementation of TMDL actions. Further, a more balanced and objective assessment of system nutrient dynamics in the TMDL would allow better assessment of potential implementation actions and key intermediate milestones en route to compliance
Response 155:
Reservoir retention rates are clearly presented and discussed. The purpose of the discussion is to make it clear that the reservoirs have both positive and negative water quality impacts. The discussion provides a balanced presentation of the issues.

Comment 156:
Page 4-36, Paragraph 1 (before section 4.2.3), Line 3. Oxygen deficits are presented here as if they occur throughout the reservoir during summer months. The Revised Draft TMDL should identify the location where deficits occur, e.g., hypolimnion.
Reponse 156:
Regional Water Board staff disagree with the commenter's interpretation of the text. The text merely implies that oxygen deficits occur, there is nothing in the text that suggests they occur throughout the reservoir. The locations of the oxygen deficits are described in section 2.5.2.3.

Comment 157:
Page 4-38, under 4.2.4.1 Temperature. The Revised Draft TMDL's analysis is invalid because the mainstem temperature model used for the TMDL under-predicts water temperature due to an inappropriate reduction of solar radiation by 20 percent in the river models.
Response 157:
Please refer to the response to comment A10 regarding the solar radiation calibration.

Comment 158:
Pages 4-40 and 4-41, Figures 4.14 and 4.15. These plots of temperature "changes" (and others like these elsewhere in the Revised Draft TMDL) provide little analytical value, particularly because: (1) there are no tabular statistics on the "changes" or differences; (2) the scales are such

that quantitative interpretation is difficult; and (3) the data sets used to calculate the “changes” or differences are not provided. Identifying a metric, most usefully based on model uncertainty, and examining results in a more rigorous manner (e.g., a basic exceedance plot), would provide considerably more information and form a more robust assessment. For example, if uncertainty analysis identified that the model was accurate to within 0.5°C, then an exceedance plot of the differences could be constructed and the probability of differences over 0.5°C could readily be presented consistently throughout the entire document.

Response 158:

See the response to comment C72.

Comment 159:

Because model uncertainty was not quantified in the Revised Draft TMDL, the results in Figures 4.14 and 4.15 cannot be interpreted in a meaningful manner. Further, when notable discrepancies occur, such as in November, some discussion in the text should follow. Why would fall temperatures be so much warmer under a TMDL compliance condition than under existing conditions? Lack of interpretation and investigation of model output throughout the draft TMDL, i.e., why discrepancies occur, suggests that the models may have been used as “black boxes” with emphasis on the final model output and minimal regard to why the values are what they are.

Response 159:

See responses to comments C73 and A2.

Comment 160:

Page 4-41, Paragraph 1, Lines 1-3. The Revised Draft TMDL states that daily average temperatures “regularly exceed” 20 °C in the Klamath River. No figure is provided, no data presented. What does the term “regularly” mean?

Response 160:

See response to comment C74.

Comment 161:

Page 4-42, Paragraph 1, Line 7. Please provide the Revised Draft TMDL’s definition of a thermal refugia. This paragraph suggests that the Regional Board staff have simply made a determination that a temperature condition below 20°C defines a thermal refugia. This is based on the statement that “temperatures above 20°C (68°F) do not adequately support adult Chinook migration and holding”. Referring to work by Strange (2006), “[R]esults from 2005 supported the conclusion from previous study years that the thermal threshold for migration inhibition for KRB adult Chinook occurs at mean daily water temperatures (MDTs) of 23.5°C during falling water temperature trends, at MDTs of 21.0°C during rising water temperature trends, and at MDTs of 22.0°C during stable temperature trends”. (See page 5 of Strange [2006]). Further, is the TMDL’s definition of a thermal refugia based on adult migration and holding, and not over-summering juveniles?

Because the conditions of thermal refugia are not defined in the draft TMDL, a quantitative approach to assessing refugial areas cannot be completed. There is considerable literature specific to the Klamath River available to draw from, but these sources were not considered in the TMDL analysis. For example, the Revised Draft TMDL does not mention the Reclamation-funded four-year study of thermal refugia in the Klamath River below Iron Gate dam. All of the documentation associated with this work, as well as other associated literature, was supplied to Regional Board staff in April in response to a request for information. This work was guided by a technical committee (USFWS, DFG, Yurok Tribe, Karuk Tribe, and others) which met each year prior to field season to provide review of study methods and results and input on study plans and flow schedules. The work was carried out cooperatively with the Yurok and Karuk Tribes, Watercourse Engineering, and Reclamation. Multiple thermal refugia were investigated representing upper river (Beaver Creek), middle river (Elk Creek) and lower river (Red Cap Creek). Intensive field surveys included mapping bed forms and fish counting polygons, collecting local velocities, extended period temperature monitoring, meteorological observations, exploring water temperatures in regions of upwelling, and extensive fish counts. In addition, many other creeks and areas were explored to further an understanding of refugial areas. Aerial FLIR was also implemented to capture a snapshot of a large number of potential refugial areas. Based on the available work of thermal refugia in the Klamath River, considerable thought has been given to the definition of thermal refugia, and the single temperature approach suggested in the Revised Draft TMDL is insufficient. Refugial areas in the Klamath River require several key attributes:

- persistence and stability (at a minimum these features must be continuously functional during the late spring through summer period).
- fish utilization (habitat, which may differ among species).
- appropriate temperatures for species present (each species may have a different thermal tolerance).
- appropriate flow (this may or may not include connectivity to the mainstem, but this is determined on a case-by-case basis. Protection of the watershed baseflow is critical).
- meteorological considerations (affects tributary stream temperatures as well as mainstem Klamath River)
- **Response 161:**

See responses to comments C74 and C75.

Comment 162:

Page 4-42, Figure 4.16. Please provide the year of the data (presumably 2000). Providing a range of years will also be useful for comparison. A more comprehensive presentation of the Shasta River analysis is required. This figure presents information, but there is no technical appendix outlining approach, assumptions, or presentation of data. There is no quantitative discussion of uncertainty. Further, recent work in the Upper Shasta River (Jeffres et al 2008, Jeffres et al 2009) should be considered in the TMDL for natural conditions baseline. Jeffres et al (2009) concludes that assumptions basic to the cold water determination on the Shasta River were overstated. More recent studies indicate that spring temperatures in Big Springs Creek are probably between 2 and 4°C warmer than assumptions in the Shasta River TMDL. Further, these studies have identified severe limitations to riparian shading for extended reaches of the Shasta River due to soils conditions. These important findings indicate the Shasta River TMDL temperature analysis should be revisited. Available data suggest that water temperature reductions that are assumed to be achievable in the Shasta River under an implemented TMDL for the Shasta River are too optimistic. Thus, the Shasta River water temperatures assumed in the Klamath River TMDL analysis are colder than can likely be achieved.

Response 162:

See response to comment C76.

Comment 163:
Page 4-51, under Effects of Sediment Loads on Klamath River Tributaries. Excessive sediment loads create unique dynamics in the Klamath River thermal refugia. In the upper system – above the Scott River – where annual flow ranges are modest, most tributaries enter at elevations that match that of the river, which essentially provides access to the creek (e.g., Bogus, Cottonwood, Beaver, Horse Creeks…Humbug Creek is an exception). As one progresses downstream and the river flow range increases dramatically, tributary mouths are often located well above the river, with the tributary crossing alluvium to reach the main stem. In certain cases these creek mouths are several feet above the Klamath River summer flow stage and become disconnected. Longitudinal location and complex geomorphology conditions have direct implications on thermal refugia formation. For example, the timing of winter floods and subsequent snowmelt hydrographs in tributary streams play an important role in the alluvial conditions at the mouth of tributaries because the flows (and thus sediment delivery) are often not coincident. These dynamics are discussed in USBR (2005). In sum, this is a complex issue and unique to each tributary. This paragraph is speculative and adds little to the technical TMDL regarding temperature impacts associated with sediments and approaches to managing these unique and valuable resources.
Response 163:
See response to comment C87.

Comment 164:
Page 4-51, Paragraph 4. Although floods have occurred, the riparian vegetation shading conditions, and associated temperature conditions, have recovered in many tributary situations. Using post-1997 flood conditions is not necessarily conservative – those conditions represent an element of natural disturbance regimes and need to be accounted for in the Revised Draft TMDL.
Response 164:
In the analysis discussed, Regional Water Board staff evaluated the elements of unnatural disturbance regimes that result in elevated temperatures.

Comment 165:
Page 4-51, last paragraph. The Revised Draft TMDL states, "Furthermore, because the downstream endpoints of the modeled reaches are near the mouths of the streams where streams are already near equilibrium…" Equilibrium with what conditions? Are they in equilibrium with the Klamath River? The discussions in the Revised Draft TMDL have not incorporated findings from four years of thermal refugia study completed by the U.S. Bureau of Reclamation in cooperation with the Karuk and Yurok Tribes.
Response 165:
See response to comments C75 and C85.

Comment 166:
The draft TMDL does not define a thermal refugia. Appendix 9 includes maps of known thermal refugia, but no specifics are provided; rather it simply looks as if the Revised Draft TMDL assumes that nearly every named tributary below the Shasta River is a refugia. A rapid assessment of all refugia, as per USBR (2006) is recommended to define the functional value of these unique areas.

Response 166:
See response to comment N11.

Comment 167:
Page 4-53, Section 4.2.4.3 Nutrients and Organic Matter. The Revised Draft TMDL states: "These loads were calculated based on the best available quality assured concentration data from 2000 through 2007 and flows from the 2000 calendar year." The Revised Draft TMDL needs to clarify whether all data used in the TMDL has undergone such quality assurance. For example, has all of this CBOD data undergone quality assurance? Further, this data covers multiple years, yet the Revised Draft TMDL does not indicate the range of values.
Response 167:
The Regional water Board staff obtained TMDL data from agencies and entities with approved QA/QC programs including PacifiCorp, Bureau of Reclamation, USGS, USFWS, Yurok Tribal Environmental Program, Karuk Department of Natural Resources, among others. Much of this data has been provided to PacifCorp for their review and use. The last sentence in the comment is unclear; many of the data analyses used in the TMDL do show ranges.

Comment 168:
Page 4-55, Figure 4.23. A fundamental flaw with Figure 4.23 is the fact that the natural conditions baseline is unattainable at a minimum for phosphorus. Year-round data from Jeffres et al (2008, 2009) throughout the Shasta Valley show that total phosphorus concentrations on the order of 0.15 mg/L are typical background river concentrations. These background concentrations in spring contributions (e.g., Big Springs, Carrick Spring, Boles Creek spring, Beaughan Creek spring, Hole in the Ground spring) to the Shasta River typically range from 0.15 mg/L to 0.20 mg/L. With a mean annual flow of 180 cfs, and an average background total phosphorus concentration of 0.15 mg/L (with winter season averages being similar when biological activity is at an annual minima) – largely derived from geologic sources – the load to the Klamath River is over 100,000 lbs/yr for the Big Springs Complex alone. Given that much of the base flow of the Shasta River above Big Springs Creek (and including Little Springs) originates as spring flow, and that the baseflow for the Little Shasta River also derives considerable base flow from similar geology, a natural conditions baseline load of roughly 100,000 lbs/yr is unachievable. Further, annual average concentrations of total N are on the order of 0.5 mg/L (with winter season averages being similar when biological activity is at an annual minima), leading to a load of approximately 300,000 lbs per year – well above the estimate of approximately 200,000 lbs/yr included in Figure 4.23. Winter concentrations are similar to annual values, which suggests that a reasonable background concentration is also on the order of 0.5 mg/L, indicating that the natural conditions baseline load of approximately 80,000 lbs/yr background is probably unachievable. To the extent that the Jeffres et al (2008, 2009) data disagree with the Shasta River TMDL assumptions, the more recent, extensive, and detailed year-round monitoring work of Jeffres et al (2008, 2009) is probably more appropriate as a starting point for TMDL analysis, and suggests that the Shasta River TMDL should be reexamined and load allocations reviewed in light of more recent data.
Response 168:
This comment is addressed in response C38.

Comment 169:
Page 4-55, Last Paragraph. There is no presentation of dissolved oxygen data. At a minimum a description of data used, methods for filling data gaps and other assumptions outlined, and graphical and tabular presentation of dissolved oxygen data along with corresponding dissolved oxygen saturation percentage should be provided. Without such information, review of assumptions is not possible. Review of the model input files shows that all minor tributaries to the Klamath River are placed at 90 percent of saturation under current conditions and 100 percent of saturation under natural baseline condition. This important assumption is undocumented in the TMDL. What is the basis for this assumption? Limited grab sample and water quality probe data suggest many of these tributaries are oligotrophic and, with perhaps the exception of sediment and in some cases temperature, have dissolved oxygen concentrations at saturation. Why assume dissolved oxygen impairment in these tributaries where none may exist? At a minimum, a sensitivity analysis should be completed and clear documentation of the conditions and results presented.
Response 169:
The following is the response drafted to this comment when it was made on the June 2009 draft of the report.

Chapter 4 of the Klamath TMDL Staff Report (pages 4-1 through 4-34) is the Pollutant Source Analysis. As described in the first paragraph of this chapter, "the purpose of a TMDL pollutant source analysis is to inventory and describe all sources of pollutants that are impacting the water quality standards of the impaired waterbody." DO is not considered a pollutant source, but one of the water quality parameters affected by pollutant sources. As such, Chapter 4 does not include a discussion of DO data, data gaps, and other assumptions with respect to DO; but, focuses on organic matter, nutrient and temperature loading as pollutant sources.

Chapter 2, describing the Klamath River Problem Statement, provides a conceptual model of the relationship among stressors (e.g., pollutants), environmental conditions (e.g., DO concentrations and diurnal fluctuation), responses/outcomes (e.g., decreases spawning and reproductive success), and beneficial use impairment (e.g., loss of salmonid fishery). It also provides in tabular and graphical form the results of DO data collection in the mainstem Klamath River. With respect to the DO data used to populate the Klamath TMDL model, a summary is given in Chapter 3, Analytic Approach, and a detailed description is given in Appendix 6, Klamath River Model for TMDL Development.

Thank you for your keen observation and detailed review with respect to the question of DO saturation values assigned to tributary streams. The difference in DO saturation assigned to tributaries between the compliance and natural conditions scenarios was an artifact of the length of time over which the Klamath TMDL model was developed, reviewed, revised, and run. The last revision of the model made consistent the DO saturation values assigned to tributaries in both the compliance and natural conditions scenarios. The new assignments are based on a review of historic DO saturation data and represent unimpaired conditions. As described in the DO Staff Report (Appendix 1 of the TMDL Staff Report), the newly assigned percent saturation boundary conditions are as follows:

1. For minor tributaries, 100% saturation
2. For the Shasta, Scott and Salmon Rivers, 95% saturation

3. For the Trinity River, 100% saturation

COMMENTS: CHAPTER 5. KLAMATH RIVER TMDLS – ALLOCATIONS AND NUMERIC TARGETS

Comment 170:

1. Previously submitted comment on BIP. (Text omitted).
2. Previously submitted comment that load allocations to the Project are improper to the extent that they are not addressed to pollutant loadings from the Project.
3. Previously submitted comments on load allocations that are improper because they have not been demonstrated to be reasonably achievable and are not achievable; reductions that cannot be enforced because the source is not regulated or, in some cases, such as sources in Oregon, cannot be regulated by California; and reductions that are not technically or economically practicable.

Response 170:
See responses to comments K40, K41, K53 and K54.

Comment 171:
The Revised Draft TMDL must be based on a reasonable estimate of achievable pollutant load reductions given the limits of the Board's and state's legal authority and technical and economic feasibility of the reductions. (Duplicate text omitted.)
Response 171:
See responses to comments K39, K53 and K54.

Comment 172:
Page 5-1, Paragraph 2. The Revised Draft TMDL states, "The targets and allocations, as discussed in Chapter 2, are consistent with trophic classifications that are ecologically appropriate and supportive of Klamath basin beneficial uses". The Revised Draft TMDL has systematically separated the concept of "ecologically appropriate and supportive of Klamath basin beneficial uses" from actual attainable conditions in the Klamath basin. This also relates to the first sentence on page 5-2 regarding targets appropriate for "well functioning stream systems." Again, however, a TMDL must be based on reasonable estimates of technically and economically achievable pollutant load reductions considering, among other things, local geology, hydrology, meteorology, and land uses. The load allocations in the Revised Draft TMDL are not based on reasonable estimates but have merely been established at whatever level is believed necessary to achieve the proposed water quality targets.
Response 172:
Regional Water board staff believe that the targets and allocations are achievable within the Klamath basin. The last sentence in the comment is not correct. The TMDL analysis demonstrated both background levels and remaining assimilative capacity. The allocations and targets are consistent with this analysis. See also responses to comments K39, K53 and K54.

Comment 173:
Page 5-1, Paragraph 2, Last sentence. The Revised Draft TMDL wrongly assumes that water quality issues within the reservoirs are "inherent to their operation". There is nothing in the operation of the reservoirs, operated largely as run-of-river impoundments with only a few feet

of change in surface elevation, that would inherently cause water quality problems. Even if the Revised Draft TMDL meant "inherent to their existence", the statement still would be in error because there is nothing inherent in the presence of reservoirs that causes water quality problems. In fact, it is the nutrients from upstream that are the cause of water quality impacts in the reservoirs.

Response 173:

The sentence has been revised to more accurately describe the point being made: "*Allocations are also assigned to the Klamath Hydroelectric Project (KHP) facilities to address water quality issues within the reservoirs that are controllable water quality conditions within the facilities, and to ensure that water quality standards are met.*"

Comment 174:

Page 5-1, Paragraph 2, Lines 9-11. The Revised Draft TMDL misrepresents what Welch (2009) actually says. Welch (2009) does not say that strategies to address both phosphorus and nitrogen are essential. From the conclusion of Welch's paper:

> "The results of these observations clearly show that P reduction, either from external or internal sources, most cost-effectively controls eutrophication in fresh water lakes. The author is unaware of any published case that demonstrates the effectiveness of N-only reduction, or for the necessity of N reduction in addition to P reduction."

The Revised Draft TMDL needs to be corrected to accurately reflect the words of the author (Welch 2009).

Response 174:

The text will be amended to more accurately reflect the author's (Welch) emphasis on phosphorus control strategies. The Regional Water Board's intent with the passage is to highlight the importance of phosphorus reductions to achieve long-term control of nuisance blooms. With well designed nonpoint source pollutant control strategies, nitrogen can be removed from the system at the same time. In discussions with Dr. Welch, he stated that short term nutrient ratios (e.g., nitrogen limited) can be an important consideration for growth rates but for a long-term control strategy the optimal control strategy was to reduce phosphorus loading. The Klamath River TMDL nutrient, dissolved oxygen, and organic matter (CBOD) allocations and related targets are designed to reduce the impacts of advanced eutrophication driven by land disturbance activities, the presence of reservoirs, flow alterations, and direct inputs of pollutants. The targets and allocations, as discussed in Chapter 2, are consistent with trophic classifications that are ecologically appropriate and supportive of Klamath basin beneficial uses. The allocation strategy addresses all of the stressors that are driving biostimulatory and toxicity related impairments including total phosphorus (TP), total nitrogen (TN), and organic matter (measured as CBOD). Comprehensive nutrient management strategies that address both phosphorus and nitrogen have been consistently demonstrated to be essential for successful ecosystem restoration (Welch 2009). The allocation strategy addresses all identified sources, but the largest reductions are related to loads from the upper basin source area (above Stateline) which exports the largest pollutant loads in comparison to historical or undisturbed conditions. Allocations are also assigned to the Klamath Hydroelectric Project (KHP) facilities to address water quality issues within the reservoirs that are inherent to their operation, and to ensure that water quality standards are met.

Comment 175:
Page 5-3, Table 5.1. Table 5.1 in the Revised Draft TMDL has several flaws:

1. Under Watershed Temperature, Table 5.1 states that allocations allow for natural disturbances, but no analysis is provided in the Revised Draft TMDL regarding frequencies, magnitudes, durations, etc. for such natural disturbances. Without such analyses, these allocations cannot be determined or targets applied.

Response 175:
Please see response to comment D35.

Comment 176:

2. In addition to not being based on a BIP determination, and unnecessary to ensure a BIP, see, e.g., Findings of Fact on USFWS/NMFS Issue 2(A) and at pages 14-19, 36, 68-69 in McKenna (2007) and PacifiCorp's 401 Certification Application (PacifiCorp 2008b) at pages 5-60 to 5-104, a temperature allocation of "zero increase above natural temperature" is not possible to meet – a "zero increase" is not measurable, and it makes no allowance for interannual variability or seasonality. No sensitivity analysis was completed to determine the range of potential "natural" temperatures. How will this be assessed by Regional Board staff: how will natural temperatures be defined for 2010 or any future year?

Response 176:
In regards to the BIP (or lack thereof), see response to comment K40. In regards to the zero increase, the allocation is quite simple, don't add heat to the system. The measurability of "zero" can be addressed in any regulatory action that implements the TMDL. However, defining zero based on what is measurable today is inappropriate, as technologies to measure water temperatures change. Ultimately, the allocation cannot be anything but zero, given the water quality standards and the absence of BIP support.

Comment 177:

3. Apart from the technical and economic infeasibility of the Stateline monthly temperature targets and allocations, they are generally, and perhaps wholly, more stringent than the Oregon water quality standard for temperature just upstream of the state line, which is 20º C (expressed as a seven-day average of daily maximum temperatures) and includes a human use allowance when the temperature exceeds 20º C. *See* OAR 340-041-0028(4)(e), (12)(b). Although the Revised Draft TMDL asserts that the Stateline targets and allocations are consistent with the "Oregon allocation scenario," it is not clear how the Stateline targets and allocations are achievable given Oregon's temperature standard.

Response 177:
The Oregon temperature standard allows for a human use allowance of 0.3 ^{o}C (0.54 ^{o}F) temperature increase when natural temperature conditions are above the numeric temperature criteria, which is 20 ^{o}C (68 ^{o}F) in this situation. Oregon's Antidegradation Policy addresses temperature increases when temperatures are below 20 ^{o}C. The human use allowance is distributed among the point and non-point sources of Klamath River temperature increases in Oregon. Because of the magnitude and locations of thermal sources in Oregon, the Klamath River temperatures at Stateline that result from implementation of Oregon's temperature standard are consistent with California's water quality objective for temperature.

Comment 178:
An allocation based on either a "compliance lens" of simultaneously achieved temperature and dissolved oxygen values or on "dissolved oxygen instantaneous mass" is improper because the allocation is not related to any pollutant loading from the Project.
Response 178:
See response to comment 180 below.

Comment 179:
The *Microcystis* target is too low because the WHO guideline is 20 µg/L chlorophyll *a*, and the biomass target is tied to the biomass of all cyanobacteria species, whereas only *Microcystis*, which sampling results indicate is of low abundance compared to other algal species in the reservoir (Raymond 2008b, 2009), produces the toxin microcystin. The TMDL provides no persuasive explanation for the logic of this target. The nutrient allocation for the hatchery of "zero net increase of nutrient and organic matter above …compliance scenario conditions" is not possible to meet – the compliance scenario assumes an unrealistically extreme reduction in nutrients in the system, a "zero increase" is not measurable, and it makes no allowance for interannual variability or seasonality.
Response 179:
The site-specific analysis of Klamath River reservoirs data (Kann and Corum 2009) provides a target that is tailored to the conditions being addressed by the Klamath river TMDL. The analysis provided in the staff report is based on the relationship between 20 µg/L chlorophyll *a* (10 µg/L), *Microcystis* (20,000 cells /mL), and microcystin (4 µg/L) that are protective of existing beneficial uses. Additionally see the response to comment D4.

Comment 180:
As discussed above at the beginning of comments on this chapter, the "Annual loading reduction[s]" applied as an allocation to PacifiCorp are improper because the allocations do not apply to loadings from PacifiCorp. By making such allocations, the Revised Draft TMDL is allocating a "negative load", which in turn means that PacifiCorp would have to reduce the load of a pollutant that PacifiCorp neither contributes nor controls. Since PacifiCorp currently discharges no load to the Klamath River (see Figure 5-1), a negative load is not only legally improper but illogical and unreasonable.
Response 180:
It is incorrect that the load allocations for the KHP force PacifiCorp to reduce a load of a pollutant that it neither contributes nor controls. First, a load allocation is a number assigned to a water body that ensures the attainment of water quality standards and protection of beneficial uses. The TMDL demonstrates that the load allocations are necessary to ensure the protection of beneficial uses in the reservoirs. The reservoirs are the source, and the impairment that the allocations address would not exist in the absence of that source. Second, a load allocation to a source will often imply that a reduction is necessary, but as previously stated, such a reduction requirement must be imposed pursuant to some order or other regulatory or non-regulatory implementation vehicle as appropriate. Regional Water Board staff have clarified in the TMDL that the load allocations could be met by alternative management measures or offsets. Regardless, PacifiCorp is responsible for the water quality conditions in its reservoirs. The TMDL implementation plan provides a flexible structure designed to allow offsets for an interim time period while restoration options are explored and pursued.

See also response to comment K53 and K54.

Comment 181:
Page 5-6, Paragraph 4. Applying a margin of safety (MOS) to periods of time during which beneficial uses (BUs) are not impaired or at risk from the pollutant is unnecessary and improper. There is a brief statement in the Revised Draft TMDL regarding periods when beneficial uses are not impaired and that the "timing of those periods changes from year to year and is difficult to predict," but there is no analysis to support this statement. Moreover, notwithstanding the availability of a "comprehensive, dynamic numerical model," no effort whatsoever has been made to identify the periods when there is sufficient uncertainty to require a margin of safety. The Clean Water Act's margin of safety requirement is not a justification for adopting the most conservative load allocation possible. The imposition of a margin of safety must be justified by facts and analysis.
Response 181:
Please see the response to comment E8.

Comment 182:
Page 5-7, Paragraph 3, Lines 7-10. The Revised Draft TMDL states that "TP, TN, and CBOD allocations are assigned to PacifiCorp at the upstream end of Copco 1 Reservoir in order to meet the chlorophyll *a*, *Microcystis aeruginosa* cell density, and microcystin targets within the reservoirs". For the reasons discussed in the comments above and below, such allocations are legally improper, unprecedented, and unreasonable.
EPA's TMDL guidance states, "The process of calculating and documenting a TMDL typically involves a number of tasks, including characterizing the impaired waterbody and its watershed, *identifying sources*, setting targets, calculating the loading capacity using some analysis *to link loading to water quality*, identifying source allocations, preparing TMDL reports and coordinating with stakeholders." Draft Handbook for Developing Watershed TMDLs, U.S. EPA, December 2008, at 1 (emphasis added). Moreover, EPA's TMDL regulations define a "load allocation" as "[t]he portion of a receiving water's loading capacity that is *attributed* either to one of its existing or future nonpoint sources of pollution or to natural background sources." 40 CFR § 130.2(g) (emphasis added). To "attribute" a loading is "[t]o relate [it] to a particular cause or source." *American Heritage Dictionary of the English Language* 120 (3d ed. 1992).[3] A load allocation, then, is a statement of fact. Because PacifiCorp is not the cause or source of the nutrient loading upstream of Copco Reservoir, the Revised Draft TMDL cannot truthfully attribute that loading to PacifiCorp. As such, the Draft Revised TMDL cannot permissibly assign any nutrient load allocation—positive, zero, or negative[4]—to PacifiCorp upstream of Copco Reservoir.
Response 182:
It is incorrect that the load allocations for the KHP force PacifiCorp to reduce a load of a

[3] Compare EPA's definition of "wasteload allocation," which applies to point sources: "The portion of a receiving water's loading capacity that is *allocated* to one of its existing or future point sources of pollution." 40 C.F.R. § 130.2(h) (emphasis added). To "allocate" a loading is "[t]o distribute [it] according to a plan." *American Heritage Dictionary of the English Language* 49 (3d ed. 1992). Thus, whereas the "attribution" of a pollutant loading is a factual statement of its source, the "allocation" of a pollutant loading is the assignment of a pollutant loading *to* a source.

[4] Given what a load allocation is, of course, a negative load allocation is nonsensical.

pollutant that it neither contributes nor controls. First, a load allocation is a number, or a condition that can be quantified, that is assigned to a water body that ensures the attainment of water quality standards and protection of beneficial uses. The TMDL demonstrates that the load allocations assigned to PacifiCorps are necessary to ensure the protection of beneficial uses in the reservoirs. By altering the assimilative capacity of biostimulatory substances, the reservoirs are the source, and the impairment that the allocations address would not exist in the absence of that source. Second, a load allocation to a source will often imply that a reduction is necessary, but as previously stated, such a reduction requirement must be imposed pursuant to some order or other regulatory or non-regulatory implementation vehicle as appropriate. Regional Water Board staff have clarified in the TMDL that the load allocations could be met by alternative pollutant load reductions and/or alternative management measures or offsets. Regardless, PacifiCorps is responsible for the water quality conditions in its reservoirs. The TMDL implementation plan provides a flexible structure designed to allow offsets for an interim time period while restoration options are explored and pursued. See also response to comment K53 and K54.

Comment 183:

Pages 5-12 to 5-14, Figures 5.1 to 5.3. There are substantial errors and flaws in Figures 5.1 to 5.3. To begin with, values in the figures don’t add up (See Table A8 below). When the difference between the loads at each division of the watershed (column 4 in the table below) is compared to the sum of the loads shown on the table (column 5 in the table), none of them match. There is no explanation for these discrepancies provided in the Revised Draft TMDL. These errors call into question the Revised Draft TMDL’s analysis and conclusions. These errors need to be corrected. It is not possible to adequately evaluate the TMDL with so many of the sources and sinks inaccurately represented.

Table A8. Klamath River Revised Draft TMDL total phosphorus load balance by locations (values from Figure 5.1)

Location	Figure Loads	Calculated Loads	Difference values	Summed values
Stateline	40,569	40,569		
PacifiCorp		-10,148		
Full flow	30,421	30,421		
input?			-2,334	30,421
Copco	28,087	30,421		
Benthic		0		
Tribs		3,709		
Benthic		0	973	3,709
Iron Gate	29,060	34,130		
Hatchery		0		
Tribs		8,026	8,120	8,026
	37,180	42,156		
Shasta		12,366		
Tribs		6,302	13,484	18,668
	50,664	60,824		
Scott		62,851		
Tribs		30,951	46,484	93,802
	97,148	154,626		
Salmon		31,898		
Tribs		14,843	0	46,741
	97,148	201,367		
Trinity		126,167		
Tribs		29,585	206,902	155,752
Total	304,050	357,119	273,629	357,119

<u>Response 183:</u>
Figures 5.1, 5.2, and 5.3, from the previous June draft were inadvertently left in the December draft. The correct figures have been inserted. PacifiCorp is reminded that the figures were not intended to add up – please refer to the figure descriptions in chapter 4 and Chapter 5 for clarification.

<u>Comment 184:</u>
Pages 5-12 to 5-14, Figures 5.1 to 5.3. These figures misrepresent the facts (at least the “facts” as they are presented in the figure) by manipulating the widths of the arrows, which are clearly meant to be understood as representing the magnitude of the loads. The figures mislead the viewer as to the relative loads. For example, the load arrow for Iron Gate reservoir is nearly four times as wide as the arrow for Copco reservoir, but the load is only 3 percent greater. Similarly, the load arrow for the Scott River is approximately 15 percent of the width of the Iron Gate arrow, but the Scott River load is more than twice as large as the Iron Gate load. These figures need to be redrawn to accurately represent the relative magnitudes of the loads, or it should be

clearly stated for these figures that the arrows are purely decorative and intended to have no quantitative meaning.

Response 184:

The arrow width was inadvertent and has been corrected. The loads were clearly labeled, the intent described by PacifiCorp in the comment is not correct.

Comment 185:

Pages 5-12 to 5-14, Figures 5.1 to 5.3. The Introduction of the Revised Draft TMDL indicated that analysis of TMDL compliance in California is based on compliance conditions being achieved in Oregon, including compliance with the Upper Klamath River TMDL and the Lost River TMDL. Figure 5-1 reinforces that by showing the load allocation from Oregon at Stateline equal to compliance conditions with the Oregon TMDLs with Keno dam and J.C. Boyle in place. However, as the Klamath River crosses the state border, the load allocation is suddenly reduced by approximately 25 percent, ostensibly to represent the Revised Draft TMDL's inappropriate negative "annual nutrient loading reduction" applied to PacifiCorp. In reality, there is no PacifiCorp facility at Stateline that could account for this difference, and PacifiCorp neither contributes to nor controls Stateline nutrient loads. Because the TMDL states that this negative load reduction is necessary to meet the unrealistic and unachievable target of 10 µg/L chlorophyll *a*, it is clear that the California TMDL targets cannot be met under Oregon TMDL compliance conditions.

Response 185:

The allocation assigned to PacifiCorp above Copco Reservoir (not at Stateline), which requires a nutrient load reduction, is required to address controllable water quality conditions within PacifiCorp facilities. The target of 10 µg/L chlorophyll *a* is both appropriate and achievable. The target of 10 µg/L chlorophyll *a* was identified as a special focus topic for the staff report peer review. The peer reviewers all agreed that the target was appropriate. The Regional Water Board will evaluate alternative means that PacifiCorp recommends as part of their TMDL implementation plan for achieving desired water quality conditions within their facility.

Comment 186:

Pages 5-12 to 5-14, Figures 5.1 to 5.3. On each of these diagrams, "Benthic load" should clearly be identified as "Net Benthic Load" or otherwise re-labeled. Any such benthic load is only from sediments to water column, and does not account for the load lost from water column to sediments.

Response 186:

Comment noted; no change of text is required.

Comment 187:

Page 5-15, Paragraph 2, Line 2-4. The Revised Draft TMDL states that uncertainty in the analysis was reduced "by applying a comprehensive, dynamic numerical model." It does not state, however, how uncertainty was reduced by the model or by how much. Models may increase precision of results (even to a ridiculous level, e.g. "load = 2,253,542 kg), but accuracy is not necessarily increased (Deas and Lowney 2000). As discussed in our comments on Appendix 7, the TMDL modeling did not incorporate enough data in model calibration and validation. Also, there was not enough evaluation of model uncertainty to make the statement that "uncertainty was reduced … by applying (this) model."

Response 187:
Regional Water Board staff does not agree with this comment. See Appendix 6 for the evaluation and analysis of model uncertainty.

Comment 188:
Page 5-15, Paragraph 2, Line 5. The Revised Draft TMDL claims that the model takes advantage of “data collected over multiple years,” but the model was only calibrated based on 2000 data. It is true that data from multiple years was used to form certain boundary conditions where limited data were available, but the hydrology and meteorology – two principal drivers – were taken from the year 2000 only. Using multiple years of data may improve certain elements of model inputs, but it may also lead to increased uncertainty by mismatching in time hydrology and meteorological conditions with actual water quality responses. This is not discussed in the draft TMDL
Response 188:
Please refer to Appendix 6 for a description of model calibration.

Comment 189:
Page 5-15, Paragraph 2, Line 9-11. What is the basis for the statement that “the largest source of uncertainty in this system is the highly variable and dominant loading from Upper Klamath Lake”? There is no analysis, no documentation, no citation, no quantification, or other description of this issue. Further, how does this relate to downstream reaches all the way to the estuary? This statement suggests that UKL boundary conditions have a larger impact on the estuary than other factors, such as Trinity River flows, lack of detailed estuary geometry, lack of detailed estuary data, etc. This line of questioning can be applied to all river reaches downstream.
Response 189:
The TP, TN, and organic matter loadings from UKL are much larger than any other single input and the year to year variability is larger than any single element of the modeling analysis.

Comment 190:
Page 5-15, four bullets summarizing “Conservative assumptions”. Klamath River water quality dynamics are complex, varying considerably in space and time. Even though the numerical model included a wide range of parameters, constants, and coefficients, the model does not include all relevant processes. For example, the model has the following limitations affecting uncertainty:

- The model includes only a single algae group on the mainstem reservoirs,
- The model includes only a simple sediment model in both the river and reservoirs,
- The model includes incorrect partitioning of organic matter at Link dam
- The two-group algae model for Keno reservoir is completely untested and parameter values have no basis,
- The model’s representation of Iron Gate outlet works has been specified instead of simulated,
- The available data for modeling are limited in winter throughout the system, and
- Only a single year is modeled.

Comments on the individual bullet points listed on page 5-15 follow.

Bullet point 1. Without a presentation of the current SOD and its impact on oxygen levels in the river, this bullet point cannot be interpreted. Further, SOD is a small player in the overall dissolved oxygen conditions in the river reaches because of the limited deposition of organic matter (high shear environment) and the near continual mechanical reaeration in the Klamath River due to the high gradient (and once the river gradient diminishes below Orleans, dissolved oxygen is much less of an issue). SOD is an insubstantial factor and, although this is a conservative assumption, it is also negligible.

Bullet point 2. "Timing of allocations" is based on the scenario with greatest loads from UKL and has no stated basis, explanation, or citation. "[M]agnitudes of allocations are based on median loading conditions from UKL," would mean that 50 percent of the time loads are greater than those upon which allocations are based. This is incorrect. Loads are based on the 1995 conditions – one of seven years of data (1992-98) used in formulating the UKL TMDL load allocation. Further, 1995 is the second lowest year of the seven years, and less than 50 percent of the 7-year mean conditions. Thus, if the UKL is accepted as "representative" of a range of conditions from 1992-98, the majority of years (5 out of 7, or 71.4 percent of the time), TMDL compliant conditions as defined in the California TMDL will not be met. The representation of this in the California TMDL is erroneous, misleading, and presented with such brevity that without considerable data and information requests from Regional Board staff, ODEQ, and EPA, such a condition would never have been identified. This is another example of the critical nature of uncertainty analysis and a clear limitation of modeling only a single year for TMDL load allocations in a complex basin such as the Klamath River.

Table A9. Upper Klamath Lake TMDL model output for 40% reduction case. Highlighted row (1995) is the information used in the California TMDL (ODEQ, 2002).

Year	Outflow (kg/yr)	Percent of 7-yr Average
1992	13,854	21.6%
1993	114,637	178.5%
1994	50,860	79.2%
1995	30,237	47.1%
1996	103,839	161.7%
1997	83,970	130.8%
1998	52,057	81.1%
Mean	64,208	100.0%

Bullet point 3. This bullet point describes a simplistic approach that reduces all nutrients to low levels. There is no nutrient reduction strategy that targets one (N or P) – an approach that is fundamental to water quality management. In retrospect, this is not a surprise because no assessment of trophic status or nutrient limitation was completed for the Klamath River under an existing or a TMDL compliant condition. Without a clear nutrient limiting strategy (even if that strategy is co-limitation), implementation actions will be severely hampered and valuable resources will be wasted. It is important to reduce both nutrients, but it is also important to identify a limiting nutrient so effective water quality improvement actions can be identified, prioritized, and implemented at an appropriate time. This may also be a conservative assumption, but it is also too simplistic and could ultimately hamper the effective implementation of the TMDL.

Bullet point 4. Basing analyses on low flow conditions is not necessarily conservative. Higher flow does not mean less WQ impact as higher flows can result in higher loadings for similar in-

stream concentrations. In short, this is not conservative, particularly if dam removal occurs prior to effective implementation of nutrient and organic matter reductions in Oregon.
Page 5-17, Table 5.2. The Revised Draft TMDL includes Table 5.2 specifying TMDLs for TP, TN, and CBOD (in pounds) by source area. It is noteworthy that the values in Table 5.2 for the "Upstream of Copco 1", and "Stateline to Iron Gate inputs" source areas are about one-tenth to one-third of the TMDL values for TP, TN, and CBOD for these source areas given in the original Draft TMDL. Such a large disparity and apparent correction made for these TMDL values in the Revised Draft TMDL suggests potential issues with the analysis used to derive these values. See comments on Appendix 7 presented later in this document.

Response: 190

The limitations identified in the first series of bullets above were identified in Appendix 6, with the exception of the model's representation of the Iron Gate outlet works. Specification of Iron Gate outlet works is not viewed as a limitation due to operations associated with the dam flow. Using the actual flow data is the most realistic and accurate way of representing outflow conditions. It should also be noted that partitioning of organic matter was documented in Appendix 6, and it was verified through model calibration. Available data are not appropriate for application to the modeling time period.
Relative to the comment on bullet point 1 on SOD: Regardless of the magnitude of SOD impact, its representation is still considered a conservative assumption.

Relative to bullet point 2 – The median UKL scenario used is *concentration-based* not load-based.

Relative to comment on bullet point 3: Nutrient limitation was indeed evaluated throughout the analysis. P-limitation and co-limitation occurred at different times and different locations. Additionally, the UKL TMDL focused on P reduction. Due to these factors, it was deemed appropriate to maintain a P-limiting or co-limiting condition downstream. The nonpoint sources are reduced for all nutrients. Reduction of P through management strategies of nonpoint sources would likely result in reduction of N and BOD as well.
Loading alone does not necessarily have a bearing on water quality compliance. Yes, higher flow would result in higher loading for a constant concentration. But, the concentration is important. For the TMDL scenario, the upstream inflow concentration is low based on the UKL TMDL. As such, even small source contributions may have a significant impact on in-stream conditions. Conditions are more critical at a lower flow. In this situation, low flow is more conservative than high flow. The TMDL model was not used to evaluate conditions without implementation with dams down.

5.2 Temperature-Related Numeric Targets and Allocations

Comment 191:

Page 5-18, 5.2.1.1 and associated figures. The Revised Draft TMDL states "Accordingly, the temperature load allocations for shade are equal to: the shade provided by topography and full potential vegetation conditions at a site, with an allowance for natural disturbances such as floods, wind throw, disease, landslides, and fire." This should include local geology, geomorphology, and some level of vegetation potential. Full vegetation potential is not defined. In the subsequent paragraph effective shade is defined as that which is "blocked by vegetation or

topography before reaching the ground or stream surface, and takes into account the differences in solar intensity that occur throughout a day." Vegetation setback is a critical element of this analysis – how far from the water's edge (on July 21st) is the vegetation located—because shading a point bar or other land features offers few benefits. What is the presumed setback for each vegetation type in this analysis? Also, is wetted depth always the same: 0.25 meters? What does this represent and how does this play into the analysis? What is buffer width? Also, the text mentions that the 1/3 of bankfull width was assumed, but the graphs identify 100 percent of bankfull width as the x-axis. What was the channel form if 1/3 of bankfull width was applied? Were different channel forms explored? Please explain the legend and an interpretation for the four lines. Which aspect will be applied for a specific application of these criteria, the average, or one of the directions? What does density refer to? As presented, the effective shade information is not readily interpreted, and a complete comment cannot be submitted.
Topographic shading is mentioned in this section, but little is said how this is included into the "effective shade" graphs. Topographic shading is due to local terrain and can include mountains, hills, stream banks, boulders, and other land features that cast shade. In fact, there is no real way to include topographic shading in the manner presented in the Revised Draft TMDL because topographic shading is a function of stream aspect, local topography and time of year. Small topographic shade elements (e.g., banks, in stream rocks and boulders) can have profound effects on small streams and should be defined on a stream-by-stream basis.
Time of year is not addressed in Figures 5.4 through 5.9. However, day length and solar altitude are critical elements in assessing solar radiation reductions for aquatic systems and how they impact local temperatures. Summer solstice provides the longest day length and highest solar altitude in the Klamath Basin, but maximum temperatures do not occur until approximately August 1. The Revised Draft TMDL needs to clarify the date that these figures apply, or whether they are seasonally averaged. If they are a seasonal average, the period used for the average needs to be clarified. Finally, the Revised Draft TMDL needs to describe the analysis, source of data, assumptions (setback from bank, density, solar transmittance), including supporting documentation.

Response 191:

The assumed setback is zero, with no overhang. Topographic vegetation would add shade to the values presented in the figures. Time of year (July 21) is discussed on page 5-18. The text states that the **wetted** width was assumed to be 1/3 of bankfull width. The wetted depth is always 0.25 meters in the analysis, but depth has no appreciable effect on results. The lines correspond to stream aspect. Density refers to the density of vegetation. See also response to comments D41 and D42.

Comment 192:

Page 5-23, Paragraph 1 under Excess Sediment. The temperature load allocation for human-caused discharges, "zero temperature increase," is not defined, and is therefore impractical and unachievable. Regarding the definition of "substantial human-caused sediment related channel alteration", it is unclear how an action that "increases channel width, decreases depth, or removes riparian vegetation to a degree that alters stream temperature dynamics and is caused by an increased sediment loading" can be measured against natural processes in the system. What is the baseline? What is the metric for sediment loading? How and where is this measured? How are legacy activities incorporated? Who is responsible for monitoring and assessing potential changes, let alone defining what fraction of the impact is due to natural processes or human-

caused actions? Without such guidance, regulatory oversight will be vague and implementation of actions ineffective.
Page 5-25, Table 5.3 (and Tables 5.4 and 5.6). Presenting a range for the temperature numeric targets would be more beneficial. The TMDL should describe exactly how the values in the table were derived. Do the values in the table account for climate change. If not, why not? Also, the TMDL should describe how monthly average temperatures were chosen as the applicable metric and time-step. Monthly averages represented in Table 5.3 (and Tables 5.4 and 5.6) have only limited biological value.

Response 192:

See responses to comments D44 and D45. Climate change is mentioned in the text, but there is no explicit mechanism to alter the TMDL targets in response to climate change. However, the Klamath TMDL is a living document that can be revised as new information and understanding warrants. The science of climate change is rapidly developing, and Regional Water Board staff expect an evaluation of anticipated climate change effects on the Klamath River to be completed as part of the secretarial determination process. The TMDL targets can be revised in the future, if information warrants it.

Comment 193:

Page 5-26, under 5.2.3 *Temperature Numeric Targets and Load Allocations to Copco 2 and Iron Gate*. The targets present in this section need to be re-assessed with the 0.8 solar reduction factor removed from the riverine sections of the TMDL's RMA-11 models. The PacifiCorp (2005) models were reviewed by USGS and Risley and Rounds (2006), including calibration performance. These reviews suggested no reason for reduction of incoming solar radiation. Further, applying such a reduction globally to the entire Klamath River is inappropriate and unreasonable.

Response 193:

Please refer to the response to comment A10 regarding the solar radiation calibration.

Comment 194:

Page 5-26, first sentence on page. The temperature allocation at Stateline is "zero increase above natural". "Zero increase" is not measurable, and is therefore impractical and unachievable. How does this allocation specifically relate to the values listed in the previous Table 5.3? The values in Table 5.3 appear to be intended as monthly average temperatures at Stateline. However, these values do not account for inter-annual variability and simply reflect modeled temperatures under the "natural conditions" scenario for the year 2000. Increases above these monthly average temperatures at Stateline as a result of natural variability will make the achievement of downstream temperature allocations impossible, if they are not already so.

Response 194:

The commenter is confusing targets with allocations. Simply put, the allocation is the condition that the responsible parties have to meet, while numeric targets are a quantification of conditions that are sure to meet standards. The allocation is quite simple: don't add heat to the system. As a practical matter, temperature limits will be addressed in any regulatory action that implements the TMDL, based on the technological capabilities that exist at that time. However, defining zero based on what is measurable today is inappropriate, as technologies that measure water temperatures improve. Ultimately, the allocation cannot be anything but zero, given the water quality standards and the absence of BIP support.

Comment 195:
Page 5-26, Paragraph 2. The Revised Draft TMDL states that “Regional Water Board staff have determined that achievement of water quality standards is necessary to support a balanced indigenous population of fish and shellfish”. See above comments on section 2.3.1 of the Revised Draft TMDL.
Response 195:
See the response to K40.

Comment 196:
Page 5-27, Paragraph 1, Lines 6-8. The Revised Draft TMDL states “Because the upstream heat loads are outside of the control of the dam operators (PacifiCorp), the allocations apply to the condition of the water as it enters the reservoirs.” This statement contradicts the Revised Draft TMDL’s treatment of nutrients, in which allocations are assigned to PacifiCorp ***upstream*** of Copco reservoir. If the upstream heat loads are outside the control of PacifiCorp, by the same logic the upstream nutrient loads are outside the control of PacifiCorp.

Response 196:
Both temperature and nutrient load allocations address water quality conditions in the reservoirs. Nutrient allocations requiring upstream reductions address water quality conditions within the reservoirs (e.g., chlorophyll-a and microcystin targets) caused by the biostimulatory conditions created by the impoundments. The revised TMDL acknowledges that PacifiCorp may also address the water quality conditions in the reservoirs through in-reservoir management or offsets. Temperature effects of the reservoirs on in-reservoir water quality are addressed through the compliance lens, another form of in-reservoir management. In both cases, the allocations address water quality conditions created by the impoundments.

Comment 197:
Page 5-27, Paragraph 2, Lines 7-8. The appropriate scenario for determining “natural temperature increases” in California is the Oregon TMDL compliance conditions at Stateline and “natural conditions” downstream. Please clarify that this is the scenario to which the Revised Draft TMDL is referring. Without the Oregon TMDL available for public review, it is difficult to confirm how temperature compliance at Stateline would be achieved.
Response 197:
See response to comment D50.

Comment 198:
Page 5-27, Paragraph 3, Lines 5-10. Discussion states that “maximum temperatures periodically increase by approximately 0.5°C”. But this analysis and accompanying Figure 5.10 have little relevance because 0.5°C is more resolution than the temperature model warrants. Without actual data to assess conditions within this reach, little can be said about the daily range of temperatures. Further, Copco reservoir occupies a more open terrain than upstream reaches that are in the canyon. Thus, a reduced daily range due to more topographic shading than in upstream reaches makes little sense.
Response 198:

See response to comment D49.

<u>Comment 199:</u>
Page 5-28, Paragraph 1 (and Figure 5.11). The Revised Draft TMDL states, "These results indicate that the daily average temperature would naturally increase by approximately 0.1°C (0.2°F) through the Iron Gate reach". This statement assumed that models can predict increases of 0.1°C, i.e., that the accuracy of these models is 0.1°C or better. This assumption is erroneous. PacifiCorp (2004) provides extensive calibration statistics that indicate the models are probably accurate to no more than about 1.0°C. Misapplication of the model in this manner points to a clear need for uncertainty quantification.

<u>Response 199:</u>
See response to comment A160.

<u>Comment 200:</u>
Page 5-30, Table 5.5. The Revised Draft TMDL's temperature load allocations in reservoir tailrace waters are substantially smaller than model accuracy. Given model accuracy and the accuracy of the data collected for model calibration, load allocations of 0.1°C are not supportable. Further, the Revised Draft TMDL should describe the specific method that the Regional Board would intend be used to measure the 0.1°C increases in Iron Gate daily average and maximum. Available temperature measuring devices (including the ones used to collect calibration data for the model) are accurate only to 0.2°C or more.
Moreover, the temperature load allocations to Copco and Iron Gate Reservoirs in Table 5.5 are expressed as tailrace temperatures, *viz.*, daily average and daily maximum temperature increases above inflow temperatures, not as thermal loads. EPA's TMDL regulations define "load" or "loading" as "[a]n amount of matter or thermal energy that is *introduced into a receiving water*." 40 C.F.R. § 130.2(e) (emphasis added). Similarly, the regulations define "load allocation" as the "portion of a receiving water's loading capacity" that is attributed or allocated to a source. *See* 40 C.F.R. § 130.2(g). The "load allocations" to the Copco and Iron Gate Reservoir tailraces are improper because they are not addressed to thermal energy introduced into the Klamath River by the reservoirs but to the daily difference in temperature of the river as it enters and leaves the reservoirs. That temperature difference may not reflect, and generally will not reflect, the daily amount of thermal energy introduced into the river by the reservoirs. Instead, the temperature differences may be attributable to the travel time between the inlet and outlet of the reservoir (which greatly exceeds one day), measurement error, and other factors that do not reflect the amount of thermal energy introduced into the river by the reservoirs.

<u>Response 200:</u>
See response to comment A160.

<u>Comment 201:</u>
Page 5-30, Paragraph 2, Lines 3-6. The Revised Draft TMDL states "there is no allowable temperature increase that can be allocated to Iron Gate Hatchery", and "[a]ccordingly, the temperature load allocation for the Hatchery equals zero temperature increase above natural temperatures (see Table 5.6)". "Zero increase", or any deviation from the temperature targets, is not measurable, and is therefore impractical and unachievable. It is unclear how this load allocation specifically relates to the values listed in Table 5.6. If Table 5.6 is intended to present

temperatures that may not be exceeded by discharges from Iron Gate Hatchery, then these temperature targets are impractical and unachievable since they do not recognize influent water temperature to the hatchery, which would be the proper parameter against which to assess whether the hatchery resulted in increases in temperature. Indeed, the concept of a "natural temperature" against which to judge Iron Gate Hatchery discharges is meaningless since the cold water supply provided to the hatchery by Iron Gate reservoir did not exist naturally.

Response: 201

See the response to K24.

Comment 202:

Page 5-31, Paragraph 3. The Revised Draft TMDL states, "The dissolved oxygen targets at Stateline are expressed as monthly average and monthly minimum DO concentrations (Table 5.7)", and further states, "These dissolved oxygen targets are consistent with the DO concentrations at Stateline under the Oregon and California allocation compliance scenarios". The DO target values in Table 5.7 match the model outputs from the Oregon and California allocation compliance scenario almost exactly (See Table A10 below). These numeric targets do not account for model uncertainty, data uncertainty, or any deviation in conditions (hydrology, meteorology, etc.) from those assumed in the Revised Draft TMDL.

Table A10. DO target values in Table 5.7 compared to model output values.

Location	Month	Chapter 5 Mean DO Numeric Targets	Monthly Mean DO From Model Output		
			Natural Baseline Scenario	No Dam Compliance Scenario	With Dam Compliance Scenario
Stateline	January	11.5	11.5	11.5	11.6
	February	10.5	10.5	10.5	10.6
	March	9.7	9.7	9.7	9.8
	April	9.1	9.1	9.1	9.3
	May	8.8	8.8	8.8	8.9
	June	8.2	8.2	8.2	8.2
	July	8.2	8.2	8.3	8.0
	August	8.2	8.2	8.2	8.1
	September	8.8	8.8	8.8	8.7
	October	9.6	9.6	9.6	9.6
	November	11.5	11.5	11.5	11.3
	December	11.8	11.9	11.8	11.4
Copco 2 Tailrace	January	11.6	11.7	11.6	11.8
	February	10.6	10.6	10.6	11.0
	March	9.8	9.8	9.8	9.9
	April	9.3	9.3	9.3	9.3
	May	8.8	8.8	8.8	8.4
	June	8.2	8.2	8.2	7.6
	July	8.2	8.1	8.2	6.5

Location	Month	Chapter 5 Mean DO Numeric Targets	Monthly Mean DO From Model Output		
			Natural Baseline Scenario	No Dam Compliance Scenario	With Dam Compliance Scenario
	August	8.2	8.2	8.2	5.9
	September	8.8	8.8	8.8	6.6
	October	9.7	9.7	9.7	8.0
	November	11.6	11.6	11.6	10.5
	December	12.0	12.0	12.0	11.5
Iron Gate Tailrace	January	11.7	11.7	11.7	12.1
	February	10.7	10.7	10.7	11.4
	March	9.8	9.8	9.8	10.2
	April	9.3	9.3	9.3	9.4
	May	8.8	8.8	8.8	8.6
	June	8.2	8.2	8.2	7.9
	July	8.1	8.1	8.2	7.1
	August	8.1	8.1	8.2	6.8
	September	8.8	8.8	8.8	7.1
	October	9.7	9.7	9.7	7.9
	November	11.7	11.7	11.6	9.5
	December	12.1	12.1	12.0	11.7

Response: 202
Comment noted.

Comment 203:
Page 5-31, Paragraph 3, Line 4. The Revised Draft TMDL needs to specify the pressure and air temperature at which the 85% saturation would be calculated.
Response 203:
The DO concentration corresponding to the percent DO saturation requirement is calculated by using site specific barometric pressure and salinity and the site specific estimate of natural receiving water temperature as generated by the T1BSR run of the Klamath TMDL model as is described in DO Staff Report (Appendix 1 of the Klamath TMDL Staff Report).

Comment 204:
Pages 5-31 to 5-34, Tables 5.8 and 5.10. The Revised Draft TMDL allocations at Stateline and for Copco and Iron Gate tailraces present a clear disconnect with the 2002 Upper Klamath Lake TMDL (ODEQ 2002). The Upper Klamath Lake TMDL seeks TP targets of 0.066 mg/L for inflows to the lake and 0.11 mg/L for the in-lake concentration, while the expectation in Tables 5.8 and 5.10 is to achieve 0.024 to 0.030 mg/L TP at Stateline (as listed in Table 5.8), 0.015 to 0.023

mg/L TP at the Copco tailrace, and 0.013 to 0.019 mg/L TP at the Iron Gate tailrace (as listed in Table 5.10). (Table 5.10 reverses the TP and TN rows for Iron Gate tailrace.) Even the allowable without-dams and natural conditions load capacities (as shown in Figure 5.12) would require nearly a 90 percent TP reduction from existing loads (compared to 95 percent for the with-dams capacity).

Response 204:

Please see the response to comment D19. Table 5.10 has been corrected.

Comment 205:

The concentration targets in Tables 5.8 and 5.10 are unrealistically low – so low, in fact, as to be substantially less than naturally-occurring groundwater concentrations that discharge to the Klamath River in the J.C. Boyle diversion reach just above Stateline. As with the original Draft TMDL, the Revised Draft TMDL is based on a huge nutrient reduction goal that is simply unrealistic and unachievable, particularly given that hypereutrophic Upper Klamath Lake is the primary source of water for the Klamath River. As a result, the proposed targets and load allocations in the Revised Draft TMDL are not achievable, practicable, or enforceable. As such, they do not comply with the Clean Water Act or EPA's implementing regulations.

As PacifiCorp made clear in our August 2009 comments on the original Draft TMDL, the Regional Board must provide a reasonable explanation of how the huge reductions of nutrient loads proposed in the Revised Draft TMDL would be achieved. Otherwise, the proposed load allocations are not reasonable estimates of the loading from existing and future nonpoint sources, including natural sources. To our knowledge, there have been no documented cases in which nutrient load reductions on such a large scale have been achieved elsewhere, or even determined to be feasible and achievable for planning and implementation purposes, particularly where nutrient sources are overwhelmingly nonpoint source-dominated as in the case of the Klamath Basin. Given the unrealistic and unattainable nutrient reductions needed to meet the Revised Draft TMDL's goals, a UAA or reassessment of water quality targets and objectives should have preceded the TMDL.

Response 205:

See response to comments K53, and above – 2, 8, 22, and 76.

Comment 206:

Page 5-32, Table 5.8. The total phosphorus allocation at Stateline is unrealistic and unachievable. It is unlikely or impossible to be met under the best of conditions because it is approximately three-fold lower than the actual natural background concentration in Klamath basin groundwater. Even if it were to be met, it would be unlikely that compliance could be measured because the allocation value is lower than the commonly achieved laboratory method reporting limit for total phosphorus.

Response 206:

Please see the responses to comments D2 and D26.

Comment 207:

Page 5-32, Table 5.8. The CBOD allocation is unrealistic and unachievable, because it is based on concentrations that are below the commonly achieved laboratory method reporting limit (1 mg/L) and could not be even measured for most of the year. In a naturally eutrophic system such as the Klamath, natural background levels during certain periods of the year (later spring through early fall) would be higher than the allocation value. See comments above on natural conditions background values (specific to Page 2-66, Figures 2.16 and 2.17).

Response 207:

Additionally, see the response to comment D26.

Comment 208:

Page 5-35, Paragraph 1. PacifiCorp is assigned an allocation that requires reduction of nutrients ***upstream*** of its facility. Assigning such an "upstream" allocation is legally improper, inappropriate and unprecedented. See PacifiCorp's previous comments.

Further, the assignment of nutrient allocations to the Project is inappropriate given that the Project does not contribute nutrients, but instead currently contributes to nutrient reductions (via annual net retention of nutrients in the reservoirs). The Project also has no control over upstream nutrient sources and no means of practicably achieving the allocation. In addition, this "upstream" or negative allocation contradicts the Revised Draft TMDL's allocation for temperature, which expressly does not make PacifiCorp responsible for upstream thermal loading.

Response 208:

See the responses to comments D61, K53, and K54.

Comment 209:

Pages 5-36 to 5-39, Figures 5.12 to 5.14. The Revised Draft TMDL states "These figures demonstrate that larger nutrient reductions are needed in order to achieve water quality standards with the Klamath Hydroelectric Project facilities in California in place". The nutrient reductions called for, however, are inconsequential compared to the huge reductions called for in the Revised Draft TMDL with or without the Project. For example, the Revised Draft TMDL concludes that an 87 percent reduction in TP is necessary to achieve compliance in California even if the Project is removed, compared to a 92 percent reduction with the Project in place. Thus, in any case, the Revised Draft TMDL calls for huge, unachievable reductions that dwarf the asserted Project-related differences.

Response 209:

See response to comment K53.

Comment 210:

Page 5-39, Figure 5.14. This figure shows the Revised Draft TMDL's estimated CBOD loadings for the Klamath River below Iron Gate dam. It is noteworthy that the values in Figure 5.14 are substantially different from this figure in the original Draft TMDL. Such a large disparity and apparent correction made for these TMDL values in the Revised Draft TMDL suggests potential issues with the analysis used to derive these values. Details are discussed in our comments on Appendix 7, presented later in this document.

Response 210:

Please refer to responses to comments on Appendix 7.

Comment 211:

Page 5-40, Paragraph 1 and Figure 5.15. As discussed above, the proposed "compliance lens" is improper because it is neither an allocation of a pollutant load nor based on any attribution of a pollutant load to PacifiCorp. In addition, the basis for the compliance lens is not well defined,

and it cannot feasibly be achieved. Defining the compliance lens as a fixed volume where temperature and dissolved oxygen are both acceptable based on the reach average depth of a free-flowing river makes no physical sense: lentic and lotic systems are fundamentally different environments. The average reach depth (the Revised Draft TMDL is unclear if this is average depth or average hydraulic depth) for a free flowing river channel is not stated, but based on modeling efforts is probably on the order of 1.0 meter. Even if the average depth were 2.0 meters, the expectation that such a lens would persist is unrealistic given thermal stratification, wind mixing, and seasonal thermal loading.
Further, the Revised Draft TMDL states that the compliance lens applies to the width and length of the reservoir. This is an unrealistic expectation for any reservoir, particularly under stratified conditions. By definition, the thermocline within Copco and Iron Gate reservoirs does not extend the entire length of the reservoir. In shallower headwater areas, the hypolimnion pinches out and there are no cold, deeper waters in the upper reaches of both reservoirs for considerable distances. Similarly, the thermocline does not extend the full width of the reservoirs. Based on fundamental stratification dynamics and the morphology of reservoir systems, the compliance lens defined in the draft TMLD is unrealistic and cannot be achieved.

Response 211:

Please see the response to comments D6, D8 and K53.

Comment 212:

Page 5-43, Table 5.14. The nutrient and organic matter targets in this table for the Klamath River below the Salmon River will be a function of assumptions throughout upstream river reaches, including tributaries. Previous comments regarding the upstream boundary conditions (including the Shasta River boundary conditions) assumed in the modeling for the Revised Draft TMDL, as well as other comments addressing the TMDL analysis, will have to be reassessed in the TMDL.

Response 212:

Please see the response to comment D24.

Comment 213:

Page 5-44, Table 5.15. No data are provided to support the values for these major tributaries. A comprehensive analysis of assumptions, approach, limitations, and uncertainty needs to be presented in the Revised Draft TMDL. Naturally occurring phosphorus levels from the spring complexes in the Shasta River are on the order of 0.15 mg/L. Because these springs form the predominant fraction of the baseflow for the system, a TMDL target of 0.071 mg/L of total phosphorus is unachievable. In addition, tables 5-15 and 5-16 are expressed as concentrations rather than as pollutant loads, which, as discussed in the comments above, is inconsistent with TMDL requirements. This issue has important environmental consequences. For example, if tributary baseflows are increased, the concentration could remain the same, but the load could increase dramatically.

Response 213:

Refer to Appendix 6 for information on the data and methodology used to develop tributary estimates. Additionally, see the response to comment D25.

Comment 214:
Page 5-44, Table 5.16. CBOD values included in this table are below both the method detection limit and the method reporting limit for standard production laboratories. A minimum value of 2.0 mg/L would be appropriate. Bogus Creek, another cascade stream supported by spring baseflow, will also have elevated phosphorus concentrations and a mean concentration allocation of 0.014 mg/L will be unachievable.
Response 214:
Please see the response to D26.

COMMENTS: CHAPTER 6. IMPLEMENTATION PLAN

Comment 215:
The specific time frames associated with the Draft Implementation Plan's use of "short-term", "longer-term", and "longer time frame" are not defined.
Response 215:
See response to comment Z54.

Comment 216:
The need for substantial upstream load reductions (in Oregon) demonstrates that the timeline or schedule for obtaining load reductions in California is particularly important in evaluating the feasibility of a trading program and other implementation actions that would be necessary in an effort to obtain the nutrient reductions proposed in the Revised Draft TMDL.
Also, because the Revised Draft TMDL fundamentally links its success to the Oregon TMDLs, it is premature for the Regional Board to seek comments on TMDLs for California before the draft Klamath River TMDL in Oregon has been completed and available for review.
Response 216:
It is unclear what the commenter is saying regarding timelines. Nutrient reduction measures in the Upper Klamath basin and in and around Upper Klamath Lake should take place simultaneously to meet the load allocations at Stateline as soon as possible. The California and Oregon TMDLs shared an analysis making it possible to release the Klamath TMDLs in California prior to the release of the Oregon TMDL.

Comment 217:
Page 6-11 to 6-18. With respect to the Klamath Hydroelectric Project, PacifiCorp will work with the Regional Board on a timeline for submitting an Implementation Plan that makes sense within the broader framework of TMDL and settlement agreements. A TMDL Implementation Plan submitted to the Regional Board pursuant to the KHSA may first require adoption of Oregon's TMDL such that TMDL implementation actions under the KHSA can be harmonized with both California and Oregon's TMDLs, as adopted.
Response 217:
The timelines in the implementation plan account for this approach and are coordinated with the KHSA. Oregon and California TMDL implementation are coordinated through an MOA to 'harmonize' implementation.

Comment 218:

Page 6-12, first bullet. It is inaccurate and inappropriate to say that the Revised Draft TMDL "found" that the Project contributed to the impairment by "altering the nutrient dynamics of the river". The Revised Draft TMDL does not provide any evidence to support this claim. The Revised Draft TMDL does find, however, that the Project is a significant sink for nutrients, thus removing them from the river. This reduces the impairment of the river rather than contributes to it. PacifiCorp disagrees with all four bulleted conclusions for the reasons discussed elsewhere in these comments.

Response 218:

Regional Water Board staff believe that the discussions on this topic in Chapter 2 and Chapter 4 conclusively demonstrate the point. Also, please see responses to comments raised by PacifiCorp elsewhere in this document (K1, B20, C3, and C13).

Comment 219:

PacifiCorp will continue working with the CDFG and the Regional Board to assess discharge from the Iron Gate Hatchery through the NPDES renewal process addressing the need for additional measures, if necessary.

Response 219:

Comment noted.

Comment 220:

The Revised Draft TMDL includes a prohibition against unauthorized discharges of waste. First, it is unclear who the responsible parties are since the prohibition is stated so broadly. Second, if the prohibition is merely a restatement of existing law it is duplicative and unnecessary. If it is not, then the Regional Board should explain exactly what additional requirements are or may be imposed.

Response 220:

The proposed prohibition would apply to discharges of waste that cause a violation of water quality standards that are not otherwise authorized by the Regional Water Board. The responsible parties would be those parties discharging in violation of the prohibition. The prohibition is necessary because it would provide an enforcement mechanism to address significant discharges of waste in the Klamath basin while the various nonpoint source programs are developed. The prohibition is not conditional and is not intended to constitute a nonpoint source program; therefore, specifying compliance measures would be inappropriate. Individuals who are concerned about any discharges of waste that may violate water quality standards should contact the Regional Water Board and inquire about obtaining an individual permit.

Comment 221:

Pages 6-61 to 6-62. The discussion about watershed trading/offsets is good to have, but vague regarding program components and responsibilities, other than mention of the KlamTrack program.

Response 221:

See response to comment I5.

COMMENTS: CHAPTER 7. MONITORING PROGRAM

Comment 222:
Page 7-1. Paragraph 4. Please expand on the program identified in NRC (2004) and identify similarities and differences.
Response 222:
Please see the response toR25.

Comment 223:
Page 7-3. Paragraph 4. The goals outlined by the Regional Board and ODEQ are not echoed in the Preliminary Review Draft: Klamath River Basin Water Quality Monitoring Plan (KBWQMCG), but rather drawn from KBWQMCG (Royer and Stubblefield 2009). Admittedly (and contrary to the statement on Page 7-5 under section 7.2.2 that states the plan is done), the plan is still in draft form, but much of the direction for the TMDL has been drawn from the KBWQMCG. Tables 7.3, 7.4, and 7.7 are drawn directly from processes involving the KBWQMCG and not properly referenced. Many participants have worked tirelessly on KBWQMCG issues and not properly referencing the sources of this information is inappropriate. Much of this chapter has been drawn from the Blue-Green algae working group and the KBWQQMCG, but these contributions are not properly cited.
Response 223:
Please see the response to R26.

Comment 224:
Page 7-4, Table 7.1, Row 6. The chlorophyll *a* target units are wrong (mg vs. µg).
Response 224:
The text has been revised.

Comment 225:
Page 7-6, Fifth bullet. Both of the examples given for project effectiveness monitoring appear to apply to projects that would occur mostly in Oregon. How does the Regional Board propose to provide grant funding and project monitoring to projects outside of its jurisdiction?
Response 225:
First, it is possible that projects of this nature will occur in California. Second, Regional Water Board staff have been working with Klamath Basin stakeholders including PacifiCorp to develop a water quality tracking and accounting system to facilitate the purchase of nutrient offset projects throughout the basin (including Oregon).

Comment 226:
Page 7-10, Table 7.3. Differences between the use of terms “trend monitoring” and “trend compliance monitoring” should be explained.
Response 226:
Please see the response to R27.

Comment 227:
Page 7-14, Paragraph 3, Lines 7-10. The statement is made that, “the results should be applied to determine whether microcystin exposures are a contributing factor to ecological impacts such as fish disease and fish health both within the reservoirs and below Iron Gate Dam”. Explain how this determination would be made.

Response 227:
Please see the response to R28.

Comment 228:
Page 7-14, First Bullet. This bullet indicates that public health monitoring in the reservoirs would occur at four shoreline sites in coves. Open water sites are not mentioned, but should be sampled also, since the open water areas are used by the public also.
Response 228:
Please see the response to R29.

Comment 229:
Page 7-18, Paragraph 5, Line 2. The Revised Draft TMDL describes sampling that "will occur in 2009". This sentence, and other sentences in this section, should be revised to reflect the correct timing of sampling.
Response 229:
The text changes have been made.

Comment 230:
Page 7-19, Paragraph 2, Line 3. The 26 ng/g value listed here should be specified as ng/g wet weight.
Response 230:
Please see the response to R30.

Comment 231:
Page 7-23, Section 7.7. The Revised Draft TMDL's proposed compliance monitoring program suffers from a lack of objectives, lack of rationale for the constituents chosen, lack of clear decision criteria, lack of congruence between the targets and the sampling sites, dates, and frequency, and lack of any apparent consideration of cost.
Response 231:
The TMDL's Ambient Compliance and Trend Monitoring Plan (Plan) was developed to track compliance with the TMDL allocations and targets and is designed to provide critical feedback to inform the adaptive management process. The Plan reflects a blending of the *Klamath Basin Water Quality Monitoring Plan* prepared for the Klamath Basin Monitoring Program and the *Water Quality Monitoring Activities – Monitoring Year 2009* developed as part of the AIP Interim Measure 12. Both of these plans were developed with input from numerous stakeholder interests, including PacifiCorp. The TMDL Monitoring Plan presented in Chapter 7 of the staff report *does* include statements of rationale for the constituents chosen and sample locations (see for example Table 7.4). Sampling frequency and methods are identified in Table 7.8.

Comment 232:
Page 7-24. Section 7.6.1 Comprehensive Water Quality Monitoring. This program of parcel tracking to assess water quality conditions is misleading and inappropriate for application in the Klamath River. This was tried by the Regional Board below Iron Gate dam and provided little useful information (in fact, there is no mention of this work in the Revised Draft TMDL). This is an inappropriate method to develop a system wide mass balance (which is stated as a desired outcome). The ability to track a parcel of water through the system requires a very clear

understanding of travel time, which is not addressed in any way in this section. The approach does not speak to dilution and the role of tributary inputs at any sufficient level to understand the approach. The more prudent approach would be to reduce the system to a reach-by-reach basis and complete information on individual reaches multiple times per year. For example, a small study of Keno reservoir over a two week period, two or three times a year, would provide dramatically more information than this proposed approach. In the Keno dam to J.C. Boyle reach, which has a short transit time, a shorter study may be required, saving additional monies and resources. The constituents seem well represented, but the timing issue of this program will result in little useful data.
Folded into this are several studies that appear to be part of this "comprehensive" parcel tracking program, but do not seem directly related. This is a confusing presentation of important matters. For example:

- The estuary sampling does not seem related to the parcel tracking program (nor should it necessarily be related)
- The open ocean boundary condition is in a very dynamic environment and trying to tie it into the parcel tracking will not provide sufficient information to form confident and robust decisions
- New flow gages and flow analyses may be useful, but where is such work needed? This does not appear to tie in with the parcel tracking. How long of a record is necessary before a comprehensive understanding of the flow records can be confidently stated?
- Water monitoring for accretions is a great topic, but what defines "significant accretions" is unknown. This would vary by season, year type, and location in the system
- A bathymetric survey for the estuary is important for two reasons. The stated reason is that the initial survey may not have characterized important elements. An equally important reason is that the estuary is not static and will change, probably frequently. Thus relatively frequent surveys would be valuable to ascertain the variability in the estuary and accommodate that in modeling (sensitivity analysis) to quantify uncertainty.

These tasks require considerable resources, funding, and ideally a level of cooperation and coordination. A framework, ideally developed with considerable public input, is required to identify rank and prioritize monitoring actions to ensure effective and responsible use of funds and resources.

Response 232:

Please see the response to comment to R31.

Comment 233:

Page 7-27, Third Bullet. This bullet is titled "Below channelized section of Iron Gate Dam". Please specify what is being referred to here. What "channelized section" is this? Also, the statement is made "This station has recently been demonstrated to have the highest rate of parasite infection of fish within the Klamath system". This statement is wrong and should be deleted. The higher rates occur downstream below the Shasta River near the confluence with Beaver Creek.

Response 233:

Please see the response to comment R32.

Comment 234:
Page 7-29, Section 7.6.2. Second bullet point pertains to the Scott River and does not appear to be related to the Klamath River TMDL. Refugia temperatures are localized areas that probably do not have a broader effect on mainstem temperatures far from the refugia. Though groundwater in the Scott Valley may play a broader role, the valley is located well over 20 river miles upstream from the Klamath River and probably has little effect on Klamath River temperatures.
Response 234:
The recommended special study is one of a few meant to address temperature improvements in the Klamath River basin, of which the Scott River is a part. The goal is "a better understanding of potential temperature improvements in the Scott River", not improvements in Klamath River temperatures.

Comment 235:
Page 7-29, Paragraph 3, Line 3. With nearly 10 years of data and two highly developed water quality models for the Klamath system, a reasonable mass balance for nutrients can be developed without extensive and costly additional data collection. In fact, it has already been done, and is referenced several times earlier in the Revised Draft TMDL (Asarian et al. 2009). What has not been accomplished, and apparently what is referred to in this paragraph, is an instantaneous mass balance to determine, for example, for a specific day whether more nutrients are leaving the Project than are coming in. However, this is an impossible, and meaningless, task because the indeterminate delay, mixing, and dilution of a particular parcel of water as it passes through the Project reservoirs makes it impossible to say with confidence how the discharge from Iron Gate dam on any particular day is related to the inflow above J. C. Boyle reservoir, or Copco reservoir, on any particular prior day. Knowledge of the instantaneous mass balance of the Project will do nothing to implement or monitor TMDL activities.
Response 235:
While it is true that a mass balance has been developed, the monitoring suggested in this paragraph would provide data to improve on existing understandings of the mass balance dynamics. Existing mass balances are based on interpolations between a very sparse set of data points and limited information on system flows. Any study designs would be developed in coordination with the Klamath Basin Water Quality Monitoring Coordination Group.

Comment 236:
Page 7-30, Section 7.6.5. Bullet point identifies a "Periphyton Advisory Committee." Does such a committee exist? If it does exist it is so poorly communicated in the basin that key water quality analysts are unaware of its existence
Response 236:
Please see the response to comment R34.

COMMENTS: CHAPTER 9. CALIFORNIA ENVIRONMENTAL QUALITY ACT (CEQA) ENVIRONMENTAL ANALYSIS

Comment 237:
It is unclear whether the Regional Board intends the revised Chapter 9 to be considered a "recirculated" environmental document pursuant to CEQA. Pub. Res. Code § 21092.1; 14 CCR §

15088.5. The “Summary of Revisions” states that Chapter 9 has been revised. In addition, the Public Notice of the availability of the December draft states that it is issued in accordance with CEQA Guidelines section 15087. NCRWQCB, Public Notice (Dec. 23, 2009), at p. 3. Indeed, recirculated environmental impact reports (EIRs) must be noticed in accordance with this section. 14 CCR § 15088.5(d).

The Public Notice states that the Regional Board and the Environmental Protection Agency (EPA) “are soliciting comments on the revised text and substantive changes only. Previously submitted comments need not be resubmitted.” NCRWQCB, Public Notice (Dec. 23, 2009), at p. 2. This is permissible when the lead agency only revises and recirculates portions of the environmental document. 14 CCR § 15088.5(f). However, the Regional Board recirculated the entire CEQA environmental analysis as well as all other chapters of the Staff Report. At the same time, the Regional Board failed to provide a redline showing the revisions to Chapter 9, making public comment on the revised portions difficult. It is unclear why these revisions could not be shown in readable format since they are simple additions or changes to the previous text.

Response 237:

Regional Water Board staff does intend that the revision to Chapter 9 be considered a “recirculated” environmental document. Staff is also confidant that the proper legal noticing requirements were met and the correct citations included in the Chapter 9 of the TMDL Staff Report (page 9-1).

The Public Notice did request that comments be limited to “revised text and substantive changes only” and that previously submitted comments not be resubmitted as they will have been responded to as part of the earlier ongoing review process. However, Regional Water Board staff will provide a written response to any new CEQA comments (i.e. CEQA comments not yet responded to in writing) despite whether the comment was based on the previously released analysis or the December 2009 analysis.

The Regional Water Board basin planning process is certified by the Secretary for Resources as “functionally equivalent” to CEQA, and therefore exempt from the requirement for preparation of an environmental impact report or negative declaration and initial study. Regardless of whether you consider the recirculation notice requirements under California Code of Regulations, title 14, sections 15072 & 15073 or sections 15087 and 15086, the revisions to Chapter 9 were recirculated, the proper legal noticing requirements were met and the correct citations included in the Chapter 9 of the TMDL Staff Report (page 9-1).

To facilitate the ongoing review of this TMDL, Regional Water Board staff summarized the changes to Chapter 9 in the “*December 2009 Public Review Drafts -Summary of Revisions.*” That Summary makes clear that the revisions to Chapter 9 were based, in large part, on the inclusion of an analysis of the potential adverse environmental impacts from a dam decommissioning scenario. This analysis was provided at the request of PacifiCorp. The Summary also explains that the revisions could not be shown in strike-through in a readable format and were therefore presented as clean, rewritten text. There is no legal requirement to show changes in strike-out and staff thought that it would be easier to review in a clean copy.

The Regional Water Board will respond to CEQA comments consistent with California Code of Regulations, title 23, section 3779 and other applicable provisions of law.

Comment 238:
As discussed elsewhere in PacifiCorp's comments, the load allocations assigned by this TMDL are impossible to meet due to a flawed natural conditions analysis and because the load allocations at Stateline are infeasible. The Revised Draft TMDL, or the "recommended alternative," is based on a huge nutrient reduction goal that is simply unrealistic and unachievable.
The nutrient targets are unrealistic because they are far below the Klamath River's naturally eutrophic condition. In addition, the Revised Draft TMDL's modeling results for natural conditions include a 20 percent reduction in solar radiation. The natural conditions scenario does not reflect water quality conditions that are attainable. Therefore, load allocations to achieve these "natural conditions" are infeasible.
The Revised Draft TMDL assumes water quality at Stateline (and by extension other downstream Klamath River locations in California) "once the Oregon TMDLs are fully implemented." (p. 6-8). In addition, the Oregon compliance conditions at Stateline determine natural temperature increases in California although it is unclear how temperature compliance at Stateline would be achieved. Chapter 9 contains no discussion of the feasibility of achieving the large nutrient reductions or the uncertainty that Oregon will otherwise meet the allocations at Stateline. Rather it simply states: "Improvements in water quality in Oregon represent a critical part of the solution in meeting water quality objectives in California." (p. 9-17) A legally adequate alternatives analysis includes a reasonable range of alternatives that may be feasibly accomplished in a successful manner considering the economic, environmental, social, and technological factors involved. *Citizens of Goleta Valley v. Board of Supervisors* (1990) 52 Cal.3d 553, 566.
The Regional Board must discuss the possibility that Stateline load allocations will not be achieved and that therefore, the downstream load allocations will be impossible to meet. One alternative should be considered that accounts for the likelihood that higher nutrient loading will occur at Stateline than is assumed under the recommended approach. Otherwise, there is no opportunity for public comment on the comparative merit of alternatives or to evaluate and respond to agency conclusions. 14 CCR § 15126.6(a). "The range of feasible alternatives shall be selected and discussed in a manner to foster meaningful public participation." 14 CCR § 15126.6(b).
Response 238:
The Regional Board must develop an implementation plan designed to meet the standards and ensure the reasonable protection of beneficial uses. The implementation plan takes into account the difficulty of enforcing objectives and, in particular, considers the options reasonably available to dischargers to comply with the objectives. The TMDL contains reopeners and the ability to adaptively manage as we learn more and measures are implemented.
CEQA does not require a discussion of the "feasibility of achieving the large nutrient reductions or the uncertainty that Oregon will otherwise meet the allocations at Stateline." (For discussions on achievability and Stateline allocations, please see K53 and G1-G14.) Load allocations are numbers representing the amount of pollution a given water body can receive and still to attain compliance with water quality standards. The reduction of a particular source may be implied, but to be enforceable the requirement to reduce must be incorporated into a permit or some other implementation mechanism. California has little to no authority to control discharges that occur in Oregon.
CEQA issues must be analyzed in the context of how the load allocations are implemented under the implementation plan. For a discussion of relative factors, please see K54. California Code of

Regulations, title 14, section 15187 requires an analysis of reasonably foreseeable means of compliance which would avoid or eliminate identified impacts. The implementation plan provides flexibility to study alternatives and various treatment projects in Oregon or California and sets up a process for that evaluation.

The premise of this bi-state Klamath River TMDL was based on the development of a single approach (i.e., computer model simulations) to be used in the development of the technical portions of both the Oregon and California source assessments and load allocations. TMDL implementation actions were then based on each State's regulatory mechanisms. Regional Water Board staff believes that when the TMDL implementation actions included in Oregon's Upper Klamath River and Upper Klamath Lake TMDLs are achieved, compliance with the Stateline load allocations will occur. If it becomes apparent that this a faulty premise, Regional Water Board staff will bring the TMDL back to the Regional Water Board for further discussion, evaluation and possible modification. It is at that time the alternative means of compliance will be addressed, although it is not clear what alternatives exist for Oregon's contribution at Stateline. Regardless, this is a TMDL issue, not a CEQA matter.

Comment 239:

The Regional Board failed to analyze potentially significant adverse environmental impacts from the load allocations proposed in the Revised Draft TMDL. The Regional Board chose a drastically reduced nutrient level to establish the load allocations. By choosing such a reduced nutrient level, the Revised Draft TMDL has potentially significant adverse environmental impacts that could have been avoided. As discussed elsewhere in these comments, sufficient nutrient levels are actually important in high temperature environments to support, among other things, salmonid species, particularly in juvenile rearing. The Regional Board failed to discuss this interaction within the environmental analysis in Chapter 9 or anywhere else. The drastic nutrient reduction proposal has potential to significantly alter food webs in the river which could adversely impact both the quantity and quality of salmonids in the Klamath River. The Regional Board also failed to consider alternatives that would reduce or avoid these impacts.

Response 239:

Proposed nutrient load allocations were set to represent natural conditions (ie. nutrient levels that existed prior to anthropogenic nutrient inputs), and necessary to prevent nuisance algae blooms in the reservoirs themselves. These natural levels, while representing a reduction in existing instream nutrient loads, will likely still provide sufficient nutrients to support salmonid species, particularly in juvenile rearing. Regional Water Board staff does not believe that potentially significant adverse environmental impacts will occur by establishing a nutrient load allocation that is set to represent "natural conditions."
To address concerns that nutrient and organic matter reductions in the Klamath River basin could lead to limitations on primary productivity in the river system over time, careful monitoring and assessment of primary productivity and associated food web dynamics within the Klamath River is appropriate and warranted. Nutrient and organic matter conditions at Iron Gate tailrace and downstream locations should be compared to the monthly mean TP, TN, and CBOD "trigger" concentrations in Table 7.9 of the Staff Report. These "trigger" concentrations are based on the California allocation scenario, which represents conditions that comply with water quality standards without dams. If observed nutrient and organic matter conditions at Iron Gate tailrace or downstream locations are comparable to the "trigger" concentrations, and if there is evidence of potential limitations to primary productivity at levels deleterious to water quality standards,

then the Regional Water Board should reevaluate the TMDL allocations and targets and nutrient controls in the basin or other appropriate action.

The implementation plan does not require PacifiCorp to meet its load allocations immediately. Nor can the implementation plan require Oregon to meet load allocations at Stateline immediately. Full compliance with load allocations at Stateline and for the KHP is likely to take time. The implementation plan provides a process and time for investigating various infrastructure improvements and modifications, all subject to subsequent detailed CEQA review. The implementation plan requires Regional Water Board review and approval prior to moving forward with any major project for TMDL compliance. Meanwhile, the Implementation Plan identifies a trigger point at the tail race of Iron Gate so the Regional Water Board can review and respond to this issue if and when nutrients are reduced to the level that impacts downstream habitat.

Comment 240:

PacifiCorp appreciates the discussion in the December draft of the environmental impacts of dam removal. As PacifiCorp stated in its August comments, the June draft identified dam removal as the measure by which compliance with the TMDL load allocations would be achieved yet failed to identify associated environmental impacts, mitigation measures or alternatives. The December draft partially corrected this deficiency by including a discussion of potential environmental impacts from dam removal and possible mitigation measures.

However, the December draft now recognizes "[b]oth dam alteration/modifications and dam removal … as possible strategies by which final compliance with the TMDL load allocations may be accomplished." (p. 9-20) Yet the methods or actions involved for dam alteration or modification are not specified or discussed further. Instead, the analysis addresses only interim compliance measures and dam removal. A CEQA document is inadequate where it "sets forth various compliance methods, the general impacts of which are reasonably foreseeable but not discussed." *City of Arcadia v. State Water Res. Control Bd.* (2006) 135 Cal.App.4th 1392, 1425-1426. By identifying dam alteration/modification as a compliance method, the Regional Board staff should have discussed what actions may be involved, the reasonably foreseeable environmental impacts, and potential mitigation measures or alternatives.

In addition, the Revised Draft TMDL does not identify several reasonably foreseeable potentially adverse environmental effects of dam removal, including the loss of electricity generated by hydropower and the potential replacement by thermal generation resources, and the loss of the Iron Gate reservoir cold water supply to Iron Gate Hatchery, which provides successful year-round fish rearing and a hatchery water supply that is free of fish disease.

Moreover, the analysis of environmental impacts from dam removal and potential mitigation measures concludes: "Although potentially significant adverse impacts from dam removal were identified, it is impossible without further study to know whether those impacts may be able to be mitigated to less than significant levels." (p. 9-39) It also suggests that the Regional Board, "when required to take a discretionary action for approval of dam removal as a final TMDL compliance measure" will adopt a statement of overriding consideration*. Id.* Although this CEQA analysis may be at the programmatic level, and additional environmental review will occur prior to removal of the dams, the Regional Board is adopting a regulation that effectively requires dam removal to achieve compliance. Therefore, the potentially significant adverse impacts from dam removal identified are not speculative. The Regional Board cannot adopt a project with potentially significant adverse environmental impacts and hope that an agency or

PacifiCorp can find a solution later. At the least, the Regional Board should have identified criteria for later mitigation measures that could mitigate the adverse impacts identified. *Sundstrom v. County of Mendocino* (1988) 202 Cal.App.3d 296, 308-309 (holding that by approving the project without data showing that a solution was possible, the county evaded its duty to engage in comprehensive environmental review.).

Response 240:

PacifiCorp confuses the assignment of load allocations with the implementation plan. As stated previously, an assigned load allocation must be viewed in context with the accompanying implementation plan. For the purposes of CEQA, the analyses must focus on the implementation plan. The Klamath TMDL implementation plan recognizes that KHP implementation will occur under one of two possible regulatory paths and in both cases under the decision making authority of agencies other than the Regional Water Board, and with consideration of other issues such as power generation and endangered species. The two possible tracks are the hydropower relicensing proceeding and the settlement agreement approach. Both tracks involve decisions to be made not by the Regional Water Board. In each, a process is in place to review technical and economic feasibility, among other things, before deciding whether modifications or removal of the project is necessary. While the Regional Water Board will decide whether a proposed implementation plan submitted by PacifiCorp is satisfactory for TMDL compliance, Regional Board approval must occur in the context of these other processes. The two regulatory paths are described in detail in K39.

Nonetheless, as PacifiCorp recognizes, staff did provide an environmental analysis of both dam alteration/modification and dam removal. Discussions of the environmental impacts of dam alteration/modification that were analyzed included a discussion of conventional wastewater treatment (9.5.2.3), the installation of a variable outlet structure (9.5.2.8), and adjustments to the turbine vent valve (9.5.2.10). These alterations/modifications were identified as potential interim measures. If it is determined after the Secretary of the Department of the Interior completes the studies and assessments that the dams will not be removed, the effectiveness of the alterations/modifications that were put in place as interim measures would have to be evaluated to determine whether TMDL compliance is being met. If not, additional means to compliance will need to be evaluated and analyzed for environmental impacts at that time. (See section 6.3.2 of Staff Report, describing implementation measures for the KHP, including requirement that PacifiCorp submit an implementation plan that includes a reassessment by the Regional Water Board in 2012 in light of the Secretarial Determination.)

Although the Revised Draft TMDL does not specifically identify the potential impacts of dam removal identified by PacifiCorp, these issues were, in fact, discussed in the reports identified by the Regional Water Board, which were incorporated into the TMDL environmental analysis by reference. (Staff Report 9-21.)

The Regional Board staff disagrees with the premise that its regulation effectively requires dam removal to achieve compliance. Nothing in the TMDL makes that conclusion. Regional Water Board staff has evaluated the use of KHP Reservoir Management Plan (RMP) measures and AIP interim water quality measures for potential TMDL compliance, which included some proposals for in-reservoir modifications. The following feasibility ranking scale was used in this process: 1) Viable – recommended; 2) Uncertain – further study needed; and 3) Not viable – not recommended. Although the initial evaluation recognized some limitations with the proposed in-reservoir modifications, the

Regional Board staff will continue to work with PacifiCorp to identify and evaluate the feasibility of infrastructure improvements and offset projects to achieve Clean Water Act compliance.

Although dam removal may be one manner in which PacifiCorp may be able to comply with the TMDL, the proposal to remove one or more of PacifiCorp' dams has come out of settlement negotiations and agreements PacifiCorp made with other parties, not with the Regional Water Board. By recognizing dam removal as a feasible means of compliance with the TMDL, the Regional Water Board is trying to recognize and accommodate the various alternatives that may come out of PacifiCorp' agreements with third parties. It is for this reason that the TMDL requires PacifiCorp to come back to the Regional Water Board after the Secretary of the Interior has made his determination, at which time the Regional Water Board will need to approve any plan that PacifiCorp puts forward for TMDL compliance – whether that involves dam removal or some other dam alteration/modification or other implementation of other measures. If a determination is made that the dams will be removed, additional environmental review will have already been conducted by the Secretary of the Interior, which would then likely be incorporated into a CEQA document that will need to be prepared for the dam removal project by the CEQA lead agency. Although the environmental analysis of the reasonably foreseeable means of compliance has considered in detail the potential impacts of interim measures that PacifiCorp identified in the AIP as means to improve water quality in the reservoirs to attempt to meet the TMDL load allocations until a decision is made by the Secretary of the Interior, the Regional Water Board has not yet approved any plan for long-term compliance. Those specific plans will come back before the Regional Water Board for approval once PacifiCorp, Settlement Parties, and the Secretary of the Interior have made their necessary determinations. At this time, therefore, there has not been a commitment by the Regional Water Board to a definite long-term course of action, since the details of any specific means of long-term compliance with the TMDL, including dam removal, are contingent upon further CEQA compliance. (*Stand Tall on Principles v. Shasta Union High School District*, 235 Cal.App.3d 772, 781 (1991).) This is, therefore, not the last opportunity for the Regional Water Board to analyze and require mitigation for potentially significant environmental impacts associated with dam removal.

Staff was surprised to hear testimony from PacifiCorp at the September 10, 2009 Board meeting stating that it could not meet the proposed load allocations without removing the hydroelectric facilities. Regional Board staff have made clear throughout the entire TMDL development process that the Klamath TMDL accommodates both "dams in" and "dams out" scenarios. Consistent with the federal Clean Water Act and state Porter-Cologne Act, often our agency articulates water quality standards but generally allows the Discharger to develop and implement measures in order to meet those standards. (See generally Wat. Code, § 13360 [no waste discharge requirement or other order of a [board] shall specify the design, location, type of construction, or particular manner in which compliance may be had….].) It is important to note that if PacifiCorp's statement is correct, not only will PacifiCorp not be able to meet the proposed load allocations, but it will also not be able to comply with current water quality objectives in the Basin Plan. The TMDL is designed to implement existing water quality objectives, and if anything, the Klamath TMDL process will make the DO objective easier to achieve if the draft site-specific objective is adopted by the Regional Board.

Comment 241:

As part of the environmental analysis of methods of compliance, the agency is required to analyze "reasonably foreseeable alternative means of compliance with the rule or regulation." Pub. Res. Code § 21159(a)(3). In its August comments, PacifiCorp stated that the June draft did not discuss any alternative means of compliance. The Regional Board did not make any changes to Chapter 9 in response to this comment and PacifiCorp continues to believe that the discussion of alternative compliance methods is inadequate for the reasons already stated.

Response 241:

Regional Water Board staff based the analysis of alternative means of compliance on the project scale (i.e. the TMDL implementation program) rather than at the responsible party scale (i.e. selection of individual compliance measures). The selection of individual compliance measures is largely in the responsible party's control, and there are numerous ways in which the potentially existing implementation measures can be combined to meet the load allocations. Moreover, most compliance measures will be applied through an already existing permitting mechanism or a permit to be developed in the future, which would likely be accompanied by a more specific CEQA review. In addition, the implementation plan itself allows for the consideration of alternatives, for example in the context of the tracking and accounting program, which will hopefully generate restoration projects and provide a process to evaluate each projects' potential. For the KHP, CEQA analyzes interim measures already agreed to by Settlement Parties based on the information available at this time. Regional Board staff see no need to speculate on KHP alternatives when the decisions on infrastructure modification and/or removal are already being evaluated as part of a parallel process. The revision to Chapter 9- CEQA Analysis (December 2009) did in fact expand on the "reasonably foreseeable alternative means of compliance with the rule or regulation" by including an analysis of potential adverse effects from dam decommissioning.

Comment 242:

The Revised Draft TMDL includes a "Prohibition of Discharges in Violation of Water Quality Objectives in the Klamath River Basin" that was not included in the June draft. Although section 9.2, "Description of the Proposed Activity," was revised to include this change, no other revisions were made to describe how this change might change the impacts of the project, including the analysis of alternatives, the analysis of compliance measures, and the description of possible mitigation measures or alternatives to the compliance measures. As discussed elsewhere in these comments, it is unclear what compliance measures will be required as a result of including this prohibition, even if it is a "restatement of existing law." Therefore, potential impacts of the reasonably foreseeable compliance measures should have been discussed to facilitate public comment. The inclusion of the prohibition was not a clarifying change in the environmental document. Rather, it was a change in the project with uncertain consequences. Similarly, the Revised Draft TMDL adopts a Thermal Refugia Protection Policy in place of the thermal discharge prohibition in the June draft and replaces a sediment discharge prohibition with the adoption of Guidance to Control Sediment Discharges. Although section 9.2, "Description of the Proposed Activity," was revised to include these changes, no other revisions were made in the environmental analysis. The Regional Board should have analyzed reasonably foreseeable compliance measures for this policy and guidance.

Response 242:

The environmental analysis does in fact contain those "reasonably foreseeable compliance measures" that Regional Water Board staff identified as those likely to be used to achieve compliance with the TMDL load allocations/targets and implementation actions, including the proposed "Prohibition of Discharges in Violation of Water Quality Objectives in the Klamath River Basin." For example, the environmental analysis includes a discussion on "reasonably foreseeable compliance measures" that may likely be implemented to control nutrient impacts from agricultural activities (pages 9-31, 9-51, and 9-55), grazing activities (pages 9-50 and 9-52), and dam modification and dam decommissioning practices (pages 9-34 through 9-38 and 9-74 through 9-78). Additional discussion was presented on "reasonably foreseeable compliance measures" to control dissolved oxygen impacts (page 9-65), and temperature impacts (pages 9-43 and 9-48). Regardless of whether the proposed regulatory approach is a "Policy" or "Guidance," Regional Water Board staff is required to evaluate the entire suite of reasonably foreseeable compliance measures that may likely be implemented to achieve compliance with the adopted regulation. The prohibition against unauthorized discharges of waste that violate water quality standards is proposed to protect against serious and significant individual threats to water quality. Individuals who are concerned about any discharges that may violate water quality standards should contact the Regional Water Board and inquire about obtaining an individual permit. A permit must be accompanied by project-level CEQA documentation. Similarly, the Thermal Refugia Policy makes recommendations to permitting agencies that will conduct site-specific CEQA documentation before issuing any permit. Regional Water Board staff believes that the programmatic analysis was adequately conducted. It should also be noted that the commenter did not identify any other "reasonably foreseeable compliance measures" that staff should have evaluated.

Comment 243:

The omissions in critical information for adequate environmental review, discussed above, require the Regional Board to revise Chapter 9 to include missing information and to recirculate the CEQA analysis for additional public comment. Pub. Res. Code § 21092.1; 14 CCR § 15088.5. Currently, the draft environmental document is "so fundamentally flawed and basically inadequate and conclusory in nature that meaningful public review and comment were precluded." 14 CCR § 15088.5(a)(4); *See also Cadiz Land Co. v. Rail Cycle* (2000) 83 Cal.App.4th 74, 87 (holding that depriving the public of critical information during public comment period resulted in public and decision-makers lack of sufficient information to make an informed decision that intelligently takes account of environmental consequences.). If the Regional Board revises the environmental analysis to appropriately discuss the missing information, the revised chapter will likely include "significant new information" showing new significant environmental impacts or new mitigation measures that may have impacts or a substantial increase in the severity of environmental impacts. 14 CCR § 15088.5(a).

Response 243:

The CEQA analyses are sufficient and recirculation is not necessary or required. The public has had sufficient opportunity to provide comments on the scope and detail of the CEQA analysis. The CEQA scoping began in February 2006 with a request for stakeholders to help develop the scope of the environmental review. Since that time and as part of the ongoing TMDL development process, Regional Water Board staff has solicited help from responsible parties and other interested stakeholders in identifying the suite of reasonably foreseeable compliance measures that could likely be implemented to achieve compliance with the TMDL load allocations.

Comment 244a:

The Regional Board violates principles of fairness by failing to make criteria for and information supporting its decisions publicly available

The Regional Board staff continues to rely on information and studies that have not been made publicly available to support its decisions. Such extra-record evidence frustrates public participation and effective judicial review. *California Assoc. of Nursing Homes, etc. v. Williams*

(1970) 4 Cal.App.3d 800, 811; *California Optometric Ass'n v. Lackner* (1976) 60 Cal.App.3d 500, 510-511. For example, as stated in PacifiCorp's comments on chapter 2, the Revised Draft TMDL cites "Ward and Armstrong 2009 in press" as the support for the benthic chlorophyll *a* target and cites the analysis and results from "Asarian et al. (2009)", neither of which have been made available for public review. (Page 2-18, paragraph 4; Page 2-41, Paragraph 4). In another example, the Revised Draft TMDL indicates the CA NNE boundary target is based on review of studies and recommendations of experts without indicating which studies or which experts and without documenting the recommendations. (Page 2-18, Paragraph 3). The Revised Draft TMDL also provides that personal communications with Richard Stocking support the Regional Board's conceptual model assumption that high levels of FPOM exported from the reservoirs are a critical factor in determining *M. speciosa* distribution and abundance. (Page 2-36-2-37). Without making this supporting evidence available for public comment, the Regional Board unlawfully relies on privately acquired data outside the record.

Response 244a:

Only publicly available documents have been cited and relied upon in the final draft Staff Report. Reference to personal communications is only one line of evidence used as part of the Regional Water Boards evidence presented in the Staff Report. Where appropriate, documentation from published reports or proceedings is provided. All references, information, and studies utilized in the development of the Klamath River TMDLs are part of the administrative record and are available to the public.

Asarian et al. 2009 was available before the release of the December 2009 Draft TMDL staff report. The report is available from the Karuk Tribe Department of Natural Resources andat the following links:

main text of reportt:
http://www.riverbendsci.com/reports-and-publications-1/Cop_IG_Budget_may05dec07_report_final.pdf?attredirects=0&d=1

report appendicest:
http://www.riverbendsci.com/reports-and-publications-1/Cop_IG_Budget_may05dec07_appendices_final.pdf?attredirects=0&d=1

Regional Water Board staff determination of the Klamath River as a mesotrophic system was made long before the draft final Ward and Armstrong (2009) publication was released. One of the primary citations for setting Klamath River periphyton targets is: *Tetra Tech. 2008. Nutrient Numeric Endpoint Analysis for the Klamath River, CA. Prepared for U.S. EPA Region 9 and North Coast Regional Water Quality Control Board. May 29, 2008. Tetra Tech, Inc., Research Triangle Park, NC.* PacifiCorp commented on the Tetra Tech 2008 technical memorandum as part of their review comments on both the June 2009 Draft TMDL staff report and the December 2009 TMDL Draft staff report. The USFWS draft final study (Ward and Armstrong 2009) has been publically available since August 2009. The peer reviewed final report by Ward and Armstrong is expected in March 2010.

Comment 244b:

Further, as noted elsewhere in these comments, the TMDL "natural" conditions load diagrams are not listed, and the supporting table does not list instream loads below Iron Gate dam; therefore, the relative magnitude of unaccounted "natural" sources and sinks along the river cannot be determined. (page 4-10-4-16). The analysis leaves the reader unable to compare TMDL "natural" baseline and estimated current conditions nutrient and CBOD sources along the river or to understand the relative importance of sources and sinks in these two scenarios. These omissions frustrate meaningful public review and result in an incomplete and misleading presentation of constituent loading in the Klamath River

Response 244b:

Table 4.2 provides natural baseline loading below Iron Gate dam and at other mainstem and tributary locations. Table 4.6 presents a comparison of current annual TP, TN, and CBOD loads at Stateline to natural conditions baseline loading estimates. The stated purpose of the diagrams and tables presented in Chapter 4 is to provide a comprehensive overview of loading within the system. In addition, PacifiCorp was provided all of the model-related files requested that relate to each of the TMDL modeling scenarios.

Comment 245:

The boards' regulations implementing CEQA provide that the Regional Board shall prepare written responses to written public comments raising significant environmental points that are received at least 15 days prior to the date on which the Regional Board intends to take action. 23 CCR § 3779(a). However, the Public Notice on the availability of the December draft states that the public comment period will close on February 9, 2010 and the Board will only accept late comments in its discretion. NCRWQCB, Public Notice (Dec. 2009), at p. 4.

The Public Notice also states that the Board intends to provide written responses to public comments prior to the Board meeting on March 24-25 during which the Board intends to consider adoption of the TMDL. NCRWQCB, Public Notice (Dec. 2009), at p. 4. Indeed, "[c]opies of such written responses shall be available at the board meeting for any person to review." 23 CCR § 3779(a). The Regional Board should not complete the written responses before March 9 when written public comments raising significant environmental points may be made to which the Board must respond but should provide the responses as far in advance as possible to provide an adequate amount of time to allow meaningful review of the responses.

In addition, the Regional Board must prepare written responses to any late written comments, if feasible, or orally respond to the significant environmental points raised in late comments at the board meeting. 23 CCR § 3779(b). The Regional Board must also respond orally to any oral comments made at the meeting. *Id.* However, the Public Notice requires that all those who plan to testify at the meeting submit written statements by February 9, 2010 and that new evidence shall not be added at the meeting. While the Regional Board may require testimony to be submitted in writing in advance, the boards' CEQA regulations require that the board respond to significant environmental points raised at a board meeting. Therefore, if the term "evidence" includes such significant environmental points, the Regional Board must accept such statements during the meeting.

Response 245:

Staff agree with the commenter that 23 CCR § 3779 requires the agency to respond to written comments on significant environmental points received at least 15 days prior to the Board taking action. It does not bar the agency, however, from establishing an alternate deadline for the receipt of written comments 45 days before the Board taking action, such as was done in this case.

The commenter suggests that staff be prepared to provide written responses to comments received up through March 9, 2010. If written comments are submitted after the close of the public comment period on February 9, 2009, it will be up to the discretion of the Board Chair to decide whether or not to accept those comments and whether staff must provide written responses.

Staff intends to respond to all significant environmental comments whether written or oral, where feasible. The public review process as described in the Public Notice establishes the framework in which staff can guarantee the thoughtful review and consideration of written comments, as well as the development of thorough responses. Written comments submitted outside of this framework can not be given the same guarantee.

With respect to oral comments, staff agrees and will be prepared to respond orally to comments on significant environmental points made during the public hearing. The Public Notice requires that all written evidence be submitted by February 9, 2010; and, requests the submittal of oral testimony in written form by February 9, 2010. Any new evidence brought orally at the hearing will be considered at the discretion of the Board Chair.

Comment 246:

The time period provided by the Regional Board for public comment on the Revised Draft TMDL was insufficient for complete review of the revised model applications. Public consultation must be preceded by timely distribution of information, sufficiently in advance of agency decision-making to allow the agency to assimilate public views into agency action. 40 C.F.F. § 25.4(d). PacifiCorp did not have sufficient time to provide constructive comments on several revised model applications, including the estuary application of EFDC and plans to submit comments on this topic later. Should PacifiCorp identify any significant issues within supplemental comments, PacifiCorp trusts that the Regional Board will consider these comments to the extent required, as described above, or pursuant to its exercise of discretion to do so.

Response 246:

Staff believes that PacifiCorp has had ample time to review all of the materials associated with the development of the Klamath TMDLs, including the model and all its components. Regional Water Board, Oregon Department of Environmental Quality, USEPA, Tetra Tech staff have been in consultation with PacifiCorp and its contractors for the last several years with respect to the development of the model and its components. PacifiCorp and its consultants have been offered numerous opportunities for review, including opportunities outside of the formal public review process which itself has been extensive. PacifiCorp has submitted extensive written comments to which staff has dedicated a significant amount of time reviewing, considering, and responding. The public review and Board adoption process can not proceed in an orderly manner if responsible parties who have been intimately involved in the development of a project do not share some subset of their concerns and suggestions until after the close of the comment period.

Comment 247:

Appendix 1: Proposed Site-Specific Dissolved Oxygen Objective for the Klamath River in California. Executive Summary, Paragraph 1. Note that the DO fluctuations, weekly averages, peaks, etc. are variable from year to year. And yet the comparisons are being made to the natural baseline scenario model output (T1BSR), which is only based on one year (2000) of data. This indicates that the Klamath River TMDL model is lacking as a tool in TMDL development because it does not adequately address annual variability.

Response 247:
The TMDL model accounts in a number of different ways for the variability associated with the parameters of concern. In addition, the model includes an inherent margin of safety to ensure resource protection even under scenarios that vary from that specifically modeled. With respect to the SSOs for DO, percent DO saturation was chosen as the appropriate parameter because it inherently accounts for interannual variability while remaining itself stable.

Comment 248:
Executive Summary, Paragraph 2, Line 4. The Revised Draft TMDL states "The proposed recalculated SSOs for DO are achievable under natural conditions…" However, "natural conditions" as identified in the Revised Draft TMDL will not likely be achieved. As noted elsewhere in the comments, the assumptions for natural conditions suggest extraordinary reductions that, given the geology, hydrology, meteorology, and land use, are unrealistic.
Response 248:
The recalculated SSOs for DO are established at levels achievable given the physical constraints of barometric pressure, temperature, and salinity in the Klamath River. This is not true of the existing SSOs for DO which can not be met at some elevations when summer temperatures naturally rise. As such, the recalculated SSOs for DO represent an important improvement to the existing SSOs for DO. In addition, the TMDL model indicates that the source reductions *will* result in compliance with the water quality objectives, including the proposed recalculated SSOs for DO. Staff believes the implementation plan can achieve the necessary source reductions. A monitoring plan is in place by which to track compliance and make adjustments as necessary. In short, staff believes implementation of the TMDLs and SSOs for DO can reasonably be expected to achieve water quality objectives.

Comment 249:
Page 4-7 to 4-10, Section 4.4. What is the significance of discussing the CADDIS model? This model was not applied to the Klamath Basin, and so the points made in this section are just general ideas that may or may not apply to the Klamath River system. Discussion of an additional model that is not relevant misleads the reader and causes confusion about the role of the CADDIS model in the TMDL.
Response 249:
The CADDIS model has been moved to Chapter 5 where it is used to provide a framework for the discussion of past activities in the watershed and their potential effect on DO, as measured in the 1950s and 1960s. This is significant because the existing SSOs for DO are based on daytime grab sample data collected in the 1950s and 1960s and represent conditions already impacted by decades of watershed alteration and nonpoint source pollution.

Comment 250:
Page 5-8, last paragraph. The Revised Draft TMDL states:

> "Altering the shape of the hydrograph through anthropogenic manipulation simultaneously alters the seasonal pattern of DO availability. For example, lower flows from April to September likely result in lower DO concentrations by increasing the rate at which the river heats during the summer months, thereby reducing the concentration of DO at saturation. Further, the warm and slow moving conditions behind the dams

> promote the excess growth of algae which simultaneously promotes wider fluctuations in DO, including much lower night concentrations than occur naturally."

While it is correct that elevated temperatures lead to a decrease in dissolved oxygen saturation concentration, this argument completely ignores mechanical reaeration dynamics and local conditions in the river. Mechanical reaeration is typically represented as proportional to velocity and inversely proportional to depth (Bowie et al. 1985). So it is true that, while decreased flows lead to decreased velocity, reduced flows also lead to decreases in depth. Further, reaeration is a local phenomenon in the river which changes considerably under various flow regimes. In short, one cannot simply state that lower flows result in decreases in DO saturation without a more comprehensive assessment. Again, there is no quantification of these statements: would this assumed reduction be 0.01% or 10 percent? Simply stating that it is "lower" is not constructive.

Response 250:

Staff agrees with the commenter that when discussing specific locations in the river, one must take into account local phenomena such as the presence of falls or rapids, deep pools, channel constrictions, channel braiding, etc. when considering the effects on DO In this case, the discussion is not about specific locations but about the overall DO dynamics. Further, the paragraph cited is referring to the alteration of DO "at saturation" which is a measure of DO regardless of reaeration. The point of the cited paragraph is to indicate the change in DO concentrations at saturation that occur simply because of the presence of the dams.

Comment 251:

Page 5-9, Paragraph 1, Line 1 (Section 5.3.1.6). The Revised Draft TMDL states "Chapter 4.0 presents a USEPA's CADDIS generic conceptual model of the effects on DO expected from activities such as…" Why should the CADDIS model be relied upon? Though the CADDIS model could possibly be a very useful tool in water quality analyses, there is nothing to suggest that the results of CADDIS are applicable to the Klamath Basin.

Response 251:

The CADDIS model has been moved to Chapter 5 where it is used to provide a framework for the discussion of past activities in the watershed and their potential effect on DO, as measured in the 1950s and 1960s. This is significant because the existing SSOs for DO are based on daytime grab sample data collected in the 1950s and 1960s and represent conditions already impacted by decades of watershed alteration and nonpoint source pollution.

Comment 252:

Page 5-11, Paragraph 1, Lines 2-10. The Revised Draft TMDL states "The phosphorus-rich volcanic geology and organic wetland soils of the upper basin naturally feed episodic algae blooms downstream in the Klamath River mainstem leading to diurnal fluctuations in DO, particularly during the summer months. These natural conditions originate in the reaches downstream of Upper Klamath Lake in Oregon. Under natural conditions, they dissipate slowly in the downstream direction. Under existing conditions, though, *the fluctuation of DO is exacerbated and perpetuated further downstream by impoundments, agricultural return flows, water diversions, reduction in stream bank stability, reduction in stream side shade, and increase in sediment delivery* – conditions which were present when the SSOs for DO were first established" (emphasis added). How were dissolved oxygen conditions assessed to determine that impoundments perpetuate exacerbated DO fluctuations – was an existing conditions without dams scenario simulated to compare to baseline, and if so, are these results available? What are the specific diversions and agricultural return flows along the Klamath River being referred to in this statement? Where has stream bank instability in the mainstem occurred (e.g., how many miles, and what is the natural instability of banks in the main stem)? To support this statement, the Revised Draft TMDL needs to quantify the reduction in stream shade on the Klamath River mainstem and provide estimates of what changes have occurred over the past 50, 100, and 150 years. What was the disturbance regime of mainstem riparian vegetation, i.e., how often was it removed by fire, flood, beaver, disease, etc.). What quantitative impact does increased sediment delivery have on DO?

Response 252:

Staff disagrees that the cited statement requires quantification of the sort suggested. The statement made is based on a qualitative assessment of the conditions and parameters influencing DO in the Klamath River and is based on the conceptual model developed specific to the Klamath River, as well as the CADDIS conceptual model.

Comment 253:

Page 5-12, last paragraph. The Revised Draft TMDL states:

> "Staff concludes that the SSOs for DO in the Klamath River mainstem must be updated to: a) accurately depict daily minima conditions and b) deliberately define background conditions. As they are currently set, the SSOs for DO in the Klamath River mainstem are outdated with respect to the monitoring tools currently available. And, they erroneously establish as background, conditions which very likely reflect significant anthropogenic influence. More accurate and protective SSOs for DO would reflect the actual daily minima expected during the early morning hours and would be based on natural background conditions."

The goal of the SSOs for DO are not to protect fish populations, but to achieve hypothesized "pre-disturbance" conditions. Such conditions and SSOs have been set with little regard to attainable water quality standards or on-the-ground conditions in the Klamath River basin.

Response 253:

One of the goals of the recalculated SSOs for DO is to protect beneficial uses, including salmonid populations. Ideally, staff would have proposed DO objectives based on the life cycle requirements of salmonids, ensuring no production impairment, particularly given the threatened and endangered species status of several of the salmonids in the basin. But, the *Klamath TMDL model* demonstrates that under natural conditions DO does not consistently achieve the concentrations required to ensure no production impairment. There are a number of reasons why this may be true and the commenter is referred back to the DO Staff Report for additional information.

In summary, rather than establish the SSOs at DO concentrations known to allow for production impairment of salmonids, staff proposes to establish the SSOs based on natural conditions. As stated by Tudor Davies, USEPA Director of the Office of Science and Technology in a memorandum dated November 5, 1997, "For aquatic life issues, where the natural background concentration for a specific parameter is documented, by definition that concentration is sufficient to support the level of aquatic life expected to occur naturally at the site absent any interference by humans."

With respect to attainability, staff point out that the existing SSOs for DO are established at concentrations unattainable under barometric pressures and temperatures naturally found in the

Klamath. The recalculated SSOs for DO are specifically designed to correct this problem and ensure their physical attainability.

Comment 254:
Page 6-6, last paragraph. The Revised Draft TMDL states:

> "In 2005, peer reviews of the Klamath TMDL model were completed by Dr. Scott Wells (developer of CE-QUAL-W2 model), Portland State University; Brown & Caldwell (under contract to the City of Klamath Falls, Oregon); and the U.S. Bureau of Reclamation (Technical Services Center – Environmental Applications and Research Group, Denver). Peer review materials were also sent to Dr. Michael Deas, Watercourse Engineering, Inc., developer of the PacifiCorp Model. Dr. Deas did not submit any comments at that time."

Please note that neither the Regional Board nor EPA issued a contract that would allow Dr. Deas the means to provide peer review comments. Thus, no comments were submitted

Response 254:
Dr. Deas was given the opportunity to comment on the Klamath TMDL model both as the originator of the model *and* as a paid consultant to PacifiCorp. The Regional Water Board and EPA hoped that PacifiCorp would fund Dr. Deas' review of the model and would have found his input useful at that juncture.

Comment 255:
Page 6-10, end of section 6.2.3. The Revised Draft TMDL states "The model simulation was run for the year 2000." The model run was only done for one year. In contrast, the existing SSOs from the 1950s and 1960s were based on monitoring data from multiple years. This suggests that the existing SSOs were based on a more comprehensive data set.

Response 255:
The existing SSOs for DO were indeed based on a comprehensive data set, covering many months and years during which numerous climatic conditions were represented. Each month's data, however, represents only one moment during the month, and generally during daylight hours. As such, it is very limited in its ability to predict daily minima. The *Klamath TMDL model*, on the other hand, produces DO simulations for every hour of every day over the course of a year. While interannual variability is not well represented, diel variability certainly is. With respect to identifying daily minima, the *Klamath TMDL model* provides a far more comprehensive data set.

Comment 256:
No Comment. This is a placeholder so as to not alter the numbering of comments below.

Comment 257:
Appendix 6: General Comments.
The number of parameters and re-specification of key boundary conditions between the original Draft TMDL and the Revised Draft TMDL are remarkable. Although some of the parameter changes were apparently in response to comments about model representation being inconsistent among reaches, other changes have also been made for reasons that are not clear. Some of these other changes appear to be attempts to further calibrate the model, and others in response to specific applications or scenarios. Specific examples include:

- Natural Conditions at Link Dam. Modification of the Link Dam boundary condition for algae and organic matter under natural conditions. Algae concentration was increased globally by a factor of approximately 1.6 and organic matter was set to negligible values in the late spring and summer period when annual concentrations would naturally be the highest.

Response 257:
The modification of the algae boundary condition aimed at more consistently representing the nutrient loading from UKL. Previously, the algae boundary condition was configured based on the chlorophyll-a results from the UKL TMDL model. This introduced inconsistency in representation of nutrients contained in living algae, i.e., algae-P and algae-N. The updated boundary condition directly uses the algae-P results from the UKL TMDL model. This results in a consistent representation of the algal boundary condition and representation of TN and TP. The OM values were derived using the TMDL results and the ratio derived from current data.

Comment 258:
- Light Extinction. Light extinction was set uniform in all CE-QUAL-W2 simulations (calibration and application). Higher light extinction values in the upper basin would be expected, at a minimum in existing conditions and probably in natural conditions as well, given the wetlands that would presumably continue to surround UKL under a restored condition. This is an important distinction because refractory organic matter (ROM) has been completely ignored in the TMDL model, while seasonal (summer) ROM concentrations are currently on the order of 20 mg/l, with higher values occurring on occasion. Although refractory, this is a considerable load and will have implications throughout the river system.

Response 258:
Only the background light extinction, which characterizes the background light extinction from "pure water," was set to be consistent among waterbodies. The total light extinction was a function of particulate OM, dissolved OM, ISS, and algae concentration. This led to highly variable light extinction coefficients in the model from location to location. Higher light extinction was typically simulated at upstream locations than downstream locations. It is inaccurate to state that the model completely ignored the refractory OM. As clarified in Appendix 6, the labile OM slot was used to represent the lumped total OM. This was done due to a lack of information providing accurate partitioning between refractory and labile OM for the boundary condition. Using the labile OM slot to represent the total OM doesn't mean that the refractory OM was neglected.

Comment 259:
See PacifiCorp comment, page 90, second bullet through page 91, Figure B1, for full text of comment.

Response 259:
Comments regarding organic matter partitioning boundary conditions at Link should be addressed to ODEQ.
Although the 2007 and 2008 data provide insight into recent organic matter characteristics, they cannot be directly applied to models for 2000 and 2002. First, the data are 5 to 8 years more recent than the modeled period. Conditions in Lake Ewauna change significantly from one year to the next. Even the 2007 and 2008 data demonstrate significant variability over only a one year period.

For the 2000 calibration, the model reproduced the observed data for both NH4 and TKN in Lake Ewauna. This suggests a reasonable representation of organic matter since TKN=Organic N+NH4. If TKN and NH4 are reasonably predicted, organic N should also be reasonably predicted. This was the approach taken during calibration in the absence of available organic matter.
See also section 2.3.2 in Appendix 6 and responses to A77 and A123.

Comment 260:
No Comment. This is a placeholder so as to not alter the numbering of comments below.

Comment 261:

- Temperature Logic – Solar Radiation Reduction. Previous comments by PacifiCorp identified that the RMA-11 model had undocumented code reducing solar radiation by 20 percent globally in the riverine reaches. In the Revised Draft TMDL, model documentation states that this was corrected for Keno Reservoir, but the solar radiation reduction remains in the river reaches. The reason provided in the Revised Draft TMDL was that when calibrating the model for the Klamath River above Copco Reservoir (near Shovel Creek), the model was too "warm" at that particular point and the analyst reduced solar radiation to improve model performance. For a specific reach this may be acceptable, but to subsequently apply this to the entire river – both upstream and downstream – has no basis. To ascertain the implications of solar radiation reduction, the PacifiCorp model (PacifiCorp, 2005) was used to simulate temperature conditions with and without the reduction from Iron Gate Dam to Turwar. The boundary conditions at Iron Gate Dam were identical in both runs – they were taken from the Iron Gate Reservoir reach simulated output of the existing conditions model where there was no solar reduction. Model performance was compared with observed data at Seiad Valley and Turwar where data were readily available (due to the limited comment period, not all data could be acquired and prepared for comparison, e.g., 2006, and in certain cases data were unavailable, e.g., 2000). Comparing model performance (see Table B1 below), the model with reduced solar radiation consistently showed a greater bias by approximately 0.5 to 0.75ºC, with mean absolute error and root mean squared error higher than the model without the reduction. This illustrates that carrying a calibration strategy derived for a single point (Klamath River at Shovel Creek) throughout the river basin resulted in poorer model performance. Table B2 illustrates that reducing solar radiation over the entire Iron Gate to Turwar reach almost uniformly results in lower average simulated monthly water temperatures. Further, average simulated temperatures in July, August, and September can be over 1ºC cooler with the reduced solar radiation logic. Because these are average monthly temperatures, there are times during particular summer months (e.g., individual days) when temperatures may be reduced even further under the reduced solar regime.

Table B1. Effects of 20 percent reduction in solar radiation over the entire Iron Gate to Turwar reach

A. No Solar Radiation Reduction

Statistic	2001		2002		2003	
	Seiad	**Turwar**	**Seiad**	**Turwar**	**Seiad**	**Turwar**
Mean bias	-0.45	0.27	-0.74	-0.98	-0.48	-0.58
Mean absolute error	1.38	1.60	1.02	1.75	0.91	1.58
Root mean squared error	1.76	2.03	1.35	2.20	1.18	1.97
n	3491	2981	5313	3420	6515	3420
Statistic	**2004**		**2005**		**2007**	
	Seiad	**Turwar**	**Seiad**	**Turwar**	**Seiad**	**Turwar**
Mean bias	-0.87	-1.25	-1.02	-0.83	-0.96	-0.99
Mean absolute error	1.20	1.56	1.27	1.35	1.05	1.19
Root mean squared error	1.56	1.79	1.48	1.64	1.32	1.59
n	3888	135	8759	8574	6638	6473

B. Solar Radiation Reduction (TMDL model)

Statistic	2001		2002		2003	
	Seiad	**Turwar**	**Seiad**	**Turwar**	**Seiad**	**Turwar**
Mean bias	-1.21	-0.57	-1.39	-1.83	-0.94	-1.29
Mean absolute error	1.63	1.57	1.47	2.07	1.14	1.78
Root mean squared error	2.07	1.87	1.83	2.58	1.47	2.21
n	3491	2981	5313	3420	6515	3420
Statistic	**2004**		**2005**		**2007**	
	Seiad	**Turwar**	**Seiad**	**Turwar**	**Seiad**	**Turwar**
Mean bias	-1.62	-2.05	-1.60	-1.37	-1.61	-1.68
Mean absolute error	1.71	2.08	1.72	1.64	1.63	1.71
Root mean squared error	2.11	2.33	1.99	1.96	1.92	2.15
n	3888	135	8759	8574	6638	6473

These findings illustrate that there is a consistent bias in reducing solar radiation globally in the riverine models. It is important to note that reservoir reaches modeled with CE-QUAL-W2 receive 100 percent of solar radiation (no reduction). Thus, when comparing cases where dams are in and dams are out, the solar radiation applied over a particular reach is not equivalent. For example, for a case where Iron Gate and Copco Reservoirs are included in an analysis, 100 percent solar radiation is applied. For the same reach under a no-dams analysis, 80 percent solar radiation is applied. The implication have not been fully explored due to limited review time, but the global reduction of solar radiation by 20 percent presents a clear bias for lower simulated temperatures that can be in excess of 1ºC on a monthly average during the warmer periods of the year. The uncertainty associated with this error and the implications for thermal criteria should be fully explored.

Table B2. Difference between full solar radiation and 80 percent solar radiation (positive numbers indicate that reduced solar radiation simulated results are cooler).

	2000		2001		2002		2003	
	Seiad	Turwar	Seiad	Turwar	Seiad	Turwar	Seiad	Turwar
January	-0.02	-0.04	0.19	0.29	0.14	0.09	0.09	0.05
February	0.04	0.01	0.31	0.36	0.24	0.17	0.24	0.17
March	0.05	-0.08	0.48	0.40	0.33	0.26	0.28	0.19
April	0.06	0.03	0.49	0.54	0.41	0.38	0.30	0.25
May	0.10	0.17	0.61	0.50	0.56	0.53	0.38	0.33
June	0.40	0.55	0.70	0.83	0.76	0.75	0.58	0.56
July	0.72	0.70	1.00	1.00	0.91	0.89	0.84	0.77
August	0.86	0.77	0.92	0.93	1.00	0.95	0.80	0.82
September	0.63	0.77	0.81	0.87	0.84	0.90	0.69	0.82
October	0.41	0.54	0.54	0.64	0.59	0.80	0.50	0.69
November	0.17	0.35	0.28	0.24	0.35	0.37	0.30	0.37
December	0.17	0.21	0.14	0.07	0.12	0.08	0.14	0.08

	2004		2005		2006		2007	
	Seiad	Turwar	Seiad	Turwar	Seiad	Turwar	Seiad	Turwar
January	0.15	0.08	0.21	0.14	-	-	0.19	0.16
February	0.21	0.13	0.41	0.27	-	-	0.26	0.20
March	0.27	0.20	0.51	0.32	-	-	0.23	0.21
April	0.40	0.37	0.57	0.31	-	-	0.46	0.44
May	0.53	0.49	0.35	0.29	-	-	0.71	0.60
June	0.71	0.67	0.75	0.56	-	-	0.88	0.97
July	0.93	0.85	1.16	0.99	-	-	1.10	1.13
August	0.91	0.86	1.15	1.28	-	-	1.11	1.29
September	0.79	0.80	0.90	1.18	-	-	0.91	1.13
October	0.59	0.65	0.56	0.78	-	-	0.48	0.58
November	0.40	0.44	0.26	0.26	-	-	0.32	0.35
December	0.23	0.19	0.10	0.07	-	-	0.18	0.14

Response 261:

As described in Section 2.2.9 of Appendix 6, solar radiation was reduced in the RMA model because internally-calculated solar radiation was found to be approximately 20% higher than solar radiation used in the comparable W2 model. It was deemed appropriate to correct the bias in the RMA equations and to make this consistent throughout all RMA models applied. This approach also enables the with-dam and without-dam scenario comparison to be made correctly. Without the 20% adjustment, the no-dam scenario (where the RMA model was applied) would actually be simulated with 20% higher solar radiation than the with-dam scenario (where the W2 model was applied).

Comment 262:

- Algae settling: In all cases algae settling rates have been set to 0.3 m/d. This rate ignored the fact that the blue-green algae that dominate UKL and main stem Klamath River reservoirs can control their buoyancy. This has considerable implications in Keno Reservoir where, under current model assumptions, loss rates of algae to settling are notable. However, blue-green algae settling rates may be negligible due to buoyancy regulation, resulting in considerably less loss. Overestimating loss rates of algae due to settling in Keno would have direct implications for transport of organic matter (algae – dead and alive) and associated nutrients to downstream reaches. The Revised Draft TMDL does not include a discussion of algal species composition under a natural baseline. The TMDL model should include multiple algal species representation in the main stem Klamath River reservoirs to assess species specific attributes.

Response 262:

Theoretically, a more detailed representation of algae species may be more accurate, however, insufficient data are available to support this approach. Species-specific boundary condition data, at a minimum, would be necessary at a high temporal and spatial resolution to confidently predict multiple species. These data simply are not available. The commenter is correct that blue-green algae may move vertically under certain environmental conditions. This phenomenon does not occur in all situations though, and quantitative measures are not readily available to model the phenomenon. The TMDL model has considerably improved predictions of algae loss compared to the previous PacifiCorp model, however loss is still somewhat underestimated. It was not deemed justifiable to use a lower settling velocity in the calibration as it would decrease the accuracy of loss predictions. Representation of blue-green algae and its vertical mobility is inconsequential with regard to the TMDL scenario analysis since it was assumed that under natural conditions UKL would not be dominated by blue-green algae.

Comment 263:

PacifiCorp has multiple concerns with model assumptions and application of the models in the TMDL analysis. As stated in other comments, application of the models to additional years and formal sensitivity analysis could have potentially headed off some of these problems, and provided at least a minimum level of testing and uncertainty analysis so that decisions could be made using the modeling framework.

In sum, the Revised Draft TMDL contains boundary conditions and parameter values that are significantly different than the original Draft TMDL. These differences create significantly different water quality conditions in the Klamath River and algae and nutrient dynamics that are unusual and untested. Because of this, the model should be viewed as a new model and not just a revision of the previously released model.

Response 263:

The model was revised to more accurately represent the system. Revisions made were based on comments provided by reviewers as well as fixes deemed necessary by the modeling team. The same fundamental models and approach were used for the revised model as for the draft model. And, results for the revised model have been presented in their entirety. Model improvement and revision is an important and necessary step in the model and TMDL development process. This approach is not unique to the Klamath TMDL development effort.

Comment 264:

Page 8, Section 2.2.2. Given the data provided, the value of this “two-state algae transformation” modification is questionable. A very limited number of data (3) seem to be the basis for this modification (please see discussion of Figure 2-1, below), and the data do not really support the scheme. The calibration plots for Miller Island and Hwy 66 in 2000, Figures E-6 and E-16, respectively, suggest that just about any function that reduces algae concentrations from Miller Island to Hwy 66 would work just as well. Furthermore, it doesn’t look as if this “phenomenon” exists in the 2002 “validation” data. In 2002, there is no large drop in chlorophyll *a* concentrations, and the healthy-unhealthy hypothesis does not fit. At the very least, the TMDL should discuss the 2002 data that were used in "validation".

Response 264:

Both the 2000 and 2002 data show a significant drop in chlorophyll-a from upstream to downstream. Also see response to comment A108.

Comment 265:

Page 8, Paragraph 3, last line. So many things can affect algal growth that it is hard to accept the statement in the Revised Draft TMDL that "available data show no other explanation for the observed phenomenon." What phenomenon is being referred to?

Response 265:

See response to comment A109.

Comment 266:

See PacifiCorp comment letter, page 94, paragraph 5, for full text of comment.

Response 266:

See response to comment A110.

Comment 267:

Page 10, Equation 3. This equation is not a "Monod-type function" in the rigorous sense.

Response 267:

This equation is not referred to as a Monod-type function on Page 10. Also, see response to comment A111.

Comment 268:

Page 11, Last paragraph. Is "smoother" more accurate and more representative of natural processes? Does this modification improve the model?

Response 268:

The modification does not have a significant impact on the model results, however it was deemed more appropriate to represent the process using a smooth transition rather than an abrupt change. Since sediment oxygen demand is essentially a diffusive process which relies on the DO gradient at the water-sediment interface, it is more reasonable to represent it as a smooth transitional process with regard to DO rather than a abrupt on-and-off process. Also see response to comment A112.

Comment 269:

Page 12, Section 2.2.4. Watercourse ran into some problems using the pH modifications. The numerical technique is not robust and can lead to errors.

Response 269:

See response to comment A113.

Comment 270:

Page 12, Paragraph 3, Equation (Ke). In this formula, is OM particulate or refractory or both (i.e., total)?

Response 270:
See response to comment A 114.

Comment 271:
Page 13, Paragraph 2, Lines 13-19. The Revised Draft TMDL needs to clarify that the numbers given here are just an example and not values fixed for all simulations.
Response 271:
See response to comment A115.

Comment 272:
Page 13, Paragraph 2, Line 19. Both settling and decomposition affect the OM fractions.
Response 272:
Correct.

Comment 273:
Page 21, Paragraph 4, Lines 6-8. Sometimes, "it is preferable to use data collected during the modeling year", but only if the site is representative of boundary conditions.
Response 273:
Comment noted.

Comment 274 :
Page 21 to 22, Paragraphs 1-4 of Section 2.3.3.1. Phosphorus data seem to come from Pelican Island, Fremont Bridge, and Miller Island, inconsistently.
Response 274:
The use of phosphorus data is described on page 22 of Appendix 6.

Comment 275:
Page 22, Paragraph 2. Boundary condition (BC) PO4 concentration is used as a calibration tool. This is not standard practice.
Response 275:
See response to comment A119.

Comment 276:
Page 22, Paragraph 3. PO4 BC is from Miller Island. But PO4 and TP used in OM BC are from Pelican Marina. This is inconsistent. The Revised Draft TMDL needs to clarify whether PO4 concentrations from Pelican Island are good or not.
Response 276:
See response to comment A120.

Comment 277:
Page 22, Paragraph 4. Boundary condition TIC and alkalinity concentrations are used as a calibration tool to get pH in Lake Ewauna. This is not standard practice.
Response 277:
See response to comment A121.

Comment 278:
Page 22, Paragraph 4. In 2002, Miller Island data were not used to estimate PO4. Again, we question this method. The Revised Draft TMDL needs to clarify why PO4 concentrations from UKL are good to use in 2002, but not in 2000.
Response 278:
See response to comment A122.

Comment 279:
See PacifiCorp comment letter, page 95, seventh paragraph, for full text of comment.
Response 279:
Refer to page 19 of Appendix 6. Also see response to comment A123.

Comment 280:
Page 36, Bullet Point 1, Line 1. Denitrification in rivers is not significant, and thus should not be a concern in Appendix 3.
Response 280:
Appendix 6, page 36 states the following: "Denitrification in the riverine sections is not simulated due to the fact that the majority of the river bed is rocky and DO in the water column is high. Neither of these conditions are favorable for denitrification bacteria and corresponding denitrification processes. This assumption may potentially cause overprediction of NO2/NO3 in the riverine sections, however the impact is expected to be minimal." Also see response to comment A124.

Comment 281:
See PacifiCorp comment letter, page 95, ninth paragraph, for full text of comment.
Response 281:
See response to comment A125.

Comment 282:
See PacifiCorp comment letter, page 95, tenth paragraph, for full text of comment.
Response 282:
See response to comment A127.

Comment 283:
Page 44, Section 3.3. Some calibrated parameters were changed during "validation." The Revised Draft TMDL needs to confirm that calibrated values were unchanged for all TMDL scenarios.
Response 283:
This has been confirmed. Also see response to comment A128.

Comment 284:
See PacifiCorp comment letter, page 95, last paragraph, for full text of comment.
Response 284:
See response to comment A129.

Comment 285:
Page 45, Paragraph 2, Line 2-5. Lumping labile and refractory OM together and using an "average decay rate" does not accurately represent the separate decay rates of refractory and labile OM. Further, when an average value is used, the combination of both extreme labile and extreme refractory OM and their respective effects on the system are actually ignored.
Response 285:
Theoretically, a higher degree of OM representation would result in more accurate predictions. Unfortunately, insufficient data are available to accurately perform this partitioning. It should also be noted that the RMA-11 model simulates OM as a lumped parameter (with no partitioning even between dissolved and particulate phases).

Comment 286:
Page 45, Table 3-3. The Revised Draft TMDL does not mention the fact that SOD parameters also change from reach-to-reach. The Revised Draft TMDL needs to explain the rationale for changing these parameters reach-to-reach.
Response 286:
See response to comment A131.

Comment 287:
Page 47, Table 3-5. The Revised Draft TMDL Table 3-5 implies that parameter values remain constant reach-to-reach and for each scenario. Also, some parameters are not listed in this table. For example, "bed algae carrying capacity" is a term added to the RMA-11 model. In earlier versions of the TMDL model, this important parameter was not kept constant. The Revised Draft TMDL needs to include all important parameters and confirm that they remain constant reach-to-reach and for each scenario.
Response 287:
Table 3-5 has been updated to include carrying capacity half-saturation for periphyton. All other applicable RAM-11 model variables are included.

Comment 288:
Page 49, Paragraph 2, Line 1. The model does not appear to "reproduce the supersaturation of DO during early summer well." Simulated DO is always 4-6 mg/L low in comparison to observed values in May.
Response 288:
An explanation is provided in paragraph 2, page 49 of Appendix 6.

Comment 289:
Page 49, Paragraph 3, Lines 6-10. There is SOD in W2. It is not clear that a fully dynamic interaction between bed and water column is necessary. Similar results might be obtained by specifying seasonal SOD.
Response 289:
It is possible that similar results may be obtained by specifying seasonal SOD, however this approach limits the predictive capability of the model when loading conditions change. Also see response to A135.

Comment 290:

Page 52, Paragraph 2, Last sentence. If “the model’s overprediction of chlorophyll *a* …is likely caused by inaccurate boundary conditions from UKL”, then why would this overprediction of chlorophyll *a* not show up in all upstream reaches? The Revised Draft TMDL suggests that the model simulates chlorophyll *a* “very well’ in the Lake Ewauna to Keno Reach (page 49, paragraph 4, line 1). Or, is the Revised Draft TMDL suggesting that inaccuracies in boundary nutrients led to poor chlorophyll *a* simulation downstream? This needs to be clarified.
<u>Response 290:</u>
Paragraph 2, page 52, last sentence states: “The model’s overprediction of chlorophyll a in Figure H-17 is likely caused by the overprediction of chlorophyll a in Lake Ewauna during the early summer, which propagate to this location in the system.” It does not refer to the UKL boundary conditions.

<u>Comment 291</u>:
Page 53, Paragraph 1, Line 3. The Revised Draft TMDL states that the model “predicts concentrations within the range of observed data”. This is misleading. Model results for NH4 and NO3 are not within any meaningful observed range.
<u>Response 291:</u>
Paragraph 1, Page 53 states: “It [the model] overpredicts NH4 and NO3 concentrations on some dates and underpredicts them on other dates for Copco Reservoir.”

<u>Comment 292</u>:
See PacifiCorp comment letter, page 96, eighth paragraph, for full text of comment.
<u>Response 292:</u>
See response to comments A3 and A139.

<u>Comment 293</u>:
Page 54, Last Paragraph, Line 1-2. Apparently, 2004 data were used to calibrate the estuary model. Why weren’t data through 2004 used for the rest of the river? Why weren’t data gaps identified and filled for the rest of the river through at least 2004?
<u>Response 293:</u>
See response to comments A3 and A140.

<u>Comment 294</u>:
Page 55, Paragraph 1, Line 7-8. Uncertainty in lab data is shown in estuary calibration figures. Why should this be done only for the estuary? The Revised Draft TMDL needs to include error bars in the presentation of lab uncertainty throughout this TMDL.
<u>Response 294:</u>
See response to comment A141.

Appendix 7: Modeling Scenarios: Klamath River Model for TMDL Development – December 23, 2009

<u>Comment 295</u>:
An approximate seasonal distribution of total phosphorus values for Klamath River “natural” conditions simulation (T1BSR), derived from the water quality input file used at Link River and the stoichiometric ratio of phosphorus in algae and organic matter as used in the Klamath River

TMDL model, is shown in Figure C1 below. Total phosphorus (TP), the sum of orthophosphate-phosphorus (PO_4), algal phosphorus (Alg-P) and non-algal phosphorus or organic matter phosphorus (OM-P), at Link River varies over the year with a low of approximately 20 µg/L in winter and a high of about 40 µg/L in midsummer. As shown in the figure, the UKL TMDL target for spring of an average 30 µg/l matches the Link River boundary conditions. But the annual mean TP concentration used as Link River boundary conditions was only about 25 µg/L, far less than the UKL TMDL annual lake average target of 110 µg/L.

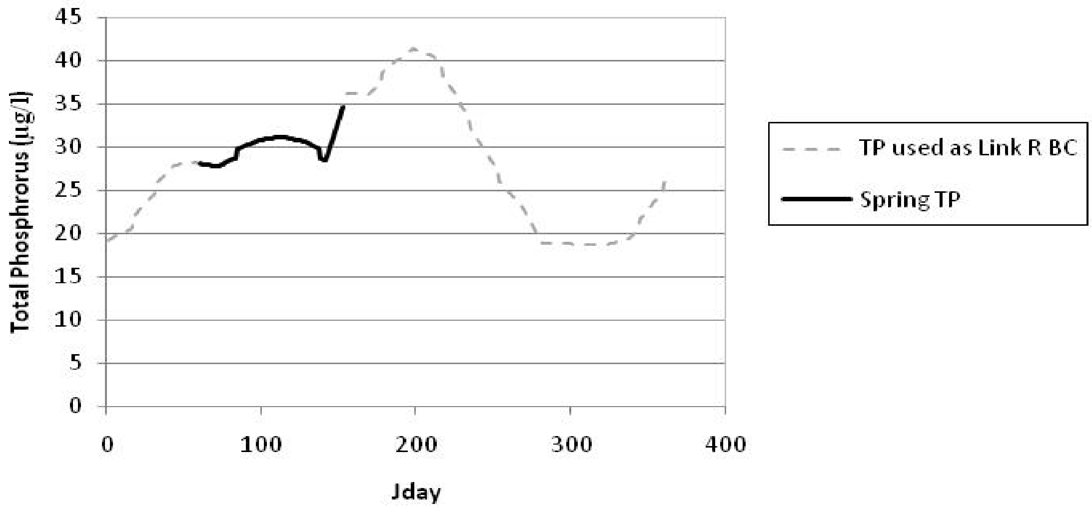


Figure C1: TP boundary conditions used at Link River for the "natural" baseline scenario (T1BSR) of the Klamath River TMDL model. Note that only the spring target specified in the UKL TMDL was matched by the T1BSR boundary conditions. Over the rest of the year, the water quality at the UKL outflow was assumed have concentrations notably lower than the UKL TMDL compliant conditions.

Communications provided with the UKL TMDL spreadsheet model indicate that a bi-weekly distribution of TP at the outflow of UKL was used to calculate T1BSR boundary conditions. The Revised Draft TMDL also indicates that these TP values for determining the T1BSR boundary conditions were based solely on one year (1995). Annual mean TP concentrations in UKL outflow for each of the seven years of these UKL simulations (Walker 2001) spanning 1992-1998 are shown in Figure C2 below. These concentrations are based on an assumed 40 percent reduction of external phosphorus load into UKL as per the UKL TMDL. As shown in the figure, the year chosen is the second lowest of the seven years. Annual mean TP for 1995 is only about 60 percent of the seven-year mean TP concentrations upon which the UKL TMDL was established.

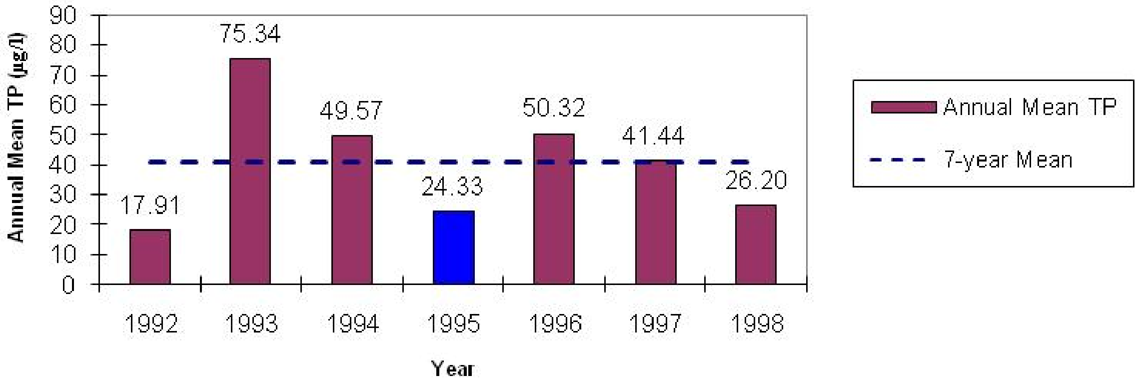


Figure C2: UKL model results of annual mean TP from 1992 to 1998. These annual mean TP concentrations in UKL outflow are based on an assumed 40 percent reduction of external phosphorus load into UKL. The blue dashed line indicates the 7-year mean TP, which is about 41 µg/l. The annual mean TP for 1995, which was the year used to formulate boundary conditions for T1BSR, is only 60 percent of this 7-year mean.

The Revised Draft TMDL claims that 1995 simulation results were used to create the boundary conditions for T1BSR because it represents the "median" conditions (Appendix 7, page 1). However, as mentioned above, the 1995 phosphorus concentrations are the second lowest of the 7-year period between 1992 and 1998. As such, 1995 is clearly not a representative condition. This is an important element in the UKL TMDL – there are times when the in-lake target will be met, but not in all years. Further, by selecting only a single year, natural variability from year to year is effectively unrepresented.

Historical data for TP loads in UKL outflow from 1992 through 1998 shows that 1995 is close to the median – although 1993 is the actual median year (see **Error! Reference source not found.** below). The 1995 scenario may have been chosen based on the historical data, but to do so would mean that historical data should also be used to create the boundary conditions for the Klamath River model, which would result in higher levels of water quality impairments for inputs to the model.

Response 295:

The median value was based on median concentration of each year predicted by the UKL TMDL model, instead of using the annual average from the UKL TMDL model.

Comment 296:

In addition to the above inconsistencies with the UKL TMDL, which the T1BSR boundary conditions at Link River were supposedly based on, changes were also made to the numbers between the original Draft TMDL and the Revised Draft TMDL. Specifically, organic matter and algae boundary conditions at Link River have been significantly changed.

In the previous public review comment period, PacifiCorp noted that boundary condition concentrations for nutrients were unrealistically low, thus making the downstream allocations and numeric targets unattainable. In the Revised Draft TMDL, changes were made to these boundary conditions without full explanation. Some of the details behind these changes were discovered upon examination of the spreadsheet used to create the Link River boundary conditions, which was provided by the Regional Board (and Tetra Tech) during the review

period (January 19, 2010). Although review time was limited, several areas of concern were identified and are discussed below.
An important change is that, although nutrients remained at the same low levels identified in the original Draft TMDL, organic matter and algae concentrations were modified considerably. During peak growth periods, algae concentrations were increased by approximately 60 percent of the values used in the original Draft TMDL (see Figure C4 below). Concomitantly, organic matter reductions ranged from approximately 30 to 99 percent.
One unrealistic outcome of the assumptions made in creating the Link River boundary conditions is that organic matter is set to a negligible concentration during summer and early fall periods when concentrations are typically at annual maxima (see **Error! Reference source not found.** below) – a dramatic shift in assumptions occurred between the June and December TMDL draft. This has a direct effect on downstream nutrient concentrations because setting organic matter low removes a primary source of nutrients from the system. Overall total organic matter (organic matter plus living algae) was reduced between the June and December draft documents by up to 35 percent, or approximately 2.25 mg/l. Based on stoichiometry, associated reductions in nitrogen and phosphorus are approximately 0.15 mg/l and 0.012 mg/l, respectively. The magnitude of these concentrations are important to consider because they are roughly 50 percent of the Stateline total nitrogen and total phosphorus monthly allocations presented in Chapter 5 of the TMDL for summer periods. Overall, no explanations were given for this significant discrepancy between the June draft TMDL and December draft TMDL modifications.
Response 296:
This comment was addressed above in the Appendix 6 discussion. It is repeated here:
The modification of the algae boundary condition aimed at more consistently representing the nutrient loading from UKL. Previously, the algae boundary condition was configured based on the chlorophyll-a results from the UKL TMDL model. This introduced inconsistency in representation of nutrients contained in living algae, i.e., algae-P and algae-N. The updated boundary condition directly uses the algae-P results from the UKL TMDL model. This results in a consistent representation of the algal boundary condition and representation of TN and TP. The OM values were derived using the TMDL results and the ratio derived from current data.

Comment 297:
As noted above, assumptions made in the determination of boundary conditions at Link Dam directly affect model results. The Revised Draft TMDL states that “average ratios…were calculated based on Pelican Marina, UKL monitoring data…(with a sample size of n=15)” (Appendix 7). These ratios were then used to generate the boundary conditions based on TP numbers from the implementation of the UKL TMDL. For example, an average ratio of 0.245 was calculated, based on a partial year of data, for soluble reactive phosphorus to total phosphorus ratio (SRP:TP). This ratio was then assumed to apply throughout the year. Following that estimation, SRP boundary conditions could be calculated as 24.5 percent of TP values based on the simulated UKL TMDL model results. However, the ratio of inorganic to total phosphorous is not constant across seasons (under existing conditions), nor would it be expected to remain constant under the posited trophic shifts (Wetzel, 2001), which are implicitly acknowledged in the Revised Draft TMDL as necessary to meet nutrient targets in California under compliance scenarios. Further, recent studies from USGS have shown that these pertinent ratios vary seasonally during any given year (Sullivan et al, 2008; Sullivan et al, 2009). During

periods of algae bloom, the amounts of SRP in relation to TP may be very low due to uptake by primary production. Following a bloom crash and subsequent senescence, the inverse may occur. Disregard for such seasonal variations in the nutrient ratios (not only the SRP:TP relationship, but all the other ratios which build upon this single ratio) is evident in the Tetra Tech spreadsheet that was used to create the Link River boundary conditions from the UKL TMDL model output: an analyst comment acknowledges that negative concentration can occur based on this assumption of a constant ratio. To circumvent this problem, an artificial minimum (the smallest calculated positive number, which is 0.239) is placed on the organic phosphorus whenever a negative concentration is calculated. This does not allow the mass balance to be closed at Link Dam, i.e., the loading determined based on the UKL Model is not equivalent to the loading into Link River in the draft Klamath River TMDL. Further, no explanation was given as to why 0.239 was chosen as the minimum for organic phosphorus calculations.

Response 297:

The approach used to derive the boundary condition at Link Dam is standard practice in situations where data are limited and thus temporal variability cannot be reasonably determined. Additionally, measured nitrogen components sometimes result in a higher TN value than measured TN. In these situations, the most reasonable approach is to maintain a mass balance. It is also worth noting that under natural conditions UKL dynamics change significantly from current conditions. Although seasonal variability can be derived from current conditions data, determination of seasonal variability under natural conditions would be purely speculative.

Comment 298:

In addition, the average ratios developed using historical data were based on impaired conditions at UKL. Hypoxia and sediment nutrient flux loading that occurs under current conditions, coupled with extensive nitrogen-fixing cyanobacteria (Kuwabara, et al, 2009), produce conditions that are inconsistent with a scenario in which UKL TMDL targets are implemented, i.e., low nutrients. Water chemistry that is fully compliant with the UKL TMDL would almost certainly lead to different SRP:TP, NO3:TN and NH4:TN ratios, and also different temporal distribution of such ratios. The attainment of the UKL TMDL also suggests that DO levels will no longer be adverse, i.e., anoxia and associated chemical processes will be absent (ODEQ 2002). Further, without anoxia, the ratio of NH4:NO3 would not be as high as depicted in the Tetra Tech spreadsheet, which is 9.4, because there would be more oxygen for the conversion of ammonia to nitrate – in theory ammonia would largely be absent. As such, the approach of applying these ratios (calculated from samples taken in impaired conditions) on simulated TP values (based on implementation of UKL TMDL) is incorrect and inappropriate.

Response 298:

See the response to the comment above. It is probable that under natural conditions the ratios between nutrient species would differ from the existing conditions. The best approach was taken given that a full-scale water quality model of UKL is not available to predict such conditions and corresponding ratios.

Comment 299:

Further, low nutrient values in the UKL TMDL "natural" conditions baseline seem untenable in the context of current conditions at UKL. UKL is commonly classified as hypereutrophic because of its high primary production rates and impaired water quality conditions. Nevertheless, the SRP values (peak ~ 0.006 mg/l) calculated from the UKL TMDL outflow TP, as well as nitrate and ammonia and associated chlorophyll *a* values, presented in Tetra Tech's "natural" boundary conditions spreadsheet suggest that UKL would be classified as mesotrophic to oligotrophic (SFPUC, 2002 and Wetzel, 2002). In fact the orthophosphate and nitrate boundary conditions used for the Link River model input are below reporting limits for production laboratories. That is, current available methods cannot reproducibly measure values this low. Finally, shifting Upper Klamath Lake from the current hypereutrophic state to mesotrophic would not only be a monumental challenge, but would also shift the lake to a lower trophic status than what existed naturally (Eilers et al, 2004).

Response 299:

The nutrient concentration is based on the approved UKL TMDL.

Comment 300:

To assess the implications of altering "natural" boundary conditions at Link Dam and changing conditions in Keno Reservoir, conditions under the "natural" baseline were examined at Keno. Examining conditions at Keno provides an opportunity to look at what water quality conditions would be at the head of the riverine sections of the Klamath River. This approach also lends insight into the critical role that Keno Reservoir plays in downstream water quality. This approach further illustrates that the Keno Reservoir model is one of the most sensitive elements in the entire Klamath River modeling framework, wherein modest modification of boundary conditions and model parameters can have profound impacts on simulated downstream water quality.

Conditions at Keno Dam – "Natural" Conditions: After considering the low loading conditions at the Link Dam boundary conditions, the 10 percent/90 percent partitioning (see comments on Appendix 6) of particulate/dissolved labile organic matter under the "natural" baseline scenario, and the potential implications of increased settling rates in the Keno Reservoir reach, an examination of the TMDL model output at Keno Dam for "natural" baseline was completed using models provided by the Regional Board. Results from the original Draft TMDL and the Revised Draft TMDL were compared to determine the implications of the aforementioned modifications in model boundary conditions and specifications between the two draft documents. The findings illustrated the following:

- The re-partitioning of labile organic matter, coupled with increased settling, and reduction of total organic matter at Link Dam, reduced labile particulate matter at Keno Dam compared to the original Draft TMDL. LPOM is reduced in the range of 70 to 90 percent, as shown in Figure C3 below.

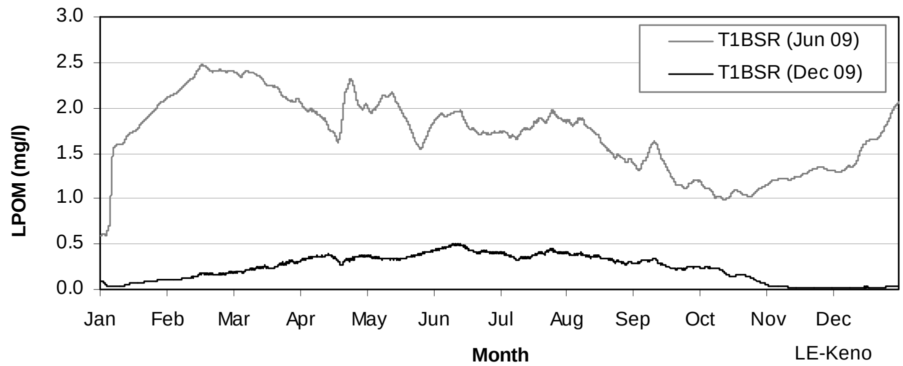


Figure C3. Labile particulate organic matter (LPOM) at Keno Dam (2000) for "natural" conditions model simulations in the original Draft TMDL (June 2009) and the Revised Draft TMDL (December 2009).

- The modified boundary condition at Link Dam employs very low seasonal organic matter (with annual lows in the late spring and summer), which results in very low labile dissolved organic matter in the summer compared to the original Draft TMDL. Typically, seasonal maxima occur during summer months; however under the current TMDL assumptions, seasonal minima occur in the summer months with values well under 0.5 mg/l, as shown in Figure C4 below.

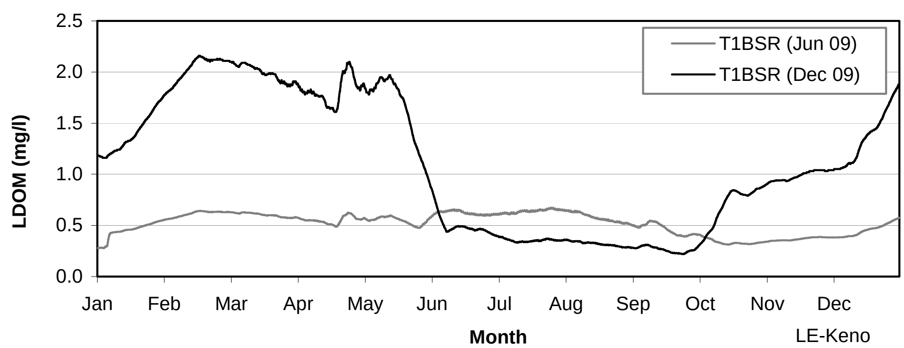


Figure C4. Labile dissolved organic matter (LDOM) at Keno Dam (2000) for "natural" conditions model simulations in the original Draft TMDL (June 2009) and the Revised Draft TMDL (December 2009).

- Phytoplankton at Keno Dam are also considerably lower in the Revised Draft TMDL than in the original Draft TMDL. Due to the changes in boundary OM concentrations and partitioning, an unusual algae dynamic in the Lake Ewauna-Keno reach is developed, as shown in Figure C5 below. Instead of a summer bloom period, there is a spring bloom and the algal standing crop actually diminishes through the late spring and summer period, suggesting nutrient limitation.

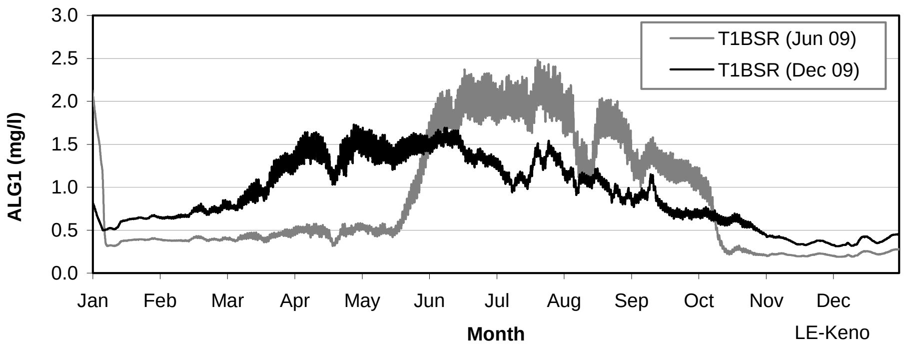


Figure C5. Phytoplankton (ALG1 – healthy) at Keno Dam (2000) for "natural" conditions model simulations in the original Draft TMDL (June 2009) and the Revised Draft TMDL (December 2009).

- Examining inorganic nitrogen and phosphorus indicates that the Revised Draft TMDL modeling assumptions produce extreme nutrient limitation by mid-June. Total inorganic P and N values, depicted in **Error! Reference source not found.** and **Error! Reference source not found.** below are on the order of 0.001 mg/l continuously for 4 months from late spring to early fall. This is an extremely low level of inorganic nutrients for an extended period of time in the typical growth season of algae (long days, warm temperatures), but algal standing crop is not high. This further illustrates the usefulness of examining both total and inorganic forms in regulatory assessments.
- PacifiCorp's previous comments on the original Draft TMDL noted low nutrient values, and the Revised Draft TMDL values are even lower, remarkably lower for all summer months and a good portion of the fall. The total organic (particulate and dissolved) load at Keno Dam is less than 1 mg/l for much of the same period, as is algae concentration.
- Why such changes were made between the original Draft TMDL and Revised Draft TMDL is not documented. Regardless, this level of reduction in everything (nutrients, algae, organic matter) is infeasible given local geology and natural eutrophic conditions at UKL. The water quality results at Keno Dam under the Revised Draft TMDL "natural" conditions simulation are unrealistic, suggesting that the model assumptions for "natural" conditions and possibly existing conditions are unrealistic. Given these extraordinarily low concentrations at Keno Dam, the implications downstream are clear: the current "natural" conditions model removes almost all nutrients and sources of nutrients by the time waters reach Keno Dam. As a result, the principal nutrient source downstream is the springs below J.C. Boyle Dam.

Response 300:

See responses to comments 296 and 297. The Link boundary condition was modified to: 1) correct double-counting of organic matter in the previous boundary condition, and 2) achieve more consistent representation of algae P and total P. It is important to note that even with changes to the boundary condition, TMDL allocations to point and nonpoint sources in Oregon determined using the previous version of the model are still valid using the revised model.

Comment 301:

The preceding discussions have shown how conditions assumed to represent the "natural" state of the river are unrealistically optimistic, and they are based on assumptions of water quality in Upper Klamath Lake that are unachievable. These assumptions affect all aspects of TMDL target assignments and load allocations. Perhaps most importantly, the TMDL does not address

Klamath River water quality if dams are removed but water quality targets have not been achieved for the UKL TMDL or the Klamath River TMDL. Until UKL TMDL compliance is met, the quality of water from Upper Klamath Lake will be poor and contain high concentrations of nutrients and organic matter. Without dams, this condition will translate directly downstream and could potentially have significant impacts on dissolved oxygen concentrations and fisheries health throughout the river and into the estuary. This requires careful consideration as potential dam removal is considered.

Response 301:

Natural conditions for the Klamath River TMDLs assessment is intended to characterize natural conditions (in the absence of anthropogenic effects) as best as possible, and identify allocations to achieve unimpaired water quality, through allocations and compliance schedules. We concur with the above statement that "the Klamath River will be far from compliance (sic) if dams are removed before Oregon is in complete compliance." Continued progress toward achievement of Upper Klamath Lake TMDL compliant conditions is necessary, and the TMDL reinforces that need by using compliant conditions as boundary conditions to assess long-term compliant conditions for the downstream Klamath River. The analysis addressed in the comment describes an interim status valuable for assessing interim conditions following potential dam removal and prior to full compliance in Oregon; it reduces upstream anthropogenic point sources but does not eliminate upstream anthropogenic sources of pollution. Such an approach may be very helpful to other processes such as the NEPA analysis for the KHSA Secretarial Determination. However, TMDLs determine long-term TMDL compliance goals, and such an interim analysis is not applicable for setting TMDL allocations.

Comment 302:

The Revised Draft TMDL emphasizes the dominating influence of UKL water quality on the entire river down to the estuary. However, this influence is never fully explored in the draft document. The TMDL does not consider effects of UKL water quality on its "natural" baseline scenario. Instead, under the TMDL "natural" condition (with dams removed), a single set of boundary conditions is applied to Link River based on the UKL TMDL (ODEQ 2002) with the assumption that compliance with the UKL TMDL will occur before dams are removed. The TMDL does not consider the possibility of a "natural" river system with non-compliant water quality in Upper Klamath Lake or in Oregon at Stateline. Given the magnitude of the difference between existing conditions and UKL TMDL-compliant conditions, a logical assessment would include, at a minimum, a transitional reduction in loading conditions at Link Dam to assess intermediate conditions en route to compliance. No such analyses were presented in the draft TMDL. Further, although the Revised Draft TMDL states in Response T13 (page 25-26, Appendix 8) that "based on TMDL modeling analysis, the TMDL allocations and targets would be achieved should the dams be decommissioned," such an analysis was not presented in the draft TMDL (and under such a massive modification to the river, the TMDL would likely need revisiting).

Response 302:

See response to comment 301. The issue of current UKL conditions relative to natural conditions scenarios is irrelevant, as the natural conditions scenario is based on achieving compliance with the UKL TMDL. Please note that the TMDL analysis provides for both dams-in and dams-out scenarios, and does not speak to the timing of meeting any particular allocations.

<u>Comment 303</u>:
The Revised Draft TMDL assumes that Upper Klamath Lake will be compliant with the UKL TMDL by the time dams are removed. The magnitude of this assumption is illustrated in the difference between Revised Draft TMDL's assumed "natural" water quality (i.e. UKL TMDL-compliant) and existing water quality at Link River, the headwaters of the Klamath River. This difference is shown for total nitrogen (TN) and total phosphorus (TP) in **Error! Reference source not found.** and **Error! Reference source not found.**, respectively (below). These figures are derived from data that comes directly from Klamath River TMDL "natural" baseline and "existing conditions" simulations.
<u>Response 303:</u>
See response to comments 301 and 302.

<u>Comment 304</u>:
As described in the Revised Draft TMDL, and shown in the figures for TP and TN, assumed "natural" conditions (simulation T1BSR) are dramatic improvements over existing water quality conditions at Link River (simulation S1). Assumed "natural" total nitrogen (TN) concentrations can be more than 18 times less than existing concentrations, and "natural" total phosphorus (TP) concentrations can be more than 25 times less than existing conditions at Link River. Significantly, the difference is most extreme during months of summer water quality impairment, a "critical" time in the TMDL, when nutrient concentrations typically reach their annual peak. This natural and historic summer peak, reflected in monitoring data, is not reflected in the T1BSR simulation. The figures illustrate the large effort that will be required to achieve water quality compliance at Upper Klamath Lake. Because Upper Klamath Lake is a naturally eutrophic system, water quality compliance in the lake will not be achieved quickly, and likely not at all.
<u>Response 304:</u>
The nutrient concentrations at the Link Dam boundary are based on the approved UKL TMDL. We agree that the differences between current and TMDL-compliant conditions are large. The Regional Water Board looks forward to working closely with ODEQ, PacifiCorp, the Bureau of Reclamation and the many other parties in the watershed to demonstrably improve water quality in the Klamath River.

<u>Comment 305</u>:
If Upper Klamath Lake or conditions at Stateline are not in compliance when dams are removed, water quality in the Klamath River will be notably different than that described in the Revised Draft TMDL. A modified "natural" baseline scenario, with dams out, is needed to evaluate these conditions. The dams-out scenario presented here represents a TMDL "natural" simulation modified by likely interim boundary conditions at Link River and is therefore referred to as C-T1BSR. Results of this simulation demonstrate the importance of using realistic boundary conditions in TMDL development. They also illustrate the likely water quality of the Klamath River after dams are removed – as early as 2020 – and that Revised Draft TMDL allocations and targets will *not* be achieved should the dams be decommissioned prior to compliance in Oregon. This modified "natural" simulation uses the Revised Draft TMDL model configured in all respects as it was for the original Draft TMDL except that, instead of UKL TMDL-compliant water quality at the headwaters, the Revised Draft TMDL's "existing conditions" (S1) water

quality at UKL is applied at the headwaters. The simulation represents “natural” conditions with the added assumption that UKL TMDL compliance will not be achieved by the time dams are removed, i.e., water quality from UKL will be essentially unchanged from existing conditions. Key components of the modified “natural” conditions baseline scenario (C-T1BSR) are:

- Klamath River and tributaries configured as in the TMDL “natural” baseline conditions including,
  - representation of the river with no dams, except Link Dam
  - absence of all point sources
  - Lost River Diversion Canal (LRDC) and Klamath Straights Drain (KSD) represented using existing conditions flow, but water quality set equal to UKL conditions
- Upper Klamath Lake (UKL) and all tributary boundary conditions based on TMDL *existing conditions*

Comparing results from RWQCB’s assumed “natural” conditions (T1BSR) and C-T1BSR, it is clear that poor water quality in Upper Klamath Lake is directly translated downstream under any “natural” conditions configuration. If Upper Klamath Lake is not in compliance when dams are removed, water quality will be markedly worse than portrayed in the Revised Draft TMDL under full compliance conditions. Total nitrogen concentrations (NTOT) at three locations along the Klamath River from both the T1BSR and C- T1BSR simulations are shown in Figure C6 through Figure C8. Locations include the Link dam boundary, below Keno dam, and below Iron Gate dam (node 757 on the Keno-IG reach). Total phosphorus concentrations (PTOT) at these three locations from both the T1BSR and C- T1BSR simulations are shown in Figure C9 through Figure C11. The “natural” simulation with modified boundary conditions (C-T1BSR) shows significantly more total nitrogen and total phosphorus at all locations than the Revised Draft TMDL simulation (T1BSR).

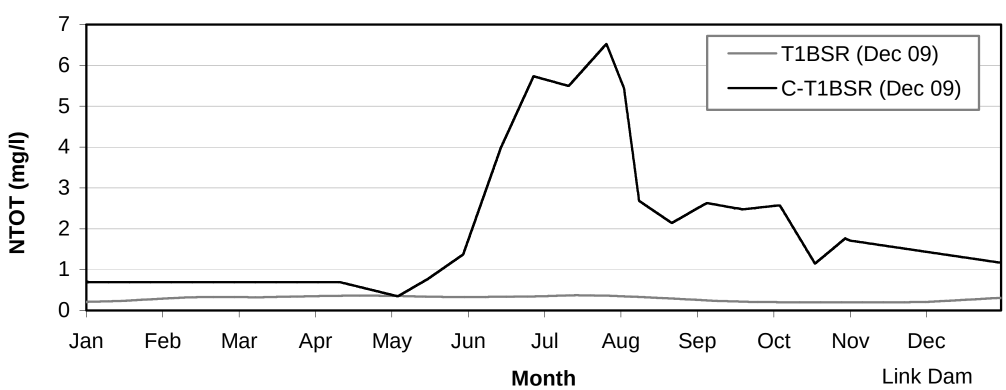


Figure C6: Total nitrogen below Link dam under Revised Draft TMDL "natural" baseline scenario (T1BSR) and under the modified "natural" baseline scenario (C-T1BSR)

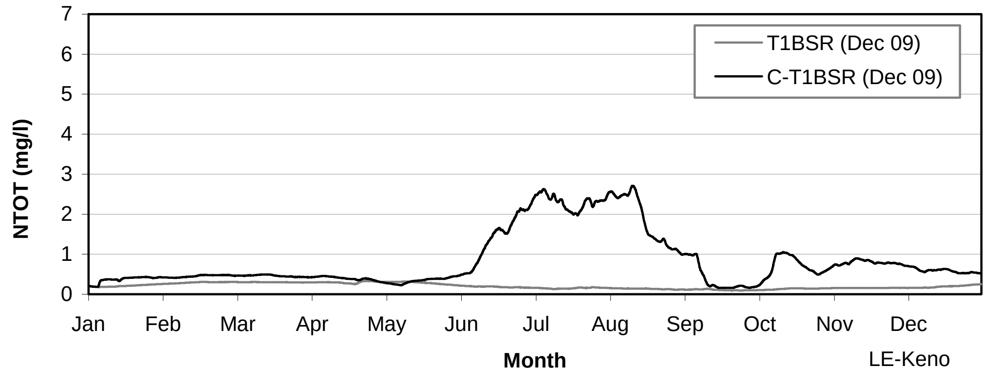


Figure C7: Total nitrogen below Keno dam under Revised Draft TMDL "natural" baseline scenario (T1BSR) and under the modified "natural" baseline scenario (C-T1BSR)

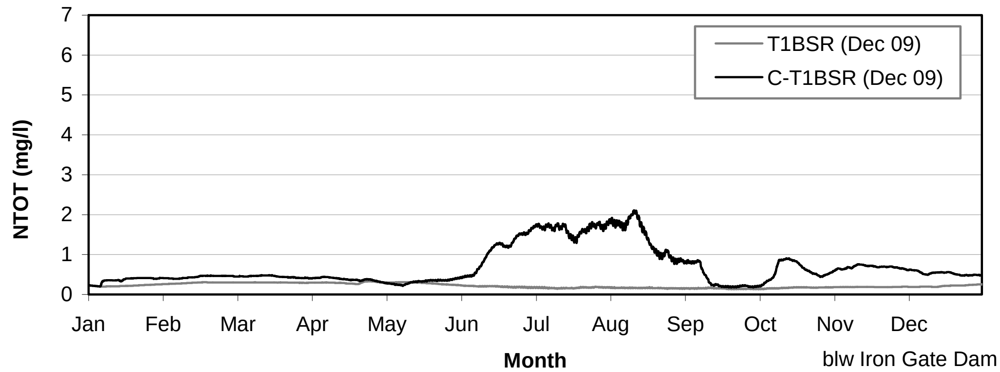


Figure C8: Total nitrogen below Iron Gate dam under Revised Draft TMDL "natural" baseline scenario (T1BSR) and under the modified "natural" baseline scenario (C-T1BSR)

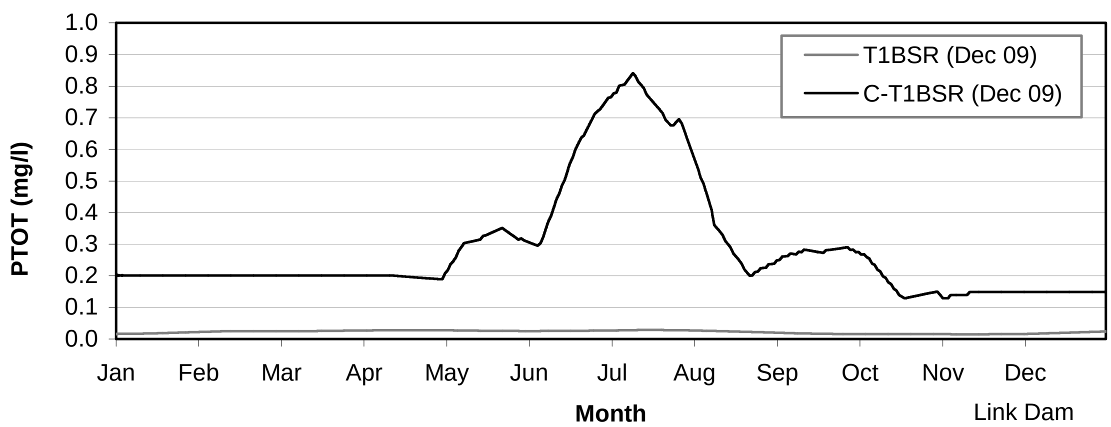


Figure C9: Total phosphorus below Link dam under Revised Draft TMDL "natural" baseline scenario (T1BSR) and under the modified "natural" baseline scenario (C-T1BSR)

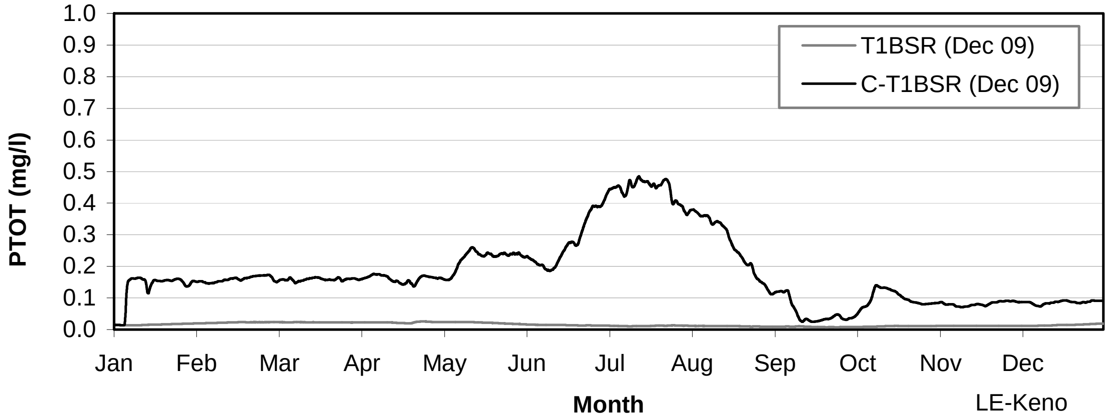


Figure C10: Total phosphorus below Keno dam under Revised Draft TMDL "natural" baseline scenario (T1BSR) and under the modified "natural" baseline scenario (C-T1BSR)

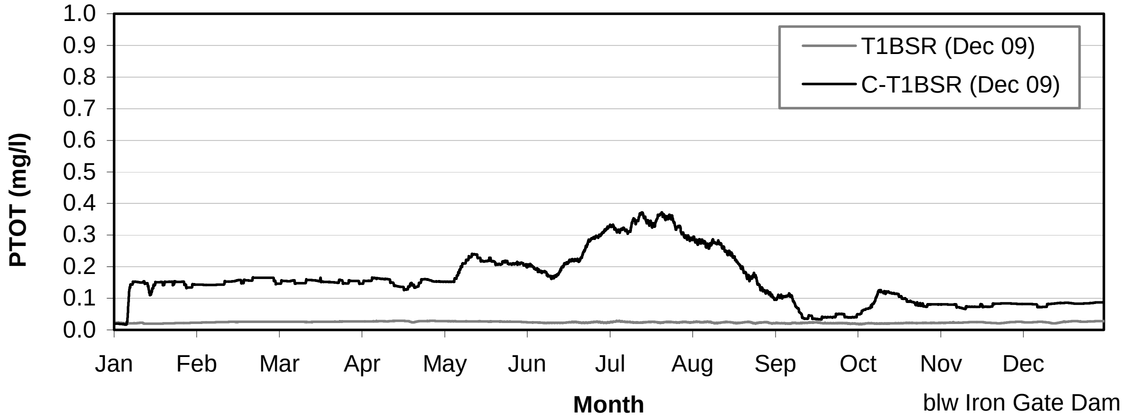


Figure C11: Total phosphorus below Iron Gate dam under Revised Draft TMDL "natural" baseline scenario (T1BSR) and under the modified "natural" baseline scenario (C-T1BSR)

The Revised Draft TMDL's "natural" baseline simulation (T1BSR) was the basis for setting targets and allocations. This simple comparison suggests that the Klamath River will be far from compliance if dams are removed before Oregon is in complete compliance. Clearly, reasonable assumptions about upstream boundary conditions can significantly change "natural" baseline water quality all along the river and thereby require alterations to water quality target and load allocations prior to full compliance in Oregon.

Conclusion: As demonstrated by the Revised Draft TMDL models, dams along the Klamath River can significantly influence water quality. With the quality of water from Upper Klamath Lake as it is now, and as long as water quality from UKL is poor, existing dams can have clear beneficial effects on the Klamath River by reducing nutrients and organic matter. Given the significant influence that Upper Klamath Lake has on water quality downstream, even reasonable progress towards TMDL compliance in Upper Klamath Lake – progress that likely will require several decades – will not be sufficient to meet water quality objectives in the Klamath River downstream when dams are potentially removed and Oregon is not in water quality compliance. This condition is likely to exist at least for decades.

Response 305:

See response to comment 301. Issues related to timing of dam removal are being addressed through the KHSA Secretarial Determination process. The scenario described in the comment is more properly termed a "modified current conditions" scenario, with dams and point sources out.

Comment 306:

2. Specific Comment: Revised Draft TMDL Allocations above Copco Reservoir for California Compliance

Allocations of loads to Copco Reservoir are based upon simulations of California compliant conditions using the Klamath River Model. But, in allocating these loads, there appears to be confusion between TMDL modelers and regulators setting the allocations. There is a significant inconsistency between the negative load allocations assigned by regulators, technical documents supporting those allocations and the simulations as provided for public review. It appears that model results have been disregarded in setting negative load allocations upstream of Copco reservoir. In addition, the process for establishing negative loads above Copco reservoir is flawed in that it does not take into account studies describing the system as nitrogen limited. Modelers appear to lack familiarity with the Klamath River system and studies describing it.

Determining Negative Load Allocations Above Copco Reservoir

The process for determining negative load allocations above Copco reservoir is described in technical documentation appearing in Appendix 7, "Modeling Scenarios," of the Revised Draft TMDL. Modelers describe establishing a model simulating "California compliant" conditions with dams in place (T4BSRN). The conditions for this simulation assume compliance with Oregon TMDLs upstream of Stateline. In establishing allowable water quality below Stateline and just above Copco, modelers modified the simulated California compliant inflow conditions to Copco reservoir in an attempt to achieve a target summertime mean concentration for chlorophyll *a* of 10 µg/L within the reservoir. As described in the technical documentation, they set incoming algae concentrations to the equivalent of this target, a constant 0.67 mg/L all year around. They then ran the simulation over and over again, iteratively reducing PO4 and non-algae organic matter (OM) until conditions in Copco met the chlorophyll *a* target. These are the conditions found in the California compliant TMDL simulation, CT4BSRN, and the basis for negative load allocations above Copco. The process is described in the TMDL as follows:

> "The chlorophyll-a concentration coming into Copco Reservoir was set at the target concentration of 10 µg/L, and the PO4 and OM were iteratively reduced until the summer mean chlorophyll-a concentration at the surface (1 m depth) in both Copco and Iron Gate Reservoirs at the location immediately upstream of the dams was equal to or below 10 µg/L. The scenario arrived at summer mean surface (1 m depth) chlorophyll-a concentrations of 9.8 µg/L for Copco and 6.7 µg/L for Iron Gate. The resulting PO4 and OM loads upstream of Copco Reservoir are 30 percent lower than those under the initially simulated T4BSRN condition." (Appendix 7, Page 21, Bullet Point 7)

In other words, the modelers disregarded simulated values of algae concentrations and, in establishing boundary conditions used to calculate load allocations, they simply set algae concentrations to 0.67 mg/l, the equivalent of chlorophyll *a* concentrations of 10 µg/L. This change has large consequences on simulated algae concentrations in Copco reservoir. The difference between initial T4BSRN simulated algae concentrations and concentrations used as inflow to the final allocation simulation, CT4BSRN, are shown in Figure C12.

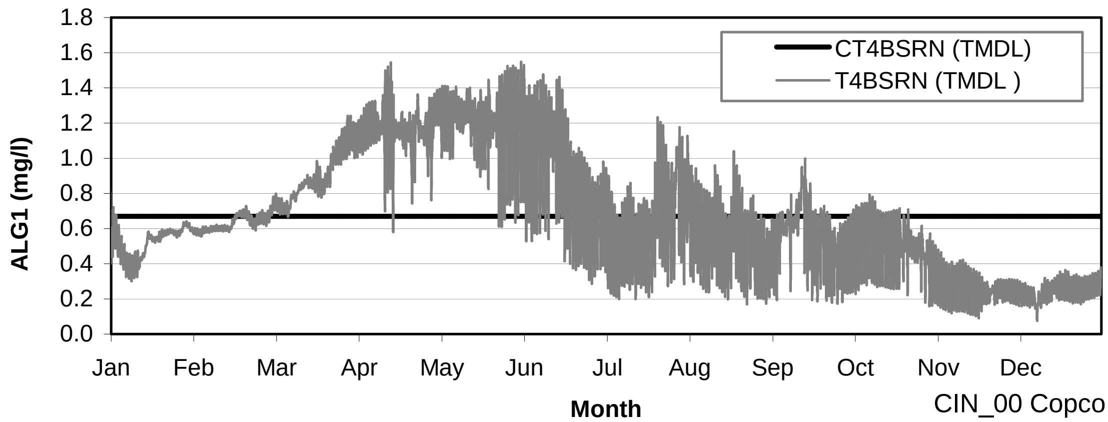


Figure C12. Chlorophyll a concentrations in Copco reservoir under California-compliant TMDL conditions. Values are taken from Revised Draft TMDL simulation CT4BSRN.

In the following sections, we describe several concerns with this approach including:

- TMDL technical documentation inconsistent with TMDL target
- Implicit condition of constant algae concentrations
- Non-representative conceptual model
- Unattainable targets
- Alternative approaches in setting allocations

Response 306:

As described in the staff report and in other responses (e.g. see K53, K54, and 108 above), the reservoirs change the capacity of the system to assimilate biostimulatory substances, resulting in violation of water quality standards in the reservoirs. Nutrient and organic matter reductions within Oregon that result in achieving ODEQ and Regional Water Board water quality standards at Stateline, do not translate to conditions that meet water quality standards within the reservoirs. The point of the CT4BSRN scenario exercise was to determine what additional reductions are needed to achieve the algal concentrations necessary to meet water quality standards in the reservoirs.

Comment 307:

Upon review of the files associated with the California compliant TMDL simulation (CT4BSRN), we find a significant inconsistency between negative load allocations, technical documents supporting those allocations and the simulations as provided for public review. As presented in simulation files for the CT4BSRN scenario, results of this process do not actually result in compliance in Copco reservoir. It is not clear from TMDL documentation how "summer" is defined, so in checking values we used the common definition of "summer" as June 21-Sept 21. The CT4BSRN files, developed from the process described in technical documentation (see above), show a summer (June 21-Sept 21) mean chlor-a concentration of 10.3 µg/L. An alternate definition of "summer" as June 1-Sept 1 produced a summer mean of 10.6 µg/L. Neither of these summer means match the 9.8 µg/L referred to in TMDL technical documentation. Both are over the Revised Draft TMDL target value and, therefore, the Revised Draft TMDL would seem to result in non-compliance according to its own model results. Results from the CT4BSRN are illustrated in **Error! Reference source not found.**.

Response 307:
With respect to the in-reservoir targets, "summer" is consistently defined in the staff report as May through September, i.e., May 1st to September 30th.

Comment 308:
Upon further review, we find a different scenario referred to in the metadata associated with CT4BSRN simulation files (i.e., in the model files and not what is documented in the Revised Draft TMDL). This scenario calls for a 30 percent reduction in total phosphorus and would require that PO4, OM, and algae all be reduced by 30 percent. When this simulation is run exactly as the CT4BSRN simulation, the summer mean chlorophyll *a* concentration is 9.8 µg/L (June 21-Sept21), exactly as described in Revised Draft TMDL technical documents referenced above. Seemingly, the negative load allocation was actually based on this simulation, and not what was documented in the Revised Draft TMDL. Results for chlorophyll *a* concentrations from this simulation, called Scenario 3, are presented in Figure C21.
Response 308:
The final CT4BSRN run was the one with 30% reduction in PO4 and OM, but not algae (which was set to 10 ug/L).

Comment 309:
Finally, the Revised Draft TMDL has established a target for chlorophyll *a* somewhat arbitrarily and yet sticks to this specific number rigorously, and without exploring uncertainty around this value. A small change in this target has large implications on the negative load allocation above Copco. When the California compliance scenario (T4BSRN) is run without reducing nutrients, OM or algae (e.g., by 30 percent as noted above) into Copco, the summer (June 21-Sept 21) mean chlorophyll *a* concentration in Copco is 11.4 µg/L. Therefore, a small change in the target of little more than 1 µg/L, or even a change in the definition of "summer" to include May or September, could result in no negative load allocation above Copco. Chlorophyll *a* concentrations in Copco under this scenario, Scenario 1, corresponding to no negative load allocations above Copco, are presented in Figure C22.

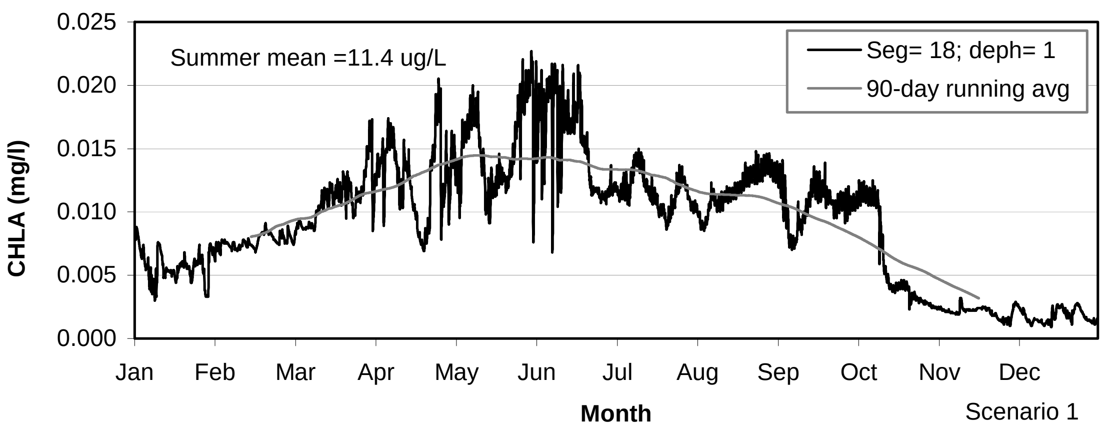


Figure C22. Chlorophyll a concentrations in Copco reservoir under California-compliant TMDL conditions with no negative load allocation above Copco.
Response 309:
The rationale for the chlorophyll-a target is described in section 2.3.2.2 of the staff report.

Comment 310:
While it seems sensible to establish allocations by iteratively reducing nutrients in simulations of Copco and Iron Gate reservoirs, it does not make sense to change simulated algae concentrations to a constant value. Concentrations of algae in the river have a predictable annual cycle that is reflected in both field studies and in model simulations. This annual cycle is an important part of reservoir algae dynamics. But in these simulations, modelers have ignored the variability in algae concentration – a variability that is carefully preserved from the Upper Klamath Lake boundary to Stateline. Instead, algae concentrations in the inflow to Copco reservoir are set to a constant value throughout the year. This condition, an implicit requirement of the Revised Draft TMDL in the California compliance scenario, has no basis in the realities of natural systems and can never be met in the field. Because simulation results have been discarded, this seems to be more like “gaming” than “simulating” water quality for decision support, and is not appropriate for setting regulatory criteria.
Response 310:
The purpose of the analysis was to determine the loading level which does not stimulate additional algal growth in the reservoirs. The load reduction derived is equivalent to the effect of the dams on algal stimulation.

Comment 311:
The approach used in the Revised Draft TMDL to establish nutrient targets above Copco reservoir is inconsistent with the nature of algae dynamics in the Klamath River system. In the Revised Draft TMDL, negative nutrient allocations above Copco reservoir are set by controlling phosphorus, under the assumption that the system is phosphorus limited. In fact, studies have shown that the system is not phosphorus limited, but nitrogen limited. Further, looking at Revised Draft TMDL model output between Stateline and Iron Gate Dam indicates that even under the extreme low nutrient conditions presented, nitrogen concentrations decrease in the downstream direction in summer months, while phosphorus remains relatively constant.
If the river system is nitrogen limited, a more efficient and direct way to control algae (and chlorophyll *a*) concentrations would be to reduce total nitrogen or both nutrients, not solely total phosphorus, into Copco reservoir.
Response 311:
The purpose of nutrient reduction at this location is to control the potential growth of blue-green algae in the reservoirs. Since blue-green algae species have the tendency to fix nitrogen when it is limited, it was deemed appropriate to control phosphorus. While nutrient ratios in the Klamath River can indicate nitrogen limitation in the short-term, a long-term strategy for controlling eutrophication of the Klamath River needs to reduce phosphorus loading. Comprehensive nutrient management strategies that address phosphorous have consistently demonstrated to be essential for successful long-term ecosystem restoration (Welch 2009).

Welch, Eugene, B. 2009. Should nitrogen be reduced to manage eutrophication if it is growth limiting? Evidence from Moses Lake. *Lake and Reservoir Management*, 25:401–409, 2009.

Comment 312:
The Revised Draft TMDL explicitly calls for a 30 percent reduction in PO4 and non-algal OM, along with an implicit condition that algae concentrations entering Copco reservoir must remain

constant at 0.67 mg/L throughout the year. First, this implicit condition on algae needs to be clearly stated in the Revised Draft TMDL, and it should be recognized as unattainable. Furthermore, removal of 30 percent of PO4 and organic matter, when influent concentrations are already so low in the compliance scenario, is unachievable. Even if an assumption of a 30 percent reduction of PO4, organic matter, and algae is made, such a condition could not be realized. The constituents in question are certainly inter-related, but are not necessarily so in a linear fashion. (Further, the influent concentration of simulated algae from upstream, even under a 30 percent reduction in the signal, exceeds 10ug/l criteria for considerable periods of the year.)

Response 312:

First, the "implicit condition" that algae concentrations entering Copco remain constant is described and documented in the staff report (Appendix 7) and supporting documentation. Second, see response to comment K53.

Comment 313:

Instead of promulgating unattainable conditions, the Revised Draft TMDL should explore alternative approaches to meeting targets. One approach may be to simply re-evaluate the target, as in the case of chlorophyll *a*, mentioned above. Another approach is to consider the dynamics of algae growth. The approach used in the Revised Draft TMDL fails to recognize that algae problems are generally associated with the spring and summer months. Alternative scenarios could be evaluated in which nutrients are reduced only when needed (e.g., only in spring or summer months) to suppress nuisance algae growth. A third alternative to the approach used in the Revised Draft TMDL would include a sensitivity analysis on settling rates in Copco. Field studies suggest a range of values not represented in the Revised Draft TMDL that would effectively lower simulated chlorophyll *a* concentrations. A fourth alternative would be to model multiple algae groups in reservoirs. Currently, all inflowing algae is assumed to contribute to harmful BGA. However, the Revised Draft TMDL identifies that little harmful BGA is found in the inflowing waters to Copco. All algae is assumed to be toxin producing, when under low nutrient concentrations, other species may make up a considerable fraction. These alternatives would likely result in more reasonable load allocations above Copco reservoir.

Response 313:

The comment initially states that alternative approaches to *meeting* targets should be considered, but then describes alternative approaches to *defining* targets. Setting TMDL targets can be approached in many ways. The Regional Water Board finds the approach used to be fully defensible, to be supported by peer-reviewed literature, and to take seasonality into consideration.

More importantly, the Klamath River TMDL clearly demonstrates that chlorophyll a targets are significantly exceeded and implementation measures are needed to begin reducing impairments represented by the chlorophyll a target. Through the adaptive management process, targets and allocations will be re-evaluated and possible changed based on new information and research during the ten-year assessment.

Finally, Regional Water Board staff have clarified in the TMDL staff report that the load allocations could be met by alternative pollutant load reductions and/or alternative management measures or offsets.

Comment 314:
Page 1, last paragraph. The 1995 median condition does not represent the median conditions from the TMDL, as noted above. Also, there is no discussion about the variability around this median – which is critical to meeting water quality targets. For all years where conditions exceed the median conditions (50 percent by definition), there is a chance for non-compliance. The frequency of acceptable non-compliance is not defined or explored.
Response 314:
The following response was included above: The median value was based on median concentration of each year predicted by the UKL TMDL model, instead of using the annual average from the UKL TMDL model. Further, as stated previously, comments on Oregon portions of the Klamath River modeling should be directed to ODEQ.

Comment 315:
See PacifiCorp comment letter, page 118, second paragraph, for full text of comment.
Response 315:
See response to comment A11

Comment 316:
Page 9 and onward. For a quantitative model to support a rigorous TMDL regulatory process, there is a lot of qualitative discussion regarding results. The Revised Draft TMDL could easily be written to describe how much less, or how significant, or the level something is diminished, etc. This language is qualitative, varies in definition for each reader (and author) and ill-defined for a technical TMDL: What is slightly higher? Higher than what? What is "smooth?" This language pervades the TMDL. While the general interpretation is appreciated, there is little quantitative basis for this discussion – information that could readily be pulled from the model results to indicate levels of concentration, magnitude of differences between the scenarios, and temporal changes at each location.
Response 316:
Qualitative discussion is provided in the staff report to describe, characterize, and in some cases interpret the vast amount of quantitative information presented. It is true, qualitative discussion can be open for interpretation, but is only intended to augment the quantitative information presented, and is not, by itself, conclusive.

Comment 317:
Page 9, bullet points. Throughout these descriptions there are indications of violations:
- "The 30-day minimum mean DO criterion of 6.5 mg/L is slightly violated at downstream locations…"
- "the Oregon 30-day DO criterion of 8.0 mg/L is violated at all locations…"
- "As for the 7-day DO criterion of 6.5 mg/L, it is only slightly violated at the upstream locations."
- "The simulated pH generally meets the Oregon criterion…"
- "The simulated pH, however, violates the California criterion of 8.5 consistently from upstream to downstream."
- "The chlorophyll *a* criterion of 15.0µg/L is violated at all locations upstream of the station D/S of Scott River due to the high concentration in the UKL boundary condition."

What are acceptable frequencies or percentages of exceedance? Does time of year matter? Is location important? Does the magnitude of deviation above or below a standard make a difference? For example on page 17 the Revised Draft TMDL states: "The predicted violations were deemed acceptable by RWQCB staff in the context of overall uncertainty." Uncertainty is not defined herein – data uncertainty, model formulation uncertainty, model calibration uncertainty, model boundary conditions uncertainty, uncertainty in setting/defining the criteria? This approach seems ambiguous at best and indefensible at worst. Specific criteria should be developed for violations definition.

Response 317:

First, much of these comments relate to Oregon water quality standards and should be directed to ODEQ. With regard to uncertainty in the sentence quoted in the comment, each of the categories mentioned in the comment apply. See other responses addressing uncertainty, such as in Attachment 1 (USGS comments/responses), and responses to comments A2 and A4.

Comment 318:

Page 9, 4th bullet point. The Revised Draft TMDL states, "The chlorophyll *a* criterion of 15.0 μg/L is violated at all locations upstream…". Is this the same chlorophyll *a* criterion that is applied to Copco and Iron Gate Reservoirs? On page 20, the target for the Reservoirs is 10.0 μg/L.

Response 318:

The chlorophyll *a* criterion of 15.0 μg/L is Oregon's water quality standard, but was used in California portions of the river for interpretive purposes.

Comment 319:

Page 13, 1st bullet point. "The most sensitive location point source loading for pH compliance was just downstream of South Suburban WWTP. The most sensitive location for DO compliance was just downstream of Klamath Falls WWTP. It is suspected that the bathymetry of historic Lake Ewauna creates this sensitive location for DO because of deep, slow moving water." Some kind of sensitivity analysis would have to be done in order to conclude that certain locations are more sensitive than others, but no details of sensitivity analyses were given anywhere in the Revised Draft TMDL. Further, this language suggests that the WWTPs had a role in local water quality. They may or they may not. River miles should be used to denote sensitivity in relation to constituents, unless specific actions (e.g., point discharges) are identified as playing a direct role. Throughout this page (the only page in the entire document where "sensitivity" is mentioned) it is confusing what is meant by "sensitive." Does it mean "variability?" What defines "sensitive" and "insensitive"?

Response 319:

The locations of the WWTP discharges are an area of particular interest in the TMDL analysis in Oregon, and are likely locations for water quality excursions. The iterative process used to assign waste load allocations to these facilities informed the observations regarding lake characteristics and water quality response.

Comment 320:

See PacifiCorp comment letter, page 119, fourth and fifth paragraph, for full text of comment.

Response 320:

First, these comments address issues in Oregon and should be submitted to ODEQ. Second, see responses to comments K53 and A3.

Comment 321:
Page 13, 3rd bullet point, line 1. "Once point source allocations were determined, the discrete nonpoint sources (KSD and LRDC) were analyzed…"
It is unclear why the point source and nonpoint source allocations were looked at in sequence. Would changes in one affect the other? Please provide discussion.
Response 321:
This approach is consistent with direction in the Clean Water Act. Comments on the approach to setting allocations to sources in Oregon should be submitted to ODEQ.

Comment 322:
Page 21, 1st bullet point. Several points:
- "outlet draws water from both the surface and the bottom" – the outlet draws from the full depth, not just the bottom and top.

Response 322:
Comment noted. The text has been modified accordingly in Appendix 7.

Comment 323:
- "This might be caused by the longer retention time in J.C. Boyle Reservoir that causes a loss of PO4 and NO3 from algal uptake while the benthic source is insufficient to compensate for this loss." – Longer retention time than what? The Revised Draft TMDL identifies retention as of minor importance in Copco and Iron Gate Reservoir but suggests that it is an important mechanism in J.C. Boyle Reservoir.

Response 323:
Longer retention time refers to the comparison with the no dams condition. Slightly lower PO4 and NO3 occur due to the longer retention time, but in a general sense retention time is not necessarily an important mechanism.

Comment 324:
- "NH4, however, appears to be slightly higher during the summer when J.C. Boyle Dam is present. This might be due to the benthic source." – J.C. Boyle does not experience persistent anoxia, so benthic sources of NH4 should be modest. Could this be coming from upstream?

Response 324:
It is a slight difference which can be caused by rather modest sources.

Comment 325:
Page 21, 2nd bullet point, lines 8-9. "The springs' concentrations are not significantly different from the upstream incoming concentration." This is incorrect according to the Revised Draft TMDL model files that indicated that the springs' concentration for PO4 is 0.066 mg/L throughout the year, whereas the PO4 coming out of J.C. Boyle dam has an average of 0.004 mg/L, and a peak of 0.009 mg/L (see Figure C23 below).
Response 325:
Comment noted. This sentence has been deleted from Appendix 7.

Hillman – Karuk Tribe

1. Comment(s):

The Karuk Tribe supports the addition of a thermal refugia protection policy for the Klamath and all other watersheds throughout the north coast region. It is a needed policy to protect the sensitive habitats provided by thermal refugia. While Scott River tributaries are identified to be included in the policy, ideally, the entire five-mile reach between Boulder Creek and Townsend Gulch that serves as thermal refuge should be included.

Response:

See response to N4.

2. Comment(s):

Closing off the thermal refugia to suction dredging for only part of the year (June 15-Sept 15) is not adequate to protect the refugia. With the proposed Action Plan, a miner could be destabilizing, destroying, or altering critical refugia as long as it is not between June 15-September 15. It would still have a negative impact on the refugia even though the fish are not present at that time. Since the habitat defines how effective (size, capacity, etc) the thermal refugia will be, it should not be impacted at all throughout the year.

Response:

The time period specified in the Thermal Refugia Protection Policy was derived from looking at the times when thermal refugia are in use in the Klamath basin. The Regional Water Board staff intend to make a reasonable recommendation on limiting suction dredging that only excludes suction dredging discharges when necessary to protect the function of the refugia. We understand that the form of the refugia is 'reset' every year by high flows in the tributaries and in the mainstem. Any channel alteration due to suction dredging can be moderated by these flows. The commenter makes a valid point regarding the potential for suction dredging discharges to impact to refugia prior to the critical time period when fish are present. The time period has been revised to account for this and also to account for short-term impacts to macroinvertebrates. Regional Water Board staff have revised the Thermal Refugia Protection Policy restrictions so they are applied from April 15 – September 15.

3. Comment(s):

In Section 6.5.4.5 of the draft TMDL, Staff essentially postulates that suction dredge miners may be required at a future date to procure NPDES permits in order to comply with the Clean Water Act. Indeed, given the precedents set in other states, this is true. However, then the document goes on to say that if NPDES permits for dredging are issued, dredging will be excluded from thermal refugia but will be allowed in other areas. Certainly, saying that dredging *would* be permitted by an NPDES permit as in the draft section 6.5.4.5 is predecisional. Any development of NPDES permits must go through the appropriate rule making procedures and comply with existing environmental laws as applicable before any regulatory body can determine where and when dredging may occur.

Recommend: 1) closing all areas listed in the policy for the entire year, not just three months, 2) strike section 6.5.4.5 from public review draft or at least strike text in section 6.5.4.5 from "To accommodate" to the end, and 3) strike #5 from p.11 of the TMDL Action Plan, Thermal Refugia Protection Policy, Policy Directives and Recommendations.

Response:
See response to Bowman – 32, 36.

4. Comment(s):
6.4.3.4 Proposed Management Agency Agreement. We support and encourage the development of the proposed MAA and think that it will be essential to restoring health in the watershed. However, we have concerns that because this action is voluntary, it will be difficult to implement. Steps need to be taken to assure that responsible parties, even though in Oregon, are still responsible for cleaning up or mitigating the nutrient pollution that occurs in their areas. (p.5)

Response:
The Regional Water Board expects the MAA to provide a mechanism to address the water quality impacts of operation of the Bureau of Reclamation's Klamath Project. The Regional Water Board has no regulatory authority in Oregon and cannot adopt regulatory requirements for discharges in Oregon.

5. Comment(s):
The Karuk Tribe is very concerned about the proposed Agricultural (Ag) Waiver and lack of interim requirements for agriculture. If all goes well, the waiver will be ready the end of 2012. The process could easily get delayed, taking over three years for any action to occur. Therefore, interim measures need to be implemented until the Ag Waiver is in effect. A minimum level of restoration needs to occur in the mid-Klamath Basin in the next three years.

Response:
The recommendations made in the Klamath implementation plan will prompt dischargers to begin organizing into groups to comply with the waiver and begin to document their water quality practices. These are steps that are needed to prepare for the adoption of the waiver. The specific regulatory requirements for agricultural dischargers will be developed through a separate stakeholder process. The Regional Water Board staff recommend the 2012 date to allow sufficient time for this process to produce a reasonable agricultural waiver program that has the support of the regulated community. See general response Q1.

6. Comment(s):
The development of the agricultural waiver needs to be inclusive and transparent. The details on the development of the Ag waiver are not included in either the implementation plan or the action plan. Tribes have been excluded from ag-related processes in the Scott River, so there is great concern that Ag interests will dominate and exclude in future processes.

Response:
See general response Q1.

7. Comment(s):
Recommendations: 1) reinstate interim measures for all responsible Ag interests, 2) require restoration of riparian areas by fencing, exclusion, etc., and 3) Regional Board should facilitate the development of the Ag waiver. A diverse group of interests should participate in developing the Ag waiver including Tribes, local community groups, and NGO's.

Response:
See general response Q1. The suggestion of requirements for inclusion in the conditional waiver will be retained and discussed during the waiver development process.

8. Comment(s):
The Scott and Shasta Ag waivers do not appear to be effective. In 2009, only 9 male coho returned to the Shasta River and only 77 coho returned to the Scott River. Recommendation: roll the Scott and Shasta Ag Waivers into the new Klamath waiver.

Response:
See response to comment L7.

9. Comment(s):
6.5.1.1 Riparian Shade Allocations and Targets. This section appears very weak and nonspecific. In the paragraph starting, "In simple terms," it is unclear when "active restoration" will occur, how this will occur, and who will decide such issues. Would the following case seen in the figure below be worthy of active restoration?

Case: The figure below shows a streambank on the mid-Klamath River from four years ago. There is no riparian area, because cows are allowed into this area in the winter. Karuk staff drove by this area 1/26/10 and was going to take an updated picture. However, it looked exactly the same, so there was no need for a new picture.

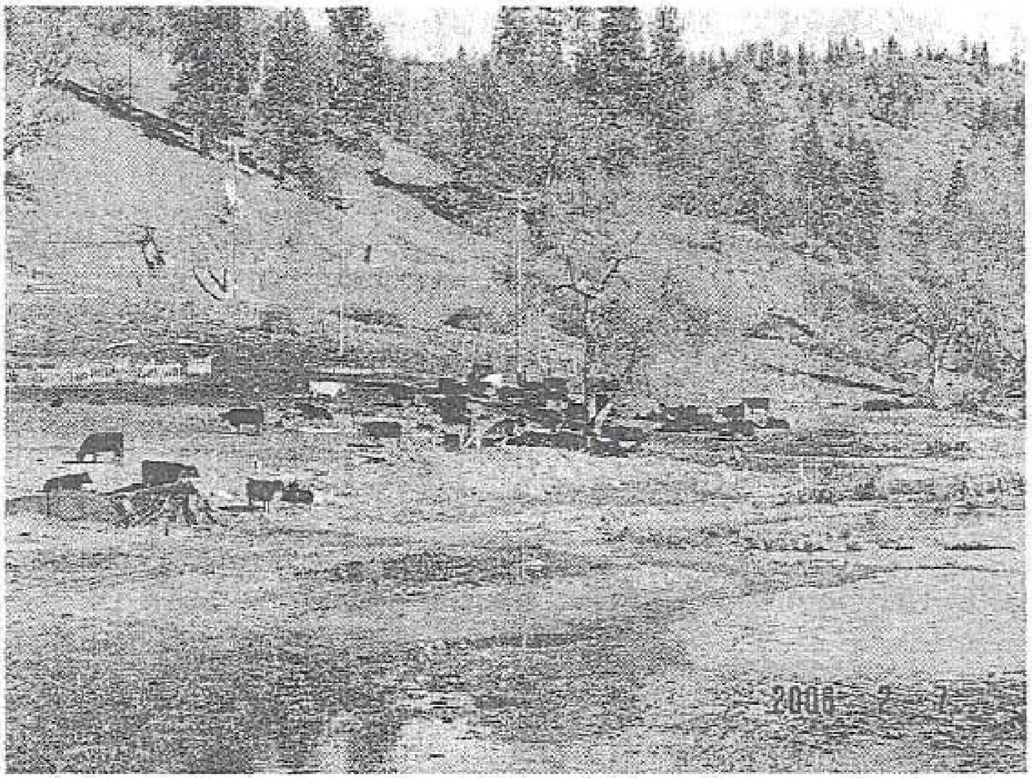


Figure 1. Cows in riparian area on the mid-Klamath River. Photo was taken looking upstream from bridge at Horse Creek by S. Corum, 2/7/2006.

Recommendation: Clarify timelines, responsible entities, and decision-making procedures for shade restoration.

Response:

The operation reported by the commenter would be expected to enroll in the agricultural waiver when it is adopted pursuant to the conditions of the waiver. Whether this operator would be expected to actively restore the riparian vegetation at this site is dependent on the conditions of the future waiver. Regional Water Board staff have accepted this case as a formal compliant and are in the process of reviewing it.

Klamath Riverkeeper – Various (Comments Via form letter over e-mail)
Musgrove – Sierra Club, Shasta Group

1. Comment(s):
Please retain the toughest possible load allocations for PacifiCorp's reservoirs and requirements for downstream clean water.

Response:
Comment noted.

2. Comment(s):
I support modeling a "dams-in" scenario, and urge you to require even greater pollution reductions by PacifiCorp so that mitigations adequately address the water quality impacts the dams cause.

Response:
The allocations and targets assigned to PacifiCorp are adequate to ensure the attainment of water quality standards. No further reductions are necessary based on the information the Regional Water Board staff have compiled so far. If the commenter has additional technical information indicating a need for greater load reductions, he/she is encouraged to submit this information to the Regional Water Board.

3 Comment(s):
Please place stringent requirements on pollution sources such as Upper Klamath Lake, the Lost River area and Columbia Forest Products. Specific compliance actions, monitoring plans and enforcement mechanisms for these sources must be clearly stated in the MOU between Oregon and California.

Response:
The Regional Water Board has no authority over dischargers in Oregon. Discharges in the Lost River basin in California are adequately addressed in the Klamath implementation plan, which includes implementation actions in the Lost River basin. The implementation actions in Oregon will be specified in Oregon's Klamath River and Lost River TMDL implementation plan. The MOU between Oregon Department of Environmental Quality (DEQ), USEPA and the Regional Water Board includes monitoring measures to track compliance. The MOU also includes a commitment by DEQ and the Regional Water Board to "enforce implementation measures and program, where appropriate, to assure consistent and effective achievement of water quality standards". A description of the Regional Water Board's enforcement mechanisms and the policy that guides their application are provided in the State Enforcement Policy. The Regional Water Board will conduct enforcement of permit terms and conditions and Basin Plan prohibitions pursuant to this policy.

4. Comment(s):
The Klamath TMDL must address fisheries crisis conditions on the Scott & Shasta Rivers, and set pollution limits as well as implementation and enforcement measures that can be adopted independently of the Scott & Shasta's existing and ineffective TMDL waivers. New interim measures that adequately address flow and temperature issues should be implemented before the 2010 spawning season.

Response:
See response to comment L7.

5. Comment(s):
I support the staff's revision prohibiting discharges from activities like grazing or suction dredge mining in watersheds with thermal refuge value. Specific measures to ensure the prohibition is enforced should be implemented within one year of TMDL adoption and should also be considered during 401 permitting and water rights enforcement in these watersheds.

Response:
The Thermal Refugia Protection Policy does what the commenter is requesting and the policy will take effect immediately upon adoption of the TMDL by the State Water Resources Control Board, Office of Administrative Law, and USEPA subsequent to Regional Water Board adoption.

6. Comment(s):
I strongly support the revised, tighter sediment prohibitions on timber waivers. I further request that interim measures for agriculture and grazing conditional waivers be mandatory as voluntary solutions to pollution problems have proven inadequate on the Klamath.

Response:
The sediment prohibition has been removed from the implementation plan and has been replaced by a separate prohibition on all discharges of waste that cause a violation of water quality standards. The interim measures on agriculture have also been removed and replaced with recommendations during the interim period. However, all conditions in the forthcoming conditional waiver for agriculture will be mandatory. The State Nonpoint Source Policy directs the Regional Water Boards to make the implementation of reasonable management practices to control agricultural waste discharges enforceable through Regional Water Board regulatory tools. It does not support voluntary compliance. See also general response Q1.

7. Comm ent(s):
The Klamath TMDL should state explicitly that all non-point source waivers of general permits (like those for the US Forest Service) must be consistent with Klamath TMDL waste-load allocations.

Response:
The staff report notes in section 6.6 that the waiver "will contain measures that implement existing TMDLs in the North Coast Region including the proposed Klamath TMDL." As a point of clarification, nonpoint source waivers would need to address load allocations, not wasteload allocations, the latter being for NPDES point sources.

8. Comm ent(s):
When considering the language to be adopted as the Klamath TMDL, please remember that California water code section 13242 requires water quality control plans to describe actions, a time schedule for those actions to be taken and a description of monitoring to ensure compliance.

Response:
Section 13242 was central to the development of the implementation plan and the plan fulfills the requirements of this section. Timelines are given specifically for each implementation action and the Reassessment and Monitoring chapter (Chapter 7) of the staff report describes the monitoring plan to track compliance and how that information will be used to adaptively manage TMDL implementation.

Lewis – California State Grange

1. Comment(s):

The California State Grange would like to express its strong support for the adoption and implementation of the December 2009 Klamath River TMDL and Action Plan. The plan is obviously a result of a significant effort on the part of its authors, and represents a critical step forward in restoring and protecting this extremely important ecosystem. The plan is commendably comprehensive in its approach.

The California State Grange represents both farmers and fishermen whose livelihoods depend on swift and significant action to ensure the sustainability of this water resource and the habitat it supports. Thank you for all the work that has and will be put into the plan. Implementation will be a difficult task to manage. We would be very happy to contribute to moving the effort forward in any way we can.

Response:

Thank you for your support. The Regional Water Board staff look forward to working with the California State Grange to further the goals of implementation and restore water quality in the Klamath basin.

Macsay – Modoc County Board of Supervisors

1. Comment(s):
The County appreciates the fact that this version of the Report has made some significant improvements over the previous draft. While distasteful and in many cases unneeded, the decision to recommend a waiver process for irrigated agriculture in the Klamath Project is preferable to the other options.

Response:
Support noted.

2. Comment(s):
The County has found the willingness of the staff to meet and discuss issues with the representatives of the impacted parties to be encouraging. We take the Regional Board at its word that this interaction will continue as the hard work of developing the agricultural waiver takes place.

Response:
Regional Water Board staff look forward to working with the counties and individuals to develop a reasonable agricultural nonpoint source program.

3. Comment(s):
While the document gives lip service to the issue of poor quality water entering at the state line, there is little or no relief from that situation in the proposed implementation of the water quality standards. This continues to place the livelihood of our Tulelake constituents at risk.

Response:
The TMDL includes load reductions and implementation measures to achieve water quality standards at the Stateline. The estimates of costs of foreseeable TMDL compliance measures are provide in the Economic Analysis, Chapter 10 of the staff report. Regional Water Board staff does not intend to put the livelihoods of Tule Lake farmers at risk. The TMDL recommends that individuals participate in the agriculture waiver development that will likely include some form of best management practices, monitoring and reporting. Participation ensures a program that is effective for water quality but also works for people.

4. Comment(s):
The County still believes that this version of the Report does not adequately address all the beneficial uses of the Klamath River system. It places too much emphasis on the inadequately proven cold water fisheries capability of the upper watershed and minimizes the other historic beneficial uses.

Response:
See response to comment O23b.

5. Comment(s):
The County continues to be bothered by the Region's position that the very existence of an activity means that it contributes to water quality impairment and needs to be regulated by the Region. The document provides little if any data to justify this increased burden of regulation.

Response:
See response to comment O17 and general response Q1.

6. Comment(s):
The Report again fails to adequately respond to the most important and overriding condition in the entire river system, the fact that water coming across the state line does not come anywhere close to meeting the proposed standards. To develop standards and impose a heavy regulatory burden on activities and livelihoods downstream without an in-depth discussion concerning impaired water from Oregon is simply unacceptable.

Response:
The TMDL accounts for impaired water in Oregon and Oregon's TMDL implementation plan will address pollutant sources in Oregon. The TMDL recognizes that restoration upstream is necessary and provides a process to assist in those efforts. As stated previously, changes have been made to the implementation plan to avoid duplication and unnecessary burdens on individuals, but still requires the development of a reasonable agriculture nonpoint source program. Individual landowners conducting nonpoint source discharge activities are only responsible for their own discharges.

7. Comment(s):
The Report continues to insist that Upper Klamath Lake water quality was historically good. While it points out how man made activities have contributed to degrading water quality in the lake, the document has failed, even though this information has been pointed out to the Board consistently since the opening scoping sessions, to document that the water quality in the lake in pre-settlement days was bad. As was pointed out by one of the Board's peer reviewers, there are major flaws in the Report with the natural background levels. This has not been addressed in the Report. This is key information, given that the proposed water standards will hold down stream users hostage to water quality problems they have no ability to control.

Response:
See response to C37. Responsible parties will only be held responsible for addressing discharges under their control.

8. Comment(s):
This appears to be a one-size-fits-all proposed solution. It does not account for coastal influences, particularly temperature, in the lower reaches of the river system. It does not account for the likelihood that there was no consistent fall run of Chinook upstream as the river often ran dry above the large tributaries before the natural reef was blown and the dam constructed at the outlet of Upper Klamath Lake. It does not account for the nutrient sink effects provided by the Klamath Project.

Response:
Regional Water Board staff disagrees with this comment. Targets and allocations have been tailored to reaches with differing characteristics and intended to provide achievable supporting conditions for existing beneficial uses. In addition, the Klamath Project impact on nutrient dynamics in the Klamath River has been accounted for in the TMDL modeling analysis and subsequent downstream allocations. Also refer to response C21 for more information on the Klamath Project.

9. Comment(s):
The Report makes no allowance for regulated activities that meet their objectives but do not meet the Board's goal. For example the Board might propose a shade objective that must be met to achieve a temperature goal for the benefit of fish. If the shade objective is met, but the temperature goal is not achieved, then there is no relief for the activity. In addition the document presupposes that all the problems they wish to solve are within the capacity of the natural and regulated activities to fix. Common sense dictates that this is not the case and that the document should recognize that possibility and make the necessary allowances.

Response:
The TMDL implementation strategy includes consideration of site specific conditions, including the potential for water quality standards to be met within the limits of the natural system and the implementation of reasonable management practices. The water quality objective for temperature is based on natural stream temperatures. If riparian shade improvements produce natural stream temperatures, there is no further obligation to improve water quality beyond this.

10. Comment(s):
While the Report mentions the ability of the Klamath Project to trap nutrients, it then proceeds to propose regulations as if that condition doesn't exist. The staff has not moved from the position that there is an increase in concentration of nutrients when Project water returns to the river. The County strongly maintains that the important conclusion from the data is that the water quality below the return site would be poorer if the water had not been diverted into the Project. Proposed standards must only hold users

responsible for the contributions they make to loading, not problems with water quality that already existed when the water was received.

Response:
Please refer to comment C 21.

11. Comment(s):
The Report has made no corrections from the last draft to adjust for the poor modeling displayed previously. The U.S. Geological Survey has continued to do new modeling runs that are not reflected in the Report and there appears to be no adequate response to the flaws pointed out in the previous draft by the Regional Board's own peer reviewers as well as the Bureau of Reclamation. The staff continues to say that the new runs would not change the allocations, but they do not explain why this is the case.

The County believes the Regional Board needs to commit to improved modeling. If this cannot be done in time to comply with court deadlines, then the Board should commit to improving the modeling afterwards and making any adjustments to the allocations indicated by additional modeling runs.

Response:
Regional Water Board staff are not stating that new runs 'would not change the allocations', but rather that new runs that have been completed have not changed the allocations. After addressing the comments made by USGS and others, making changes in the model, and rerunning the model, that the load allocations have not substantively changed. See Attachment 1 to the December staff report that details the responses to USGS comments.

12. Comment(s):
The County finds unacceptable the time frame for the MAA and the water quality study indicated therein. It is likely that it will take time and considerable effort to begin to work productively together. The development of the water quality management plan cannot begin efficiently until the MAA is complete. The County believes this holds the Klamath Project producers hostage to potential in fighting between the agencies.

Response:
The timeline for the MAA does not begin until after the TMDL implementation plan is approved by the State Office of Administrative Law. Six months from that data is predicted to be around summer of 2011, leaving ample time to develop an MAA that lays out a plan for further action by the signatory parties. The responsibilities of the producers are independent of the responsibilities of the federal agencies. Producers' discharges in California will be addressed through the future conditional waiver for agriculture.

13. Comment(s):
The County believes too much burden is placed on the activities in the watershed to prove their "innocence" from water quality impairment. The Regional Board should accept more responsibility for demonstrating there actually is a problem before placing restrictive regulations on uses occurring within the watershed.

Response:
California has listed the portions of the Klamath River within its jurisdiction (from the CA/OR Stateline to the mouth) for impairments due to elevated water temperatures, elevated nutrients, and organic enrichment/low dissolved oxygen. In addition, the portion of the Klamath River watershed downstream of the Trinity River, partially within the Yurok Reservation, is listed for sedimentation/siltation impairment. The evidence for these listing was documented as part of the 303(d) listing process and has been approved by the USEPA. In addition, the Klamath River TMDL staff report and the Lost River TMDL prepared by EPA provide ample demonstration of water quality impairment. Moreover, changes have been made to the implementation plan removing interim requirements for agricultural landowners and instead recommending the development of an agricultural waiver for adoption in 2012. As explained in the Staff Report, the Regional Water Board has independent responsibilities to develop these nonpoint source programs even in the absence of evidence of impairments. Staff recommends incorporating TMDL requirements into the normal programs where possible to avoid duplication and to provide more streamlined and effective water quality control. The waiver should allow for individual watershed groups to propose measures that fit a particular area, however. It is also worth mentioning that management measures are often the same for TMDL compliance and Basin Plan compliance in the absence of a TMDL, underscoring the practicality of combining these programs.

14. Comment(s):
The County believes that there should be a stronger commitment from the Regional Board in the development of reasonable agricultural waivers. The staff has been good about meeting with the County and other stakeholders during the development of the TMDLs and the County appreciates that gesture. However, the details of the waiver are critical to the continued operations of the producers in the Klamath Project and the staff must do more than listen if rational waiver conditions are to be developed and accepted.

Response:
See general response Q1.

ORAL COMMENTS ON THE DECEMBER 2009 PUBLIC REVIEW DRAFT

1. Comment(s):
Having consistent regulation for everybody does not allow for differences in hydrology, custom and culture, economic systems, and capacity of people to comply.

Comment(s) Made By:
Marcia Armstrong – Siskiyou County Supervisor

Response:
See response to Walker – 2, and general response Q1.

2. Comment(s):
You have to draw back to where somebody's activity is polluting the system, and having just a blanket regulation, where everybody has to implement measures in the same manner does not follow the rules of proximate cause.

Comment(s) Made By:
Marcia Armstrong – Siskiyou County Supervisor

Response:
See response to O17.

3. Comment(s):
We've seen what happens with stakeholder groups before. What ends up happening is the guys on the ground and timber people in the woods can't show up. You end up with one supervisor trying to represent all the interests and each special interest group has a representative. That's an unfortunate thing. I don't relish that as a solution.

Comment(s) Made By:
Marcia Armstrong – Siskiyou County Supervisor

Response:
See general response Q1. The waiver development process will be inclusive of all stakeholders in the basin. Regional Water Board staff intend to rely on representatives to represent their constituencies during the development process to consolidate stakeholder perspectives and streamline the effort.

4. Comment(s):
You should not prohibit suction dredge mining at the mouth of the rivers – that's where the gold is. Due to the moratorium on suction dredging (Senate Bill 670), the Mid River RV Park did not have bookings – the Seiad café did not have customers – because the

suction dredgers are the people that came in the summertime. You have to be sensitive to what you are doing.

Comment(s) Made By:
Marcia Armstrong – Siskiyou County Supervisor

Response:
See response to O23a.

5. Comment(s):
The part I think has been weakened is the agricultural section. It says over and over again that it has been weakened by comments sent in. There's no interim requirements anymore – status quo will remain until 2012 – not adequate either.

Comment(s) Made By:
Susan Corum – Karuk Tribe

Response:
See response to Bowman – 2.

6. Comment(s):
When waivers are developed we want to see it led by Regional Board staff, we want it to be inclusive as they can be – that includes tribal members, environmental groups being part, not just agricultural interests.

Comment(s) Made By:
Susan Corum – Karuk Tribe

Response:
See general response Q1. The waiver development process will be inclusive of all stakeholders in the basin.

7. Comment(s):
An outright ban in these thermal refugia on the basis of the potential impact to thermal refugia isn't justified.

Comment(s) Made By:
Ric Costales – Siskiyou County Natural Resource Policy Specialist

Response:
See response to N17a, N20 and section 4.2.4 of the TMDL staff report.

8. Comment(s):
This basinwide approach, I think is not going to work for us, the people that know these issues are the people who work locally and can help the staff identify where the waiver is appropriate.

Comment(s) Made By:
Ric Costales – Siskiyou County Natural Resource Policy Specialist

Response:
See response to Walker – 2, and general response Q1.

9. Comment(s):
Most people are concerned about the requirements and permits, and costs, and studies that could potentially down the road be associated with these things.

Comment(s) Made By:
Ric Costales – Siskiyou County Natural Resource Policy Specialist

Response:
See general response Q1.

10. Comment(s):
CA state law forbids regulation of mining or regulations that affect mining that are not reasonable. It is because these people have claims in these areas have a private property right. To prohibit them from extraction of minerals on their own private property is not only unreasonable, it's illegal.

Comment(s) Made By:
James Foley – Upper Mid-Klamath Watershed Council and miners statewide

Response:
See response to O22 and N24.

11. Comment(s):
Thermal refugia is benefitted by suction dredge mining, studies show it over and over again. This Board is in possession of these studies and I sent them to your council.

Comment(s) Made By:
James Foley – Upper Mid-Klamath Watershed Council and miners statewide

Response:
Thank you for submitting these studies. They were considered in the review of the literature on the impacts of suction dredging. See response to N19, N20 and section 4.2.4 of the TMDL staff report.

12. Comment(s):
In the area of thermal refugia, suction dredging creates thermal refugia where there is none now; it breaks up compacted gravels that salmon are not able to spawn in and makes a spawnable situation.

Comment(s) Made By:
James Foley – Upper Mid-Klamath Watershed Council and miners statewide

Response:
See response to comment N25. Also, the proposed Thermal Refugia Protection Policy is intended only to protect the function of thermal refugia, it does not address other impacts of suction dredging discharges, such as impacts on spawning gravels. These other impacts will be considered during the process to develop the new Department of Fish and Game suction dredging permit.

13. Comment(s):
What's lacking is a review of the cumulative impact of the regulations that are a part of this program on the communities that you're going to be regulating.

Comment(s) Made By:
Thomas Guarino – Siskiyou County's Counsel

Response:
See response to S11.

14. Comment(s):
This process may have been directly utilized to effect goals in the Klamath settlement agreement. It appears there are some inconsistencies in the proposals we're seeing moving forward and what was in those agreements. The county was interested in seeing the communications that took place, and you were looking to make those documents available. That gets back to the concern with the process – fears of the manipulation of the underlying information to achieve the goal of removing the dams, regardless of those agreements. The protocols for releasing the information of that agreement have not been met. You have a Feb. 9th date and we would be within a couple of days of the close of comment and we have no way of responding. Then you leave the door open to a legal challenge here; that is what you're stuck with. Make the information available in an expeditious manner.

Comment(s) Made By:
Thomas Guarino – Siskiyou County's Counsel

Response:
See response to ZZ15.

15. Comment(s):
There doesn't appear to be any light at the end of the regulatory tunnel. If one of the watersheds meets your regulatory criteria, how do we get out from under this waiver process or the permitting process. It's unlikely that I would go beyond the baseline that Ben has put out for us if there's no hope to get out from the waiver and permitting thing. It would help if there were standards for each of these subbasins, and once you make that, we're going to take affirmative steps to relieve you from this permitting process. I think you'll get landowners that go above and beyond to get the watershed out of there.

Comment(s) Made By:
Robert Walker – Rancher and Chairman of the Upper Mid-Klamath Watershed Council

Response:
See response to Walker – 1.

16. Comment(s):
I can see from the Board's point of view, you want a uniform method. And that is troubling from our perspective. We live in the Bogus Creek watersheds, and next door is the Willow Creek watershed. Willow Creek has twice the acreage. Bogus is a spring fed stream, has year round water. Willow almost never contributes any water to the Klamath because it's a snow-melt stream and it dries up. Bogus has spawning, and Willow Creek has none. No one in Willow Creek should be held responsible for Bogus Creek. To the extent we can, we should treat them separately.

Comment(s) Made By:
Robert Walker – Rancher and Chairman of the Upper Mid-Klamath Watershed Council

Response:
See response to Walker – 2.

17. Comment(s):
Important thing is dealing with the refugia – they are absolutely critical – that is where they are during the warmer part of the year. Regulation to prevent pollution in these areas is critical.

Comment(s) Made By:
Glenn Spain – Northwest Regional Director for PCFFA

Response:
Comment noted.

18. Comment(s):
Compliance by Oregon is going to be necessary. We want to see that agreement (MOU) have specific actions, timelines, emphasize compliance, and talk about the consequences of noncompliance.

Comment(s) Made By:
Erica Terence – Klamath Riverkeeper

Response:
See response to Terence – 20.

19. Comment(s):
MAA to address the Klamath Irrigation Project might allow more leeway than is appropriate by making measures voluntary – which doesn't work.

Comment(s) Made By:
Erica Terence – Klamath Riverkeeper

Response:
See response to H27 for an explanation of the MAA. This approach has worked in the Central Valley Region and Regional Water Board staff believe this approach is appropriate in the Lost River basin considering the various agencies involved in the operation of the Bureau's Klamath Project and the issue of interstate jurisdiction.

20. Comment(s):
Would like to see a timeframe attached to the Thermal Refugia Protection Policy – we would like to see that policy put in place.

Comment(s) Made By:
Erica Terence – Klamath Riverkeeper

Response:
The policy would take effect as soon as the Basin Plan amendment takes effect, which is after approval by the State Office of Administrative Law.

21. Comment(s):
We are interested to know how the Technical Advisory Group would be formed and who would sit on that team, and that fish interests, environmental, tribal governments be represented.

Comment(s) Made By:
Erica Terence – Klamath Riverkeeper

Response:
See general response Q1. The waiver development process will be inclusive of all stakeholders in the basin.

22. Comment(s):
We're pretty concerned that we will operate on a recommendations level (for agriculture) – and I feel worried about that – including recommendations rather than requirements.

Comment(s) Made By:
Erica Terence – Klamath Riverkeeper

Response:
See response to Bowman – 2.

23. Comment(s):
It's good to include the Lost River, one of the things, is that the USBR needs to step up to the plate, and make an adequate contribution to things like centralized treatment, because they have a relationship there and they should not ignore it.

Comment(s) Made By:
Petey Brucker – Representing Klamath Forest Alliance

Response:
Regional Water Board staff agree with this comment.

24. Comment(s):
Regulations are based on estimates of background, estimates are computer manipulated to arrive at pre-European background levels that are then used as criteria for water quality. These estimates are extremely distorted and unachievable and reflect water quality in a system that is an expectation that never existed.

Comment(s) Made By:
Rex Cozzalio

Response:
See response to Bennett – 6 and C37.

25. Comment(s):
That unachievable quality will cause greater regulatory oppression that will exclude everyone except special interests and those capable of paying fees. Emergency repair and access will be lost due to blanket waiver requirements. You could not do flood damage control, or cut a tree without permission. The cost of participation will break many from the start.

Comment(s) Made By:
Rex Cozzalio

Response:
See response to P26.

26. Comment(s):
Cap and trade program will prove extortive and corruptive, to fulfill NGO special interest wish list that only entities with deep pockets could afford, primarily those able to pass costs directly to customers. That's why this causes no objection through PacifiCorp because in the KHSA they can pass on the cost to customers.

Comment(s) Made By:
Rex Cozzalio

Response:
The implementation plan proposes the Tracking and Accounting program to provide a mechanism that would allow for collaboration among basin stakeholder on common projects while earning credit toward their regulatory requirements related to TMDLs and other mandated programs. It is accurate to state that the types of projects that will most likely be considered would necessarily be relatively costly because of the scale of the pollution problems they are intended to address. One of the purposes of the Tracking and Accounting Program is to provide a scientifically sound method for evaluating the cost-effectiveness of projects in order to make the best use of funds.

27. Comment(s):
No goals or benefits are guaranteed or even ensured by obtaining goals and it is all paid for by ratepayers and landowners. 20 years and over half a billion in prior restoration based on prior TMDLs have been ineffective and have caused community losses.

Comment(s) Made By:
Rex Cozzalio

Response:
The TMDL analysis as documented in the staff report provides extensive demonstration that achieving the TMDL allocations and targets will improve water quality conditions in the Klamath basin, which is the purpose of the TMDL and the charge of the Regional Water Board. The TMDL implementation plan supports the best use of resources and provides considerable flexibility for the regulated community to develop cost effective management practices that are appropriate for their operations. There are also a variety of grant, loan, and technical support programs available to landowners to assist in implementation, as discussed in section 10.4 of the TMDL staff report.

28. Comment(s):
There are no regionally specific studies done that quantify the human impacts relative to natural and the cost effective ratios involved.

Comment(s) Made By:
Rex Cozzalio

Response:
The TMDL technical analysis quantifies the anthropogenic source loading to the Klamath River basin where appropriate and where sufficient data is available to do so. The TMDL quantifies the nutrient and organic matter load reductions necessary to control to risk of blooms of toxic algae in the Klamath Hydroelectric Project reservoirs. It also quantifies loading from the Iron Gate Hatchery and the Tulelake Wastewater Treatment Plant based on NPDES permit monitoring and reporting. For nonpoint source of pollution, the TMDL characterizes and sets load allocations consistent with conditions that meet water quality standards.

29. Comment(s):
The TMDL ensures a step by step regulatory imposition upon the landowners upon failed improvements and need for additional funding and moving the restrictions and fees out from the mainstem into the tributaries. It imparts no responsibility for results, and rather establishes non-productive requirements that are difficult to change, giving the Regional Water Board control without liability.

Comment(s) Made By:
Rex Cozzalio

Response:
The TMDL staff report (section 6.1.4) describes the approach to regulation proposed by the TMDL implementation plan. The Regional Water Board is required by the State Nonpoint Source policy to regulate all nonpoint source discharges to waters of the state. The policy does not cite failed water quality improvements or water quality trends as the basis for regulation. Dischargers of waste to waters of the state that could affect the quality of those waters must file with the appropriate Regional Water Board a report of

the discharge (Porter-Cologne Water Quality Control Act, section 13260). This requirement is based on the premise that the people of the state have a primary interest in the conservation, control and utilization of the water resources of the state, and the quality of all the waters of the state shall be protected for use and enjoyment by the people of the state (Porter-Cologne Water Quality Control Act, section 13000). The Klamath implementation plan recommends a regulatory strategy for improving water quality by addressing the pollutant sources identified by the Klamath technical TMDL analysis. The plan includes provisions for adaptive management in Chapter 7 of the staff report. Opportunities to revise the plan and make it more effective as necessary will present themselves during the periodic reassessments conducted by the Regional Water Board. While the Regional Water Board is responsible for developing the appropriate regulatory structure, the terms and conditions of permits, and enforcement programs, the responsibility for improving water quality is shared with the regulated community. The Regional Water Board's programs will not be nearly as effective as they could be without the proactive participation of that community.

30. Comment(s):
No evidence that expanding wetlands improves water quality.

Comment(s) Made By:
Rex Cozzalio

Response:
The TMDL does not make this assertion, nor does it require the expansion of wetlands. The implementation plan does suggest wetland restoration and wetland treatment as a potential means for reducing nutrient and organic matter loading. Evidence does exist that shows this as at least a potentially viable option. One such reference is:

Kadlec, R.H., and R.L. Knight. 1996. Treatment wetlands. Lewis Publishers, Boca Raton, FL.

31. Comment(s):
Extorting everyone to participate in a waiver in a group like the RCD, and puts the RCD as the enforcement arm and collector of inevitable fees, shielding the agencies.

Comment(s) Made By:
Rex Cozzalio

Response:
The Regional Water Board will enforce the waiver. No one will be forced to participate in a group program and may choose to comply individually, although many stakeholders have specifically requested a group compliance option. For more information and opportunities to participate in the agriculture programs, please see section 6.5.6 of the TMDL staff report.

32. Comment(s):
Self defined authority and superiority through policy and agreements does not allow people to challenge the regulations regardless of the destruction it creates.

Comment(s) Made By:
Rex Cozzalio

Response:
Chapter 11 of the TMDL staff report documents the multitude of opportunities for public input.

33. Comment(s):
Stopping the diversion at Young's dam is a perfect model for removing the dams on the Klamath River. When Bryan (McFadin of Regional Water Board staff) modeled the Scott River with no diversion at Young's dam, the water heated up, that 26 mile exposure of the Scott River allowed the water going into the Klamath to be warmer than when the water was being diverted.

Comment(s) Made By:
John Menke – landowner – rancher in Quartz Valley

Response:
The comment is incorrect. The analysis referenced by the commenter found that eliminating the diversion at Young's dam resulted in a decrease in temperature for approximately 5 miles, followed by a temperature increase for approximately 25 miles. The temperature at the mouth of the Scott River was estimated to be slightly higher with diversions, albeit a very small difference. The results of the analysis can be seen in Figure 4.17 of the Scott River TMDL staff report, which can be found at :
<http://www.waterboards.ca.gov/northcoast/water_issues/programs/tmdls/scott_river/092005/sr/31figures4.1to4.18.pdf>.

34. Comment(s):
Your studies have not taken into consideration, that 60,000 acre-feet of water from the Klamath River being recirculated and diverted into the Shasta River would increase the water quality in the Shasta, and the Klamath, and make more refugia.

Comment(s) Made By:
Anthony Antiso – representing the Shasta Valley Waters Users Association in partnership with the Shasta Valley Nation.

Response:
Potential projects of this type are not relevant to the conclusions of the TMDL analysis, but may be considered as possible restoration projects.

35. Comment(s):
The temperature in the Klamath River below the Trinity is affected by different factors due to the coastal influence. It is important to recognize the differentials between upstream and downstream.

Comment(s) Made By:
Gary Rynearson – Green Diamond Resource Company

Response:
The same factors influence stream temperatures upstream and downstream of the Trinity River. While the effect of the factors change, the factors remain the same. Regional Water Board staff acknowledge that cooler air temperatures and reduced solar exposure due to coastal fog result in lower equilibrium temperatures.

36. Comment(s):
We have found that results and samples (for microcystis in the reservoirs) were taken in backwashes, kept for several days before getting to a laboratory, skewing the data terribly.

Comment(s) Made By:
Dr. Richard Gierak – Degrees in Biology, Chemistry, Doctorate in Healing Arts, Prior FERC member and also prior research laboratory director in the Bay Area

Response:
The samples were collected consistent with the Klamath Blue-Green Algae Workgroup standard operating procedures.

37. Comment(s):
Under the dormant commerce clause, it states that the Klamath River falls under the Magnusson Stevens Act and the Sustainable Fisheries Act as passed by Congress. And under both of those acts, no state may administer any regulatory action on this river without congressional approval.

Comment(s) Made By:
Dr. Richard Gierak – Degrees in Biology, Chemistry, Doctorate in Healing Arts, Prior FERC member and also prior research laboratory director in the Bay Area

Response:
See response to O21.

Quirmbach – Timber Products Company

1. Comment(s):
Would like to acknowledge two positive revisions: 1) the removal of additional prescriptive measure within Section 6.5.7 pertaining to timber harvest in favor of reliance on the Forest Practice Rules, including the recently enacted Anadromous Salmonids Protection Rules 2009 rule package and 2) elimination of the requirement within Section 6.5.7 to apply Forest Practice Rules pertaining to anadromous salmonids throughout the entire Klamath Basin (i.e. outside of locations where anadromous salmonids are present or restorable to).

Response:
Thank you for your acknowledgement. However, it is important to note that the water quality objective for temperature applies to all waters of the state. Foresters proposing to reduce effective shade on watercourses or prevent recovery of site-potential shade must demonstrate how the proposal meets the water quality objective for temperature.

2. Comment(s):
The end of Section 6.5.7 of the Public Review Draft details one measure for parties conducting timber harvest activities on nonfederal lands. Timber Products Company is supportive of this language but requests that the following double-underlined edits be incorporated into the final version so that the paragraph reads:

"Implement riparian management measures that meet the riparian shade allocations by implementing the Anadromous Salmonid Protection Rules (CDF, 2010). Where the ASP rules are not sufficient to meet the TMDL allocations, whether as a result of insufficient prescriptions or geographic limitations, implement additional measures as directed by Regional Water Board staff during the THP/NTMP review process and/or waiver/WDR enrollment process. The necessity for such additional measures shall be supported by substantial evidence unless the landowner agrees to the additional measures in which case substantial evidence is not required.

Response:
Regional Water Board staff will include clear reasoning for the necessity of added protection to meet temperature allocations in cases where added protection is necessary to meet the water quality objective for temperature, however, the suggested language is unnecessary. The TMDL does acknowledge some latitude for modified shade requirements on a case by case basis.

3. Comment(s):
Timber Products Company has expressed concerns with Section 6.5.1.2 of the Public Review Draft in our previous letter dated August 20, 2009, and it appears that the language was not revised in the December 2009 version. Our concerns for the second

target (bottom of page 6/31 of the December 2009 version) were related to a lack of connection to water quality impacts as well as the burdens placed on all parties to determine compliance.

In our August 20, 2009 letter, we suggested deletion of Targets 2 and 3 from Section 6.5.1.2. In this letter, we once again suggest deletion of these targets but also offer an alternative. We believe a better approach would be to rely on the Forest Practice Rules and the waiver/WDR process to address sediment inputs. Of course, the revised Implementation Plan already takes this approach for temperature/shade canopy issues.

Response:
The watershed targets present a depiction of conditions that are consistent with water quality objectives. They are not enforceable absent an implementation mechanism such as a permit, nor do they represent compliance criteria. Even in a non-point source permit, the target is likely to be translated into management requirements. These targets should be met over time, as crossings are installed or replaced. They represent a goal for the future.

Stream crossing diversions and failures have been demonstrated to have tremendous impacts on downstream water quality (Hagans and Weaver, 1987). The approach to implementing the sediment-related temperature targets is through the waiver/WDR process, as recommended.

Hagans, D.K., and W.E. Weaver. 1987. Magnitude, cause and basin response to fluvial erosion, Redwood Creek basin, northern California. In: Beschta, R.L., T. Blinn, G.E. Grant, F.J. Swanson, and G.G. Ice (Eds), Erosion and Sedimentation in the Pacific Rim. Wallingford, United Kingdom: International Association of Hydrologic Sciences Press. Publication 165: 419-428.

4. Comment(s):
In comments submitted in a letter dated August 20, 2009 on the June 2009 Klamath TMDL Public Review Draft, Timber Products Company recommended that the Board formally recognize the Forest Practice Rules (FPR) as an appropriate implementation program for the Klamath River TMDL. While the December 2009 version does not formally recognize the FPR as an appropriate implementation program, the revised version does move in that direction by eliminating prescriptive requirements pertaining to timber harvest. Therefore this comment from the previous TPC letter was partially addressed in the December 2009 version.

Response:
Comment noted.

5. Comment(s):

In comments submitted in a letter dated August 20, 2009 on the June 2009 Klamath TMDL Public Review Draft, Timber Products Company was concerned about the concept of site-potential shade discussed in Section 6.5.1.1. TPC recommended that, in lieu of focusing on the ability of individual trees to provide shade, the Public Review Draft instead rely on the FPR to implement shade standards. While the language relating to site potential shade still exists within Section 6.5.1.1, revisions within Section 6.5.7 make it clear that the Implementation Plan will rely on the FPR for the implementation of shade measurements. Therefore, the main recommendation from our previous letter appears to have been addressed although a discussion of site potential shade still exists within Section 6.5.1.1. The necessity of this discussion, at least in terms of timber harvest on private lands, is questionable given that the FPR will be relied upon and that the FPR contribute towards the eventual development of the site potential tree heights in Watercourse and Lake Protection Zones.

Response:

Section 6.5.7 addresses timber harvest on non-Federal lands, which is only one of many activities that have the potential to reduce riparian shade. Therefore, the language in section 6.5.1.1 is still relevant.

6. Comment(s):

In comments submitted in a letter dated August 20, 2009 on the June 2009 Klamath TMDL Public Review Draft, Timber Products Company recommended that targets 2 and 3 of Section 6.5.1 be deleted. The December 2009 version did not delete these sections so this comment was not addressed by revisions in the December 2009 version.

Response:

Please refer to the response to comments Quirmbach-3 and Quirmbach-5, above.

7. Comment(s):

In comments submitted in a letter dated August 20, 2009 on the June 2009 Klamath TMDL Public Review Draft, Timber Products Company recommended deletion of the third sentence of Section 6.5.7.2 regarding basin-wide application of rules related to the protection of anadromous salmonids. This sentence was deleted so it appears that this comment was addressed by revisions within the December 2009 version. This deletion along with personal communication with Board Staff clearly indicate that rules related to anadromous salmonid protection are not to always be applied in the entire Klamath Basin (i.e. even where anadromous salmonids do not occur nor are restorable) as part of the Implementation Plan.

Response:

All responsible parties have the responsibility to ensure their activities do not lead to exceedences of water quality objectives, including the temperature objective. Calfire's Anadromous Salmonid Protection rules only apply to areas where anadromous salmonids are present, or waterbodies that have the ability to effect downstream reaches open to anadromy. Regional Water Board staff recommend and may require foresters manage riparian areas consistent with the Anadromous Salmonid Protection Rules' riparian prescriptions where salmonids are present regardless of whether a reach is open to anadromy. Foresters proposing to reduce effective shade on watercourses or prevent recovery of site-potential shade must demonstrate how the proposal meets the water quality objective for temperature.

8. Comment(s):
In comments submitted in a letter dated August 20, 2009 on the June 2009 Klamath TMDL Public Review Draft, Timber Products Company recommended deletion of certain prescriptive measures related to timber harvest within Section 6.5.7.3. These measures have been deleted in the December 2009 version so this comment appears to have been addressed by revisions within the December 2009 version.

Response:
Comment noted.

Rynearson - Green Diamond Resource Company

1. Comment(s):
We greatly appreciate the recognition of the AHCP road management plan and sediment reduction efforts as meeting the goals for the Klamath TMDL, and look forward to implementing the coordinated DF&G and Water Quality permits.

Response:
Regional Water Board staff commend Green Diamond Resources Company for taking a pro-active approach to protecting water quality.

2. Comment(s):
We also believe that the riparian management sections of our AHCP provides equal or superior means to achieve the temperature goals compared to those proposed in the Draft Klamath TMDL. Our riparian measures include enhanced stream buffers and buffer reentry restrictions that limit harvest entries to once during a forest management rotation (50 + years). We have also implemented additional buffers for geologically sensitive areas. Our riparian and geological measures apply to the entire area within the Klamath Basin covered by our AHCP, not just the planning watersheds where salmonid species are present. Please note that our lands are situated in the lower portion of the Klamath basin and are not subject to the solar loading of the middle and upper Klamath.

Response:
Regional Water Board staff will carefully evaluate the riparian management sections of the AHCP and communicate our findings in a letter to Green Diamond Resource Company.

3. Comment(s):
The Draft TMDL provides implementation measures recommended to achieve the temperature goals including the development of watershed-wide WDRs and ownership specific WDRs. GDRCo has been involved in discussions with Regional Board staff regarding the development of property wide WDRs for all activities related to timber harvesting. We look foreword working with the staff to complete this property-wide permit; however, due to staff limitations, we do not expect this permit to be completed for over a year. In the interim period, we believe that our AHCP provides equal or superior measures to achieve the Klamath TMDL temperature goals associated with timber harvesting. [Commenter provided charts comparing ASP and AHCP prescriptions related to temperature protection.] We believe that attached comparison chart indicates that the GDRCo AHCP measures provide equal or superior measures to the ASP rules. We therefore respectfully request that the AHCP be considered as meeting the Klamath TMDL temperature goals for timber harvesting.

Response:
Regional Water Board staff will carefully evaluate the riparian management sections of the AHCP and communicate our findings in a letter to Green Diamond Resource Company

4. Comment(s):
Thank you for the opportunity to provide comments and consideration of our request. We appreciate working with the Board and staff to develop cooperative solutions to meet water quality objectives.

Response:
Thank you for the comments. We look forward to working together with Green Diamond Resource Company to preserve, protect, maintain, and restore water quality.

Siskiyou County Board of Supervisors

1. Comment:
Siskiyou County Board of Supervisors (Siskiyou Board) submitted additional comments after its review of the documents it requested under the Public Records Act. The Siskiyou Board's main point is that it believes that the TMDL process has been inappropriately influenced by those engaged in KBRA and KHSA discussions, including a State Water Board member who was participating in Settlement discussions for the State Water Board Negotiation team. The Siskiyou Board argues that because of this "influence" the staff should "start over in an open and transparent manner, disclosing all of the information that was discussed and omitted or included at the request of those parties who may have had a set objective for dam removal rather than an objective study of an appropriate TMDL." (Comment at p. 12-13.) The bulk of the comment consists of a bulleted list of excerpts from various emails between Regional Water Board staff to various Settlement Parties, primarily in the context of the KHSA section addressing TMDL compliance and interim water quality measures. The Siskiyou Board requests that the PRA documents be included in the TMDL record, and also joins technical comments submitted by PacifiCorp on February 9, 2010.

Response:
The Regional Water Board has added all of the documents produced under the Siskiyou County Counsel's PRA request to the TMDL record. For responses to PacifiCorp's February comments, please see specific responses to PacifiCorp in the December Responses to Comments.

The Siskiyou Board's main argument appears to misunderstand the rules about communications with outside parties in a quasi-legislative action. The adoption of a TMDL and Basin Plan amendment is a rulemaking process, which is not subject to the prohibition on ex parte communications. The ex parte rule prohibits communications with Board members on a pending item where all interested parties are not present or privy to the communication. This rule applies in the context of issuing waste discharge permits or enforcement actions.[1] In contrast, Regional Water Board staff frequently meet with stakeholders individually and in larger groups in the TMDL development process. In fact, TMDL Guidance and regulations require outreach to the community and there is no statutory or constitutional prohibition against this practice.[2] There is nothing untoward about any group's attempt to influence a rulemaking process. In fact, one could characterize the TMDL public participation and outreach as largely an exercise of various interested parties exerting "influence" to result in a TMDL that addresses the particular

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1 Even in quasi-adjudicative actions like issuing a permit, staff will often work with the discharger and interested parties separately to help develop the permit prior to when the hearing is scheduled.

2 Public participation is that part of the decision-making process through which responsible officials become aware of public attitudes by providing ample opportunity for interested and affected parties to communicate their views. Public participation includes providing access to the decision-making process, seeking input from and conducting dialogue with the public, assimilating public viewpoints and preferences, and demonstrating that those viewpoints and preferences have been considered…. Disagreement on significant issues is to be expected among government agencies and the diverse groups interested in and affected by public policy decisions. (40 CFR §25.3.)

needs of various groups. Note that Regional Water Board staff and individual Board members have met with Siskiyou County officials and staff privately to discuss the TMDL, which is appropriate.

In addition, Siskiyou County's allegations regarding the nature of Regional Water Board staff communications in the settlement are false. The precise scope and nature of staff involvement is demonstrated by the email communications cited by the Siskiyou Board, and by public documents already in the TMDL record. The Siskiyou Board attempts to portray a scenario that involves secret dealings between pro-dam removal groups and the Regional Water Board staff simply by relying on the fact that Settlement Parties executed a Confidentiality Agreement that limits disclosure of certain documents and communications in settlement discussions. This is an incorrect characterization. Settlement meetings involved numerous groups and hundreds of people, and it is not at all clear that confidentiality was enforced or maintained. Siskiyou County itself is a Settlement Party and has access to far more information about the settlement process than the Regional Water Board staff. The Regional Water Board and its staff members were never a party to the AIP, KHSA or the KBRA.

The Regional Water Board's interest in the settlement discussions is clearly spelled out in a letter dated January 6, 2009, that was sent to the entire settlement group including Siskiyou County Counsel Tom Guarino. This letter has always been a public document and came after a discussion about the AIP in a public meeting. The Regional Water Board has always made clear to the public the difficulties it faces with enforcement of the Clean Water Act as it applies to the Klamath Hydroelectric Facility (KHP). (See Resolution No. 2007-0028 and Supplemental Analysis [denying a petition requesting that it order PacifiCorp to file a Report of Waste Discharge (ROWD) and/or issue waste discharge requirements (WDR) for Copco and Iron Gate Reservoirs because of Federal Power Act preemption].) In contemplation of the absence of the FERC/401 process, it was appropriate for Regional Water Board staff to participate in discussions about how the Parties view the regulatory pathways envisioned in the Agreement and the Agreement's relationship to Oregon's and California's TMDLs. This is reflected in section 6.3 of the draft Klamath Hydroelectric Settlement Agreement released on September 30, 2009. In addition, Regional Water Board staff engaged in discussions regarding the content of interim water quality measures included in the Agreement. These interim measures have great potential to make water quality improvements while further studies on the long-term infrastructure of the KHP are conducted. The emails produced under Siskiyou County's PRA request demonstrate that Regional Water Board staff was working on these precise issues.

Nothing in these documents suggests that members of Tribes, NGOs or others were exerting improper influence on the TMDL. To the contrary, the correspondence make clear that Regional Water Board staff was trying to influence the content of the interim water quality measures in the Agreement. In the absence of regulatory authority over the KHP, the Regional Water Board staff had an interest in making the Agreement as good as possible for water quality in the interim time period. The email from John Corbett acting as Yurok attorney does not show a Board member "inappropriately intervening" in the

TMDL process. This message is clearly in response to concerns raised by Regional Water Board staff over the lack of regulatory control of PacifiCorp's commitments in the interim water quality measures. Catherine Kuhlman's initial email dated 6/18/09[3] to the settlement group is requesting more transparency and agency control in the Agreement's interim water quality measures--not the other way around. Mr. Corbett's response attempts to defend and explain how the parties intended the interim measures in the Agreement to work. The County Board's specific comments about communications with Oregon and EPA demonstrates its fundamental misunderstanding about the collaborative and coordinated effort of the Klamath TMDL and has nothing to do with the Settlement Agreement.

Regional Water Board staff involvement in settlement discussions does not amount to any prohibited or improper influence. There is no communication that occurred in those discussions that is relied upon to support the technical TMDL. The information and bases for the TMDL are all well documented in the Staff Report. The TMDL only relates to the settlement because the implementation plan relies in part on the content of TMDL section of the KHSA, which is also a public document reflected in the record. The TMDL record includes the public documents cited above, and specific email communications are now part of the TMDL record at Siskiyou Board's request. Interested persons have had ample opportunity to comment on the TMDL implementation plan as it relates to the KHP, and which includes the KHSA interim measures. Nothing contained in the emails changes or alters any of the conditions in the implementation plan. The TMDL process has been open and transparent, and the communications between Regional Water Board staff and various Settlement Parties do not raise any grounds for starting the process over.

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[3] The email raises two issues with the Agreement relating to the governance structure of the Interim Committee and funding of interim projects. "PacifiCorp wishes to maintain control and reduce the role of the water quality agencies to less than that of the parties serving on the committee discussed in interim 1. Please note that the Regional Water Board isn't even on the committee as proposed."

Sloan –Yurok Tribe

1. Comment(s):

Overall the technical analysis presented in the Klamath TMDL is scientifically rigorous and provides a solid foundation for remediation of the river's pollution problems. The technical analysis has been further refined in recent *Revised Public Draft TMDL (December 2009)*. We commend Regional Board Staff for their effort on the TMDL conceptual framework and technical analysis.

Response:

Thank you for your comment.

2. Comment(s):

We are alarmed by Regional Water Board staff's back-sliding on important issues, such as dropping the interim requirements to develop farm and ranch water quality management plans and the removal of the conditional sediment prohibition that included requirements to control sediment discharges. The Regional Water Board is shirking its duty and abrogating its authority by not requiring farm and ranch plans similar to those required by the Garcia River TMDL (Regional Water Board 1998). We are concerned that the interim requirements to develop farm and ranch water quality management plans that were included in the June public draft is no longer contained in the December public draft.

Response:

See response to Bowman – 2.

3. Comment(s):

We also find provisions with respect to timber harvest and roads left too vague, and the lack of targets and time-lines for reducing cumulative effects risks are likely to confound the plan's refugia protection policy.

Response:

See response to Bowman – 3.

4. Comment(s):

Despite more than five years of recommendations from the QVIC to the Regional Board staff, the Klamath TMDL still lacks a tributary monitoring program based on trusted scientific methods (Knopp 1993, Kier Associates and NMFS 2008) with a timeline for attainment of targets. Consequently, adaptive management will remain elusive (NRC 2004) as will compliance with CEQA.

Response:

See response to Bowman – 4.

5. Comment(s):
The Revised Draft Klamath TMDL falls short of any scientific standard for the use of adaptive management (Walters, 1997). It instead falls into the pattern of "deferred action" described by the NRC (2004). The Klamath TMDL must be clearer in defining how it will enforce water quality standards, the monitoring that will be used for compliance assessment, and a timeline for abating water pollution under CEQA. These shortcomings of the Klamath TMDL, in aggregate, render it, in our view, non-compliant with the California Environmental Quality Act.

Response:
See response to Bowman – 5.

6. Comment(s):
We strongly support the concept of the Thermal Refugia Protection Policy outlined in the Basin Plan amendment language and section 6.5.4 of the staff report (Page 6-33). We would, however, propose two improvements: 1) update the list of thermal refugia (section 6.5.4.1) to include the locations in the Scott River submitted by the QVIR (2009), including the five-mile reach from Boulder Creek to Townsend Gulch. 2) extend the discharge restriction in and around instream buffer areas from June 15-September15 to year-round.

Response:
See response to Bowman – 6.

7. Comment(s):
Additionally, the shortcomings with regard to cumulative effects from timber harvest and roads (Higgins 2010) are likely to confound attainment of the proposed thermal refugia protection, as is the lack of farm and ranch plans in tributaries like Bogus and Horse Creeks (Kier Associates 1991, 1999).

Response:
See response to Bowman – 7.

8. Comm ent(s):
A clear timeline needs to be developed for this waiver and proper staffing needs to be allocated to ensure its success. This is a critically important process in which the Tribes must participate fully and expect Regional Board staff to engage our technical staff in the development of this waiver.

Response:
See response to Bowman – 8.

9. Comment(s):
There are many well-documented Middle Klamath water quality problems related to agriculture that persist (Kier Associates 1991, 1999), including water diversion and thermal pollution in Bogus Creek. Agricultural operators in Bogus Creek need to be held accountable. The plan should incorporate "salmon safe" practices, including those related to water diversions and thermal refugia, in farm and ranch plans as soon as possible.

Response:
Thank you for the suggestion. The Regional Water Board will be retaining suggestions regarding the content of the future agricultural waiver and will consider them during the development process.

10. Comment(s):
The Klamath TMDL should clearly recommend that agriculture reduce pesticides and herbicides that are problematic for water quality restoration and push for integrated pest management (Dieckhoner and Galvin 1999). Given the extremely low flows in the Shasta and Scott River basins there is the clear potential for the concentration of pesticides to levels that could cumulatively affect salmonids. The Regional Water Board should err, if at all, on the side of caution.

Response:
Pesticides and herbicides are not addressed by the TMDL but will be addressed by the agricultural waiver.

11. Comment(s):
As noted in Section 6.5 "Nonpoint Source Control and the Watershed-Wide Allocations" of the *Revised Public Draft TMDL*, the "Prohibition on the Discharge of Excess Sediment" section of the *Public Draft TMDL* was dropped and replaced with a voluntary "Guidance for the Control of Excess Sediment".

This is another disappointing example of the weakening of the Implementation Plan. We recommend the original language be restored. Given that sediment is a well-known contributor to stream warming and that the Klamath TMDL has prohibitions on inputs to Middle Klamath tributaries to protect refugia, this new, lax language is inconsistent with the temperature refugia policy and will confound attainment of that objective.

Response:
See response to Bowman – 11.

12. Comm ent(s):
Wasted Discharge Requirements or Waivers for private timber are unlikely to be sufficient. The Klamath TMDL should require analysis with available landslide risk tools like SHALSTAB (Dietrich et al. 1998) and should prohibit activities on steep slopes with high or extreme landslide risk, especially those in the inner gorge where sediment may be delivered directly to streams (de la Fuente and Elder 1998).

Response:
See response to Bowman – 12.

13. Comm ent(s):
The Quartz Valley Indian Community and Yurok Tribe remain disappointed that there is no specific requirement to reduce road densities on USFS lands despite the fact that watershed analyses and road management plans on both Six Rivers and Klamath National Forest set such targets (SRNF 2000, 2003, KNF 2000). By simply adding their own targets to the TMDL the Forest Service would likely accelerate federal funding for bringing their lands into compliance. Absent such language the KNF will likely continue to delay such improvements indefinitely. Proactive National Forests like the Six Rivers could use the TMDL to leverage significant funds for road decommissioning projects.

Response:
See response to Bowman – 13.

14. Comment(s):
There is a profound need for more trend monitoring and compliance enforcement. Even when aquatic indicators are trending negatively, required corrective action, using adaptive management, has not been taken. The Regional Water Board has failed to press for data and assessments from the Klamath National Forest. There has been a pattern of incompetence that has been tacitly allowed.

Response:
The USFS waiver will address trend monitoring and compliance enforcement. Regional Water Board staff are working with KNF on an expanded monitoring plan to assess water quality impacts from KNF activities.

15. Comm ent(s)
Despite the numerous requests and recommendations made by the QVIC over the past several years, the Klamath TMDL still does not acknowledge the urgent need to commence the restoration of the Klamath River basin's freshwater habitat immediately, given the imminent ocean and climate cycles, (Hare 1998, Hare et al. 1999, Collision et al. 2003) if we are not to lose coho salmon forever.

To let these fish slip through the fingers of the Regional Water Board would violate the Clean Water Act and would deliver a perpetual loss to the Klamath Basin Tribes. Given the existing water quality and fish health crisis and the onset of global warming (Van Kirk and Naman 2008), the bureaucratic backsliding represented by the devolution of the Klamath TMDL is inappropriate, unacceptable and clearly legally challengeable.

Response:
See response to Bowman – 15.

16. Comment(s):
Page 1-27. The following text seems to be describing the old figure (now removed from the text), not the new one, and is thus obsolete and should be deleted or revised: "The estimated unimpaired flows represented in Figure ~~1.11~~ 1.12 illustrate the magnitude and pattern of flows … whereas the estimated natural Scott and Shasta River flows are reported by the U.S. Geological Survey (USGS ~~(~~2006) as monthly means."

Response:
The comment is correct; the language was inadvertently left in the document. The language has been removed from the final draft.

17. Comment(s):
Page 2-36. Richard Stocking has done excellent research on the Klamath River, but it is our understanding that he has an MS, not Ph.D., and thus the title "Dr. Richard Stocking" is incorrect.

Response:
The text has been revised.

18. Comment(s):
Page 2-39. "*Microcystis aeruginosa, Anabaena flos-aquae, Anabaena flos-aquae, and Gleotricia echinulata.*" should read, instead, "*Microcystis aeruginosa, Aphanizomenon flos-aquae, Anabaena flos-aquae, and Gleotricia echinulata*."

Response:
The text has been revised.

19. Comment(s):
Page 2-59. Table 2.10: "Summary of fall temperature effects resulting from human alteration" is an informative table; however, the river location is nowhere mentioned. We assume it is the site of Iron Gate Dam, but this should be stated explicitly.

Response:
The table has been revised to include specific mention of the location.

20. Comment(s):
Page 2-102. Incorrect citation in the references:
"E. J. Kann, and W. Walker, 2009. Multi-year Nutrient Budget Dynamics for Iron Gate and Copco Reservoirs, California. Final Technical Report to the Karuk Tribe Department of Natural Resources, Orleans, CA. 55pp + appendices." The names should read "Asarian, E, J. Kann, and W. Walker"

Response:
The reference has been revised.

21. Comment(s):
The changes made to the water quality model to address comments by the U.S. Geological Survey appear to be minor improvements. While we still have some concerns regarding the model, expressed in many rounds of previous comments, it is our opinion that on the whole, the model is robust enough to serve its intended purposes in the TMDL (i.e. setting load allocations). It is abundantly clear that the current nutrient concentrations in the river are far higher than natural background and that substantial reductions are necessary to restore water quality.

Response:
Comment noted.

22. Comment(s):
Page 4-29. Erroneous dates in "Table 4.3 Hydraulic Parameters for Klamath Reservoirs (May 2004 – May 2005)" if information is based on Kann and Asarian (2007), as that report examined the period May 2005-May2006. This was noted in previous comments, please fix.

Response:
The table has been revised.

23. Comment(s):
Page 4-32. "For the purposes of this report the term retention is meant as net retention, which is the difference between influent and effluent loads. The net retention includes both permanent losses to the atmosphere and deep burial along with temporary storage and exchanges with the active sediment and gains from the atmosphere due to nitrogen fixation." We suggest the following revision to make this more explicit and accurate: "For the purposes of this report the term retention is meant as net retention, which is the difference between influent and effluent loads. The net retention includes permanent

losses (denitrification to atmosphere and deep burial), temporary storage and exchanges (within reservoir water column and active sediment), and gains from the atmosphere due to nitrogen fixation. This definition of net retention is slightly different from that used by Asarian et al. (2009) because that report excluded (subtracted) changes in reservoir storage in calculating retention."

Response:
The text has been revised to more accurately and completely describe retention and loss of nutrients within the reservoirs.

24. Comment(s):
Page 4-34. "Table 4.5 Estimated Nutrient Retention and Export for Copco and Iron Gate Reservoirs". All instances of 2004-2005 in this table should in fact be 2005-2006. Also the values from Kann and Asarian (2009) should not include decimal places, as the values in that report are rounded to the nearest integer. Additionally, we suggest adding notes to clarify the sources of the literature-based empirical models. These include changing "Range of 5 methods cited by Kann and Asarian (2007)" to "Range of 5 literature-based empirical models applied by Kann and Asarian (2007)". Additionally, a note should be added to indicate that the Vollenweider (1976) and Nürnberg (1984) values were derived by TetraTech (one way to do this would be to say change "Vollenweider (1976)" to "Vollenweider (1976) empirical model applied by TetraTech (2008)", etc. In addition, the "PacifiCorp (2006)" nitrogen estimate is derived from Kann and Asarian (2005) and should be noted as such suggested revision: "PacifiCorp (2006), based on Kann and Asarian (2005).

Response:
The text has been revised.

25. Comment(s):
Page 5-3. This comment was previously submitted, but has not been resolved and is thus re-stated here. Table 5.1 in the Public Draft TMDL is generally an excellent table, nicely summarizing all of the numeric targets and allocations; however, it contains something that does not make any sense: "Microcystis aeruginosa cell density < 50% of the blue-green algae biomass, or < 20,000 cells/L (which ever is lower)" (p 5-3). We agree that the Microcystis aeruginosa cell density < 20,000 cells/L is an excellent target, but the Microcystis aeruginosa cell density <50% of the blue-green algae biomass it is unnecessary and not supported. For example, if the total blue-green algae biomass is very low, then it should not matter if Microcystis aeruginosa is 50% of the total -- because the total amount of Microcystis aeruginosa would still be very low. Public health risks are driven by the concentration of Microcystis aeruginosa cells and microcystin toxin, not the relative percent of the blue-green algae biomass that is Microcystis aeruginosa. We suggest a revised target of simply "Microcystis aeruginosa cell density < 20,000 cells/L". This is the only place in the entire TMDL that we can find any mention of a 50% target, so we suspect that its inclusion in Table 5.1 may have been unintended.

Response:
The table has been revised to provide a target based on cell density without reference to a percent biomass condition.

26. Comment(s):
We agree with staff that Alternative 3, using a percent saturation based on natural receiving water temperatures, is the most appropriate method to use for setting the criteria; however, we disagree with the values proposed in Table 7.5. It is our opinion that the values the Regional Water Board proposes in Table 7.5 are erroneous, based on artifacts of the TMDL water quality model, and should be revised. We suggest a value of 90% year-round for Stateline to above Turwar, and 85% for Turwar.

Response:
See response to Bowman – 26.

27. Comment(s):
Regarding the values proposed for the various portions of the Estuary, at this time we cannot endorse setting site-specific dissolved oxygen objectives based on the TMDL water quality model for the Estuary, given: 1) the complex dynamics of the Estuary are not well understood, in part due to the lack of data, 2) the inherent difficulty of modeling a system as complex as the Estuary, 3) due to reasons 1 and 2 we regard the Estuary as the most uncertain geographic area of the TMDL water quality model, and 4) we have not closely examined model outputs for the Estuary. Furthermore, Table 6.7: "Minimum Percent DO Saturation at Locations throughout the Klamath River Mainstem under Natural Conditions (T1BSR Model Run)" does not included modeled percent saturation values for the Estuary (only displays as far downstream as Turwar).

It is our understanding that given that the Estuary is located on the Yurok Reservation, the Regional Water Board does not have authority to set a criterion anyway, as is alluded to in the text of page 7-3 "To the extent that the State lacks jurisdiction, the proposed SSO is extended as a recommendation to the applicable regulatory authority". Given the substantial uncertainty regarding the model predictions for the Estuary (even under current conditions, aside from the issue of natural conditions), and the lack of a need for the Regional Water Board to recommend a criteria due to lack of jurisdiction, we recommend that the Upper and Middle Estuary and Lower Estuary be removed from Table 7.5, and that area be left as a gap in the site-specific D.O. criteria.

Response:
See response to Bowman – 27.

28. Comment(s):
Barometric pressure and water temperature are key determinants of dissolved oxygen saturation, and barometric pressure is dependent on elevation (higher elevation means lower barometric pressure and hence lower dissolved oxygen). The information included in the "Table 6.6: Barometric Pressure Assignments, corrected for elevation at key locations" indicates that while representations of barometric pressure in the TMDL water quality model have been improved since previous versions of the model, the situation is still less than desirable, particularly for the portion of the Klamath River that lies within the Hoopa Valley Reservation.

Response:
See response to Bowman – 28.

29. Comment(s):
We object to staff's proposal of a standard that automatically weakens with climate change. The text on page 7-15 does not explicitly state whether climate change is natural or human-caused, an important distinction that should be made. It is our opinion that the majority of climate change that has occurred in the past few decades (and will continue to occur) is human-caused. Thus, climate changes are not "natural" and should not be included in "natural receiving water temperatures."

Response:
See response to Bowman – 29.

30. Comment(s):
Comment on the North Coast Basin Plan language. The following language should be inserted into the first introduction paragraph prior to the Problem Statement or in the opening paragraph in the Thermal Refugia Protection Policy of the Action Plan:
In order to ensure the Native American Cultural (CUL) and Subsistence Fishing (FISH) Beneficial Uses in the Klamath River are met all life cycles of cold water fishes and up-river habitats, in particular cold water refugia, will be protected.

Response:
The beneficial uses listed above already reference the protection of all life stages of salmonids and the Thermal Refugia Protection Policy in conjunction with the nonpoint source implementation measures are protective of cold water refugia and water quality related to up-river habitats. This statement in the Basin Plan, however, has been revised to better recognize the relationship among the beneficial uses.

31. The following language should replace sentence 2 of paragraph 2 in the Thermal Refugia Protection Policy section of the Action Plan:
The restriction applies year round to account for annual and seasonal temporal variability when thermal refugia is functioning in the mainstem Klamath River and its

tributaries and to incorporate a margin of safety to protect beneficial uses associated with cold water.

Response:
See response to Bowman – 32.

32. Comment(s):
The following language should be inserted into Section VIII. Reassessment and Adaptive Management of the Basin Plan language:
Within one year Regional Board staff shall evaluate the inventory of cold water refugia AND the effectiveness of thermal refugia protection regulations and make recommended revisions to the Regional Board as necessary to adequately protect cold water refugia.

Response:
See response to comment Bowman - 35.

33. Comment(s):
The following language should be inserted into Section VIII. Reassessment and Adaptive Management of the Basin Plan language:
Within one year Regional Board staff shall make an appraisal to determine if the Scott and Shasta Rivers are improving water quality in the Klamath River and make recommended revisions to the Scott and Shasta TMDLS as necessary to meet water quality targets in the Klamath River.

Response:
The effectiveness of Scott and Shasta implementation will be considered by the Regional Water Board when the conditional waivers adopted as part of their respective implementation plan are considered for renewal.

Terence – Klamath Riverkeeper, Pacific Coast Federation of Fishermen's Associations, Institute for Fisheries Resources, and the Northcoast Environmental Center

1. Comment(s):
   We wish to commend the NCRWQCB staff for its efforts in making the mainstem Klamath TMDL as scientifically sound as possible.

   Response:
   Thank you for your comment.

2. Comment(s):
   Clearly, California's ability to achieve the water quality objectives set forth in its TMDL hinge on an equally stringent and enforceable TMDL in Oregon backed by timely commitments and follow-through from the Oregon Department of Environmental Quality (ODEQ), Oregon Department of Agriculture (ODA) and other responsible parties in Oregon.

   Response:
   Regional Water Board staff agree and are committed to working with ODEQ and USEPA to meet the Klamath TMDL in Oregon and California as outlined in the implementation MOA signed in June 2009.

3. Comment(s):
   We suggest the addition of the underlined text below to the last paragraph of Section 6.2.3.3:
   Regional Water Board, Oregon (ODEQ) and USEPA 9 and 10: Measure
   Work together as specified in the Klamath River/Lost River TMDL Implementation Memorandum of Agreement developed to implement, monitor and ensure enforcement of measures that will achieve compliance with the Klamath and Lost River TMDLs in Oregon and California.

   Response:
   The suggested text has not been added to the staff report and Basin Plan language.

4. Comment(s):
   It is critical that the MAA is written in such a way that it retains ultimate authority over the TMDL implementation and monitoring in the hands of the NCRWQCB. Dependence on voluntary measures to achieve compliance has rarely proven effective in the past and especially not in this basin, where the largely voluntary Scott and Shasta TMDLs are already sadly behind their compliance schedules.

Response:
The MAA is not an enforcement mechanism and is being proposed as a cooperative means for addressing water quality impacts attributed to the operation of Reclamation's Klamath Project. There is precedent for this approach in the Central Valley where the Regional Water Board (Region 5) and the USBR developed an MAA that describes the cooperative actions USBR will take under the Salt and Boron TMDL for the lower San Joaquin River. See response to comment H27 for more on the purpose of the MAA.

5. Comment(s):
We think it particularly important that use of wetlands restoration or expansion be specifically mentioned as part of the suite of tools available to address these nutrient problems stemming from irrigated agriculture in the Lost River, in addition to a large-scale nutrient reduction project such as a treatment plant.

Response:
See response to Bowman – 38.

6. Comment(s):
It is also important to recognize that use of these tools amounts to pollution trading by not only Klamath Irrigation Project farmers, but also by PacifiCorp.

Response:
The staff report recognizes this in sections 6.3.1.3 and 6.3.2.3.

7. Comment(s):
Pollution trading may be the fastest and most feasible way of cleaning up the pollution inputs at Klamath Straits Drain, but should not relieve polluters of their responsibility to deal with their own pollution, and should be subject to frequent effectiveness monitoring and reporting.

Response:
Regional Water Board staff agree with this comment. Individuals discharging to waters of the state in the Lost River basin in California are responsible for addressing those discharges regardless of the successes or failures of larger restoration efforts in the basin.

8. Comment(s):
It is important to note that responsible parties such as the federal government cannot disown the cleanup of the pollution they generation under the Clean Water Act, and they should not be able to do so in the TMDLs.

Response:
The US Bureau of Reclcamation and the US Fish and Wildlife Service are named as responsible parties in the Klamath implementation plan.

9. Comment(s):
Strong and independent, enforceable TMDL's are important backstops to the Klamath Settlement Agreement which have the independent force of law, and it is the needs of the river and its beneficial uses, expressed in terms of these TMDLs, that must drive the TMDL Implementation Plans in Sec. 6.3.2 of the Klamath Hydroelectric Settlement Agreement -- not vice versa.

Response:
Regional Water Board staff have clarified where the Regional Water Board lacks jurisdiction to enforce TMDLs. Specifically, The Regional Water Board has always made clear the difficulties it faces with enforcement of the Clean Water Act as it applies to the Klamath Hydroelectric Facility (KHP). (See Resolution No. 2007-0028 and Supplemental Analysis [denying a petition requesting that it order PacifiCorp to file a Report of Waste Discharge (ROWD) and/or issue waste discharge requirements (WDR) for Copco and Iron Gate Reservoirs because of Federal Power Act preemption].) The Regional Water Board is not a party to the Settlement Agreement, but did participate in the discussions for the limited purpose of discussing KHP implementation of the TMDL. Because the Regional Water Board is preempted from directly issuing waste discharge requirements to the KHP so long as the project is operated under a federal license issued by FERC, the TMDL load allocations (and existing water quality objectives) as they apply to the KHP cannot be directly implemented and enforced without a relicensing decision from FERC and accompanying 401 water quality certification. Section 6.3 of the draft Klamath Hydroelectric Settlement Agreement released on September 30, 2009 contains the content that Settlement Parties agreed should suffice for TMDL compliance. The Regional Water Board must approve the plan submitted by PacifiCorp, and we expect it to be fairly consistent with provisions of the Settlement Agreement. Regional Water Board staff remain committed to working with PacifiCorp and other parties to ensure that interim measures provide the most effective water quality improvements as possible.

Regional Water Board staff have also made clear its lack of authority over discharges in Oregon, but remain committed to working with Oregon to strengthen and coordinate implementation.

10. Comment(s):
We agree with your assessment that PacifiCorp's request for 18 months to submit its implementation plan is unnecessarily long. Please require the company to

submit its plan on the shortest possible timeline, preferably no later than three months after final adoption of a mainstem Klamath TMDL.

Response:
The implementation plan requires PacifiCorp to submit their plan within 60 days of the Basin Plan amendment taking effect.

11. Comment(s):
Before measuring nutrient levels in the Shasta, near-total dewatering in the Shasta River must be addressed. The reality is that heavy and regular dewatering during the irrigation season may prevent direct and measurable pollution inputs to the mainstem Klamath River, but surely also deprives the mainstem Klamath of cold, clean, oxygenated water that it might otherwise get from the Scott and Shasta Rivers.

Response
See response to comment X1.

12. Comment(s):
Assignment of sediment, temperature, nutrient and organic matter allocations to the Scott River (Section 6.4.5) in order to comply with mainstem TMDLs is also appropriate, and should be implemented immediately. While we certainly would support rolling Scott and Shasta polluters into a sufficiently strong, basin-wide conditional agricultural waiver, we do not believe that the NCRWQCB or any other agency tasked with protecting water and fisheries can afford to wait even a year to push for substantial changes of practices in either the Scott or Shasta rivers. With just a handful of coho left in the Shasta, merely voluntary dedication of instream water rights under Water Code 1707 will almost certainly fail to bridge the gaps between extinction and survival, much less recovery.

Response:
The Shasta and Scott TMDL implementation plan incorporate separate waiver programs for those basins and the Klamath implementation plan does not assign any new requirements to individuals in these basins. The effectiveness of Scott and Shasta implementation will be considered by the Regional Water Board when the conditional waivers adopted as part of their respective implementation plan are considered for renewal. Regarding water rights dedications, see also response to comment X1.

13. Comment(s):
There is good reason to create a stringent, conditional waiver that would apply to farming, ranching and grazing throughout the basin. However, we take issue with the removal of interim nonpoint source requirements on individual landowners.

What's more, this weakening of interim efforts flies in the face of the state anti-degradation policy. We therefore ask that interim implementation measures be required via an interim waiver, not just encouraged. In the 2012 development of a conditional waiver for all agricultural activities, the stakeholder process referred to in the TMDL also needs to include a fair representation of impacted downriver communities.

Response:
See response to Bowman – 2.

14. Comment(s):
We are confused and dissatisfied that the TMDL states that the contents of the agricultural waiver will be punted to a stakeholder process, yet a de minimus allowance of discharges will be included in the waiver. It also does not account for the cumulative impacts of many such supposedly "de minimus" impacts combined. Such a statement seems out of order and lacks rationale.

Response:
The definition of a 'de minimus' discharge will be determined during the waiver development process and is mentioned as a placeholder for later consideration. One of the primary purposes of the waiver is to control the cumulative impacts of agricultural discharges.

15. Comment(s):
Language in Section 6.5.4.5 of the implementation plan discussing the point that if in the future suction dredging was found to be a point source that the prohibition on point source discharges in the Klamath River would not apply to suction dredging activities except within the instream buffer lengths designated by the policy should be stricken, due to its pre-decisional nature.

Response:
See response to Bowman – 36. This action is not "pre-decisional"; rather, it is a decision based on a contingency.

16. Comment(s):
The language in Section 6.5.7 of the implementation plan does not seem to agree with the language in the proposed Action Plan. We recommend minimally that the use of an 85%/65% canopy requirement (as found in the implementation plan) be used consistently in both, rather than the Anadromous Salmonid Protection (ASP) Rules adopted by California Department of Fire and Forestry last year (which is cited in the Action Plan in the December 2009 TMDL draft.) Scientists suggest that the ASP rules (now referred to as the T and I rules) are not adequately protective of fisheries and water quality, and effectively downgraded

protections for class I and II streams where coho salmon spawn and rear, potentially even further jeopardizing these salmon.

Response:
The language in the Action Plan and the staff report has been made consistent. The 85/65 language was removed from the June 2009 draft, but the new language in the staff report is equally protective. The TMDL affirms the ability of the Regional Water Board staff to require additional riparian management measures during the timber review process if the Forest Practice Rules, including the ASP rules, are not sufficient to meet the TMDL allocations or water quality standards. The ASP rules are referenced because they are part of the existing FPRs. While Regional Water Board staff acknowledge that they provide adequate temperature protection in the majority of situations, staff are not endorsing the rules as protective of all water quality and fisheries concerns.

17. Comment(s):
We support development of the USFS waiver using best-available science, and we support the ambitious April 2010 timeline established in the December 2009 Klamath TMDL draft implementation plan.

Response:
Comment noted.

18. Comment(s):
It is good to see acknowledgment of the long term impacts of a wildfire suppression regime on Klamath River water quality in Section 6.6.6 of the implementation plan. It is worth noting, however, that depletion of vegetation and subsequent erosion are not only a result of post-fire activities such as salvage logging, but also a cumulative result of fire suppression tactics. The TMDL should reflect the fact that fire management tools other than suppression (prescribed burning in the spring and fall, for instance) may be more protective of water quality.

Response:
Thanks for the comment; the Regional Water Board staff will consider this as part of the USFS waiver process.

19. Comment(s):
Allowing the dissolved oxygen calculations and standards to shift with climate change incorrectly implies that climate change is natural, rather than manmade. We recommend that the TMDL language clarify that climate change is not natural, and should not be included in natural receiving water temperatures.

Response:
Clarification on this issue is not necessary or appropriate at this time. The Regional Water Board staff intend to closely examine any data regarding the effects of climate change as it becomes available, and not automatically accept climate change as a natural phenomenon. The intention of the text as currently written is only to highlight the benefit of a percent DO saturation objective based on natural receiving water temperatures. That is, in a changing climate, a percent DO saturation objective based on natural receiving water temperatures allows for a flexibility that does not exist with concentration-based objectives. But, it requires a maintenance of conditions as close to natural as possible which does not exist with a percent DO saturation criteria based on existing receiving water temperatures. The text as quoted will be changed to better describe staff's intentions.

20. Comment(s):
Basin Plan Language, Table 4-18, Stateline Allocations, Action: Add the following underlined text.

Work together as specified in the Klamath River/Lost River TMDL Implementation Memorandum of Agreement (MOA) developed to implement and monitor measures that will achieve compliance with the Klamath and Lost River TMDLs in Oregon and California. The MOA will specify actions to be taken by responsible parties, timelines for those actions and consequences of noncompliance. Timely compliance in Oregon is imperative to avoid further impairments to California waters and to downstream beneficial uses protected under the Clean Water Act.

Timeline
Complete MOA within 6 months of adoption of OR TMDL.

Response:
The MOA has already been completed and signed and is available at:
http://www.waterboards.ca.gov/northcoast/water_issues/programs/tmdls/klamath_river/
It contains an outline of the items suggested in the comment.

21. Comment(s):
Add the following underlined text to the Basin Plan Language under: Klamath Irrigation Project (KIP) Actions:
"…Coordinate with the Klamath River water quality improvement tracking and accounting program in implementing offset projects, which may include a treatment facility and/or wetlands restoration/expansion;"

Response:
While these types of treatments are supported by the Regional Water Board staff, we do not believe this language is necessary in the Basin Plan language.

22. Comment(s):
Add the following underlined text to the Basin Plan Language under "Agricultural Activities on Non-Federal Lands, Regional Water Board, Action and Responsible Parties":

Action
The waiver/WDRs shall require compliance with the Klamath TMDL watershed-wide allocations where they apply in the Klamath River basin, including the Scott and Shasta watersheds.

Responsible Parties
(Any party conducting grazing activities or activities associated with irrigated agriculture on non-federal land in the Klamath River basin, including the Scott and Shasta watersheds).

Response:
See response to Terence – 12 above.

23. Comment(s):
Make the following additions shown below as underlined text to the Basin Plan Language section Timber Harvest Activities on Non-Federal Lands; Regional Water Board:

Action
Regional Water Board staff shall ~~make recommendations for~~ require additional measures to ensure the water quality objective for temperature is achieved during the timber harvest review process, if necessary

Timeline
Develop for consideration by Regional Water Board by December 2010, and as necessary thereafter

Response:
This action refers to recommendations made by staff during the timber harvest review process, so 'ongoing' is a better expression of the appropriate timeline. During the timber harvest review process, the Regional Water Board staff may make recommendations for additional measures in the Timber Harvest Plan (THP) to ensure it is fully protective of water quality. If the THP is insufficient in this regard, the Regional Water Board Executive Officer has the ability the withhold enrollment in the general WDRs or waiver of WDRs.

24. Comment(s):

Add the following underlined text to the Basin Plan language:

Action

Implement riparian management measures… waiver/WDR enrollment process.

Timeline

Ongoing following adoption of TMDL Action Plan.

Response:

This text has been added.

25. Comment(s):

Add the following underlined text to the Basin Plan language:

VI. Enforcement

The Regional Water Board shall take enforcement actions for violations of this implementation plan where elements of the plan are enforceable restrictions such as application of the waste discharge prohibitions, application of the thermal refugia protection policy, or as required under a specific permit or order, as appropriate. Enforcement implementation is ongoing. Enforcement tools include, but are not limited to, the authority to: require a time schedule of specific actions to be taken, in accordance with CWC 13300; issue a cease and desist order, in accordance with CWC 13300; issue a cleanup and abatement order, in accordance with CWC 13304; imposition of monetary liabilities or fines (administrative civil liabilities), in accordance with CWC 13268 and 13350. Nothing in this plan precludes actions to enforce any directly applicable prohibition or provisions found elsewhere in the Basin Plan or to require clean up and abatement of existing sources of pollution where appropriate.

Response:

The enforcement tools proposed for addition as Basin Plan language are already in the Basin Plan, in Chapter 4 POLICIES & REGULATORY TOOLS APPLICABLE TO TMDLS. The repetition of the available Regional Water Board enforcement tools is not necessary in this Basin Plan amendment and has not been added. The suggested text for enforcement of the Thermal Refugia Protection Policy is not appropriate because the policy provides recommendations to inform future permitting actions to ensure thermal refugia are afforded enhanced protection. Enforcement of those permits, or participation in the development of those permits, does not require additional text to the Basin Plan amendment.

26. Comment(s):

Add the following underlined text to the Basin Plan language:

Compliance Monitoring

… monitoring plan and may describe specific monitoring requirements to include in the plan. Monitoring requirements or efforts may also involve other monitors, such as representatives of watershed groups, water quality protection groups, adequately trained local citizens or the regional water board.

Response:

A discussion of the groups that may conduct monitoring is not the subject of this paragraph and is not appropriate as Basin Plan language.

27. Comment(s):

Basin Plan Language, p.8:

… Klamath basin water quality improvement tracking and accounting program. The cooperation and participation of PacifiCorp has been instrumental in supporting this endeavor."

Comment: Not appropriate to effectively thank sponsors in basin plan language.

Response:

The Regional Water Board frequently acknowledges water quality improvement efforts by stakeholders. The text has not been revised.

28. Comment(s):

Complete a water quality study based on best-available science to characterize the seasonal and annual nutrient and organic matter loading through the KIP and refuges.

Response:

Text has been added.

29. Comment(s):

Basin Plan Language, P. 16, Agricultural Activities on Non-Federal Lands

Action: The Regional Water Board ~~encourages~~ requires the following actions:

…3. Participate in the development of the conditional waiver through a Technical Advisory Group, comprised of all interested stakeholders, that will convene to develop the draft waiver by December 2011.

Response:

See response to Bowman – 39.

30. Comment(s):
Basin Plan Language, P. 18
"Evaluation of instream water quantity and quality"
Comment: Add the underlined text above. To evaluate quality, it will be necessary to evaluate instream quantity as well.

Response:
Water quality includes consideration of the effect of water quantity on quality. The text has not been changed to maintain consistency with Regional Water Board authorities.

31. Comment(s):
It should be clear that grazing does not have to be the primary land use. For example, private timber leases land to ranchers for grazing in summer months.

Response:
Regional Water Board staff are aware of this practice and grazing on timber lands will be addressed in the future agricultural waiver program.

Walker – Upper Mid-Klamath Watershed Council

1. Comment(s):
There is a concern among the Watershed members that there is little or no discussion in the December 2009 Public Review Draft of the Klamath TMDL about how the landowners in a sub-watershed will be relieved of the burdens of the permitting process when their tributary stream meets the TMDL baselines for a non-impaired water body. If there is not opportunity for a sub-watershed to get out from under the "impaired" listing and for landowners to be relieved of the burdens of the permitting process, there is little positive incentive to go above and beyond the minimum mitigation requirements of the permit. This can result in a loss for both the landowners and the environment. Additionally, with close cooperation between the Water Board staff and landowners in the minor tributary basins, it is very possible that one or more streams could be improved to such a point that they would no longer be classified as "impaired". This will provide remaining landowners in the Klamath system concrete evidence that the Plan's goals are achievable and realistic.

Response:
The Regional Water Board is required by the State Nonpoint Source Policy to regulate all discharges of waste to waters of the state. This is the statewide policy direction for the Regional Water Board nonpoint source programs, which is independent of TMDL impaired waters listings. While TMDLs and listings will inform the development of the waiver, the waiver itself is required by the State Nonpoint Source Policy. Delisting the waterbody does not relieve a discharger of the requirement to be in compliance with the Nonpoint Source Policy and likewise would not be grounds for ending the waiver program. While the specifics of the waiver enrollment process will be decided during the waiver development, the baseline trigger for enrollment is a discharge of waste to waters of the state. Individuals that aren't discharging would not need to enroll in the waiver.

While the waiver program itself is necessary to comply with Statewide policy, the conditions of the waiver can be made flexible and be heavily dependent on local water quality conditions. The waiver could have varying requirements depending on the character of the discharge and the threat to water quality. If groups of dischargers establish that local water quality conditions are meeting TMDL requirements and water quality standards, they could fall into a different category that would carry less burdensome monitoring and reporting requirements. For example, in the current Central Coast Region's irrigated agriculture program, parties who attend training and develop water quality management plans are placed into a separate 'tier', which has half of the standard reporting requirements. The waiver development process will give stakeholders an opportunity to work with Regional Water Board staff to develop waiver conditions that can allow for a lessening of waiver requirements based on compliance rates and water quality improvements on the ground. Also, the waiver must be renewed every five years, which will provide further opportunity to revise the waiver conditions based on local monitoring and reporting results.

2. Comment(s):
A one size fits all approach does not work. The TMDL appears to lump the small tributaries together into 4 general groupings. Substantial differences in stream flow, geography, and land use exist between many of the streams in a single grouping. These differences make it impractical and ineffective to attempt to manage stream improvement with a single set of permitting requirements. Mitigation could be improved by tailoring the mitigation techniques to the specific watersheds. It is more likely that the goals of the TMDL will be met if local landowner knowledge is utilized in combination with the scientific expertise of the Water Board.

Response:
The TMDL technical analysis used the available data at the mouths of the tributaries for the purpose of setting boundary conditions in the mainstem Klamath River model. That part of the TMDL analysis will not be used to inform the permitting requirements of the agricultural waiver program. The waiver requirements will be based on meeting applicable water quality standards for the waterbody in question and effective implementation will depend on local landowner knowledge in identifying management practices. While the waiver will establish the performance standards that must be met, landowners will have the flexibility to choose the management practices that are appropriate for their operation and protect water quality. Specific management practices will not be prescribed in a 'one size fits all' manner.

3. Comment(s):
One example of inappropriate grouping is Figure 4.2 of the TMDL, which fails to measure the differences for each minor-tributary. While this is understandable for administrative purposes, it provides little assistance to the landowner in a particular tributary. With no measurement, there can be no management. One of the primary objectives of the plan is to identify the "responsible party" for a particular pollutant. It is neither effective nor equitable to assert that a landowner in the Willow Creek basin is a responsible party for any occurrence in the Bogus Creek basin. A further example of the confusion caused among our members is found in Table 5.16. Wherein, 19 creeks have been allocated precisely identical allocations for TP, TN, and CBOD with apparently no regard to differences in the unique features of the watersheds.

Response:
As stated in the previous response, the TMDL technical analysis used data at the mouths of the tributaries as boundary conditions for the purposes of the mainstem Klamath River model. The agricultural waiver program will support discharger groups monitoring local water quality conditions and trends to inform management. Individual landowners conducting nonpoint source discharge activities are only responsible for their own discharges. At the same time, Regional Water Board staff see great benefit to landowners in organizing watershed groups for purposes of planning, implementing, monitoring and reporting, and would encourage such organizations.

4. Comment(s):
Section 4.1.1. *Pollutant Source Categories,* highlights the difficulties encountered in attempting to enforce a single set of regulations on every sub-basin. It is acknowledged in this section that it is difficult to quantify pollutant sources, that watershed models sometimes do not reflect the expected impact of non-point pollutant sources, and that it is difficult to quantify loading within source areas from individual source categories. The Water Board proposes to resolve these difficulties by basing mitigation on the use of best management practices that have demonstrated effectiveness. What is unclear is whether these methods have been used in the unique environments of the varied sub-basins of the Klamath River. Undoubted these "best methods" were determined through trial and error, and such "best methods" may not apply universally, especially given the extreme differences in sub-basins. It would seem unwise to place landowners in every sub-basin in a regulatory straight-jacket that would require landowners to employ practices that would be of little use in their environment while hampering innovation.

Response:
The Regional Water Board will be relying on the local landowners to select and propose appropriate practices. As explained in the previous response, the Regional Water Board will not prescribe specific practices as part of the regulatory approach. This will allow the flexibility at the local level to account for differences between sub-basins.

5. Comment(s):
The members of UMKWC would like to extend their appreciation to the Regional Water Board staff for their support and encouragement in locating and disseminating information to the members regarding possible funding sources for water quality improvement projects. Many of the UMKWC members operate ranches that do not produce high cash flows. These ranches are unable to support the costs of return systems, fencing, and piping that are involved in many of the water quality improvement programs. Without the assistance of programs such as EQUIP or outside grants, these improvements would be impossible to initiate. In addition, the Water Board has provided valuable technical expertise, scientific assistance and field measurements to UMKWC Members. To the extent the Water Board staff can continue their assistance in these areas, it would facilitate meeting the goals of the TMDL.

Response:
Regional Water Board staff look forward to continued cooperation in the development of the agricultural waiver to make it a reasonable program that is workable for the permittees. We also look forward to facilitating future technical and financial assistance.

Woodley – Klamath Soil & Water Conservation District

1. Comment(s):
We believe that the NCRWQCB lacks the statutory authority to develop load allocations for the Straits Drain in Oregon. Also we do not believe that the State of California can impose requirements for riparian shade on lands in Oregon.

Response:
The California Klamath TMDL does not assign load allocations to the Klamath Straits Drain or place any other requirements on discharges in Oregon.

2. Comment(s):
Furthermore, Klamath Lake upstream of the California-Oregon Border is currently out of compliance with water quality standards. This, in conjunction with the lack of a cohesive document addressing the Klamath River in its entirety, and independent timelines associated with implementation, will produce inconsistency between the states, and may limit the effectiveness of the Implementation Plan. It stands to reason that TMDL's, and the associated Implementation Plans for both the Oregon, and California segments of the Klamath River, should be developed jointly and contained in one plan.

Response:
Although the Klamath and Oregon TMDLs are separate documents, they work together to address pollutant sources and achieve the shared TMDL load allocations basinwide through differing regulatory structures. The coordination between the states is agreed to in two memorandums of understanding (MOUs) signed by the USEPA Regions 9 and 10, the Regional Water Board, and the Oregon Department of Environmental Quality. The first is an MOU that outlines the framework for the shared TMDL technical analysis and coordinates the assignment of load allocations so the Oregon and California allocations are consistent. The second MOU describes the ways in which the states, in conjunction with the USEPA, will coordinate implementation of the TMDLs through the states' respective regulatory structures. The implementation timelines will be coordinated through adaptive management as outlined in the implementation MOU. While the analysis is shared, the implementation plans must be separate documents because TMDL measures will be implemented pursuant to state-specific programs and legislation.

3. Comment(s):
Naturally occurring background inputs must be properly addressed in the load allocations. The assertion that load reductions for phosphorous and nitrogen may be as much as 84 and 60 percent respectively, is not consistent with natural loads in the system. Moreover, according to the Basin Plan, the NCRWQCB must recognize the current state of Klamath Lake is due to these natural and historic inputs will make the implementation these standards unattainable. Background loads are also associated with deep well water that is brought to the surface and intermixed. The five large wells at stateline may

contribute to this problem and need to be studied under the Antidegradation Policies in section 2.2.1.3.

Response:
See response to comment C37.

4. Comment(s):
The economic concerns of the Klamath Basin are not adequately addressed in this document, including the amount of funding that will be necessary to achieve these goals, and the costs to both public, and private enterprise that will be necessary to plan and implement measures to attain TMDL's.

Response:
See response to comment S7.

5. Comment(s):
Load allocations must be based on truly independently peer reviewed sound science. The "scientifically sound method" for sampling DO levels is not delineated.

Response:
See response to U1 and the appropriate sampling methods are described in Chapter 7 of the Klamath TMDL Staff Report.

6. Comment(s):
These documents do not fully address the loading in the Klamath Straits Drain. Loads in this drain are associated with water quality in Upper Klamath Lake, Clear Lake, Lost River, Mt. Dome, Lower Klamath Lake, and significant inputs from wildlife refuges. It is also important to state that there are significant reductions in the total load of nutrients, and temperature reductions associated with the diversion, and recirculation of water for agriculture and wildlife use throughout the Klamath Project.

Response:
Comments concerning the allocations to Klamath Straits Drain in Oregon should be directed toward the Oregon Department of Environmental Quality. The Klamath TMDL in California addresses discharges of waste in California, but does provide a framework for working with Oregon, USEPA and interested parties to address water quality problems upstream, which includes the identification of potential funding sources.

7. Comment(s):
Measurement of Chlorophyll-a for the purposes of determining toxic algae levels needs to be undertaken by an uninterested party. The methods for these samples need to be consistent with sound scientific standards and procedures.

Response:
Monitoring for toxic algae and other water quality parameters is described in section 7.6.1 of the TMDL staff report. Pursuant to the 2009 monitoring program, microcystin toxins in water samples were analyzed by the US EPA Region 9 laboratory, in accordance with the U.S. EPA Region 9 Laboratory Standard Operating Procedure. Analysis and data QA/QC review and reporting are being conducted in accordance with the Quality Assurance (QA) plans requirements for each monitoring entity, which for public health monitoring includes PacifiCorp, the Karuk Tribe, and the Yurok Tribe.

8. Comment(s):
The influence of inflows of geothermal water through springs throughout the Lost River watershed are not well know, and not well addressed in these documents. Also, though the Lost River is not specifically listed for temperature the DO listing effectively regulates the temperature of this river.

Response:
The nutrient analysis addresses existing conditions which would include the effect of any inputs from geothermal water. The Klamath River SSO for DO does not address conditions in the Lost River. The DO objective does not regulate the Lost River temperature.

9. Comment(s):
This document calls for management of Klamath River stream flows to be more consistent with natural flow regimes. We believe this is a very important change that will result in more natural conditions, which should significantly alleviate some water quality issues, especially those related to the propagation of C. Shasta and other parasites. It is unclear however how these recommendations will work with a BO and court mandated flow levels. This needs to be clearly defined in this document.

Response:
The TMDL does not address the regulation of stream flows. This issue is being addressed through the Klamath Basin Restoration Agreement.

10. Comment(s):
We are happy that you have listened to comment and addressed many of the nonpoint source issues in the Implementation Plan. The importance of consistency between Oregon and California for both load allocations, and implementation plans for the Klamath River cannot be overstated. It is also important to jointly develop the programs and processes that will be implemented in order to reach these standards. We believe it is extremely important to have a locally led process to address non-point source contributions, and the regulation and enforcement of those loads. In this light, the Klamath Soil and Water Conservation District would like to be integrally involved in the

development of any plan, or monitoring effort that deals with either private, or agricultural land, and any issue dealing with the interstate connectivity of these water courses. In addition the KSWCD should be included in interstate MOU's for the implementation of Ag water quality plans under section 6.2.1.

Response:
Soil and water conservation districts have been designated by the Oregon legislature as local management agencies for the implementation of agricultural water quality management area plans. It is the Regional Water Board's understanding that the TMDLs will be implemented through Oregon's existing agricultural water quality management programs. The Klamath TMDL recommends that management plans developed pursuant to this program be updated to incorporate the TMDL load allocations after Oregon adopts its TMDL. The development of the Regional Water Board's conditional waiver program for agriculture in California will not affect landowners and agricultural operators in Oregon. However, Regional Water Board staff agree that it is important to coordinate state water quality programs in Oregon and California wherever appropriate, particularly for the Tule Lake area. Staff look forward to working with the Klamath SWCD during the development of the conditional waiver in recognition of the experience SWCD has in addressing water quality issues in the Upper Klamath and Lost River basins in Oregon.

11. Comment(s):
Section 6.2 deals with issues at stateline. It is important that this section recognizes that nutrient and sediment impacts to Straits Drain are impacted by nonpoint source pollution in the 70,000 acres of agricultural land in the California area of the Lost River Drainage, and the two National Wildlife Refuges.

Response:
Section 6.2 deals with implementation and coordination between the states. Sources of pollution are described in Chapters 3-5 of the TMDL staff report. Please also refer to the Lost River TMDL for a discussion of pollution sources in the Lost River basin: http://www.epa.gov/region09/water/tmdl/final.html

12. Comment(s): Section 6.5.1.2 may have unintended implication with a highly channelized Lost River system in Oregon.

Response:
The allocations and targets presented in this section do not apply to Oregon.

13. Comment(s):
Section 6.2.3 addresses water quality monitoring for nutrients and temperature in tailwater of irrigation systems throughout Ag lands. This prescription treats nonpoint source as if it were point source and should not be used as a regulatory tool for the implementation of TMDL's. The KSWCD would again like to be part of any monitoring

effort, especially those on private agricultural land. The KSWCD should also be listed as an implementation party in section 6.2.3.3 of this document.

Response:
The monitoring referred to in this section is a required element of the water quality management plans developed consistent with Oregon Administrative Rules. It is the Regional Water Board staff's understanding that these plans were developed by the Oregon Department of Agriculture with input from the Klamath SWCD. Both the Regional Water Board and Oregon DEQ regulate agricultural tailwater as a nonpoint source of pollution. The MOA described in section 6.2.3.3 has already been developed and signed. It is available at:
http://www.waterboards.ca.gov/northcoast/water_issues/programs/tmdls/klamath_river/
The implementation parties named in the MOA were included because they are the parties responsible for implementation in both Oregon and California. Regional Water Board staff, however, appreciate the desire to work together and look forward to working with the Klamath SWCD on water quality issues in the Klamath basin.

14. Comment(s):
Assumptions made in the formations of TMDL's about the delivery of water that meets California standards from Oregon are dangerous. Upper Klamath Lake is currently out of compliance, and in all likelihood will remain so due to the high levels of background inputs. This danger is compounded when there is currently no vehicle with which Oregon can use to attain these standards.

Response:
See response to comment C37 that discusses background levels of nutrients in the Upper Basin. Oregon has committed to meeting California water quality standards at the Stateline. Oregon's administrative rules provide several vehicles for implementing water quality programs to address the Klamath River TMDLs in Oregon.

15. Comment(s):
Section 6.4.3.1 addresses Lost River's contribution to water quality issues through Straits Drain, however the background, natural pollution is not addressed, and therefore skews this information.

Response:
This section provides factual information on operation of the Klamath project and the approximate pollutant loadings to the Klamath River from the Klamath Straits Drain. Regional Water Board staff are aware that a portion of this loading originates from a natural source. Refer to comment C21.

16. Comment(s):
The opportunity for a programmatic discharge waiver may adequately address non-point source issues. However, it is imperative that local stakeholders are intimately involved in this process.

Response:
The implementation plan proposes the development of the California Regional Water Board's waiver program through a separate process involving all stakeholders and tribes in the Klamath basin in California. The waiver will not apply to Oregon.

17. Comment(s):
It is unclear how a pollution trading program would be implemented in the Klamath Basin. Also, from a conservation standpoint, it is unclear whether this would lead to actual water quality improvements, and the best use of funds for projects.

Response:
Regional Water Board staff in cooperation with the Oregon Department of Environmental Quality, PacifiCorp, and USEPA is developing the specifics of the tracking and accounting program. (See staff report section 6.7).

18. Comment(s):
The Regional Board should acknowledge that Klamath Basin landowners have made vast investments in conservation practices aimed to improve water quality, reduce water use, and improve overall watershed health. Landowners here have been proactive in conserving natural resources, including the improvement of water quality, and have done so without the threat of regulation, and with their own resources. Klamath Basin landowners continue these efforts with an enormous conservation ethic.

Response:
Regional Water Board staff appreciate these efforts, and plan to utilize existing programs to meet TMDL needs as appropriate. Section 6.4.3.3 lists some of the water quality measures implemented in Oregon and California, including specific mention of the Klamath SWCD.