Chapter 5
Effects Analysis

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Acronyms and Abbreviations

AFRP	Anadromous Fish Restoration Program
Basin Plan	water quality control plan
BDCP	Bay Delta Conservation Plan
BiOp	biological and conference opinion
BMP	best management practice
CDFW	California Department of Fish and Wildlife
CEQA	California Environmental Quality Act
CESA	California Endangered Species Act
cfs	cubic feet per second
CM	conservation measure
CNDDB	California Natural Diversity Database
CVP	Central Valley Project
D-1641	State Water Resources Control Board water right Decision 1641
DBEEP	Delta-Bay Enhanced Enforcement Project
Delta	Sacramento–San Joaquin River Delta
DO	dissolved oxygen
DPM	Delta Passage Model
DPS	distinct population segment
DRERIP	Delta Regional Ecosystem Restoration Implementation Plan
DSM	Delta Simulation Model
DWR	California Department of Water Resources
EBC	existing biological conditions
EFH	Essential Fish Habitat
ELT	early long-term
ESA	federal Endangered Species Act
ESO	evaluated starting operations
ESU	evolutionarily significant unit
fish and wildlife agencies	U.S. Fish and Wildlife Service, National Marine Fisheries Service, and California Department of Fish and Wildlife
FLaSH Studies	Fall Low Salinity Habitat Studies
fps	feet per second
FMWT	fall midwater trawl
FR	*Federal Register*
GIS	geographic information system
HCP	habitat conservation plan
HOS	high-outflow scenario
HSI	habitat suitability index
HU	habitat unit
IAV	invasive aquatic vegetation
IOS	Interactive Object-Oriented Salmon Simulation
LLT	late long-term

LOS	low-outflow scenario
mg/L	milligrams per liter
MHHW	mean higher high water
MLLW	mean lower low water
mm	millimeters
NCCP	natural community conservation plan
NEPA	National Environmental Policy Act
NHD	National Hydrography Dataset
NMFS	National Marine Fisheries Service
OBAN	Oncorhynchus Bayesian Analysis
OMR	Old and Middle River
POD	pelagic organism decline
ppt	parts per thousand
PTM	Particle Tracking Model
Reclamation	Bureau of Reclamation
RMA	Resource Management Associates
ROA	restoration opportunity area
RPA	Reasonable and Prudent Alternative
SacEFT	Sacramento Ecological Flows Tool
SAV	submerged aquatic vegetation
SRWQM	Sacramento River Water Quality Model
SWP	State Water Project
TAF	thousand acre-feet
UC Davis	University of California, Davis
USFWS	U.S. Fish and Wildlife Service
VAMP	Vernalis Adaptive Management Program
VPA	viable population attribute
VSP	viable salmonid population
YOY	young-of-year

Chapter 5
Effects Analysis

5.1 Introduction and Summary of Conclusions

This chapter describes how the Bay Delta Conservation Plan (BDCP or Plan) will affect ecosystems, natural communities, and covered species, and presents conclusions regarding expected outcomes from implementing the conservation strategy (described in Chapter 3, *Conservation Strategy*) and covered activities (described in Chapter 4, *Covered Activities and Associated Federal Actions*). Those conclusions are reached through a systematic, scientific evaluation of the Plan's potential adverse, beneficial, and net effects.

The effects analysis also provides the fish and wildlife agencies—U.S. Fish and Wildlife Service (USFWS) National Marine Fisheries Service (NMFS), and California Department of Fish and Wildlife (CDFW)—with the information that they will need to issue incidental take permits and authorizations for the BDCP, to prepare findings regarding the contribution that the BDCP will make to the conservation and management of covered species and natural communities, and in certain other ways to comply with regulatory requirements that are described below (Section 5.1.3, *Regulatory Scope*) and detailed in Chapter 1, Section 1.3, *Regulatory Context*.

The overall goal of the BDCP is to restore and protect ecosystem health, water supply, and water quality within a stable regulatory framework. This chapter documents how implementing the BDCP will meet the ecosystem health portion of that goal by providing for the conservation and management of each of the natural communities and covered species. For an evaluation of how the BDCP will meet the goal of protecting and restoring water supply and water quality, see the environmental impact report/environmental impact statement (EIR/EIS) developed for the Plan (California Department of Water Resources et al. 2012). The BDCP will contribute to the restoration of Sacramento–San Joaquin River Delta (Delta) ecosystems largely by addressing ecological functions and processes on a broad landscape scale. Proposed actions will result in fundamental, systemic, long-term physical changes to the Delta. These changes include substantial alterations to water conveyance and management and extensive restoration of tidal, floodplain, and terrestrial natural communities. Addressing such fundamental and large-scale change has required the development of new analytical tools and new ways of looking at Delta ecosystems and species.

5.1.1 Basis for Evaluation

The effects analysis is built on and reflects an extensive body of monitoring data, scientific investigation, and analysis of the Delta compiled over several decades (well summarized in Healey et al. 2008), including the results and findings of numerous studies initiated under the CALFED Bay-Delta Science Program, the long-term monitoring programs conducted by the Interagency Ecological Program, research and monitoring conducted by state and federal resource agencies, and research contributions of academic investigators.

To ensure that the BDCP is based on the best scientific and commercial data available, the California Department of Water Resources (DWR) undertook a rigorous process to develop new and updated information and to evaluate a wide variety of issues and approaches as it formulated a cohesive, comprehensive conservation strategy. This effort included an evaluation in early 2009, conducted by multiple teams of experts, of BDCP conservation options using the CALFED Bay-Delta Program Ecosystem Restoration Program Delta Regional Ecosystem Restoration Implementation Plan (DRERIP) evaluation process. Implementation of the DRERIP evaluation process brought together a large group of scientific experts on various aspects of the Delta ecosystem and its species. The information generated from this process provided some of the most advanced thinking on the effects of conservation actions (as proposed at that time) on key ecological stressors. Results of the 2009 DRERIP evaluation were used, as applicable, to add support to various parts of the BDCP effects analysis and are detailed by Essex Partnership (2009). The analysis also benefited from two reviews published by the National Research Council (2010, 2011) and from independent scientific reviews that are described in Chapter 10, *Integration of Independent Science in BDCP Development*.

The analysis presented in this chapter is lengthy and complex. The complexity is inevitable because of the large size of the Plan Area, the large number of natural communities and covered species addressed, the scale of the covered activities, the long time horizon of the Plan, the intrinsic and often highly variable properties of the Bay-Delta environment (e.g., salinity gradients, hydrology, projected effects of climate change), and the confounding effects that climate change may have on ecosystems and species in the Plan Area. Despite its length, this chapter is intended to be a summary of all technical analyses, and presents the key technical results and methods needed to meet permit issuance criteria. Conclusions and summaries in this chapter are written to minimize jargon, literature citations, and technical data. The full technical description of all methods and results is provided in a number of appendices, which are cited in this chapter as appropriate. In many cases a reader will have to refer to the appendices to fully understand the methods used or other technical detail underlying conclusions and summaries presented in this chapter. The following appendices support the analyses in this chapter.

- Appendix 2.A, *Covered Species Accounts,* presents information for each of the covered species that occurs in the Plan Area, including legal status, species distribution and status, habitat requirements, life history, threats and stressors, relevant conservation efforts, habitat suitability modeling for terrestrial covered species, and recovery goals.
- Appendix 2.C, *Climate Change Implications and Assumptions,* provides an overview of the scientific understanding of climate change and observed and projected changes anticipated in California and the Plan Area.
- Appendix 5.A.1, *Climate Change Implications for Natural Communities and Terrestrial Species,* summarizes the effects of climate change in California and the Plan Area that are relevant to the BDCP natural communities and terrestrial (non-fish) covered species. This appendix provides the scientific background for the effects of climate change on natural communities and terrestrial species and descriptions of how the BDCP has taken into account many of these expected changes in the design of the conservation strategy presented in Chapter 3, *Conservation Strategy.*
- Appendix 5.A.2, *Climate Change Approach and Implications for Aquatic Species,* characterizes the potential effects of climate change on aquatic covered species and identifies the approach and methods used to incorporate climate change into the BDCP models.
- Appendix 5.B, *Entrainment,* provides a description of the potential mechanisms for entrainment; an overview of the historical and current significance of entrainment on each fish species; a description of the methods used to predict the potential entrainment under the BDCP; results of

the application of these methods; and, based on these results, a comprehensive description of the potential entrainment of each life stage of each covered fish species.

- Appendix 5.C, *Flow, Passage, Salinity, and Turbidity,* includes a description of the physical changes in flows in the Plan Area and in upstream habitats; an evaluation of the effects on fish that would result from changes in flows and flow-related parameters as a result of the BDCP compared with existing conditions. This appendix includes a description of the potential mechanisms for changes in flow and the related parameters of temperature, salinity, turbidity, and dissolved oxygen; an overview of the historical operations and management of flows in the State Water Project (SWP) and Central Valley Project (CVP) systems; a description of species exposure to potential flow changes; a description of methods used and the results of the potential effects of flow changes under the BDCP; and a comprehensive description of the expected flow-related effects on each life stage of the covered fish species.
- Appendix 5.D, *Contaminants,* analyzes the potential for the BDCP to result in increased concentrations and bioavailability of contaminants within the Plan Area, including mercury and methylmercury, selenium, copper, ammonia/ammonium, and pesticides, and an evaluation of the potential effects on fish.
- Appendix 5.E, *Habitat Restoration,* analyzes the habitat restoration associated potential under the BDCP associated with *CM4 Tidal Natural Communities Restoration, CM5 Seasonally Inundated Floodplain Restoration,* and *CM6 Channel Margin Enhancement,* and includes an evaluation of the effects on fish species, including a discussion of the specific mechanisms by which each life stage could benefit.
- Appendix 5.F, *Biological Stressors on Covered Fish,* examines 10 conservation measures that address three key biological stressors that have contributed to the current state of covered fish species within the Plan Area. Key biological stressors include invasive aquatic vegetation, predation, *Microcystis*, and invasive mollusks. This appendix also evaluates the effects of implementing these conservation measures on the covered fish species.
- Appendix 5.G, *Fish Life Cycle Models,* describes the application of two life-cycle models to help determine population-level effects of the covered activities on winter-run Chinook salmon. This appendix includes a description of the available suite of models that could be applied, the selection of models that were used in this analysis, the environmental covariates identified in model formulation that are important drivers of the population dynamics for a species or life stage, and the conclusions of these models.
- Appendix 5.H, *Aquatic Construction and Maintenance Effects,* evaluates the potential effects of construction and maintenance activities associated with the covered activities on covered fish species. Analysis of these potential effects was conducted based on engineering data developed to date, assumptions made based on monitoring data for similar projects, and assumptions made about restoration design.
- Appendix 5.J, *Effects on Natural Communities, Wildlife, and Plants,* presents the detailed information used in the effects analysis for natural communities and covered terrestrial wildlife and plant species. Tables provide information about the quantitative effects analysis methods and assumptions; the effect type for each covered activity and the associated conservation measures; key assumptions related to the effects of tidal restoration; the indirect effect distances for covered activities for each species; loss of habitat and natural communities; and natural community restoration and protection contributing to covered species conservation.

This chapter begins with a summary description of analytical methods (Section 5.2, *Methods*). It then describes effects on aquatic ecosystems in general (Section 5.3, *Ecosystem and Landscape Effects*), focusing on ecosystem stressors that determine, to a large degree, the mechanisms by which the BDCP will affect covered species. Section 5.4, *Effects on Natural Communities,* provides an overview of how natural communities will be affected. Section 5.5, *Effects on Covered Fish,* describes the net effects of the Plan on each covered fish species. Finally, Section 5.6, *Effects on Covered Wildlife and Plant Species,* presents the comparable analysis for the other covered species (amphibians, reptiles, birds, mammals, and plants).

The remainder of this introduction describes the relationship of the effects analysis to other components of the Plan, the regulatory scope of the BDCP, and a summary of the actions evaluated (i.e., the conservation measures). See the *Executive Summary* for a summary of effects on each covered species.

5.1.2 Structure of the BDCP

The structure of the BDCP includes four elements: the biological goals and objectives, the conservation measures, the effects analysis, and the adaptive management and monitoring program. The relationship between these elements is described in Section 5.2, *Methods*. Briefly, the biological goals and objectives state the anticipated outcomes of the BDCP with regard to minimizing and mitigating for incidental take, and providing for the conservation and management of covered species and natural communities. The conservation measures define the actions that will be implemented under the BDCP to achieve the biological goals and objectives. The effects analysis describes what the conservation measures are expected to achieve at certain time steps during Plan implementation, based on the best available information. The adaptive management and monitoring program will guide the BDCP during implementation and will provide a means of revising the conservation strategy in response to new and updated information in order to advance the biological goals and objectives. These four elements work together to ensure that the BDCP ultimately will achieve its biological goals and objectives.

5.1.3 Regulatory Scope

5.1.3.1 The BDCP

The regulatory scope of the BDCP is detailed in Chapter 1, *Introduction*. Table 5.2-1 briefly summarizes the compliance requirements for each state and federal permitting agency under the federal Endangered Species Act (ESA), the Natural Communities Conservation Planning Act, California Environmental Quality Act (CEQA), and National Environmental Policy Act (NEPA) and the trigger for each compliance action. These actions are directly related to the BDCP and its endangered species authorizations. Additional regulatory authorizations are required to implement many conservation measures as described in Chapter 6, *Plan Implementation*, and the BDCP EIR/EIS (California Department of Water Resources et al. 2012).

Table 5.2-1. Environmental Regulation Requirements Applicable to the BDCP (by Agency)

Agency	Required Regulation Compliance	Trigger for Compliance
California Department of Water Resources	• Endangered Species Act (Section 10, incidental take permit application) • Natural Community Conservation Planning Act (incidental take permit application) • California Environmental Quality Act	Potential for take of federally listed species from covered activities requires permit from the U.S. Fish and Wildlife Service and National Marine Fisheries Service; potential for take of state-listed species required permit from CDFW; DWR adoption of the BDCP and incorporation into the State Water Project
California Department of Fish and Wildlife	• Natural Community Conservation Planning Act (NCCP permit decision) • California Environmental Quality Act	DWR submits NCCP and requests take permit for covered species under Fish and Game Code Section 2835. CDFW issuance of take authorization and approval of NCCP (California Endangered Species Act 2081 permit not required if NCCP permit issued for state-listed species) is subject to California Environmental Quality Act compliance
Bureau of Reclamation	• Endangered Species Act (Section 7 consultation with U.S. Fish and Wildlife Service and National Marine Fisheries Service) • National Environmental Policy Act	Adoption of the BDCP and its incorporation into the Central Valley Project; potential to adversely affect federally listed species
U.S. Fish and Wildlife Service	• Endangered Species Act (Section 10 permit decision, internal Section 7 consultation) • National Environmental Policy Act	Receipt from DWR of an application for a Section 10 permit; internal Section 7 consultation within agency; request for formal consultation by the Bureau of Reclamation and receipt of biological assessment
National Marine Fisheries Service	• Endangered Species Act (Section 10 permit decision, internal Section 7 consultation) • National Environmental Policy Act	Receipt from DWR of an application for a Section 10 permit; internal Section 7 consultation within agency; request for formal consultation by the Bureau of Reclamation and receipt of biological assessment

DWR = California Department of Water Resources; CDFW = California Department of Fish and Wildlife; NCCP = natural community conservation plan

5.1.3.2 Other Federal Regulatory Analyses

USFWS and NMFS require additional information to support the federal decision-making process. These analyses include an assessment of essential fish habitat (EFH) and analyses of effects on designated or proposed critical habitat for species occurring in the action area. The EFH assessment is required, because the BDCP is a federal action subject to review and approval under the Magnuson-Stevens Fishery Management and Conservation Act (62 *Federal Register* [FR] 244, December 19, 1997). The EFH assessment will support decisions by NMFS. The critical habitat evaluation is required, because Bureau of Reclamation (Reclamation) activities and permit issuance both are federal actions subject to review under Section 7 of the ESA. Species under the jurisdiction of both USFWS and NMFS have designated critical habitat in the action area, so this assessment provides information for both federal regulatory agencies.

5.1.4 Actions Evaluated

The effects analysis evaluates the effects of implementing covered activities, including all conservation measures (Chapter 4, *Covered Activities and Associated Federal Actions*, and Chapter 3, Section 3.4, *Conservation Measures*). The 22 conservation measures (CMs) and are briefly summarized below.

- *CM1 Water Facilities and Operation* is intended to meet or contribute to a variety of biological goals and objectives that are expressed mostly at the landscape scale and are related to flow. Many of the implementation actions proposed under CM1 constitute a continuation of existing activities being implemented under the existing biological and conference opinions (BiOps) (Table 5.2-2) that currently govern SWP/CVP operations.
- *CM2 Yolo Bypass Fisheries Enhancement* describes how the Implementation Office will modify the Yolo Bypass to increase the frequency, duration, and magnitude of floodplain inundation. These actions will improve passage and habitat conditions for Sacramento splittail, Chinook salmon, green and white sturgeon, lamprey, and possibly steelhead.
- *CM3 Natural Communities Protection and Restoration* describes how the Implementation Office will provide the mechanism and guidance to establish a system of conservation lands in the Plan Area, called a reserve system, by acquiring lands for protection and restoration. Such a system is needed to meet the habitat protection goals and objectives for natural community and species habitat.
- *CM4 Tidal Natural Communities Restoration* describes how the Implementation Office will provide for the restoration of tidal perennial aquatic, tidal mudflat, tidal freshwater emergent wetland, and tidal brackish emergent wetland natural communities in the restoration opportunity areas (ROAs). Tidal natural communities will be restored along a contiguous gradient encompassing shallow subtidal aquatic, tidal mudflat, tidal marsh plain, and adjoining transitional upland natural communities. The transitional upland areas will accommodate approximately 3 feet of sea level rise in topographic settings and can function as tidal marsh plain at some future time, if necessary.
- *CM5 Seasonally Inundated Floodplain Restoration* describes how the Implementation Office will set back river levees and restore seasonally inundated floodplains that historically existed in the Plan Area but have been lost as a result of flood control and channelization.
- *CM6 Channel Margin Enhancement* describes how the Implementation Office will restore channel margin habitat by improving channel geometry and restoring riparian, marsh, and mudflat habitats on the inboard side of levees.
- *CM7 Riparian Natural Community Restoration* describes how the Implementation Office will restore riparian forest and scrub in association with restoration of tidal and floodplain areas (*CM4 Tidal Natural Communities Restoration* and *CM5 Seasonally Inundated Floodplain Restoration*, respectively) and channel margin enhancements (*CM6 Channel Margin Enhancement*). Riparian forest and scrub will be restored to include the range of conditions necessary to support habitat for each of the riparian-associated covered species.

- *CM8 Grassland Natural Community Restoration* describes how the Implementation Office will restore grassland natural community in Conservation Zones 1, 8, and/or 11.
- *CM9 Vernal Pool and Alkali Seasonal Wetland Complex Restoration* describes how the Implementation Office will restore vernal pool complex in Conservation Zones 1, 8, or 11 to achieve no net loss of vernal pool acreage from covered activities.
- *CM10 Nontidal Marsh Restoration* describes how the Implementation Office will restore nontidal freshwater marsh in Conservation Zones 2 and 4.
- *CM11 Natural Communities Enhancement and Management* describes how the Implementation Office will prepare and implement management plans for protected natural communities and for the covered species habitats that are found within those communities throughout the reserve system.
- *CM12 Methylmercury Management* describes how the Implementation Office will minimize conditions that promote production of methylmercury in restored areas and its subsequent introduction to the foodweb, and to covered species in particular.
- *CM13 Invasive Aquatic Vegetation Control* describes how the Implementation Office will take actions to control the introduction and spread of invasive aquatic plant species in aquatic restoration areas that degrade habitat for covered fish species, waterfowl, and rare native plants.
- *CM14 Stockton Deep Water Ship Channel Dissolved Oxygen Levels* describes how the Implementation Office will ensure that the Stockton Deep Water Ship Channel DWR Aeration Facility, which is currently operational, will continue to operate as needed during the permit term in order to maintain the concentrations of dissolved above target levels during the entire permit term.
- *CM15 Localized Reduction of Predatory Fishes* describes how the Implementation Office will reduce the local effects of predators on covered fish species by conducting predator control at hotspot locations that have high densities of predators with a disproportionately large adverse effect on covered fish.
- *CM16 Nonphysical Fish Barriers* describes how the Implementation Office will improve the survival of outmigrating juvenile salmonids by using nonphysical barriers to redirect juvenile fish away from channels and river reaches in which survival is lower than in alternate routes.
- *CM17 Illegal Harvest Reduction* describes how the Implementation Office will reduce illegal harvest of Chinook salmon, Central Valley steelhead, green sturgeon, and white sturgeon in the Delta, bays, and upstream waterways by funding enforcement actions.
- *CM18 Conservation Hatcheries* describes how the Implementation Office will establish new, and expand existing, conservation propagation programs for delta and longfin smelt.
- *CM19 Urban Stormwater Treatment* describes how the Implementation Office will provide a mechanism for implementing urban stormwater treatment measures that will result in decreased discharge of contaminants to the Delta.
- *CM20 Recreational Users Invasive Species Program*, describes how the Implementation Office will fund actions to reduce nonnative invasive species within the Plan Area by supporting the CDFW Watercraft Inspection Program in the Delta.

- *CM21 Nonproject Diversions* describes how the Implementation Office will provide funding for actions that will minimize the potential for entrainment of covered fish species associated with operation of nonproject diversions (diversions of the natural surface waters in the Plan Area for purposes other than meeting SWP/CVP water supply needs).
- *CM22 Avoidance and Minimization Measures* describes how the Implementation Office will implement measures to avoid and minimize effects on covered species and natural communities that could result from covered activities.

5.2 Methods

This section presents the qualitative and quantitative methods used to analyze the effects of the covered activities on the San Francisco Bay/Sacramento–San Joaquin River Delta (Bay-Delta) ecosystems and landscapes, natural communities, and on all covered species. This section first describes the spatial scope of the effects analysis, the environmental baseline used in the effects analysis, and the incorporation of climate change into the analysis. The section then presents the qualitative and quantitative methods used to analyze the effects on natural communities and covered aquatic and terrestrial species. In most cases, the evaluation of effects is made by comparing baseline environmental conditions to the biological performance of covered species with expected environmental conditions under the BDCP at future implementation periods. As required by the federal Endangered Species Act (ESA), the effects analysis also describes the level of take and the effect of that take on each covered species expected from implementation of all covered activities.

5.2.1 Spatial Scope of the Analysis

The BDCP will affect conditions and species across a wide array of geographies and environments with varying mixes of stressors, environments, and species. Assessment of the effects of individual actions and stressors is enhanced by considering them within the biological and geographical structure of the Delta and its tributaries. Structure and function of ecological systems are often described hierarchically (O'Neill et al. 1986); a hierarchical structure is particularly applicable to estuarine species encompassing a variety of physical and biological features (Peterson 2003). Large-scale areas can constrain the performance of small-scale areas. In turn, the performance at any level reflects the performance of small-scale features. A hierarchical structure for the spatial scope of the effects analysis includes the following components.

- **Study Area** (Figure 5.2-1). This is the area where physical changes attributable to the BDCP may affect covered fish species. The Study Area includes the Sacramento River upstream to Keswick Dam, the San Joaquin River upstream to the Stanislaus River, tributaries downstream of SWP and CVP dams (Clear Creek, Feather River, American River, and Stanislaus River), and the Plan Area (see below). The Study Area is equivalent to the action area defined in the EIR/EIS for the BDCP (California Department of Water Resources et al. 2012).
- **Plan Area** (Figure 5.2-2). This is the area in which all covered activities will occur. The effects analysis will focus on the Plan Area. The Plan Area includes the statutory Delta (as defined in California Water Code 12220), Suisun Bay, Suisun Marsh, and the Yolo Bypass south of the Sacramento River.
- **Geographic regions.** These are large-scale areas that can be distinguished hydraulically, ecologically, and geomorphologically. Regions include terrestrial and aquatic environments. The Study Area is divided into three geographic regions: the Sacramento River watershed, the San Joaquin River watershed, and the Plan Area, as described above.
- **Geographic subregions** (Figure 5.2-2). Subregions are broad geographic and hydrologically distinct areas that are relevant to the life history of Delta fish and wildlife species. Subregions include both terrestrial and aquatic resources. In the Plan Area, the subregions are based largely on hydrodynamic subregions used by Stoms (2010) that were interpreted from a graphic conceptual model developed by the DRERIP team (Burau pers. comm.). Outside the Plan Area,

subregions include tributary reaches below dams that prevent fish passage and that may experience indirect effects from BDCP-related activities such as changed release schedules. Note Geographic subregions are distinct from the conservation zones, which are defined for the terrestrial natural communities and covered species (Figure 3.2-2, *Conservation Zones and Restoration Opportunity Areas*, in Chapter 3).

- **Restoration opportunity areas (ROAs)** (Figure 5.2-2). ROAs encompass those locations considered the most appropriate for the restoration of tidal habitats in the Plan Area and within which restoration goals for tidal and associated upland natural communities will be achieved. For a description of how ROAs were developed, see Chapter 3, Section 3.2.2, *Identifying Conservation Zones and Restoration Opportunity Areas*.

5.2.2 Temporal Scope of the Analysis

The covered activities will be implemented over a 50-year period. Conservation measures will begin at different points over that period, reflecting the implementation schedule in described in Table 6-1, *Implementation Schedule for Water Facilities and Other Stressors Conservation Measures*, and Table 6-2, *Implementation Schedule for Natural Community Protection and Restoration Conservation Measures*, in Chapter 6. Over the implementation period, climate across the Study Area is expected to change at local, regional, and larger scales. Therefore, evaluations of the conservation measures are made using conditions expected during four periods within the 50-year permit term. Analytical comparisons use all or a subset of these periods as appropriate. Evaluation periods for the effects analysis are as follows.

- **Current conditions.** Current conditions exist prior to implementation of the BDCP. See the next section for a definition of the environmental baseline, which is equivalent to current conditions. Current conditions are described in Chapter 2, *Existing Ecological Conditions*.
- **Near-term conditions.** Near-term conditions are expected in the period from BDCP permit issuance (year 0) through year 10 (i.e., 2020). During this period, the BDCP is expected to address a substantial portion of the planned aquatic and terrestrial restoration with associated improvements in water quality and food production. Benefits will not be immediate but will accumulate because of time required for land acquisition and for maturation of restoration actions. During this period, the new water facilities will be constructed but no new operations will occur. Near-term climate conditions were assumed to be the same as existing conditions.
- **Early long-term (ELT) conditions.** ELT conditions are expected from years 10 through 15. During this period, changes in the Delta environment will result from the new BDCP water operations. In addition, floodplain restoration will have begun and more tidal wetland restoration will have been implemented. ELT climate conditions reflect the physical analysis of the 2025 conditions, with 15 centimeters (0.5 foot) of sea level rise.
- **Late long-term (LLT) conditions.** LLT conditions reflect the full implementation and maturation of covered activities from years 15 through 50. All planned restoration actions will have occurred by year 40 along with full application of the new water facility and full implementation of other conservation measures. LLT climate conditions reflect the physical analysis of the 2060 conditions, with 45 centimeters (1.5 feet) of sea level rise.

The assumptions and methods for estimating the effects of climate change (warming and sea level rise) on runoff hydrology, water temperatures, and salinity intrusion in the Delta are described in Appendix 5.A.2, *Climate Change Approach and Implications for Aquatic Species*.

5.2.3 Definition of the Environmental Baseline

Biological responses expected to result from the implementation of the conservation measures have been evaluated in the context of the environmental baseline. The environmental baseline ensures that the effects of a proposed action are evaluated in the context of other, unrelated effects on covered species. By regulation, "effects of the action" is defined as "the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline" (50 CFR sec. 402.02). The ESA regulations specifically provide:

> [t]he environmental baseline includes the past and present impacts of all Federal, State, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of State or private actions which are contemporaneous with the consultation in process. (50 CFR sec. 402.02).

The federal Consultation Handbook (U.S. Fish and Wildlife Service and National Marine Fisheries Service 1998) advises that determinations regarding environmental baseline conditions for ongoing water projects should be made in the same manner as for other types of projects. Specifically, the handbook directs that:

> The total effects of all past activities, including the effects of past operation of the project, current non-Federal activities, and Federal projects with completed Section 7 consultations, form the environmental baseline; to this baseline, future direct and indirect impacts of the operation over the new license or contract period…are added to determine the total effect on listed species and their habitat (Consultation Handbook, p. 4-30).

Regulatory approaches to describing existing conditions differ between the ESA, the NEPA, and the CEQA. Differences in the approaches to defining baseline conditions under NEPA and CEQA are addressed by applying two different baselines conditions.

The environmental baseline, referred to as the *existing biological condition* (EBC), reflects the environmental conditions of the Study Area at the time of BDCP approval. These include the extent of species habitats, water quality and pollutant inputs, and water temperatures described in Chapter 2, *Existing Ecological Conditions*. The environmental baseline also includes the anticipated ecological effects of implementing most of the actions in the BiOps developed by USFWS for delta smelt (2008) and NMFS (2009) for salmonids and green sturgeon for the long-term operations of the SWP/CVP facilities. These actions were added to the regional water operations objectives (i.e., rules) previously required under D-1641 provisions of the State Water Resources Control Board (1999), including the Vernalis Adaptive Management Program. Because the baseline is defined by conditions and operating rules at a particular moment in time, it does not include future effects that may result from climate change (discussed in Section 5.2.4, *How Climate Change Was Incorporated into the Analysis*). The environmental baseline also does not include the effects of water operation agreements that are currently being negotiated.

To reflect the differing regulatory directives for determining environmental baseline, two EBCs (EBC1 and EBC2) are included in most analyses of the effects on aquatic natural communities and aquatic covered species. EBC1 and EBC2 are defined as when the Notice of Preparation of the BDCP EIR/EIS was revised, February 13, 2009[1] (Table 5.2-1). Both EBC1 and EBC2 are defined to be

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[1] EBC1 was defined to meet CEQA requirements. Under CEQA, the environmental baseline is defined as the physical conditions that exist at the time the Notice of Preparation is published.

consistent with the regulatory requirements for baseline or existing conditions, as described above. In addition, both EBC1 and EBC2 include relevant provisions of the USFWS (2008) and NMFS (2009) BiOps that have been implemented up to this point or are expected to be implemented by the time BDCP is approved[2], as described further below. EBC1 is defined to address the baseline under CEQA, whereas EBC2 is defined to address the baseline under the ESA and NEPA (Table 5.2-1). Although some of the CALSIM modeling assumptions for north of Delta and south of Delta demands (level of development) and water facilities (e.g., Freeport Intake, Intertie, and Stockton Intake) were different for EBC1 and EBC2, the monthly modeling results were very similar (except for the effects of Fall X2, which were included in the EBC2 modeling but not in the EBC1 modeling).

Table 5.2-1. Environmental Baselines for Evaluation of BDCP Net Effects

Baseline Scenario	Regulatory Basis	Description
Existing biological conditions 1 (EBC1)	California Environmental Quality Act	Most actions in the USFWS (2008) and NMFS (2009) BiOps (Table 5.2-2), excluding the Fall X2 provisions
Existing biological conditions 2 (EBC2)	Section 7 of the Endangered Species Act; National Environmental Policy Act	Most actions in the USFWS (2008) and NMFS (2009) BiOps (Table 5.2-2), including the Fall X2 provisions

Table 5.2-2 summarizes the actions required by the USFWS (2008) and NMFS (2009) BiOps, indicates whether the anticipated effects of each action are or are not assumed in the environmental baseline and the reasons why, and indicates if and how the action is incorporated in the BDCP. The following summarizes which actions are reflected in the environmental baseline (both EBC1 and EBC2).

- The anticipated effects of actions required by the USFWS (2008) and NMFS (2009) BiOps that have already occurred or are expected to be implemented prior to BDCP approval are assumed in the environmental baseline, if enough was known about the effects of the action in early 2010 (when the assumptions for hydrodynamic modeling were established) to define modeling assumptions for the change in water operations[3]. In some cases, changes in water operations required by the BiOps were not expected to occur until after BDCP approval but were reasonably certain to occur prior to the operation of the new north Delta intakes (*CM1 Water Facilities and Operation*). To summarize, if assumptions could be developed by early 2010 about these anticipated actions, they were included in the environmental baseline for water operations.

- The anticipated effects of some actions required by the USFWS (2008) and NMFS (2009) BiOps in the Plan Area are also included in the conservation strategy. In some cases, these actions are included in the environmental baseline and in other cases they are not. A key reason for these assumptions is that the BiOps will be superseded by the BDCP and its associated BiOp for SWP/CVP operations in the Delta. As described in Chapter 1, *Introduction*, the current operations of the SWP/CVP facilities are governed by requirements that include the USFWS (2008) and NMFS (2009) BiOps. The requirements of these BiOps may be modified in response

[2] Although the 2009 NMFS BiOp was issued June 4, 2009, after the time set for the environmental baseline (February 13, 2009), its relevant provisions described here were included in the environmental baseline because of the importance of these actions for the operations of the SWP/CVP in the Plan Area.

[3] For a detailed explanation about these modeling assumptions, see EIR/EIS Appendix 5A, *BDCP EIR/EIS Modeling Technical Appendix*.

to a court-ordered remand process as early as 2013 and as late as 2019, depending on the schedule approved by the court. Operations under the BDCP will occur once the new north Delta intakes are constructed, by about 2024. Once the new intakes are operational, the BDCP and its BiOp will replace the current (or remanded) BiOps for long-term operations of the SWP/CVP in the Plan Area (but not outside the Plan Area). Therefore, the requirements in the USFWS (2008) and NMFS (2009) BiOps in the Plan Area that overlap with the BDCP will apply for approximately 5 to 11 years, until the new north Delta intakes are operational. Because of this expectation of overlap in operations between the existing BiOps and the BDCP, some existing BiOp actions and their effects were also assumed in the BDCP.

Examples of effects assumed in the environmental baseline, but also associated with conservation measures, include the effects of operations of the Delta Cross Channel gates (NMFS Action IV.12 and *CM1 Water Facilities and Operation*) and those related to measures to reduce entrainment at the south Delta export facilities (NMFS Action IV.3 and CM1). An example of the effects of actions that are attributable to the BDCP and not assumed in the environmental baseline include Yolo Bypass improvements and floodplain restoration (NMFS Actions I.6.1, I.6.2, and I.7; and *CM2 Yolo Bypass Fisheries Enhancement*). More discussion of these assumptions is provided below.

- In some cases, actions included in the USFWS (2008) and NMFS (2009) BiOps also included in BDCP were modified or improved to take into account new scientific information available since the BiOps were issued, or additional planning done for BDCP beyond what was developed for the BiOps. Examples of this include *CM16 Nonphysical Fish Barriers*, which is similar to, but much more defined and specific than, NMFS Action IV.1.3.
- Requirements of the USFWS (2008) and NMFS (2009) BiOps that call for conducting planning or feasibility studies with undefined outcomes were not assumed in the environmental baseline. By themselves, these planning or feasibility studies would have no effect on environmental conditions. Their outcomes are unknown at this time and therefore too speculative to include in the environmental baseline. Further, environmental compliance, permitting, and ESA and California Endangered Species Act compliance would be needed to implement any recommendations of these future studies. Examples include fish passage over SWP/CVP terminal dams such as Shasta (NMFS Actions NF4.4 and LF2).
- Requirements of the USFWS (2008) and NMFS (2009) BiOps that involve reporting, monitoring, or research actions are not assumed in the environmental baseline because they are not expected to affect the environment or covered species (monitoring and research actions required by the BiOps, and their overlap with the BDCP, are discussed in Section 3.6, *Adaptive Management and Monitoring Program*).

EBC1 does not include the implementation of the USFWS (2008) BiOp provisions related to Fall X2, the location, expressed in kilometers from the Golden Gate Bridge, at which channel-bottom water salinity is 2 parts per thousand (ppt). Component 3, Action 4 of the BiOp requires that Fall X2 be maintained by increasing Delta outflow during wet and above-normal water years. Additional information regarding the specific assumptions for each modeling scenario is provided in Appendix 5.C, Attachment 5C.A, *CALSIM and DSM2 Modeling Results for the Evaluated Starting Operations Scenarios*.

EBC2 assumes full implementation of the Fall X2 provisions of the USFWS (2008) BiOp. EBC2 captures the ESA Section 7 requirements of the environmental baseline to include the impacts of all past and present federal, state, and private actions and other human activities in the action area, the anticipated impacts of all proposed federal projects that have undergone Section 7 consultations, and the impacts of state or private actions that are contemporaneous with the consultation in process. Taken into the late long-term to include sea level rise and climate change (EBC2_LLT), the EBC2 conditions also satisfy the NEPA baseline. Additional information regarding the specific assumptions for each modeling scenario is provided in Appendix 5.C, Attachment 5C.A.

As discussed above, the NMFS (2009) BiOp actions related to the Yolo Bypass improvements and floodplain restoration were not included in the environmental baseline and have been assumed to occur under the BDCP in *CM2 Yolo Bypass Fisheries Enhancement*. This decision was made for four reasons.

- At the time the NMFS (2009) BiOp was issued, the Yolo Bypass actions (NMFS Actions I.6.1, I.6.2, and I.7) were not of sufficient clarity or detail to include them in the hydrodynamic modeling or to determine the future effects of the actions. Action I.6.1 required Reclamation and DWR to submit to NMFS by December 31, 2011, a "plan to implement this action." The Action specified a range of options to consider and a list of potential constraints on those options (e.g., operations of Shasta). A similar plan was required in the related Actions I.6.2 and I.7. To date, no such plans have been developed by DWR or Reclamation. Instead, DWR conducted much of the planning necessary to implement these actions as part of the BDCP.
- The joint BiOp for the BDCP will provide Section 7 authorization for Reclamation's actions carried out pursuant to the BDCP. With respect to Reclamation's operation of the CVP, the joint BiOp for the BDCP will cover only those operations that occur after the new water conveyance facilities are operational, which is expected to be in 2026. At that time, the joint BDCP BiOp will supersede the existing USFWS (2008) and NMFS (2009) BiOps for the coordinated long-term operation of the SWP and CVP, but only for those operations that occur within the Plan Area. The USFWS (2008) and NMFS (2009) BiOps will continue to provide Section 7 authorization for operations of the SWP and CVP that occur outside of the Plan Area. Alternatively, Reclamation may choose to seek a revised BiOp or BiOps for the coordinated long-term operations of the SWP and CVP that incorporates the new operations of the BDCP.
- Because of the long time necessary to plan and obtain necessary permits for the Yolo Bypass actions, few if any effects or benefits of the NMFS (2009) BiOp actions in the Yolo Bypass are expected to occur before the BDCP BiOp takes effect in 2024. In late 2012, Reclamation issued a Notice of Intent to prepare an EIS that would examine a range of alternatives to meeting the NMFS (2009) BiOp Actions related to the Yolo Bypass improvements. This planning process is expected to take several years. The planning process would then be followed by the permitting and construction phase, which would take several more years. Construction of Yolo Bypass improvement is unlikely to occur sooner than 5 years (the shortest time the existing BiOps will be in place for Delta operations). If construction occurs within 11 years, there would be only a few years of benefits provided by those facilities before the BDCP BiOp supersedes the USFWS (2008) and NMFS (2009) BiOps for Delta operations.
- The BDCP proposes actions in the Yolo Bypass that go beyond those in the NMFS (2009) BiOp actions. *CM2 Yolo Bypass Fisheries Enhancement* includes 20 "component projects" that are to be implemented in four phases (years 1 to 5, 6 to 10, 11 to 25, and 26 to 50). The NMFS BiOp actions in the Yolo Bypass are subsumed within these component projects, but at a much greater level of detail and analysis than presented in the NMFS BiOp. CM2 also includes more actions in the Yolo Bypass than proposed in the NMFS BiOp. An example of the additional detail and

analysis in BDCP is provided by CM2 Component Projects 6 (Experimental Sturgeon Ramps at Fremont Weir) and 7 (Auxiliary Fish Ladders at Fremont Weir). While these projects would be considered similar to NMFS Action I.7 (Reduce Migratory Delays and Loss of Salmon, Steelhead, and Sturgeon at Fremont Weir and Other Structures in the Yolo Bypass), BDCP includes far more detail about how and where these structures would be built (e.g., location, conceptual designs) and what performance measures they would have (e.g., BDCP biological objectives specify maximum passage delay times for salmon and sturgeon at the Fremont Weir) than is found in the NMFS Action I.7. This additional detail was not known at the time of the NMFS BiOp and therefore could not be assumed in the environmental baseline for the effects analysis.

Table 5.2-2. Actions Identified under USFWS (2008) and NMFS (2009) BiOps in the Plan Area Represented in the Environmental Baseline

Requirement[a]	Summary of Requirement	Assumed In BDCP Baseline?	In Conservation Strategy?	Comment/Explanation
NMFS Action I.5	Funding for Central Valley Project Improvement Act (CVPIA) Anadromous Fish Screen Program	Yes	Modified	*CM21 Nonproject Diversions*, supports a program in the Plan Area similar to that funded by CVPIA, and extends it to include consideration of potential benefits to other covered fishes.
NMFS Action Suite I.6, Sacramento River Basin Salmonid Rearing Habitat Improvements				
NMFS Action I.6.1	Restoration of Floodplain Rearing Habitat	No	Yes	This action is one of the many actions proposed under *CM2 Yolo Bypass Fisheries Enhancement*. Accordingly it was not considered as part of the environmental baseline, but was evaluated as a component of the effects analysis.
NMFS Action I.6.2	Near-Term Actions at Liberty Island/Lower Cache Slough and Lower Yolo Bypass	No	Yes	These actions are underway already but are also part of the larger suite of actions proposed under CM2 and CM4. Their completion and maintenance would be covered under BDCP. They were not treated as part of the baseline, and their effects were evaluated within the analysis of the effects of CM2 and CM4.
NMFS Action I.6.3	Lower Putah Creek enhancements	Yes	No	BiOp indicated that by December 31, 2015, the Lower Putah Creek enhancements shall be developed and implemented. Expected to completed prior to Plan implementation.
NMFS Action I.6.4	Lisbon Weir improvements	Yes	No	BiOp indicated that by December 31, 2015, Reclamation and/or DWR shall, to the maximum extent of their authorities, assure the improvements to the Lisbon Weir are made. Expected to be completed prior to Plan implementation.

Requirement[a]	Summary of Requirement	Assumed In BDCP Baseline?	In Conservation Strategy?	Comment/Explanation
NMFS Action I.7	Reduce Migratory Delays and Loss of Salmon, Steelhead, and Sturgeon at Fremont Weir and Other Structures in the Yolo Bypass	No	Yes	This action is one of the many actions proposed under CM2. Accordingly, it was not considered as part of the environmental baseline, but was evaluated as a component of the effects analysis.
NMFS Action IV.1.1, Monitoring and Alerts to Trigger Changes in Delta Cross Channel Operations				
NMFS Action IV.1.2	Delta Cross Channel Gate Operation	Yes	Yes	This would continue to be a part of real-time operations.
NMFS Action IV.1.3	Consider Engineering Solutions to Further Reduce Diversion of Emigrating Juvenile Salmonids to the Interior and Southern Delta, and Reduce Exposure to CVP and SWP Export Facilities	No	In Part	This planning action may contribute to cumulative changes in baseline conditions, but the extent of the change cannot be predicted. Accordingly, most effects of this Action were not evaluated in the effects analysis. However, one engineered solution, nonphysical fish barriers (CM16), is considered within the Plan and evaluated within the effects analysis.
NMFS Action Suite IV.2, Delta Flow Management				
NMFS Action IV.2.1	San Joaquin River Inflow to Export Ratio	Yes	Modified	Export volume is same as baseline; inflow is same but uses Sacramento flow downstream of new north Delta diversions; operations are initially the same but subject to modification under BDCP adaptive management provisions.
NMFS Action IV.2.3	Old and Middle River Flow Management	Yes	Modified	BDCP continues to protect and manage Old and Middle River flows, but flow constraints are expressed differently; see Section 3.4.2.4.3, *Flow Constraints*. BDCP is generally more protective of OMR flows than the BiOp.
NMFS Action IV.3	Reduce Likelihood of Entrainment or Salvage at the Export Facilities	Yes	Yes	This would continue to be a part of real-time operations, but will be improved relative to the baseline condition.
NMFS Action Suite IV.4, Modifications of the Operations and Infrastructure of the CVP and SWP Fish Collection Facilities				
NMFS Action IV.4.1	Tracy Fish Collection Facility Improvements to Reduce Pre-Screen Loss and Improve Screening Efficiency	Yes	No	The action names many requirements and deadlines, some of which have passed; these actions are not described in the conservation strategy.
NMFS Action IV.4.2	Skinner Fish Collection Facility Improvements to Reduce Pre-Screen Loss and Improve Screening Efficiency	Yes	No	The action names many requirements and deadlines, some of which have passed; these actions are not described in the conservation strategy.

Requirement[a]	Summary of Requirement	Assumed In BDCP Baseline?	In Conservation Strategy?	Comment/Explanation
NMFS Action IV.4.3	Tracy Fish Collection Facility and the Skinner Fish Collection Facility Actions to Improve Salvage Monitoring, Reporting and Release Survival Rates	Yes	No	The action names many requirements and deadlines, some of which have passed; these actions are not described in the conservation strategy
NMFS Action IV.5	Formation of Delta Operations for Salmon and Sturgeon Technical Working Group	Yes	Modified	Real-time operations would continue to be directed, in the manner described in CM1, by a multi-agency group.
NMFS Action IV.6	South Delta Improvement Program—Phase I (Permanent Operable Gates)	No	Modified	BiOp directs to not install permanent operable gates, but to study predation at the gate (studies are currently underway). NMFS now approves of installation of an operable gate at the Head of Old River Barrier, and this is part of the proposed project. Because of reduced south Delta exports, other barriers called for in the BiOp (the agricultural barriers) are not included.
Actions Identified in U.S. Fish and Wildlife Service BiOp				
USFWS RPA general	Smelt Working Group and Water and Operations Management Team	Yes	Modified	Real-time operations would continue to be directed, in the manner described in CM1, by a multi-agency group.
USFWS RPA Component 1	Protection of the Adult Delta Smelt Life Stage	Yes	Yes	Enhanced entrainment minimization measures are included in BDCP. BDCP measures improve baseline conditions.
USFWS RPA Component 2	Protection of Larval and Juvenile Delta Smelt	Yes	Yes	Enhanced entrainment minimization measures are included in BDCP. BDCP measures improve baseline conditions.
USFWS RPA Component 3	Improve Habitat for Delta Smelt Growth and Rearing	Yes	Conditional Yes	The flow criterion for fall outflow in wet and above-normal years will be set through the fall outflow decision tree as described in CM1.
USFWS RPA Component 4	Habitat Restoration	No	Yes	In addition to efforts currently underway, CM4 addresses this 8,000-acre tidal habitat restoration requirement.
USFWS RPM 1	Minimize adverse effects of the operations of the Permanent Operable Gates	Yes	Modified	A gate will be installed at the Head of Old River Barrier, but no agricultural barriers in the south Delta will be installed.

Requirement[a]	Summary of Requirement	Assumed In BDCP Baseline?	In Conservation Strategy?	Comment/Explanation
USFWS RPM 2	Minimize adverse effects of operations of the North Bay Aqueduct	Yes	Modified	In a separate action, Solano County Water Agency is constructing an additional diversion to the North Bay Aqueduct. BDCP provides for operation of the two diversions in a manner minimizing impacts on covered fish.
USFWS RPM 4	Minimize adverse effects of Banks and Jones Pumping Plants on delta smelt	Yes	Yes	Achieved by BDCP through North Delta diversion operations, and by entrainment minimization measures in the south Delta at the Jones and Banks Pumping Plants.

[a] BiOp required actions not listed in this table address actions that occur outside the Plan Area and thus are not covered activities under BDCP, or that concern research and/or monitoring and thus do not have the potential to alter environmental conditions in the Plan Area.

BiOp = biological opinion; CVP = Central Valley Project; NMFS = National Marine Fisheries Service; RPA = Reasonable and Prudent Alternative; RPM = Reasonable and Prudent Measure; SWP = State Water Project; USFWS = U.S. Fish and Wildlife Service

5.2.4 How Climate Change was Incorporated into the Analysis

Over the implementation period, regional climate likely will change in response to global changes in climate (Pachauri and Reisinger 2007). While the expectations of climate change are robust, predictions of changes must depend on model projections that may differ from what actually occurs. In California, climate change is expected to increase air and water temperature, change precipitation patterns, raise sea level, and change salinity patterns across the Study Area (Cloern et al. 2011). Climate change will affect hydrologic conditions and water management (Willis et al. 2011) and likely the success of covered activities such as habitat restoration (Battin et al. 2007).

Observed climate and hydrologic records indicate that more substantial warming has occurred in the Study Area since the 1970s. Warming is expected to continue to increase across the state, with greatest changes in spring and summer and greater changes farther away from the coast. Annual median temperature increases are projected to be approximately 1.1°C and 2.3°C for 2025 and 2060, respectively, with less warming in winter and higher warming in summer. Summer temperatures may increase by 4°C by 2060 (Moser et al. 2009).

Precipitation in California is characterized by extreme variability over seasonal, annual, and decadal time scales. For this reason, projections of future precipitation are more uncertain than projections of temperature. While it is difficult to discern strong trends from the full range of climate projections, the California Climate Action Team analysis generally indicated a drying trend in the 21st century (Cayan et al. 2009). Changes in precipitation address not only total precipitation but also the form of the precipitation and the mix of rain and snowpack accumulation. In general, snowpack is expected to decrease in California, and more of the precipitation will fall as rain (Moser et al. 2009). Even for hydrologic model simulations with mean precipitation virtually unchanged, there were large impacts on snowpack accumulation, changes in the monthly pattern of runoff, and soil moisture.

Sea level is projected to increase more rapidly than current rates as a result of thermal expansion of water in the oceans due to global warming, changes in the freshwater input to the oceans from melting of glaciers and ice sheets, and changes in water storage on land. For the scenarios selected for the California Climate Action Team report, sea level rise in California by 2050 is projected to be 30 to 45 centimeters (12 to 18 inches) higher than 2000 levels (Rahmstorf 2007) suggests end-of-century sea level rise in the range of 50 to 150 centimeters (20 to 59 inches) (National Research Council 2012).

The effects analysis explicitly considers the effects of climate change over the permit term by incorporating assumptions of sea level rise and temperature increase into relevant analyses in the early long-term and early long-term for future scenarios with and without the BDCP (Table 5.2-3).

Sea level is assumed to increase by 15 centimeters (0.5 foot) in the early long-term and by 45 centimeters (1.48 feet) in the early long-term. Temperature, flow, and salinity are also assumed to be affected by climate change. In many cases, the effects of climate change on the environment will be greater than the effects of the BDCP. In these cases, comparisons between future scenarios within a single timeframe (i.e., ELT or LLT) are more useful than comparisons of existing conditions to conditions with the BDCP, in which a substantial environmental change due primarily to climate change could obscure the actual effects of the BDCP.

Sea level rise particularly affects the estimate of tidal acres restored under *CM4 Tidal Natural Communities Restoration*. Rising sea levels will increase the expanse of land flooded beyond that called for under this measure.

An overview of climate change and more details on the assumptions of climate change made for modeling purposes is found in Appendix 5.A.2, *Climate Change Approach and Implications for Aquatic Species.*

5.2.5 Model Scenarios

Effects of the BDCP are addressed relative to existing biological conditions. Table 5.2-3 includes a description of each of the modeling scenarios used in the effects analysis.

In the discussion of the effects analysis below, references to conditions under the BDCP are meant to include all BDCP scenarios (i.e., ESO_ELT, ESO_LLT, HOS_ELT, HOS_LLT, LOS_ELT, and LOS_LLT) unless specific scenarios are identified. Comparisons to “existing conditions” are meant to include EBC1 and EBC2. If climate change effects were relevant to the analysis, conditions under the BDCP were compared to future conditions without the BDCP (i.e., EBC2_ELT and EBC2_LLT), which account for climate change. Attachment 5C.A, *CALSIM and DSM2 Modeling Results for the Evaluated Starting Operations Scenarios*, includes a complete listing of the major CALSIM assumptions and model changes (e.g., sea level rise, inflow hydrology, north Delta intakes, flow bypass rules) that were used to produce the monthly calculations of reservoir storage, river flows, and Delta operations (north and south Delta exports and outflow).

Table 5.2-3. Analytical Conditions of the Modeled Scenarios[a]

Condition		Description
Existing Biological Conditions	EBC1	Current operations, based on the USFWS (2008) and NMFS (2009) BiOps, but excluding the September-November outflows in wet and above normal years required to achieve the Fall X2 provisions of the USFWS (2008) BiOp.
	EBC2	Current operations based on the USFWS (2008) and NMFS (2009) BiOps, including the September-November outflows in wet and above normal years required to achieve the Fall X2 provisions of the USFWS (2008) BiOp. Slightly different demand and facilities assumptions than EBC1.
Projected Future Conditions without the BDCP	EBC2_ELT	EBC2 projected into year 15 (2025) accounting for climate change conditions expected at that time.
	EBC2_LLT	EBC2 projected into year 50 (2060) accounting for climate changes conditions expected at that time.
Projected Future Conditions with the BDCP[b]	ESO_ELT	Evaluated starting operations in year 15; assumes the new intake facility is operational but restoration actions are not fully implemented.
	ESO_LLT	Evaluated starting operations in year 50; assumes the new intake facility is operational and restoration actions are fully implemented.
	HOS_ELT	High-outflow operations (high-outflow outcomes of decision tree for management of spring and fall outflow) in year 15; assumes the new intake facility is operational but restoration actions are not fully implemented.
	HOS_LLT	High-outflow operations (high-outflow outcomes of decision tree for management of spring and fall outflow) in year 50; assumes the new intake facility is operational and restoration actions are fully implemented.
	LOS_ELT	Low-outflow operations (low-outflow outcomes of decision tree for management of spring and fall outflow) in year 15; assumes the new intake facility is operational but restoration actions are not fully implemented.
	LOS_ELT	Low-outflow operations (low-outflow outcomes of decision tree for management of spring and fall outflow) in year 50; assumes the new intake facility is operational and restoration actions are fully implemented.

[a] Additional information regarding the specific assumptions for each modeling scenario is provided in Appendix 5.C, Attachment 5C.A, *CALSIM and DSM2 Modeling Results for Evaluated Starting Operations Scenarios*.

[b] The decision-tree process, described in Section 3.4.1.4.4, *Decisions Trees*, provides a mechanism for selection of one of four potential operational outcomes for *CM1 Water Facilities and Operation*: evaluated starting operations, high-outflow scenario, low-outflow scenario.

5.2.6 Effects Analysis for Natural Communities

Adverse effects on natural communities were assessed primarily by quantifying the areal extent of each natural community permanently or temporarily lost, by overlapping construction footprints and hypothetical restoration footprints with geographic information system (GIS) data for existing natural communities. The methods and assumptions used were similar to those used for assessing effects on covered species habitat, and are detailed in Section 5.2.7.2, *Analysis of Adverse Effects*. The effects analysis for natural communities, however, does not provide the level of detail that is provided for species habitat effects because there is no regulatory standard for natural communities as there is for species that requires establishment of take limits or findings related to long-term survival or conservation.

Factors considered when assessing the quality of affected natural communities included landscape connectivity, natural community patch size, hydrologic connectivity, native biodiversity, and presence of rare species. Additional factors specific to each natural community were also assessed, as described in the results section for each natural community (Section 5.4, *Effects on Natural Communities*). For natural communities with adverse effects widely dispersed throughout the Plan Area, quality was assessed generally and the areas with the greatest areal extent of loss were assessed in more detail.

Beneficial effects on natural communities were also evaluated, based on the ecosystem and natural community goals and objectives provided in Section 3.3, *Biological Goals and Objectives*, and implementation of the conservation measures described in Section 3.4, *Conservation Measures*. The net effects on each natural community were then evaluated, taking into consideration the amount lost; the amount restored, protected, and enhanced; and the anticipated quality of the natural communities conserved relative to that lost.

5.2.7 Effects Analysis for Covered Fish

5.2.7.1 Take Assessment

Implementation of covered activities will result in incidental take of covered fish species. To meet regulatory requirements and to ensure adequate mitigation of effects, the amount of take must be discussed and, if possible, quantified. The overall take of covered fish as a result of the conservation measures is not quantifiable. Take was evaluated by determining the mechanism and direction of positive or negative effects. These determinations were used to establish a qualitative ranking of beneficial and adverse effects of the conservation measures. These rankings led to a qualitative determination of overall effects and a set of conclusions regarding take. Effects on fish populations will also be tracked to ensure permit compliance.

The following types of effects could result from the covered activities.

- Change in entrainment of fish in water diversions.
- Change in predation as a result of new structures.
- Modification of river flow.
- Change in habitat.
- Change in food and foraging.
- Permanent indirect and other indirect losses.
- Disturbances related to construction and maintenance.

Several of these activities should benefit covered fish species by increasing habitat suitability including food resources. Adverse conditions that could result in take are dependent on flow conditions and are captured in a detailed quantitative analysis. A list of covered activities and corresponding conservation measures are summarized in Table 5.2-4. Detailed results from quantitative and qualitative analysis of the covered activities are provided in the appendices to this chapter.

Table 5.2-4. Covered Activities, Associated Conservation Measures, and Appendices in which Effects on Covered Fish Species Are Evaluated

Covered Activity	Relevant Conservation Measure(s)	Appendix(ces)
Conveyance Facility Construction and Operation		
Conveyance facility construction	CM1 Water Facilities and Operation	5.H, *Aquatic Construction and Maintenance Effects*
Conveyance facility operation	CM1	5.B, *Entrainment* 5.C, *Flow, Passage, Salinity, and Turbidity* 5.D, *Contaminants* 5.F, *Biological Stressors on Covered Fish* 5.G, *Fish Life Cycle Models* 5.J, *Effects on Natural Communities, Wildlife, and Plants*
Conveyance facility maintenance	CM1	5.H
Fremont Weir/Yolo Bypass Improvements		
Fisheries enhancement construction	CM2 Yolo Bypass Fisheries Enhancement	5.H
Fisheries enhancement facility maintenance	CM2	5.H
Yolo Bypass operations	CM2	5.C, *Flow, Passage, Salinity, and Turbidity* 5.D, *Contaminants* 5.E, *Habitat Restoration* 5.F, *Biological Stressors on Covered Fish* 5.G, *Fish Life Cycle Models*
Tidal Natural Communities Restoration		
Grading, levee breaching, and resulting tidal inundation	CM4 Tidal Natural Communities Restoration	5.E, 5.H
Riparian restoration	CM4, CM7 Riparian Natural Community Restoration	5.E
Floodplain Restoration		
Levee construction	CM5 Seasonally Inundated Floodplain Restoration	5.H
Restoration activities resulting in seasonal flooding	CM5	5.E
Riparian restoration	CM5, CM7 Riparian Natural Community Restoration	5.E
Nontidal Marsh Restoration		
Marsh restoration	CM10 Nontidal Marsh Restoration	5.H
Conservation Hatcheries Facilities		
Facilities construction	CM19 Urban Stormwater Treatment	5.H

The effect of construction of the water conveyance facility (*CM1 Water Facilities and Operation*) on fish is limited to the construction of the three intake structures on the Sacramento River and the construction of temporary barge landings to support construction of this facility. Construction effects are discussed in Appendix 5.H, *Aquatic Construction and Maintenance Effects* along with proposed actions to minimize effects on covered fish species. These effects will be temporary during construction. Operation of the intakes is expected to have minimal effect on covered fish species because of their location (smelts), and design criteria for screens and operations (all covered fishes).

Construction effects of habitat restoration activities cannot be quantified because designs and locations have not been identified. However, adverse effects of restoration are expected to be temporary and soon overshadowed by beneficial effects of the restoration. Hypothetical disturbance footprints were developed to estimate maximum change in species habitat resulting from tidal natural community restoration (*CM4 Tidal Natural Communities Restoration*) and seasonally inundated floodplain restoration. These actions are intended to benefit covered fish species and are not expected to result in take beyond temporary construction impacts. The hypothetical footprints for tidal restoration were developed using outputs of the tidal restoration model described in Section 5.2.7.2, *Use of Models in the Effects Analysis.* The hypothetical footprint for floodplain restoration was developed by evaluating restoration opportunities and applying assumptions about the most likely locations for floodplain restoration as described in Chapter 3, *Conservation Strategy* (*CM5 Seasonally Inundated Floodplain Restoration*) and Appendix 5.E, *Habitat Restoration*.

Take limits for covered fish species are established by operational criteria and estimates of in-water habitat loss, which define maximum impacts. These take limits are not constrained by the assumptions used to model effects. Rather, take limits for covered fish are defined by the flow criteria identified in Table 3.4.1-1, *Water Operations Flow Criteria and Relationship to Assumptions in CALSIM Modeling*, and Table 3.4.1-2, *Flow Criteria for North Delta Diversion Bypass Flows*, in Chapter 3, and the natural community impact acreage caps identified in Table 5.6-1.

5.2.7.2 Use of Models in the Effects Analysis for Covered Fish

Assessment of the effects of stressors resulting from the BDCP involves a combination of quantitative and qualitative models. A model is a logical organization of data and observations leading to a conclusion about how a system functions or performs. For purposes of the effects analysis, *models* include formal quantitative models such as CALSIM as well as non-quantitative conceptual models such as those developed in the DRERIP process. Quantitative models produce a numeric outcome of an action based on the manipulation of data by mathematical algorithms. The algorithms in a quantitative model are a formalization of conceptual models of the relationships between attributes, processes, and outcomes in mathematical terms. Development of useful quantitative models requires that sufficient theory and data are available to construct algorithms that explicitly describe the relationship between system attributes. Conceptual models describe a logical relationship between variables and summarize the results of scientific investigations, although the result is not a quantification of biological change. Conceptual models are the first step in constructing quantitative models but they can also stand alone as working hypotheses of the phenomenon.

Models used in the BDCP are listed and described in Table 5.2-5 along with a reference to the appendix where the models are applied. The models are categorized based on their general scope and intent. In addition, benefits and limitations of each model are listed in Table 5.2-5.

5.2.7.3 Conceptual Models

Conceptual models organize information within a logical structure that provides a plausible explanation for a phenomenon. A conceptual model describes key attributes, linkages, and structure associated with an issue. An important value of conceptual models is that they explicitly lay out assumptions and logic underlying arguments and assessments. Conceptual models have been developed through regional processes that summarize information by groups of regional scientists. DRERIP (California Department of Fish and Game undated) has developed conceptual models for key species and processes in the Delta (DiGennaro et al. 2012). The Interagency Ecological Program has constructed conceptual models associated with the pelagic organism decline (Baxter et al. 2010). Conceptual models are also a fundamental component of the net effects approach for covered fish effects, and are included in Section 5.3, *Ecosystem and Landscape Effects*, and in the Chapter 5 appendices. More information about the use of conceptual models for assessment of fish effects is in Section 5.2.7.10, *Approach for Determining Net Effects on Fish Species*. Conceptual models were used in several appendices to guide discussion and to lay out important relationships.

5.2.7.4 Environmental Models

Environmental models set the stage for the analysis of biological effects by describing key physical and chemical conditions across the Study Area. These conditions include flow, temperature, salinity, and turbidity. In the Delta, the analysis of physical conditions and biological effects is most often based on CALSIM II and Delta Simulation Model (DSM) 2 (Figure 5.2-3). Because flow is a *master variable* (Poff et al. 1997) in the sense that it creates and maintains many other habitat characteristics, CALSIM II and DSM2 are the basis for many other analyses used in the effects analysis (Figure 5.2-4). For example, CALSIM II and DSM2 are used extensively in Appendix 5.B, *Entrainment*, and in Appendix 5.C, *Flow, Passage, Salinity, and Turbidity*. CALSIM II includes an 82-year record and DSM2 includes 16 years at a 15-minute time step. As such, they each generate a large volume of information that is used directly in the effects analysis and as inputs to other models.

Inflow to the Delta from the Sacramento and San Joaquin Rivers is highly variable, reflecting annual variation in precipitation, regional climate trends, and hydrologic operations. As discussed above, water management changes month to month and between years to accommodate a variety of water needs. As such, there is incredible variability within results. To aid in reporting the meaningful changes and trends in the environment and effects on covered fish species, some analyses report results by one of five water-year types. These water-year types have been established by DWR for hydrologic analysis (California Department of Water Resources 2009). While all of the results are available and accounted for in the effects analysis, many of the flow-related analyses, summarize the change in biological condition resulting from covered activities for each of the following water-year types to help aggregate the information in a meaningful way.

- Critical (occur in 12 years out of the 82-year base period, or 15% of the time).
- Dry (18 years of 82, or 22%).
- Below normal (14 years of 82, or 17%).
- Above normal (12 years of 82, or 15%).
- Wet (26 years of 82, or 32%).

Table 5.2-5. Models Used in the Effects Analysis for Covered Fish Species

Model	Description	Benefits	Limitations	Model Type	Appendix[a] in Which Model Is Applied						
					5.B	5.C	5.D	5.E	5.F	5.G	5.H
Conceptual models	Conceptual models organize factors and relationships to explain phenomena. They are a starting point for development of quantitative models and stand on their own as a way to structure discussion and analyses. Because the models are not temporally explicit, there is no time step.	Organize information obtained from literature into comprehensive hypotheses.	Outputs are limited to qualitative assessments based on best professional judgment.	Conceptual	X	X	X	X	X	X	
Delta Regional Ecosystem Restoration Implementation Plan (DRERIP)	The DRERIP conceptual models and scientific evaluation process were developed to aid in planning and decision making for potential ecosystem restoration actions in the Delta. The 2009 DRERIP assessment of the BDCP (Essex Partnership 2009) provided qualitative rankings for the effects on covered fish species from the conservation measures proposed at that time. Because the models are not temporally explicit, there is no time step.	Conceptual models have been peer-reviewed and include individual fish species and habitat functions. Provides information on potential stressors and mechanisms for effects analysis.	Outputs are limited to qualitative assessments based on best professional judgment of topical experts.	Conceptual	X	X	X	X	X		
CALSIM II	The CALSIM II planning model simulates the operation of the CVP and SWP over a range of hydrologic conditions based on an assumed set of demands, regulatory requirements and climate-related factors using an 82-year record of hydrology. CALSIM II produces key outputs that include river flow volumes and diversion volumes, reservoir storage, Delta flow volumes and export volumes, Delta inflow volumes and outflow volumes, deliveries to project and nonproject users, and controls on project operations. The model operates at a monthly time step, but for the BDCP analysis daily flows on the Sacramento River were used to estimate Fremont Weir diversions and north Delta intake bypass flow requirements. These daily Sacramento River flows were estimated from the historical daily patterns adjusted to match the monthly CALSIM flows.	Based on a long, hydrologically diverse record and system-wide. Allows comparisons of changes in flows under a range of alternative operations. Used extensively to determine change in water operations and flows.	Monthly time step limits use for daily or instantaneous effects analysis; does not accurately simulate real-time operational strategies to meet temperature objectives or flood control requirements.	Environmental	X	X	X	X	X	X	
Delta Simulation Model (DSM) 2	DSM2 is a one-dimensional hydrodynamic and water quality simulation model used to simulate hydrodynamics, water quality, and particle tracking in the Sacramento-San Joaquin Delta. The DSM2 model has three separate components or modules: HYDRO, QUAL, and PTM. The model operates at a 15-minute time step.	See below for HYDRO, QUAL, and PTM.	See below for HYDRO, QUAL, and PTM.	Environmental	X	X	X		X		
DSM2 Hydro	DSM2-HYDRO estimates flow rates, velocities, and depths for the Delta for a given scenario (e.g., the BDCP or climate change). It is tidally averaged. Outputs are used to determine the effects of these hydrodynamic parameters on covered terrestrial and fish species and as inputs to other biological models. The model operates at a 15-minute time step.	Numerous output nodes throughout the Plan Area. Provides information in short time steps that can be used to assess tidal hydrodynamics. Used extensively to determine change in water operations and flows. The 16 years modeled in DSM2 represent the range of conditions found in the 82 CALSIM II years.	One-dimensional model; very data-intensive; runs for limited period (only 16 years). Open-water areas are treated as a fully mixed system, which is an oversimplification.	Environmental		X	X				
DSM2 Qual	The DSM2-QUAL module simulates fate and transport of conservative and non-conservative water quality constituents, including salts, given a flow field simulated by HYDRO. Outputs are used to estimate changes in salinity and their effects on covered species as a result of the BDCP and climate change. The model operates at a 15-minute time step.	Numerous output nodes throughout the Plan Area. Used extensively in Central Valley fishery assessments.	One-dimensional model; very data-intensive; runs for limited period (only 16 years).	Environmental		X			X		
DSM2 Particle Tracking Model (PTM)	The DSM2-PTM module simulates fate and transport of neutrally buoyant particles through space and time. Outputs are used to estimate the effect of hydrodynamic changes on the fate and transport of larval fish and toxics through the Delta, as well as entrainment of larval fish at various locations. The model operates at a 15-minute time step.	Allows assessment of particle fate, transport, and movement rate from numerous starting points to numerous end points. Provides information on movement of planktonic larval fish such as delta and longfin smelt in a tidal environment. Used extensively in Central Valley fishery assessments. It is possible to recode the model to assign behavior to particles	One-dimensional model; no “behavior” has been given to particles; very data-intensive and generally allows tracking for only up to 180 days; only particular months and years have been run using this model.	Environmental	X	X	X		X		

					Appendix[a] in Which Model Is Applied						
Model	**Description**	**Benefits**	**Limitations**	**Model Type**	**5.B**	**5.C**	**5.D**	**5.E**	**5.F**	**5.G**	**5.H**
DSM2-Fingerprinting	Calculates the proportion of water from different sources at specific locations in the Delta. The model operates at a 15-minute time step, although the fingerprinting outputs are monthly-averages for the 16-year period.	Allows assessment of water composition at numerous locations throughout the Plan Area. Useful for assessing changes in potential olfactory cues and attraction flows as well as water movement through the Delta.	One-dimensional model; very data-intensive; runs for limited period (only 16 years).	Environmental		X					
Resource Management Associates (RMA)	The RMA model is a two-dimensional depth-averaged hydrodynamic and water quality model that computes two-dimensional depth-averaged velocity and water surface elevation and a temporal and spatial description of conservative and nonconservative water quality parameters. Model output is used to evaluate the effects of tidal habitat restoration on flows throughout the Delta and the subsequent effects on covered species, aquatic and terrestrial, as well as to assess water temperature and dissolved oxygen levels throughout the Delta. It is also used to calibrate DSM2 and in turn, Artificial Nueral Networks (ANNs) used by CALSIM II. The model is computed using a 7.5-minute time step and saves results every 15 minutes.	The RMA model includes accurate channel geometry (two dimensional) and this may allow more accurate simulation of tidal flows and velocities.	Very data-intensive and runs shorter periods at a time (1 or 2 years).	Environmental					X		
Sacramento River Water Quality Model (SRWQM)	SRWQM is an application developed to use the HEC-5Q model to simulate mean daily (using 6-hour meteorology) reservoir and river temperatures at key locations in the Sacramento River from Shasta Dam to Knights Landing. Output (temperature and flow) from the SRWQM is used as an input to a number of biological models for upstream life stages of salmonids and sturgeon. The model operates at a daily time step.	Daily time step allows more accurate simulation and can be used to assess temperature effects at a more biologically meaningful time step. Provides input to the Reclamation egg mortality and SALMOD models, as well as IOS and OBAN Used extensively in Central Valley fishery assessments. Uses modified meteorological data that incorporates future climate change for ELT and LLT scenarios.	Temporal downscaling routines have limited precision and are not always accurate. Cannot reflect real-time management decisions for coldwater pool and temperature management.	Environmental		X	X			X	
Bureau of Reclamation Temperature Model	The Reclamation Temperature Model is used to assess the effects of operations on water temperatures in the Feather, Stanislaus, Trinity, and American river basins, which are then used as inputs to the Reclamation Salmon Mortality Model and species-specific habitat evaluations. The model operates at a monthly time step.	Large geographic extent makes model widely spatially applicable to the effects analysis study area. Used extensively in Central Valley fishery assessments. Uses modified meteorological data that future climate change for ELT and LLT scenarios.	Monthly time step limits use for daily or instantaneous effects analysis; does not accurately simulate real-time reservoir operational strategies to meet temperature objectives.	Environmental		X	X		X		
MIKE-21	MIKE-21 is a two-dimensional hydrodynamic model used to model steady-state inundation. Outputs of MIKE-21 are used to estimate the area of inundated habitat in the Yolo Bypass for species such as splittail and Chinook salmon. Because the model is not temporally explicit, there is no time step.	Two-dimensional model provides improved definition over one-dimensional models. Can be used to assess changes in physical habitat conditions for fish within the inundated floodplain as a function of specific flows.	The model is steady-state such that changes in flows are not modeled dynamically.	Environmental		X					
Sacramento splittail habitat area	Estimates suitable habitat area for splittail spawning and early rearing habitat in the Yolo Bypass as a function of area weighted by depth. Because this analysis is not temporally explicit, there is no time step.	Accounts for the duration of flooding required for successful spawning and rearing.	No weighting is applied across months; does not account for sources of inundation to the Yolo Bypass	Habitat suitability		X					
Striped Bass Bioenergetics Model	The bioenergetics model is an energy budget-based model that combines striped bass abundance, size distribution, and metabolism with prey density and size distribution to estimate consumption by striped bass of Chinook salmon and splittail at the proposed north Delta intakes. The model operates at a weekly time step for Chinook salmon and at a monthly time step for splittail.	The growth or consumption estimates of an individual species are expanded to the stock or population level. Can estimate the dynamics of predator-prey interactions.	Predation of juvenile salmon is proportional to salmon relative abundance, regardless of size; this results in an overestimation of predation loss. Incorporates only the large prey equation, although smaller salmon fry would fall under the small prey category. The large prey predation regression was based on data for small striped bass (69 to 478 millimeters); thus, they mainly reflect responses of juvenile striped bass.	Biological					X		

Model	Description	Benefits	Limitations	Model Type	Appendix[a] in Which Model Is Applied						
					5.B	5.C	5.D	5.E	5.F	5.G	5.H
Delta Passage Model (DPM)	DPM simulates migration and mortality of Chinook salmon smolts entering the Delta from the Sacramento, Mokelumne, and San Joaquin Rivers through a simplified Delta channel network, and provides quantitative estimates of relative Chinook salmon smolt survival through the Delta to Chipps Island. DPM is used to estimate through-Delta survival for winter-, spring-, fall-, and late fall–run juvenile Chinook salmon passing through the Delta, as well as estimates of salvage in the south Delta export facilities. Model inputs are DSM2-HYDRO and CALSIM data. The model operates at a daily time step.	Provides estimates of overall proportions of migrating juvenile Chinook salmon runs that are lost to entrainment, while accounting for movement down different Delta channels; allows differentiation of fall-run populations by Sacramento, San Joaquin, and Mokelumne River basins. Reach-specific survival/behavior at junctions can be post-processed to investigate specific hypotheses regarding conservation measures not included in the model.	Many of the model assumptions are based on results from large, hatchery-reared fall-run Chinook salmon that may not be representative of smaller, wild-origin fish. Model is applicable only to migrating fish and not to those rearing in the Delta. Model is mostly limited to operations-related effects on flow. Model only accounts for smolts and not other migrating juvenile life stages.	Biological	X	X					
Fall-run/spring-run Chinook salmon smolt survival (based on Newman 2003)	Estimates through-Delta survival of fall-run and spring-run Chinook salmon smolts on the Sacramento River, based on the coefficients determined by Newman (2003). Model inputs are DSM2-HYDRO and DSM2-QUAL data. The model operates at a daily time step.	Based on peer-reviewed paper including many years of coded-wire tag survival studies and includes numerous covariates (Sacramento River flow, south Delta exports, water temperature, turbidity, conductivity, position of Delta Cross Channel); provides information applicable to smaller size smolts (80 millimeters) than DPM.	Applied only to fall-run and spring-run Chinook salmon from the Sacramento River; limited to operations-related covariates (flow and exports, plus Delta Cross Channel gate position); does not account for potential benefits of the Yolo Bypass for migrating smolts.	Biological		X					
Interactive Object-Oriented Salmon Simulation (IOS)	IOS is a winter-run Chinook salmon life-cycle model used to evaluate the effects of multiple aspects of the BDCP on survival of winter-run Chinook salmon and population viability. Model inputs are CALSIM and SRWQM data. The flow and temperature effects are calculated with a daily time step, and the overall cohort survival is calculated for each year.	Life cycle model that includes several of the BDCP conservation measures. Hypotheses about reach-specific effects can be included in the model.	It is primarily operations focused and there is little to inform values for conservation measures including habitat restoration. Flows through the Delta are provided by CALSIM and therefore do not have daily variation.	Population and life history						X	
Oncorhynchus Bayesian Analysis (OBAN)	Complementary to IOS, the OBAN model is a winter-run Chinook salmon life-cycle model used to evaluate the effects of multiple activities on winter-run Chinook salmon survival, population dynamics, and population viability. Model inputs are CALSIM and SRWQM data. The model operates at an annual time step.	Life cycle model that reflects historical relationships between Chinook salmon abundance and environmental conditions.	Limited in terms of the flow variables included in the Delta portion of the model; does not readily account for north Delta effects of *CM1 Water Facilities and Operation*. The geographic scale of the model is broad.	Population and life history		X				X	
Sacramento Ecological Flows Tool (SacEFT)	SacEFT is used to assess the effects of flow changes in the Sacramento River on a set of physical (spawning area, juvenile rearing area, redd scour, and redd dewatering) and biological (egg survival, juvenile stranding, and juvenile growth) parameters for all races of Chinook salmon and steelhead. The model also illustrates flow-based effects on green sturgeon egg survival. The model operates at a daily time step.	Incorporates flow and water temperature inputs with multiple model concepts and field and laboratory studies to assess effects on multiple performance measures for fish species; peer-reviewed model.	Limited to upper Sacramento River; limited set of focal species (steelhead, Chinook salmon, and green sturgeon); third in a sequence of models (CALSIM and SRWQM), so limitations of previous models are compounded.	Biological and habitat suitability		X	X				
SALMOD	SALMOD is a simulation model for salmonids in the Sacramento River from Keswick to Red Bluff that is used to assess the effects of flows in the Sacramento River on habitat quality and quantity and ultimately on juvenile production of all races of Chinook salmon. The model operates at a weekly time step.	Measures effects of flows and water temperatures on spawning, egg incubation, and juvenile growth in terms of smolt production. Used extensively in Central Valley fishery assessments.	Model only extends from Keswick to Red Bluff. Not all life stages are represented (e.g., outmigration, ocean dwelling, upstream migration). Only assesses effects of flow and water temperature; not reasonably accurate for small spawner numbers (<500 fish). The number of spawners for each year is defined by the user.	Biological and habitat suitability		X					
Bureau of Reclamation Salmon Mortality Model	The Salmon Mortality Model is used to assess temperature-related proportional losses of eggs and fry for each race of Chinook salmon in the Trinity, Sacramento, Feather, American, and Stanislaus Rivers. The model operates at a daily time step and provides output on an annual time step.	Assesses effects at multiple locations within multiple rivers. Used extensively in Central Valley fishery assessments.	Limited to effects of water temperature on eggs only; daily time step requires linear interpolation between monthly temperatures to compute daily temperatures; third in a sequence of models (CALSIM and Reclamation Water Temperature Model), so limitations of previous models are compounded.	Biological		X					

					Appendix[a] in Which Model Is Applied						
Model	**Description**	**Benefits**	**Limitations**	**Model Type**	**5.B**	**5.C**	**5.D**	**5.E**	**5.F**	**5.G**	**5.H**
Delta Smelt Abiotic Habitat Index	Used to calculate area of delta smelt abiotic habitat in fall (September-December) based on the relationship described by Feyrer et al. (2011). Model input is CALSIM data for X2. Because the model is not temporally explicit, there is no time step.	Method has been peer-reviewed and includes relationships based on observed data.	Was developed based on a portion of delta smelt fall habitat (primarily Suisun Bay, Suisun Marsh, and West Delta subregions) that does not incorporate other areas where recent occurrence has been appreciable; based on two abiotic factors; based on linked statistical models without accounting for uncertainty in each model.	Habitat suitability		X					
Salvage-Density Method	The Salvage-Density Method uses historical salvage and flow data to estimate entrainment for a number of covered fish species. Model input is CALSIM data for south Delta exports. The model operates at a monthly time step.	Numerous data exist for covered fish species. Method has been used before to analyze effects of other projects.	Assumes a linear relationship between flow and entrainment, which may not be justified. Estimates of numbers of fish entrained should be viewed as highly uncertain, and focus should be on relative change between scenarios. In essence, the method is an indicator of changes in south Delta export pumping weighted by species seasonal patterns.	Biological	X						
Old and Middle River Flow Proportional Entrainment Regressions (delta smelt)	The Old and Middle River Flow Proportional Entrainment Regressions use linear regression (based on estimates from Kimmerer [2008, 2011]) and CALSIM data to estimate the proportion of delta smelt population that entrained. Model input is CALSIM data for Old and Middle River flows and X2. Because the model is not temporally explicit, there is no time step.	Provides estimates of the overall proportion of the delta smelt population that is lost to entrainment	Regressions are based on relatively few data points and on predictors averaged over several months, which may simplify underlying dynamics. Analysis does not include consideration of other factors such as turbidity.	Biological	X						
Effectiveness of Nonphysical Barriers	The effectiveness of nonphysical barriers assessment discusses results of recent studies at Georgiana Slough and Old River as well as literature studies to determine potential effectiveness of barriers at these and other Delta locations. Because the model is not temporally explicit, there is no time step.	Represents the analysis of a panel of experts and based partly on Delta-specific studies.	Does not directly address solely agricultural diversions within the BDCP restoration opportunity areas (ROAs) (but is probably sufficiently similar). Qualitative analysis only (however, estimates of number of diversions to be decommissioned as part of habitat restoration allow some context for the extent of entrainment reduction). Considerable uncertainty about velocities in barrier vicinity and potential predation.	Biological	X	X					
Screening Effectiveness Analysis (north Delta intake)	The screening effectiveness analysis estimates the potential for screening based on different sizes of fish approaching the north Delta intakes. Because the model is not temporally explicit, there is no time step.	Based on published literature for exclusion of fish at screened intakes.	Little is known of the occurrence of larval fish in the area and how fish that can be screened may respond to such large intakes. Qualitative discussion based on likely sizes of fish that will be excluded.	Biological	X						
Screen contact/ impingement/ passage time	Uses various equations to estimate the potential for mortality (delta smelt), screen passage duration (Chinook salmon), and screen contact rate (Sacramento splittail, adult delta smelt) at the proposed north Delta intakes. Because the model is not temporally explicit, there is no time step.	Based on published studies (UC Davis fish treadmill studies) that were specifically undertaken to inform risk of fish injury at water intake screens. Uses local species.	Uncertain the extent to which relatively benign laboratory conditions of the published studies are representative of field conditions.	Biological	X						
Kimmerer et al. (2009) X2-abundance regressions (longfin smelt)	The Kimmerer regression relationships use X2 to estimate annual abundance indices of longfin smelt in fall midwater trawls, bay midwater trawls, and bay otter trawls. Model input is from CALSIM data. Because the model is not temporally explicit, there is no time step.	Method has been peer-reviewed and includes regressions based on observed data.	Changes in the nature of the relationship in recent years appear to have occurred as a result of factors other than outflow; method does not account for population dynamics such as stock-recruitment relationships. The specific mechanism(s) underlying the flow/abundance relationship are not clearly understood.	Biological		X					
Wetland bench inundation	Assesses potential change in wetland bench inundation with differences in river stage along the Sacramento River and other locations in the North Delta and East Delta subregions. Model input is from DSM2-HYDRO stage data. Because the model is not temporally explicit, there is no time step.	Provides information about the potential changes in restored riparian areas along the Sacramento River.	Specific data for wetland bench elevations are not included, which limits inference regarding results. Results are complex and challenging to interpret.	Environmental		X					

					Appendix[a] in Which Model Is Applied						
Model	**Description**	**Benefits**	**Limitations**	**Model Type**	**5.B**	**5.C**	**5.D**	**5.E**	**5.F**	**5.G**	**5.H**
Sutter Bypass Inundation	Assesses potential negative effect of *CM2 Yolo Bypass Fisheries Enhancement* on Sutter Bypass inundation caused by Sacramento River backwatering. Model input is from CALSIM data. Because the model is not temporally explicit, there is no time step.	Provides information on potential trade-off between enhanced inundation in the Yolo Bypass and less inundation in the Sutter Bypass	Does not account for previous days of inundation in Sutter Bypass; assumes that empirically derived Verona flow-stage rating curve can be applied to CALSIM flow outputs at Verona.	Environmental			X				
Habitat suitability Models	Estimates weighted habitat potential of restored tidal wetland habitat for covered fish species in the Plan Area as a result of Conservation Measure 4. Model inputs include DSM2-QUAL and modeling of habitat types to obtain area and depth of potentially restored tidal areas. The model is not temporally explicit, although conditions reflect modeled conditions at the BDCP time steps.	Evaluates characteristics of potentially restored habitat against explicit habitat suitability relationships to convert acres of tidal environments into habitat units for life stages of covered fish species.	Physicochemical variables are based on DSM2 modeling for adjacent existing areas, for which spatial coverage varies; input data is monthly for broad segments of the Plan Area and miss potentially important finer scale habitat features. Turbidity data are based on historic observations and not modeling. Habitat suitability does not address species conservation needs.	Habitat suitability				X			
Egeria densa habitat suitability	Two related methods that estimate the extent of potential *Egeria* habitat within restoration opportunity areas primarily as a function of water depth and velocity, and changes in existing channel velocity in relation to a maximum annual flow threshold for *Egeria* presence. Model inputs are from DSM2-HYDRO data and RMA model. Because the model is not temporally explicit, there is no time step.	Provide quantitative basis for potential *Egeria* habitat	Methods do not include other potential factors of importance such as turbidity and substrate type; velocity method only considers a threshold velocity and does not account for potential continuous change	Habitat suitability					X		
Potamocorbula amurensis habitat suitability	Estimates extent of potential *Potamocorbula* habitat in the Suisun Bay and West Delta subregion based on X2 during the summer-fall recruitment period. Model input is from CALSIM data. Because the model is not temporally explicit, there is no time step.	Includes consideration of seasonal pattern of recruitment	Does not include Suisun Marsh subregion; habitat suitability is based only on salinity and does not include other factors such as substrate type; does not consider subsequent flow effects that could affect adults	Habitat suitability					X		
Selenium Loading	Selenium loading uses DSM2 and the calculated total load of the contaminant within each watershed to estimate the diluted concentration of contaminant in the Plan Area. Because the model is not temporally explicit, there is no time step.	Largemouth bass (example fish used in modeling) is a high level consumer and shows effects of bioaccumulation.	Water and fish tissue modeling results do not account for reasonable future decrease in selenium in the system and likely overestimates concentrations.	Environmental			X				
Mercury/ Methylmercury Loading	Mercury/methylmercury loading uses DSM2 and the calculated total load of the contaminant within each watershed to estimate the diluted concentration of contaminant in the Plan Area. Because the model is not temporally explicit, there is no time step.	Largemouth bass (example fish used in modeling) tissue concentrations have been described recently over a wide area of the Delta and are they are excellent indicators of long-term average mercury exposure, risk, and spatial pattern for both ecological and human health.	The DSM2-estimated water concentrations consistently over-predicted the fish concentrations as compared to the regression model	Environmental			X				
Noise Effects of Underwater Construction	Underwater sound generated by impact pile driving was determined by using The California Department of Transportation (2009) information on pile driving and estimating the attenuation of sound using a spreadsheet model created by the National Marine Fisheries Service (NMFS) (2009c). Because the model is not temporally explicit, there is no time step.	Based on best available science and understanding associated with underwater sound impacts to fish species.	Assumptions regarding type of pile driving results in uncertainty regarding the effects associated with underwater sound.	Environmental							X
Yolo Bypass Fry Growth Model	Used to estimate the differences in growth of Chinook salmon fry in the Yolo Bypass compared to the mainstem lower Sacramento River. Model input is from CALSIM data. The model operates at a daily time step.	Provides comparison of alternate migratory routes for fry in terms of growth and size-related survival.	Currently limited to fall-run Chinook salmon. Enhanced growth rate on Yolo Bypass floodplain is modeled as a function of duration of flooding and does not include potential benefits of productivity related to flooded area.	Biological		X					
Total Models				**68**	**11**	**24**	**12**	**4**	**11**	**5**	**1**

[a] Appendix 5.B, *Entrainment*; Appendix 5.C, *Flow, Passage, Salinity, and Turbidity*; Appendix 5.D, *Contaminants*; Appendix 5.E, *Habitat Restoration*; Appendix 5.F, *Biological Stressors on Covered Fish*; Appendix 5.G, *Fish Life Cycle Models*; Appendix 5.H, *Aquatic Construction and Maintenance Effects*;.

DRERIP = Delta Regional Ecosystem Restoration Implementation Plan; CVP = Central Valley Project; DSM = Delta Simulation Model; PTM = Particle Tracking Model; RMA = Resource Management Associates, SRWQM = Sacramento River Water Quality Model; ESO = evaluated starting operations; DPM = Delta Passage Model; IOS = Interactive Object-Oriented Salmon Simulation; SacEFT = Sacramento Ecological Flows Tool; ROA = restoration opportunity area; OBAN = Oncorhynchus Bayesian Analysis; NMFS = National Marine Fisheries Service.

5.2.7.5 Biological Models

Biological models link environmental change, often characterized by the environmental models, to the change in biological performance of life stages or species. Biological performance is typically measured as a change in abundance, survival, or physical impact such as the percentage of a life stage entrained in pumps. Many of the biological models used in the effects analysis are statistical in nature and consist of single or multinomial regressions between physical change, such as flow or exports, and life stage biological performance. Biological models are often linked to environmental models and characterize a biological change expected from the modeled change in physical conditions. Figure 5.2-4, for example, shows the biological models used to assess entrainment effects on delta smelt and the relationship to CALSIM II and DSM2. This figure also shows how biological models relate to specific life stages and reflect unique hypotheses about stressors and biological performance. Models used to evaluate entrainment (Appendix 5.B, *Entrainment*) and the effects of flow, temperature, salinity, and turbidity (Appendix 5.C, *Flow, Passage, Salinity, and Turbidity*) on biological performance fall into this category.

5.2.7.6 Habitat Suitability Models

Habitat suitability models (or habitat suitability index models) provide an index of habitat acreage weighted by the suitability of the habitat for individual species. Habitat suitability does not directly translate into abundance or evaluate conservation needs for individual species. The technique provides a way to compare potential value of restoration between areas and between species. Suitability is measured by a habitat suitability index (HSI) that incorporates suitability criteria for multiple attributes of habitat (e.g., temperature or salinity), where 0 indicates entirely unsuitable habitat and 1 represents ideal habitat for the life stage and species. Suitability only addresses a restricted set of attributes potentially determining habitat occupancy by a species at any time or place; hence a suitability of 1.0 does not necessarily translate into high fish abundance, and fish will occupy less suitable habitat. While these indices do not guarantee the level of use by species or translate directly into abundance of individuals, they provide an indication of the relative differences among habitat types for a particular species and provide a means to compare habitat conditions between areas and species. HSI values for species life stages in a geographic subregion are applied to estimates of area-depth strata within the subregion to calculate habitat units (HUs) for a species life stage. In Appendix 5.E, *Habitat Restoration*, habitat suitability models are used to evaluate the potential habitat that could be provided by restoration of tidal natural communities under CM4.

Habitat suitability models bring together knowledge of life history, key habitats, and environmental requirements to create an index of habitat quality and quantity where a quantitative life cycle–habitat model is not available. Habitat suitability models collect a variety of information relating to habitat requirements to create hypotheses of species-habitat relationships rather than statements of proven cause-and-effect relationships (Schamberger et al. 1982).

Habitat suitability models are commonly used in fish and wildlife assessments. Although they evaluate habitat for a single species, results can be compared across areas and species but do not incorporate ecological or biological community effects. The resulting suitability-weighted acreage (HUs) is almost always greater than zero. Because almost any habitat has some suitability, HUs are almost always appreciably greater than zero. HUs do not address potential habitat limitations or project the effects of restoration in terms of population abundance or extinction risk. Nonetheless, the technique provides a species-specific adjustment of potentially restored acres that can be compared across the Plan Area and species. Habitat suitability models are used to evaluate the value of restored wetland and intertidal environments (*CM4 Tidal Natural Communities Restoration, CM5 Seasonally Inundated Floodplain Restoration, CM6 Channel Margin Enhancement,* and *CM7 Riparian Natural Community Restoration*) for covered fish species in Appendix 5.E, *Habitat Restoration*.

5.2.7.7 Population and Life-History Models

Life-history models integrate the effects of multiple stressors across multiple life stages to evaluate impacts of actions at population scales. Life-history models are conceptually attractive because they offer the prospect of evaluating the effect of multiple stressors on the ultimate survival or abundance of the species (National Research Council 2011). However, life-history models are not available for most species. In addition, the available life-history models address particular subsets of environmental conditions, but not all conditions that might be affected by the BDCP. Several life-history models for salmonids are listed in Table 5.2-5, reflecting the rich quantitative literature associated with population dynamics of salmonids (Hilborn and Walters 1992). For other covered fish species such as longfin smelt, delta smelt, splittail, and sturgeon, life-history models do not exist or are still relatively new.

5.2.7.8 Conceptual Model of the Effects Analysis

The premise of the effects analysis model is that the BDCP will alter the physical and biological environment of the Delta, which in turn will affect biological performance (abundance, persistence, and fitness) of covered fish species. The performance of a species in an environment is the result of characteristics of the habitat shaped by natural and anthropogenic (human-caused) factors (Southwood 1977; Peterson 2003). Alteration of these conditions through covered activities will produce a corresponding, though not typically proportional, change in species performance (Hall et al. 1997).

The quality and quantity of habitat available for a species is controlled at multiple scales by ecological drivers. Geology, biogeography, marine conditions, and climate are large-scale drivers of conditions in the Study Area that set the intrinsic potential of the system. These interact with human-controlled land use to shape the environment that controls biological performance under present conditions. Flow is a secondary driver that is controlled in the Study Area by the primary drivers of climate (precipitation) and land use (flow regulation). It is included as a driver because of its importance in shaping freshwater and estuarine environments. The BDCP is a modifier of human land use that changes the underlying environmental template resulting in positive and negative changes in species performance.

5.2.7.9 Measures of BDCP Impacts

5.2.7.9.1 Habitat

The BDCP will affect the environment in ways that are viewed positively or negatively as habitat for species. Hence, habitat and habitat change are important measures of species impacts under the BDCP. As stated above, a premise of the effects analysis is the relationship between qualities of the environment and species performance. Fundamental to this is the notion of *species perception.* This is the view of the environment from the perspective of the species and reflects the species' unique physiological and life-history requirements (Mobrand et al. 1997). From the perspective of the species, the environment is viewed as *habitat,* which is the suite of physical, chemical, and biological factors determining species abundance and persistence over time (Hayes et al. 1996). As noted in Ecological Principle 7 from the BDCP Science Advisors, "habitat should be defined from the perspective of a given species and is not synonymous with vegetation type, land (water) cover type, or land (water) use type."

Habitat can be described in two general categories that relate to species performance (Figure 5.2-5). The *quantity* of habitat is a measure of amount of suitable habitat. The *quality* of the habitat is characteristics of the habitat that relate to species performance such as temperature, water quality, prey density, water currents, instream structures, or turbidity. Habitat quantity and quality are not independent. Habitat quantity is not just the amount (e.g., square meters or volume) of particular habitats but is also a function of the quality of that habitat. Both habitat quantity and quality are defined with respect to life stages, which can often provide dramatically different habitat perceptions within the same species. For example, fish often seek particular types of habitat for spawning that are quite different from those used by adults for feeding.

5.2.7.9.2 Species Performance

Habitat quantity and quality can be related to species performance. While habitat *writ large* clearly is a key determinant of species performance, the relationship can be quite complex and the direct, simple relationships between habitat attributes and species performance are rarely demonstrated. The notion of a relationship between species performance and environmental conditions underlies efforts to restore habitat or to limit the impact of human-induced environmental change. Restoration and environmental conservation are both based on the premise that environmental conditions constrain species performance including measures of abundance, survival. and persistence.

Quantity of suitable habitat is a key determinant of capacity of the environment for a species. Quality of habitat is a control on survival. In terms of fish population dynamics, quantity of habitat determines carrying capacity and quality of habitat controls density-independent survival or productivity. Together, capacity and productivity control the abundance of fish that can be supported in an environment (Hilborn and Walters 1992). The quantity and quality of habitat can be quite variable over time and space due to variation in factors of larger and smaller scales. Biological diversity within a species is a reflection of that habitat variation. Over larger scales, the spatial distribution of habitat patches across the landscape results in biological diversity and spreads the risk of failure or loss of habitat patches (Lindley et al. 2007).

Habitat characteristics can be measured in metrics of species performance such as growth, survival, abundance, and population recovery. The concept of viable salmonid population (VSP) (McElhany et al. 2000) provides a useful framework for defining fish population performance. Because VSP is based on general fisheries population biology, including stock recruitment (Hilborn and Walters 1992), the general outline of VSP has application for nonsalmonid fish species, including Delta fish species. Note that there are issues discussed in McElhany et al. (2000) that are specific to recovery of salmon populations that may not be applicable to all species.

VSP defines fish performance along four axes:

- Abundance or population size
- Population growth or productivity over the life history

- Diversity
- Spatial distribution of the population

Abundance is simply the number of fish making up a fish population that results from the balancing of productivity and capacity that in turn reflect the quality and quantity of habitat. Populations must be sufficiently abundant to counter the effect of stochastic events (e.g., catastrophes) and genetic effects of small population size.

Population growth or productivity is the rate of change in population size over time constrained by overall carrying capacity and density dependence. Density dependence means that survival and population growth are expected to be highest at low population abundance when competition for resources is least and declines as abundance increases and approaches capacity.

Diversity refers to the variety of morphological, behavioral, and life life-history history traits that can occur within a fish population. Life-history diversity represents the range of solutions that allow a population to cope with environmental variation and heterogeneity. Diversity is generally assumed to have a genetic component, although phenotypic plasticity also contributes to diversity in salmonid populations (Hutchings 2011).

Spatial distribution of the population refers to its structure across the landscape. To be viable over long periods, populations need to have multiple centers of productivity to cope with catastrophic events, such as volcanic eruption or earthquakes, which could wipe out the population if it was confined to a single restricted location. Strictly speaking, with respect to VSP, this measure refers to the structure of the population across the landscape within an evolutionarily significant unit (ESU) for salmon or distinct population segment (DPS) for steelhead. Although these types of population definitions have not been developed for nonsalmonids, the need for multiple centers of population production holds for others species as well.

Other measures of biological performance are encompassed by these four overall measures. Growth of individuals within a population, for example, reflects productivity and the availability of resources relative to abundance.

The VSP measures can be related to characteristics of habitat (McElhany et al. 2000) and hence to actions, including the covered activities. The following relationships are assumed to occur in Delta fish species.

- Abundance, while of obvious importance, is a poor discriminator of habitat conditions because it can be affected by change in many different attributes of the environment. However, abundance is affected by carrying capacity, which is a function of habitat quantity. For purposes of evaluating habitat change as a result of BDCP we will consider capacity measured as the quantity and type of habitat. Species have unique requirements that define key habitats for each life stage. Hence, habitat quantity refers the amount (e.g., square meters) of specific key habitats for the species and not simply the size of the environment.
- Productivity is affected by habitat quality that is set by values of environmental attributes filtered through the species perception. This includes species requirements for temperature, water quality, nutrients, and so on.
- Diversity is a function of heterogeneity of habitat across the landscape. Habitat heterogeneity reflects the natural dynamics of flow and other habitat forming processes that create a mosaic of habitat of varying quantity and quality spatially and temporally. Within the genetic capabilities

of the species, phenotypic, behavioral, and life-history diversity develops in response to habitat heterogeneity.

- Spatial structure reflects the distribution of suitable habitat patches across the landscape that can support productive centers for population abundance and productivity (McElhany et al. 2000).

Biological performance and habitat conditions can be measured and monitored using a variety of indicators to chart progress over time. These indicators can be related to the biological goals and objectives developed for the BDCP. This provides a completed structure to relate covered activities to the biological goals and objectives.

5.2.7.10 Approach for Determining Net Effects on Covered Fish Species

Typically, an effects analysis for a habitat conservation plan (HCP) or natural community conservation plan (NCCP) evaluates the adverse effects of development projects or other ground-disturbing activities that seek take coverage. These adverse effects are then combined with the beneficial effects of the conservation measures to determine the net effect of all covered activities (conservation measures are also covered activities). The BDCP is unusual in that the conservation measures themselves account for the majority of the covered activities and have both beneficial and adverse effects, depending on the covered species. To account for this structure, the effects analysis evaluates the combined effects of all covered activities, including the conservation measures, to determine the net effect of implementing the Plan.

To do this, it is necessary to determine three outcomes for each covered species: the effects of incidental take on organisms and populations, the beneficial effects expected to result from the conservation strategy, and how these outcomes yield a net effect on the species during the BDCP term. HCPs are required (Section 10(a)(2)(A)(i) of the ESA) to describe the impact of the take on each covered species. The impact of the take is defined as the effect of all take on species and their populations. Take is not necessarily equivalent to adverse effects; some adverse effects may not rise to the level of take. Beneficial effects are those effects that have a demonstrable benefit for the species, such as by supporting population recovery, establishing new or enhanced habitat, or reducing habitat fragmentation. Net effects are derived by integrating adverse and beneficial effects.

The biological effects of individual conservation measures were integrated to arrive at overall conclusions regarding the effects of the BDCP on covered fish species. The Chapter 5 appendices detail the results of quantitative and qualitative analysis and review of scientific literature associated with the covered activities and conservation measures. Table 5.2-4 identifies the different covered activities and conservation measures, and where the analysis and results for each fish species related to these measures can be found.

The material and conclusions from each appendix to this chapter are integrated in this chapter to form a set of overall conclusions on adverse, beneficial, and net effects. The net effects analysis assumes that there is no overarching analytical framework that integrates all effects and derives a quantitative estimate of the overall effect of the BDCP. Instead, the BDCP effects analysis is designed to provide a transparent, systematic, and comprehensive process for combining results from quantitative and qualitative analyses. This process is described below. The conclusions represent qualitative judgments of the effects of the BDCP that are grounded in the detailed quantitative and qualitative analyses in the appendices.

The effects analysis is intended to summarize the results from the detailed analyses in the appendices and derive an overall conclusion regarding the potential impacts of BDCP on the ecosystem and on covered fish species. Conclusions of net effects must be based on the best available science. The evaluation of BDCP is based on extensive quantitative and qualitative analysis and consultation with the fishery managers. Ideally, a model would exist that combined all of the individual effects to derive overall conclusions on each covered fish. This ideal model would also take into account interactions among factors, for example. However, no such model exists. Therefore, BDCP net effects conclusions are necessarily qualitative and synthesize results from the more detailed (and often quantitative) analyses found in the appendices to this chapter. While qualitative, the net effects conclusions are derived from a transparent and structured approach. This approach is based on conceptual models that describe the logic and assumptions embedded within the effects analysis.

The effects analysis focuses on the impacts of covered activities, including conservation measures, on covered fish species in the Plan Area. This impact is measured as the biological significance of change to the environment within the Plan Area as a result of covered activities. More precisely, we assess the biological significance of covered activities in regard to two factors.

- The relative importance of environmental attributes as constraints on species population and life stage performance.
- The potential change in the environmental attributes as a result of conservation measures.

The first component is biological in nature and relies on available information to derive a general conceptual model for each covered fish species. The second component captures conclusions drawn from the detailed quantitative and qualitative analyses contained in the appendices to this chapter. The final step is to combine these two scores to derive an overall conclusion regarding the biological importance of environmental changes expected to result from the conservation measures.

The intent of this process is to distinguish four possible conclusions for the effects of the conservation measures.

- The BDCP has a substantial impact on environmental attributes that have little importance to the covered fish species.
- The BDCP has a small impact on attributes of major importance to the species.
- The BDCP has a substantial impact on attributes of major importance to the species.
- The BDCP has no effect on an attribute.

As discussed further below, *importance* of an attribute to a species refers to the relative importance of an attribute as a constraint on current performance (capacity, productivity, and diversity) of the species.

Alternative approaches to the net effects analysis were also considered. One alternative would be to only assess BDCP effects on the environment. This would avoid the step of establishing a pattern of relative importance for the attributes for the species and its associated scientific uncertainty and variability. While simpler, this approach would not provide any insight on biological significance of environmental changes caused by conservation measures, and it would be expected to either overestimate or underestimate effects on the covered species because BDCP effects on the environment were not calibrated to their importance to the covered species. The process used here provides the best transparency and documentation for the net effect determinations for the following reasons.

- There is precedent for describing the relative importance of attributes (stressors) on performance of covered fish species in other regional processes, including the DRERIP process discussed below.
- Prioritization of problems and solutions (either implicitly or explicitly) is the basis for most planning exercises, including the BDCP.
- Although noting that assessing or ranking attributes (stressors) is very complex, the Delta Independent Science Board (2011) suggested that the relative importance of stressors cannot be assessed, or prioritized, independent of the relative importance of the objective that is stressed.
- The Delta Science Program's Science Review Panel on the BDCP Effects Analysis (2012) provided favorable reviews of an earlier version of this approach in the draft net effects analysis, notwithstanding important suggestions for refinement. There was no suggestion that such a methodology was not feasible.

5.2.7.10.1 Description of Conceptual Models Used in the Effects Analysis for Covered Fish

The BDCP effects analysis is structured around a description of the environment and a set of conceptual models linking environmental controls to covered activities. The environment is described in terms of a set of environmental attributes listed and defined in Table 5.2-6. The environmental attributes are similar to those used in the DRERIP models (in DRERIP they are referred to as stressors). The list of attributes in Table 5.2-6 was developed from review of the scientific literature relating to the Delta and from discussions with delta scientists and managers. The attributes were also chosen for their relationship to the conservation measures and to the biological performance of listed fish species. The attributes are grouped into categories of conditions that affect the listed fish species. The 12 attribute categories are the conditions that are generally discussed by resource managers, scientists, and stakeholders in relation to delta fish performance.

The attributes are defined in Table 5.2-6 in regard to *change in the attribute due to human actions relative to the natural condition in the Plan Area*. For the effects analysis, the natural condition of the attribute is its condition without recent anthropogenic constraints. In this case, the natural condition is not the same as the historical condition. For example, the natural reference for the *Zooplankton Community* attribute is the zooplankton community that existed in the Delta prior to the major species shift that occurred in the 1980s (Kimmerer 2002), recognizing that the condition in the 1980s was appreciably different than the condition prior to large-scale human alteration of the environment starting in the midnineteenth century. This defines the attribute of *Zooplankton Community* as the change in that species list that has occurred as a result of human actions (e.g., species introductions) and that has potentially positive or negative impacts on fish species. The natural reference also applies to attributes that are entirely anthropogenic in nature, such as entrainment. The natural condition of *Entrainment* is no entrainment. The attribute captures the effects of entrainment under the BDCP baseline (EBC2) as a constraint on current species performance while accounting for pumping restrictions implemented under the USFWS (2008) and NMFS (2009) BiOps. In the case of the north Delta intakes, which currently do not exist, the attribute is defined as the projected configuration and intakes under ESO relative to the current condition where the intakes will be built.

In Table 5.2-6, the "*Appendix Where Evaluated"* column refers to appendices to this chapter that describe analyses related to an attribute or an attribute category. The *Entrainment* and *Predation* conceptual models are found in Figure 5.B.2-1, *Conceptual Model of Biotic and Abiotic Factors Influencing Entrainment and Impingement Loss of Covered Fish Species*, in Appendix 5.B, and Figure 5.F.6-4, *Conceptual Model of Predation-Related Effects of BDCP Conservation Measures*, in Appendix 5.F, respectively. The remaining attributes' conceptual models are in Section 5.3, *Ecosystem and Landscape Effects*.

The conceptual models explicitly define the attribute categories that describe Delta conditions and link them to covered activities and to specific attributes that act as constraints on current fish performance. Figure 5.2-6 illustrates the elements of the conceptual models. *Drivers* are large-scale controls on the environmental character of the Delta, such as precipitation, climate, and geology (DiGennaro et al. 2012). *Environmental attributes* (Table 5.2-6) are factors that directly affect biological outcomes of covered fish species. These attributes are affected by *contributing factors* that may not directly affect survival, for example, but create conditions that affect the environmental attribute to in turn affect survival. Some contributing factors (designated by grey shading) are influenced by one or more BDCP conservation measures. Broad arrows on the top or bottom of an attribute box indicate an increase or decrease in factor; the color of the arrow indicates whether the change is positive (blue) or negative (red) for the biological outcome. The result is a logic path linking environmental attributes and conservation measures to biological outcomes.

To illustrate this concept, a hypothetical environmental attribute, created in Figure 5.2-6, directly affects fish survival. Explanatory boxes illustrate the relationships within the figure. As shown by the red broad arrow up, increasing the environmental attribute is bad for covered fish species and decreasing it results in improved biological performance (blue broad arrow down). The environmental attribute is affected by a contributing factor in the same way, shown in the upper left. The environmental attribute is also affected by a second factor below it, which is influenced by one or more conservation measures (grey box). In this example, the conservation measure reduces the contributing factor (blue arrow down), which has a positive effect on the environmental attribute (directional linkage to the blue arrow down in the environmental attribute). The same contributing factor is also affected by a driver that acts independently. The result is a logic path explaining a hypothesis regarding factors controlling the environmental attribute and the linkages to this attribute from drivers and contributing factors, some of which will be affected by conservation measures. Using this approach, the assumptions and linkages in the analysis provide a roadmap to how the net effects were derived.

Table 5.2-6. Environmental Attributes Used in the Effects Analysis

Category	Appendix[a] Where Evaluated	Attributes	Definition
Plan Area Environmental Attributes			
Food	5.E	Zooplankton community	Species composition of the zooplankton community and presence of suitable prey species
		Zooplankton abundance	The abundance of zooplankton
		Benthic and epibenthic prey abundance	The abundance of epibenthic prey species such as amphipods
		Insect abundance	The abundance of insect prey
Entrainment and impingement	5.B	North Delta intakes	Potential entrainment/impingement from the proposed North Delta intakes
		South Delta pumps	Pumping rate from the CVP/SWP south Delta export facilities and resulting entrainment
		North Bay Aqueduct	Entrainment from the SWP NBA facilities
		Agricultural diversions	Entrainment from Agriculture Diversions
Migration and movement	5.C	Plan Area flows	Magnitude, timing, direction, and duration of flows during migratory periods throughout the Plan Area
		Interior Delta entry	Entry of fish into the interior Delta from the mainstem Sacramento or San Joaquin Rivers through channels such as Georgiana Slough or Old River
		Passage barriers	Structures or conditions that potentially block upstream or downstream migration
Habitat	5.E	Intertidal habitat	Intertidal area from the mean low low water level to the extreme high water level that may support intertidal vegetation and form mudflats; dynamic elements of habitat such as appropriate salinity are considered on a species-specific basis
		Channel margin	The extent of shallow water, low slope habitat that generally is characterized by structural complexity, native emergent vegetation and riparian shading cover
		Floodplains	The interface between upland topography and river hydrology during high flow events
		Riparian	Forest and scrub that occurs along the margins of river channels and within floodplains
		Subtidal habitat	Extent and location of sub-tidal area in the Plan Area, including the low salinity zone; dynamic elements of habitat such as appropriate salinity are considered on a species-specific basis
Sediment	5.C (5.C.D)	Water clarity	Water clarity in the Plan Area as influenced by amount of suspended material within the water column
Temperature	5.C	Temperature	Adverse effects of high temperatures within the Plan Area
Dissolved oxygen	5.C	Dissolved oxygen	Adverse effects of low dissolved oxygen level within the Plan Area

Category	Appendix[a] Where Evaluated	Attributes	Definition
Contaminants	5.D, 5.F	Contaminants	Adverse effects of methylated mercury, selenium, pesticides and other pollutants
		Microcystis	The abundance of Microcystis aeruginosa blooms that are toxic to covered fish species and their food
Predation	5.F	Predation	The species-specific consumption of covered fish species by predatory fish (e.g., striped bass, Sacramento pikeminnow, centrarchid bass species, catfish, and inland silversides); note that the attribute aims to isolate predation effects that may not be captured by other attributes, e.g., at manmade structures such as the north Delta diversions
		Illegal harvest	Illegal harvest of covered fish species in the Plan Area
Sacramento River Environmental Attributes			
Instream habitat	5.C	Sacramento River habitat	Flows in the Sacramento River mainstem (below Keswick Dam to the Plan Area) that influence spawning, egg incubation, rearing, or holding habitat
		Feather River habitat	Flows in the Feather River (below Oroville Dam to the confluence with the Sacramento River) that influence spawning, egg incubation, rearing, or holding habitat
		American River habitat	Flows in the American River (below Nimbus Dam to the confluence with the Sacramento River) that influence spawning, egg incubation, rearing, or holding habitat
Migration and movement	5.C	Sacramento River migration flows	Flows in the Sacramento River mainstem (below Keswick Dam to the Plan Area) that influence migration and movement
		Feather River migration flows	Flows in the Feather River (below Oroville Dam to the confluence with the Sacramento River) that influence migration and movement
		American River migration flows	Flows in the American River (below Nimbus Dam to the confluence with the Sacramento River) that influence migration and movement
Temperature	5.C	Sacramento River temperature	Adverse effects of high water temperatures in the Sacramento River mainstem (below Keswick Dam to the Plan Area)
		Feather River temperature	Adverse effects of high water temperatures in the Feather River (below Oroville Dam to the confluence with the Sacramento River)
		American River temperature	Adverse effects of high water temperatures in the American River (below Nimbus Dam to the confluence with the Sacramento River)

[a] Appendix 5.B, *Entrainment*, Appendix 5.C, *Flow, Passage, Salinity, and Turbidity*, Appendix 5.D, *Contaminants*, Appendix 5.E, *Habitat Restoration*, Appendix F, *Biological Stressors on Covered Fish.*

5.2.7.10.2 Linking Environmental Attributes to Biological Performance

Models like the one described above provide a helpful roadmap to evaluate the effects of conservation measures on environmental attributes, such as predation, that are important to covered fish. Additional models are then needed to link these changing environmental attributes to the life histories of the covered species. Once this link is made, changes in biological performance can be assessed.

Defining Biological Performance

The attributes in Table 5.2-6 are related to biological performance for life stages and the populations. For each life stage, attributes are scored as constraints on the current survival and abundance of the life stages. These scores are based on reference to current scientific literature and consultations with the fish and wildlife agencies (USFWS, NMFS, CDFW). For salmonids, the attributes are associated with the components described in the NMFS VSP concept (McElhany et al. 2000). For BDCP purposes, these concepts are expanded to nonsalmonids and designated viable population attributes. These measures of performance are discussed below.

Life Stage Attribute Importance

The attributes in Table 5.2-6 have widely varying impacts as constraints on the current status of the covered fish species and life stages. A pattern of the relative importance of attributes as constraints on the current biological performance of the species emerges from the available research on these impacts. This pattern of relative importance may vary considerably between years as a result of water conditions (dry versus wet years); spatially between geographic subregions within the Plan Area; and due to many other factors, some of which are know but many of which are not. Nonetheless, there is a general pattern to the importance of attributes as constraints on species and life stages and that pattern provides a useful means to assess the relative importance of environmental changes resulting from conservation measures on the covered fish species.

The relative importance of each attribute is defined in the species model as a constraint on potential performance of life stages using a scale of 0 (no constraint on performance) to 4 (highly important constraint on performance). Establishing the pattern of attribute importance is similar to the ranking of stressors in the DRERIP species models (e.g., Williams 2008; Nobriga and Herbold 2009; Rosenfield 2010). The conclusions made regarding the relative importance of attributes as constraints on species performance are qualitative and represent expert conclusions based on review of available literature. The rationale and support for these conclusions are captured in the associated rationale statements.

Population Level Attribute Associations

Implicit in the pattern of attribute importance for life stages is their effect on species performance of each species. To define species performance we refer to the concept of VSP (McElhany et al. 2000) developed by NMFS to describe performance of salmonid populations listed under the ESA. While developed specifically for populations of listed salmonids, the VSP metrics are strongly rooted in standard fish population dynamics theory and have broad conceptual applicability to covered fish species.

The VSP concept provides four metrics for defining biological performance of fish species: abundance, population growth rate (lifecycle productivity), spatial structure both within and between populations, and biological diversity (McElhany et al. 2000). A viable fish population must be sufficiently abundant to maintain fitness and weather environmental variation; it must have sufficient productivity to maintain abundance above the minimum viable level (productivity should exceed replacement); it should be spatially distributed across the landscape to spread the risk of adverse events and to promote development of genetic diversity within the population; and finally, a viable fish population needs to have a diversity of biological and behavioral traits to accommodate environmental variation over time. Development of these traits within fish populations is the result of habitat conditions and the inherent biological capabilities of the species (dispersal, life history, and genetics).

Although the VSP concept is well-grounded in fisheries population dynamics, it has proven difficult to implement for salmon populations and has not been applied to other covered fish species. Productivity, spatial structure, and diversity are difficult to measure in the field. Furthermore, meaningful trends in any of the VSP parameters only arise from long time series of observations, which are generally lacking. NMFS has used the VSP concept to set recovery criteria and to guide recovery planning (Lindley et al. 2007). However, making quantitative linkages between specific actions, such as those in the BDCP, and VSP parameters has proven difficult (National Marine Fisheries Service 2009b).

The application of the VSP concept to the evaluation of BDCP effects relies on the fact that fish population dynamics are a reflection of habitat characteristics (Hayes et al. 1996) and that the VSP metrics can be related to habitat attributes (McElhany et al. 2000). Because the conservation measures affect habitat, the expected change in attributes can be related to the VSP parameters. Abundance can be related to biological carrying capacity, which is a function of the quantity of habitat. Productivity is a function of habitat quality, spatial structure relates to the distribution of suitable habitat across the landscape (spatial variation in habitat), and diversity arises in response to environmental variation. This allows associations between the attributes in Table 5.2-6 and the VSP parameters to be mapped. The quantity (e.g., acreage) of specific habitat can be related to abundance; habitat quality attributes such as temperature, salinity, toxins, and turbidity map to species productivity; and the quantity and diversity of habitat types (e.g., shallow tidal habitat) creates the potential for development of population structure and greater biological diversity.

For purposes of the effects analysis, the mapping of environmental attributes (Table 5.2-6) onto the VSP/viable population attribute(VPA) parameters applies to the assemblage of salmonid species addressed by the analysis. In other words, we assume that the quantity, quality, distribution, and heterogeneity of habitat across the Plan Area relate to the development of abundance, productivity, spatial structure, and diversity of fish species generally. However, the effect of conditions in the Plan Area and the BDCP vary greatly between species at a population level because of the variation in use of the Delta between species and exposure to BDCP effects. The viability of Central Valley salmonid ESUs, for example, is only partially the result of conditions in the Plan Area; salmonid population viability is a function of conditions in tributaries, the Sacramento and San Joaquin Rivers, the Delta, and the Pacific Ocean, and is only partially affected by covered activities. However, the viability of species whose habitat is largely restricted to the Plan Area, such as delta smelt, is affected to a much greater degree. With this caveat, mapping the associations between environmental attributes and VSP parameters and then associating conservation measures to future change in the attributes provides insights into how the BDCP potentially relates to population performance and the VSP parameters.

5.2.7.10.3 Determination of BDCP Effects on Covered Fish Species

The conservation measures will result in changes to many of the environmental attributes in Table 5.2-6. These changes are illustrated in the conceptual models that are drawn in the format of the example in Figure 5.2-6. Some of these changes are very direct, such as the change in water exports

(*CM1 Water Facilities and Operation*) and the restoration of tidal habitat (*CM4 Tidal Natural Communities Restoration*). Other changes are more indirect, such as changes in turbidity or water quality that occur indirectly as a result of other measures. These effects have been analyzed in detail in Appendices 5.A through 5.F. In the analysis of net effects of the BDCP, qualitative conclusions are made regarding the changes to the environmental attributes in Table 5.2-6 as a result of the BDCP, based largely on the detailed analyses discussed in the appendices. Conclusions regarding changes to the attributes as a result of the BDCP have components of magnitude and direction. Magnitude captures qualitative ranking of the amount of change in the attributes (Table 5.2-6) expected in the LLT as a result of a conservation measure. Change is scored from 0 (no change) to very high (a major change in the attribute). Direction indicates change relative to the normative condition; a positive direction indicates that the conservation measure was assessed to move the current condition of the attribute in the direction of the natural condition while a negative direction indicates movement away from the natural condition.

The overall conclusions regarding the effect of the conservation measures on covered fish species was made by weighting the conclusion regarding the environmental effects of conservation measures by the assumed importance of environmental change to the species. The logic of this process is illustrated in the following example: On the basis of quantitative and qualitative analyses in the appendices to this chapter, it is concluded that the BDCP will result in a positive (toward natural) change in an attribute, and, on the basis of the species attribute importance, change in that attribute is important to one or more life stages of a species. Therefore, it is concluded that the BDCP has an high change on that species/lifestage. This conclusion is documented by computing a simple score: BDCP effect on an attribute times the importance of the attribute to the species/life stage.

5.2.7.10.4 Certainty of Effects Conclusions

The qualitative conclusions regarding the effect of BDCP conservation measures on covered fish species are based on analyses in Appendices 5.A through 5.F as well as existing scientific literature and studies. These conclusions vary in regard to certainty due to scientific support as well as environmental variability and unpredictability. To capture this, the certainty of the conclusions made regarding the scientific basis for ratings of attribute importance for the species life stages (4.a) and on the potential outcome of conservation measures on the attributes (4.b) are characterized using a scale from low to very high certainty. The certainty scoring definitions listed in Table 5.2-7 are adapted from DiGennaro et al. (2012) but separated into certainty regarding scientific conclusions of species attribute scores (4.a) and BDCP environmental effects (4.b).

5.2.7.11 Biological Goals and Objectives for Covered Fish

As described in Chapter 3, *Conservation Strategy*, the biological goals and objectives reflect the expected ecological outcomes of the Plan and set out the broad principles that were used to guide the development of the conservation strategy. Biological objectives also serve as benchmarks for evaluating BDCP performance relative to ecological health. Biological objectives are intended to be attainable by the conservation measures. The specific biological goals and objectives of the Plan are described in Section 3.3, *Biological Goals and Objectives*. They are described at the landscape scale, for natural communities, and for most covered species (species-specific goals and objectives are not necessary for some covered species because the goals and objectives at the higher levels address their needs). In all cases, progress toward achieving these objectives will be measured as described in Section 3.6, *Adaptive Management and Monitoring Program*.

Table 5.2-7. Definitions of Certainty Scores Regarding Scientific Conclusion and BDCP Outcomes

Certainty Score	Importance of the environment attribute to the species/life stage	Effect of BDCP on the environmental attribute
Very High	Understanding is high based on peer-reviewed studies from within the system and scientific reasoning supported by most experts within the system	Underlying mechanisms are well known and effect of environmental variability is well defined
High	Understanding is high but the conclusion may be based on studies from outside the Plan Area, on less reliable sources, or limited data from within the Plan Area	The underlying mechanisms are known but the outcome is dependent on other highly variable ecosystem processes or uncertain external factors
Moderate	Understanding is low (limited direct studies) and extrapolated from studies in other systems or other species with limited scientific consensus	Underlying mechanisms are uncertain and the outcome is largely unconstrained by variability in ecosystem dynamics or other external factors
Low	Understanding is largely speculative based on limited studies or data but emergent from general scientific reasoning	Action is largely experimental and underlying mechanisms are hypothetical based on extrapolations and sound reasoning

As described in Section 3.3, *Biological Goals and Objectives*, many of the biological objectives for covered fish are expressed as a population metric such as species growth or survival. Biological objectives with such specific metrics can be challenging to meet because of the natural variation in fish population dynamics, stressors that influence these populations beyond the influence of the BDCP, the challenges of measuring changes in highly dynamic populations, and other factors. This chapter includes analyses that can be used to test the feasibility of the biological objectives for covered fish. Table 5.2-8 lists each of the biological objectives for covered fish and describes whether and how the objectives are assessed in the effects analysis and where this assessment can be found. Of the 39 biological objectives for covered fish, 26 of them (67%) can be assessed fully or partially in the effects analysis. Not all of the biological objectives for covered fish can be evaluated at this time because of a lack of field data, lack of modeling tools suitable for a robust assessment, or a combination of these factors. Biological objectives that cannot be assessed in the effects analysis informed the key uncertainties described in Section 3.4, *Conservation Measures*. These gaps in knowledge and tools also generated research and monitoring needs that were incorporated into Appendix 3.D, *Monitoring and Research Actions*.

The effects analysis links conservation measures and expected species responses based on best available science applied through conceptual and quantitative models. Because of the complexities of biological responses, environmental variability, and limitations in scientific understanding, it can be difficult to directly link conservation measures to a species response and then to achievement of a biological objective. Hence, the conceptual and quantitative analyses in the effects analysis create an expectation of biological response based on the information available. These expectations represent a working hypothesis of the relationship between actions, stressors, and biological performance. The working hypotheses will be tested and refined through experimentation and adaptive management over the term of the BDCP, as described in Section 3.6, *Adaptive Management and Monitoring Program*. The effects analysis captures current scientific understandings of how environmental conditions relate to the biological response of covered fish species. However, analytical methods are expected to improve in the future, new information will be collected, and environmental conditions will change. These changes in conditions and current knowledge will be incorporated through the scientific synthesis step in the adaptive management process.

1 **Table 5.2-8. Biological Objectives for Covered Fish Species and their Assessment in the Effects Analysis**

Covered Fish Species	Biological Objective	Objective Assessed in Effects Analysis?	Explanation
Delta smelt	**DTSM1.1:** Increase fecundity of delta smelt over baseline conditions as measured through field investigations and laboratory studies conducted through year 10 and refined through adaptive management.	No	The data do not currently exist to make reliable quantitative predictions about the influences of a range of prey production estimates stemming from BDCP restoration on the survival and/or per capita fecundity of delta smelt. The capacity to meet this objective will be addressed through the adaptive management program.
	DTSM1.2: Limit entrainment mortality associated with operations of water facilities in the south Delta to ≤5% of the delta smelt population, calculated as a 5-year running average of entrainment for subadults and adults in the fall and winter and their progeny in the spring and summer. Assure that the proportional entrainment risk is evenly distributed over the adult migration and larval-juvenile rearing time periods.	Partial	Proportional entrainment was estimated in the effects analysis (Appendix 5.B, *Entrainment*) using methods based on the USFWS (2008) BiOp; the estimates exceeded this objective. It is not presently known how well the currently available method can be used to predict future entrainment in a Delta with different hydrodynamics due to restoration, dual conveyance, and changing habitat conditions. The capacity to meet this objective will be a topic of the adaptive management program.
	DTSM1.3: Achieve a recovery index ≥239 for delta smelt for at least 2 years of any consecutive 5-year period; measured from initial operations through the end of the permit term, the midpoint of any two consecutive recovery index values cannot be lower than 84.	No	Assessment of this objective would require a life cycle or population model for which the inputs could be reasonably estimated. Although some models do exist, inputs such as delta smelt prey abundance and water clarity cannot be predicted with accuracy and are subject to considerable uncertainty. Therefore achievement of this objective cannot be assessed quantitatively in the effects analysis.
	DTSM2.1: Increase the extent of suitable habitat, as defined by flow, salinity, temperature, turbidity, food availability and presence of delta smelt, to provide for the conservation and management of delta smelt in the Plan Area by the achieving the following subobjectives.[4] a) Provide a monthly average of at least 37,000 acres of	Partial	Evaluated in Appendix 5.E, *Habitat Restoration*, using the Habitat Suitability Index; and in Appendix 5.C, *Flow, Passage, Salinity, and Turbidity*, using the Fall Abiotic Habitat index. The habitat suitability analysis focuses on the direct benefits to fish in terms of increased availability of suitable habitat. The habitat suitability analysis does not provide information

[4] The same restored tidal area can meet more than one of the subobjectives, but not necessarily all of the subobjectives. For example, the same area could satisfy subobjectives (a) and (b) or (b) and (c), but potentially not (a) and (c). The exact combination will be informed by the decision-tree process described in the rationale below.

Covered Fish Species	Biological Objective	Objective Assessed in Effects Analysis?	Explanation
	open-water habitat in hydrologically wet years*, and at least 20,000 acres of connected open-water habitat in hydrologically above-normal years*, of 1 to 6 psu habitat surface area during July–November. This habitat will meet all of the following criteria: extensive vertical circulation including gravitational circulation, contiguous with other open-water habitat, lateral mixing, and other hydrodynamic processes keeping Secchi disk depths less than 0.5 meter, high calanoid copepod densities (over 7,000 per cubic meter), hydrologically connected to substantial tidal marsh areas, and maximum water temperatures less than 25°C. * Because July–November crosses a water-year boundary, the water-year type criteria apply to the first 3 months of that period. b) Increase the extent of tidal wetlands of all types in the Plan Area by 10,000 acres by year 10, 17,000 acres by year 15, and 48,000 acres by year 40. In Suisun Marsh, West Delta and Cache Slough ROAs, individual restoration projects must show a net-positive flux of calanoid copepods and mysids off of the restored wetlands into open water occupied by delta smelt. Food production targets and export distances will be determined through field investigations and modeling, and refined through adaptive management. c) Increase by 100% the surface area of open-water, very low-salinity (<1 psu) habitat in the Cache Slough ROA during July–November by 2060. This habitat will meet all of the following criteria: extensive lateral mixing, contiguous with other open-water habitat, hydrodynamic processes keeping Secchi depth less than 0.5 meter, high calanoid copepod density (over 7,000 per cubic meter), and temperature criteria described in item b, above.		regarding the extent to which covered fish species may or may not use the habitat, nor can it quantitatively estimate density of calanoid copepods. The Abiotic Habitat Index uses Feyrer et al. (2011) to estimate the potential fall habitat for Delta smelt in the low salinity zone with and without habitat restoration. As noted elsewhere in Appendix 5.C, there is appreciable uncertainty regarding changes in water clarity (Secchi depth) because of the BDCP. The capacity to meet this objective will be a topic of the adaptive management program.

Covered Fish Species	Biological Objective	Objective Assessed in Effects Analysis?	Explanation
Longfin smelt	**LFSM1.1:** Achieve longfin smelt population growth, to be measured as follows. • Future indices of annual recruitment that are equal or exceed expected levels based on the 1980–2011 trend in recruitment relative to winter-spring flow conditions.	Partial	Evaluated qualitatively in Appendix 5.E and Chapter 5.5. Tidal natural communities restoration (CM4)will need to succeed in producing and exporting additional food for longfin smelt to support an increase in longfin smelt abundance to meet this objective. However, the data do not currently exist to quantitatively estimate how much additional longfin smelt production can be generated by CM4. The capacity to meet this objective will be a topic of the adaptive management program.
	LFSM1.2: Limit entrainment mortality associated with operation of water facilities to ≤5% of the longfin smelt population, calculated as a 5-year running average of entrainment for subadults and adults in the fall and winter and their progeny in the winter and spring. Assure that the proportional entrainment risk is evenly distributed over the adult migration and larval-juvenile rearing periods.	No	Estimates of proportional entrainment for longfin smelt have not yet been made in any study and therefore no analysis of proportional entrainment was possible for the effects analysis. The distribution of longfin smelt larvae is typically seaward of delta smelt larvae (Dege and Brown 2004), so it is anticipated that this objective for longfin smelt proportional entrainment will be met. The capacity to meet this objective will be a topic of the adaptive management program.
Winter-run Chinook salmon	**WRCS1.1:** For winter-run Chinook salmon originating in the Sacramento River, achieve a 5-year geometric mean interim through-Delta survival objective of 52% by year 19 (from an estimated 40%), 54% by year 28, and 57% by year 40, measured between Knights Landing and Chipps Island. This survival metric is an interim value based on limited data from fall-run Chinook salmon in the Sacramento River. This survival metric will be revised to account for new monitoring data and improved modeling expected by year 10.[5]	Partial	Evaluated qualitatively because assessment of absolute values is not possible. Through-Delta survival is evaluated using the Delta Passage Model. This model, however, is for smolts only, which move through the Delta rather quickly. The model is not well- suited for fry or those fish that may rear and grow within the Plan Area before they migrate out of the Delta. The results of the model are best viewed comparatively between scenarios as opposed to comparing estimated values to the biological objectives. The capacity to meet this objective will be a topic of the adaptive management program.

[5] New monitoring data and improved modeling are expected as a result of ongoing and anticipated future research, under the BDCP and independent of the BDCP.

Covered Fish Species	Biological Objective	Objective Assessed in Effects Analysis?	Explanation
	WRCS1.2: Create a viable alternate migratory path through Yolo Bypass in >70% of years for outmigrating winter-run Chinook salmon juveniles by year 15.	Partial	This is evaluated with the Delta Passage Model for smolt-sized individuals.
	WRCS1.3: Reduce illegal harvest of adult winter-run Chinook salmon in the Plan Area by year 5.	Partial	Qualitative analysis is provided in Section 5.5, *Effects on Covered Fish*, and Appendix 5.C, *Flow, Passage, Salinity, and Turbidity*, Section 5.C.5.4.1, *Yolo Bypass Floodplain Habitat (CM2 Yolo Bypass Fisheries Enhancement)*. Under *CM17 Illegal Harvest Reduction*, the Implementation Office will fund CDFW to hire and equip additional game wardens to police the Plan Area and upstream areas. This measure will be fully implemented by year 3. Increased enforcement is expected to reduce illegal harvest in the Plan Area and, in particular, in upstream holding areas where prespawning adults may be susceptible to illegal harvest; however, the benefits of this measure cannot be quantified in terms of number of fish. The Fremont Weir is a known temporal passage barrier for all races of Chinook salmon using the Yolo Bypass, while leakage from the Sacramento Weir creates an attraction flow that contributes to stranding. Illegal harvest of adult Chinook salmon at these passage barriers is well-documented and substantial. Passage improvements at the Fremont Weir and related improvements at the Sacramento Weir are expected to reduce migratory delay and stranding, thereby reducing illegal harvest. CM2 has an extended implementation schedule beginning in year 1 with construction of all passage improvements completed by year 25. Phase I will be implemented in years 1 through 5 and includes immediate passage improvements at the Fremont Weir and annual fish stranding monitoring and rescue activities.

Covered Fish Species	Biological Objective	Objective Assessed in Effects Analysis?	Explanation
	WRCS2.1: Limit adult winter-run Chinook salmon passage delays in the Yolo Bypass to fewer than 36 hours by year 15.	Partial	While the benefits of CM2 passage improvements are evaluated in Appendix 5.C as described above, the duration of future migration delays has not been quantified. However, the passage improvements planned through year 15 are intended to significantly reduce passage delays at the known major barriers in the Yolo Bypass. This suggests that this biological objective will be realized.
	WRCS3.1: Implement covered activities so as to not result in a reduction of the primary constituent elements of designated critical habitat for winter-run Chinook salmon upstream of the Plan Area.	Partial	Analyses in Appendix 5.C address this issue. In addition, the BDCP will be operated so as not to degrade critical habitat on the Sacramento River.
	WRCS3.2: Operate water facilities to support a wide range of life-history strategies for winter-run Chinook salmon without favoring any one life-history strategy or trait over another (e.g., Real-time operation of water facilities will have an implementation window covering at least 95% of the life stages present in the Plan Area.).	No	The biological objective requires further refinement in order to establish the metrics by which it could be assessed. The capacity to meet this objective will be a topic of the adaptive management program.

Covered Fish Species	Biological Objective	Objective Assessed in Effects Analysis?	Explanation
Spring-run Chinook salmon	**SRCS1.1:** For spring-run Chinook salmon originating in the Sacramento River and its tributaries, achieve a 5-year geometric mean interim through-Delta survival objective of 49% by year 19 (from an estimated 40%), 52% by year 28, and 54% by year 40, measured between Knights Landing and Chipps Island. The Sacramento River survival metric is an interim value based on limited data from fall-run Chinook salmon in the Sacramento River. This survival metric will be revised to account for new monitoring data and improved modeling expected by year 10.[6] For spring-run Chinook salmon originating in the San Joaquin River and its tributaries, achieve a 5-year geometric mean interim through-Delta survival objective of 33% by year 19, 35% by year 28, and 38% by year 40, measured between Mossdale and Chipps Island. Spring-run Chinook salmon do not currently exist in the San Joaquin subbasin, thus these subbasin metrics are considered very interim.	No	Not addressed. Would require modeling exercise to inform the necessary improvement in survival required to result in a stable or expanding population. No life-cycle models are available that integrate the factors that the BDCP will influence. The capacity to meet this objective will be a topic of the adaptive management program.
	SRCS1.2: Create a viable alternate migratory path through Yolo Bypass in >70% of years for outmigrating spring-run Chinook salmon juveniles by year 15.	Yes	This is evaluated with the Delta Passage Model.
	SRCS1.3: Reduce illegal harvest of adult spring-run Chinook salmon in the Plan Area by year 5.	Partial	See WRCS1.3.

[6] New monitoring data and improved modeling are expected as a result of ongoing and anticipated future research, under the BDCP and independent of the BDCP.

Covered Fish Species	Biological Objective	Objective Assessed in Effects Analysis?	Explanation
	SRCS2.1: Limit adult spring-run Chinook salmon passage delays in the Yolo Bypass and at other human-made barriers and impediments in the Plan Area (e.g., Stockton Deep Water Ship Channel) to fewer than 36 hours by year 15.	Partial	See comments above for Winter-run WRCS1.2 regarding the benefits of passage improvements in the Yolo Bypass. The benefits of *CM14 Stockton Deep Water Ship Channel Dissolved Oxygen Levels* (funding the installation of an aeration system) are evaluated in Appendix 5.C. CM14 will be implemented in year 1. This aeration system is expected to increase dissolved oxygen levels above Basin Plan objectives during the spring-run Chinook migration period. While the effect of this action on the duration of passage delays is not explicitly evaluated, it is reasonable to conclude that maintaining dissolved oxygen levels above this threshold will eliminate passage barriers exceeding 36 hours in duration.
	SRCS3.1: Implement covered activities so as to not result in a reduction in the primary constituent elements of designated critical habitat for spring-run Chinook salmon upstream of the Plan Area.	Yes	A variety of analyses are presented in Appendix 5.C addressing this issue. In addition, the BDCP will be operated so as not to degrade upstream critical habitat.
	SRCS3.2: Operate water facilities to support a wide range of life-history strategies for spring-run Chinook salmon without favoring any one life-history strategy or trait over another (e.g., Real-time operation of water facilities will have an implementation window covering at least 95% of the life stages present in the Plan Area.).	No	The biological objective requires further refinement in order to establish the metrics by which it could be assessed. The capacity to meet this objective will be a topic of the adaptive management program.

Covered Fish Species	Biological Objective	Objective Assessed in Effects Analysis?	Explanation
Fall-run Chinook salmon	**FRCS1.1:** For fall-run Chinook salmon originating in the San Joaquin River and its tributaries, achieve a 5-year geometric mean interim through-Delta survival objective of 27% by year 19 (from an estimated 5%), 29% by year 28, and 31% by year 40, measured between Mossdale and Chipps Island. For fall-run Chinook salmon originating in the Sacramento River and its tributaries, achieve a 5-year geometric mean interim through-Delta survival objective of 42% by year 19 (from an estimated 40%), 44% by year 28, and 46% by year 40, measured between Knights Landing and Chipps Island. For late fall–run Chinook salmon originating in the Sacramento River and its tributaries, achieve a 5-year geometric mean interim through-Delta survival objective of 49% by year 19 (from an estimated 40%), 51% by year 28, and 53% by year 40, measured between Knights Landing and Chipps Island. These survival metrics are interim values, based on limited data from fall-run Chinook salmon in the San Joaquin and Sacramento Rivers, and will be revised to account for new monitoring data and improved modeling expected by year 10.[7]	No	Not addressed. Would require modeling exercise to inform the necessary improvement in survival required to result in a stable or expanding population. No life-cycle models available that integrate the factors that the BDCP will influence. The capacity to meet this objective will be a topic of the adaptive management program.
	FRCS1.2: Create a viable alternate migratory path through Yolo Bypass in >70% of years for outmigrating fall-run/late fall–run Chinook salmon juveniles by year 15.	Partial	This is evaluated with the Delta Passage Model for smolt-sized individuals.
	FRCS1.3: Reduce illegal harvest of adult fall-run/late fall–run Chinook salmon in the Plan Area by year 5.	Partial	See WRCS1.3.

[7] New monitoring data and improved modeling are expected as a result of ongoing and anticipated future research, under the BDCP and independent of the BDCP.

Covered Fish Species	Biological Objective	Objective Assessed in Effects Analysis?	Explanation
	FRCS2.1: Limit adult fall-run/late fall–run Chinook salmon passage delays in the Yolo Bypass and at other human-made barriers and impediments in the Plan Area (e.g., Stockton Deep Water Ship Channel) to fewer than 36 hours by year 15.	Partial	While the benefits of CM2 passage improvements are evaluated in Appendix 5.C as described above, the duration of future migration delays has not been quantified. However, the passage improvements planned through year 15 are intended to significantly reduce passage delays at the known major barriers in the Yolo Bypass. This suggests that this biological objective will be realized.
	FRCS3.1: Implement covered activities so as to not result in a degradation of current habitat conditions for fall-run/late fall–run Chinook salmon (e.g., spawning sites, rearing sites, migration corridors) upstream of the Plan Area.	Yes	A variety of analyses are presented in Appendix 5.C addressing this issue. In addition, the BDCP will be operated so as not to degrade critical habitat on the Sacramento River.
	FRCS3.2: Operate water facilities to support a wide range of life-history strategies for fall-run/late fall–run Chinook salmon without favoring any one life-history strategy or trait over another (e.g., Real-time operation of water facilities will have an implementation window covering at least 95% of life stages present in the Plan Area).	No	The biological objective requires further refinement in order to establish the metrics by which it could be assessed. The capacity to meet this objective will be a topic of the adaptive management program.
Steelhead	**STHD1.1:** For steelhead originating in the San Joaquin River and its tributaries, achieve a 5-year geometric mean interim through-Delta survival objective of 44% by year 19 (from an estimated 10%), 47% by year 28, and 51% by year 40, measured between Mossdale and Chipps Island. For steelhead originating in the Sacramento River and its tributaries, achieve a 5-year geometric mean interim through-Delta survival objective of 54% by year 19 (from an estimated 45%), 56% by year 28, and 59% by year 40, measured between Knights Landing and Chipps Island. These survival metrics are interim values based on limited data from fall-run Chinook salmon in the San Joaquin and Sacramento Rivers. These survival metrics will be revised to account for new monitoring data and improved modeling expected by year 10.[8]	No	Not addressed. Would require modeling exercise to inform the necessary improvement in survival required to result in a stable or expanding population. No life-cycle models are available that integrate the factors that the BDCP will influence. The capacity to meet this objective will be a topic of the adaptive management program.

[8] New monitoring data and improved modeling are expected as a result of ongoing and anticipated future research, under the BDCP and independent of the BDCP.

Covered Fish Species	Biological Objective	Objective Assessed in Effects Analysis?	Explanation
	STHD1.2: Create a viable alternate migratory path through Yolo Bypass in >70% of years for outmigrating steelhead juveniles by year 15.	No	The availability of the Yolo Bypass pathway for steelhead has not been explicitly analyzed, although analyses have been conducted for Chinook salmon smolts via the Delta Passage Model. The capacity to meet this objective will be a topic of the adaptive management program.
	STHD1.3: Reduce illegal harvest of adult steelhead in the Plan Area by year 5.	Partial	See WRCS1.3.
	STHD2.1: Limit adult steelhead passage delays in the Yolo Bypass and at other human-made barriers and impediments in the Plan Area (e.g., Stockton Deep Water Ship Channel) to fewer than 36 hours by year 15.	Yes	See SRCS3.1.
	STHD3.1: Implement covered activities so as to not result in a reduction to the primary constituent elements of designated critical habitat for steelhead upstream of the Plan Area.	Yes	Analyses in Appendix 5.C address this issue. In addition, the BDCP will be operated so as not to degrade upstream critical habitat.
	STHD3.2: Operate water facilities to support a wide range of life-history strategies for steelhead without favoring any one life-history strategy or trait over another (e.g., real-time operation of water facilities will have an implementation window covering at least 95% of the life stages present in the Plan Area).	No	The biological objective requires further refinement in order to establish the metrics by which it could be assessed. The capacity to meet this objective will be a topic of the adaptive management program.
Sacramento splittail	**SAST1.1:** Maintain a 5-year running average of age-0 splittail index of abundance in the Plan Area of 150% of baseline conditions by providing increased access to suitable spawning and rearing habitat in the Plan Area by year 15.	Yes	Considered qualitatively in Appendix 5.C and Appendix 5.H, *Aquatic Construction and Maintenance Effects*.
Green sturgeon	**GRST1.1:** Increase juvenile green sturgeon survival (as a proxy for juvenile abundance and population productivity) throughout the BDCP permit term and increase adult green sturgeon survival (as a proxy for adult abundance and productivity) by year 15.	No	Current spawning-to-adult abundance is unknown, so evaluating an increase as a result of the BDCP is not currently feasible. The capacity to meet this objective will be a topic of the adaptive management program.

Covered Fish Species	Biological Objective	Objective Assessed in Effects Analysis?	Explanation
	GRST2.1: Eliminate stranding of adult green sturgeon at Fremont Weir, the scour pools directly below Fremont Weir, and the Tule Pool, by providing passage at these locations, by year 15, and minimize stranding until this time.	Yes	Qualitatively evaluated in Appendix 5.C.
	GRST3.1: Improve water quality parameters and physical habitat characteristics in the Bay-Delta to increase the spatial distribution of green sturgeon in the Plan Area by year 15.	Yes	Qualitatively discussed in Appendix 5.D, *Contaminants*. Some uncertainty regarding white sturgeon sensitivity to water quality and whether current water quality conditions negatively affect white sturgeon. Thus, evaluating the response of white sturgeon to improved water quality conditions is difficult, and may be somewhat negative (low potential for effect). However, certain conservation measures to be implemented as part of BDCP will contribute to improved water quality, including *CM19 Urban Stormwater Treatment*, *CM12 Methylmercury Management*, and *CM14 Stockton Deep Water Ship Channel Dissolved Oxygen Levels*. So while the BDCP has a low potential for negative effects, certain conservation measures will be implemented to provide a benefit to covered fish species.
White sturgeon	**WTST1.1:** Increase juvenile white sturgeon survival (as a proxy for juvenile abundance and population productivity) throughout the BDCP permit term and increase adult white sturgeon survival (as a proxy for adult abundance and productivity) by year 15.	No	See GRST1.1.
	WTST2.1: Eliminate stranding of adult white sturgeon at Fremont Weir, the scour pool directly below Fremont Weir, and the Tule Pond, by providing passage at these locations, by year 15, and minimize stranding until this time.	Yes	Discussed qualitatively in Appendix 5.C with Fremont Weir improvements. No data available on current stranding rates at Fremont Weir but this will be measured during early implementation to create a baseline with which to compare after improvements are made to the weir.
	WTST3.1: Improve water quality parameters and physical habitat characteristics in the Bay-Delta to increase the spatial distribution of white sturgeon in the Plan Area by year 15.	Yes	See GRST3.1.

Covered Fish Species	Biological Objective	Objective Assessed in Effects Analysis?	Explanation
Pacific and river lamprey	**PRL1.1:** Reduce passage delays for lamprey adults migrating upstream within the Yolo Bypass by year 15.	Yes	Considered qualitatively in Appendix 5.C.
	PRL1.2: Improve downstream passage conditions for lamprey ammocoetes and macropthalmia at the Fremont Weir by year 15.	Partial	No specific analysis has been conducted for lamprey juvenile downstream passage changes at Fremont Weir, but qualitative analyses for other covered fish species based on the DRERIP assessment of conservation measures (Essex Partnership 2009) provide the means by which to infer positive changes because of the BDCP. The capacity to meet this objective will be a topic of the adaptive management program.
SWP = State Water Project; CVP = Central Valley Project; USFWS = U.S. Fish and Wildlife Service; BiOp = biological opinion; RPA = reasonable and prudent alternative; CDFW = California Department of Fish and Wildlife; DRERIP = Delta Regional Ecosystem Restoration Implementation Plan.			

5.2.8 Effects Analysis for Wildlife and Plants

5.2.8.1 Take Assessment

Implementation of covered activities will result in incidental take of covered wildlife and plants. To meet regulatory requirements and to ensure adequate mitigation of effects, the amount of take must be discussed and, if possible, quantified. The allowable amount of take is quantified by estimating the loss of habitat for each covered species (methods for impact estimation are described below). Effects on plant populations will also be tracked to ensure permit compliance, as described in Section 5.2.8.1.1, *Use of Plant Occurrence Data*.

The following types of effects will result from covered activities.

- Permanent habitat loss or conversion
- Periodic inundation
- Temporary loss
- Injury or mortality
- Permanent indirect and other indirect losses

A list of covered activities, these effects, and corresponding conservation measures are summarized in Appendix 5.J, *Effects on Natural Communities, Wildlife, and Plants*. The detailed methods used to estimate effects and key assumptions related to these methods are listed in Appendix 5.J and in Figure 5.2-7. The effects of construction of the water conveyance facility (*CM1 Water Facilities and Operation*) can be assessed precisely based on a known maximum disturbance footprint. Similarly, the locations of construction for some other conservation measures are relatively well defined (e.g., *CM2 Yolo Bypass Fisheries Enhancement, CM18 Conservation Hatcheries*). However, the locations for other covered activities are to be determined during BDCP implementation through project planning (*CM3 Natural Communities Protection and Restoration* and Chapter 6, *Plan Implementation*) and therefore have been assessed at a programmatic level.

The habitat loss estimates for covered activities addressed at the programmatic level are intended to reflect approximate maximum losses rather than a precise quantification of effects on land cover types. Actual losses will be reduced through careful restoration design and avoidance and minimization measures. However, the estimates represent the limit, or cap, on total loss allowable under the Plan. The Implementation Office will track actual effects during Plan implementation to ensure that effects do not exceed the allowable levels. Once these habitat loss levels are reached, no further take is permitted pursuant to the Plan without a plan amendment (see Chapter 6, *Plan Implementation*, for a description of the amendment process).

Hypothetical disturbance footprints were developed to estimate maximum loss of species habitat resulting from tidal natural community restoration (*CM4 Tidal Natural Communities Restoration*) and seasonally inundated floodplain restoration. The hypothetical footprints for tidal restoration were developed using outputs of the tidal restoration model described in Section 5.2.7.2, *Use of Models in the Effects Analysis.* The hypothetical footprint for floodplain restoration was developed by evaluating restoration opportunities and applying assumptions about the most likely locations for floodplain restoration as described in Chapter 3, *Conservation Strategy* (*CM5 Seasonally Inundated Floodplain Restoration*) and Appendix 5.E, *Habitat Restoration*. Both tidal and floodplain restoration hypothetical footprints are located in the conservation zones in which they are most likely to be implemented, based on existing conditions and restoration opportunities.

Assumptions were developed for each covered species that will potentially be affected by tidal inundation or desiccation (resulting from changes in the tidal prism as a result of tidal restoration), based on expected effects of inundation and desiccation on the species' habitat; these assumptions are provided in Appendix 5.J, *Effects on Natural Communities, Wildlife, and Plants*.

Other covered activities that potentially affect covered wildlife and plants and were analyzed at the programmatic level include nontidal marsh restoration, riparian restoration, and conservation fisheries enhancement. Effects resulting from these activities were assessed using the methods and key assumptions summarized in Appendix 5.J.

5.2.8.1.1 Use of Plant Occurrence Data

Effects on plant species were assessed by using habitat models as well as plant occurrence information. Occurrence data include a general location of a current or historic plant population[9]. Occurrence data often also has additional information such as the total number of plants, the general condition of the occurrence, the status of the occurrence (e.g., extant, presumably extirpated) as well as any identifiable threats. Occurrence data are from the California Natural Diversity Database (CNDDB), the Consortium of California Herbaria, and the Delta Habitat Conservation and Conveyance Program.

All occurrence data were represented spatially in GIS. To assess the potential for take and inform the decision of maximum allowable loss of occurrences, occurrence data were intersected with those covered activities that had known or hypothetical footprints. If a footprint intersected with an occurrence, the potential for take was assessed and described. Considerations regarding the potential for take included the nature of the footprint, (known or hypothetical), the likelihood that the occurrence could be completely avoided, the abundance and distribution of the occurrence, the impact mechanism (habitat removal versus inundation or desiccation), and the species' life form (annual versus perennial).

During implementation, there is potential for temporary or partial loss of plant occurrences. Partial occurrence effects are defined as the loss of some individuals but not enough to compromise the long-term survivability of the occurrence. Temporary effects on plant occurrences are those that may affect most or all of an occurrence but the effect is such that the occurrence can naturally recolonize to an abundance and distribution similar to the preproject condition. Discussing effects and benefits in terms of occurrences has limitations. Occurrence data often have numbers of individuals and these can fluctuate widely from year to year due to environmental variation (e.g., rainfall). Some occurrences in the CNDDB include estimates of numbers of individuals; however, many occurrences do not or the estimates are from only one year. Additionally, in the rare cases where there are multiple years' data, these numbers often vary widely (e.g., from hundreds in one year to thousands in another for just one occurrence). This especially makes tracking partial and temporary effects and recolonization success difficult given that factors outside the control of the

[9] Occurrence points may or may not correspond to a plant population. Widely separate occurrences likely represent distinct populations, while closely spaced occurrences may be part of the same population. Occurrence points were used as the unit of analysis because of their consistency across plant species. Most occurrence data do not allow translation into population units.

Implementation Office can determine the size of the affected occurrence as well as that of the recolonized occurrence.

Take limitations based on occurrences are proposed for a select number of plant species (Section 5.6, *Effects on Covered Wildlife and Plant Species*). The protection of extant occurrences is the first conservation method. When the protection of unprotected or previously undetected occurrences is feasible, protection is required. However, when extant occurrences are unlikely to be found, the Implementation Office may create occurrences through planting or seeding. For applicable species, the rationale is provided to justify the creation of an occurrence (e.g., known creation or restoration success, ability of plant to be grown in a nursery setting and outplanted).

In addition to the quantitative effects assessment, occurrence data were used to inform the qualitative effects discussion. Primarily, state-wide occurrence data were used to provide context for the Plan Area occurrences (i.e., what percentage of the state's total occurrences are in the Plan Area).

5.2.8.1.2 Habitat Suitability Models

Habitat suitability models (or HSI models) evaluate multiple attributes of the environment as habitat for life stages and species. The result is an index of habitat suitability where 0 indicates entirely unsuitable habitat and 1 represents ideal habitat for the life stage and species. Habitat suitability brings together knowledge of life history, key habitats, and environmental requirements to create an index of habitat quality and quantity where a quantitative life cycle-habitat model is not available. Habitat suitability models collect a variety of information relating to habitat requirements to create hypotheses of species-habitat relationships rather than statements of proven cause and effect relationships (Schamberger et al. 1982).

Habitat suitability models are commonly used in wildlife and fish assessments and are used to evaluate the effects of the BDCP on terrestrial species, as described for these species in Section 5.2.6, *Effects Analysis for Natural Communities*. Habitat suitability models for terrestrial species are formulated primarily using vegetation data from existing GIS data sources as described in Appendix 2.A, *Covered Species Accounts*, Section 2.A.0.1.7, *Species Habitat Suitability Model Methods*.

5.2.8.2 Analysis of Adverse Effects

Adverse effects on each species were assessed in each of five categories: permanent habitat loss, conversion, and fragmentation; periodic inundation; construction-related effects; effects of ongoing activities; and other indirect effects. Adverse effects from each of these categories were then assessed collectively in the context of species survival and conservation to determine the impact of take on the species. For each effect category, effects were assessed collectively for all covered activities, and for conveyance facility construction. For covered activities addressed at the programmatic level, only those activities with the greatest level of effects in each effect category were assessed in detail. Each of the effects categories applied in the adverse effects analysis is described below.

5.2.8.2.1 Permanent Habitat Loss, Conversion, and Fragmentation

This effect category includes permanent habitat loss as a result of development-related covered activities (e.g., water conveyance facility) and conversion to a different natural community type as a result of restoration (e.g., from grasslands to tidal brackish emergent wetland). It also includes habitat fragmentation effects. For example, tidal marsh restoration may result in habitat fragmentation for grassland-dependent species. Adverse effects were assessed for each of the covered activities listed in Appendix 5.J, *Effects on Natural Communities, Wildlife, and Plants*.

Tidal restoration will result in a conversion of existing natural community types to tidal perennial aquatic and tidal marsh natural communities. In some areas, the tidal restoration footprint overlaps with existing tidal brackish emergent wetland and tidal freshwater emergent wetland natural communities. Therefore, for some of the natural community and species habitat types, it was assumed that tidal inundation would not result in a loss or conversion of the natural community or habitat. These assumptions are provided Appendix 5.J.

For most covered activities, habitat loss and conversion was assessed quantitatively by overlaying GIS data layers that represent the actual or hypothetical geographic footprints for covered activities with GIS data layers for species habitat models (Figure 5.2-7). As described above in Section 5.2.7.1, *Take Assessment*, the conveyance facility footprint represents the known location for this covered activity, while footprints for most other covered activities are hypothetical. For many covered activities, assumptions were applied to the GIS output in order to adjust acreage numbers to refine the effects analyses. The methods applied to assess habitat loss and conversion for each type of activity and the key assumptions related to each method are described in Appendix 5.J.

Habitat fragmentation was assessed qualitatively based on an evaluation of covered activities in relation to modeled species habitat, and evaluation of the quality of habitat affected. The effects analysis recognizes that the quality of modeled species habitat, in terms of long-term conservation value and ability to sustain covered species populations, varies throughout the Plan Area. The quality of species habitat lost or converted as a result of covered activities was assessed to the extent possible with existing information. Information used to assess the quality of affected habitat include patch size and fragmentation of modeled habitat, adjacent land uses such as roads and other development based on aerial imagery, information from literature and species experts related to species distribution in the Plan Area, species occurrence data, and proximity to Type 1 or Type 2 conservation land. The conservation land types are defined in Section 3.2.4.2.2, *Existing Conservation Lands*.

For species with habitat loss distributed in many locations throughout the Plan Area, habitat quality was only evaluated for areas with the greatest effects. More detailed habitat quality analysis was conducted for the conveyance facility effects, for which location of effects is known, than for other covered activities for which hypothetical footprints were used. The habitat quality factors considered differ by species, and are described in the methods sections for each species (Section 5.6, *Effects on Covered Wildlife and Plant Species*).

Species occurrence data were evaluated as a component of the quality assessment for habitat permanently lost or converted. For most of the covered species, occurrence data is incomplete and therefore has limited utility for assessing the extent to which modeled habitat is occupied or determining where the greatest population effects will occur. However, DWR has conducted extensive field surveys recently in and around the conveyance facility footprint and alternative alignments for this facility. Therefore, occurrence data are used to assess effects of the conveyance facility construction more than they are used to assess effects of other covered activities. In general, the effects analysis relies on occurrence data for plants more than for wildlife, as described in Section 5.2.8.1.1, *Use of Plant Occurrence Data*.

5.2.8.2.2 Periodic Inundation

This effect category includes periodic inundation from flooding in the Yolo Bypass (*CM2 Yolo Bypass Fisheries Enhancement*) and seasonal flooding in restored floodplains (*CM5 Seasonally Inundated Floodplain Restoration*). Periodic flooding in the Yolo Bypass will increase as a result of CM2. The effects analysis addresses the difference between existing conditions and projected conditions after project implementation under seven different flow scenarios (a notch flow of 1,000 cubic feet per second [cfs] to notch flow of 6,000 cfs, with two different baseline flow scenarios for 6,000 cfs) based on the MIKE 21 model. For each of these seven scenarios, the GIS footprint for the difference between existing and proposed flows were overlain on GIS layers for modeled covered species habitat. Figures 5.J-1 through 5.J-7 in Appendix 5.J, *Effects on Natural Communities, Wildlife, and Plants*, show the footprint of the difference between existing and proposed conditions for each flow scenario. Results from all seven scenarios are presented in Section 5.4, *Effects on Natural Communities,* and Section 5.6, *Effects on Covered Wildlife and Plant Species*, for each natural community and covered species affected. The effects of increase in frequency and duration of inundation were addressed qualitatively where relevant for covered species.

The quantitative analysis of seasonally inundated floodplain inundation is based on the area between the setback levees in the hypothetical floodplain restoration footprint. These quantitative assessment methods are outlined, and key assumptions and limitations described in Table 5.J-1, *Quantitative Effects Analysis Methods and Assumptions*, in Appendix 5.J. Floodplain restoration will involve removal of sections of existing levee, allowing flood flows to periodically inundate portions of the historical floodplain.

5.2.8.2.3 Construction-Related Effects

This effect category includes nonpermanent, construction-related habitat loss and indirect effects of construction-related factors such as dust, noise, vehicle traffic, human disturbance, and night lighting. Habitat loss addressed in this category includes effects categorized as *short-term temporary* (restored to predisturbance conditions within 1 year after construction is complete) and *long-term temporary* (restored to preproject conditions, and timeframe undetermined but within permit term). Short-term temporary and long-term temporary habitat loss was assessed quantitatively and qualitatively using the same methods described above in Section 5.2.8.2.1, *Permanent Habitat Loss, Conversion, and Fragmentation,* and described in Table 5.J-1, *Quantitative Effects Analysis Methods and Assumptions*, in Appendix 5.J.

Indirect effects on covered species habitat adjacent to development and restoration-related construction activities were quantitatively assessed based on covered activity footprints and species habitat models. The types of indirect effects assessed using this method included noise, lighting, line-of-sight disturbance, dust, and construction-related runoff. These effects will be temporary, as they will only occur during construction. The effect on each species was calculated by intersecting the assumed area of indirect effect extending from the construction area for each species with each species modeled habitat; the intersection represents the extent of effect expressed as acres of disturbed habitat. For noise and visual disturbances on covered wildlife species, existing areas of disturbance (e.g., road traffic, urban developments, farm buildings) that intersect disturbance areas associated with covered activities were also calculated and were subtracted from the area of effect calculated for covered activities. The indirect effect distances used for covered activities are summarized in Table 5.J-4, *Indirect Effect Distances from Covered Activity, Wildlife*, and Table 5.J-5, *Indirect Effect Distances from Covered Activity, Plants*, in Appendix 5.J.

5.2.8.2.4 Effects of Ongoing Activities

This effect category includes indirect effects on species habitat near facilities, related to ongoing maintenance and operation, and effects of reserve system management and enhancement. Ongoing indirect effects near facilities were assessed quantitatively based on designated disturbance distances as described above in Section 5.2.8.2.3, *Construction-Related Effects*, except that these indirect effects of ongoing activities were treated as permanent rather than temporary. Effects of reserve land enhancement and management activities such as native species plantings and nonnative species control were assessed qualitatively.

5.2.8.2.5 Other Indirect Effects

This effect category includes effects that, while not caused solely by covered activities, are influenced by covered activities and could extend beyond the immediate vicinity of the covered activities. Two examples are the methylation of mercury and the increase or decrease in salinity related to tidal restoration. These potential effects were assessed qualitatively. Methylmercury effects are only discussed for those species potentially affected. These include wildlife species that feed on fish or invertebrates from the Bay and Delta with potential exposure to methylmercury.

5.2.8.3 Summarizing Effects on Wildlife and Plants

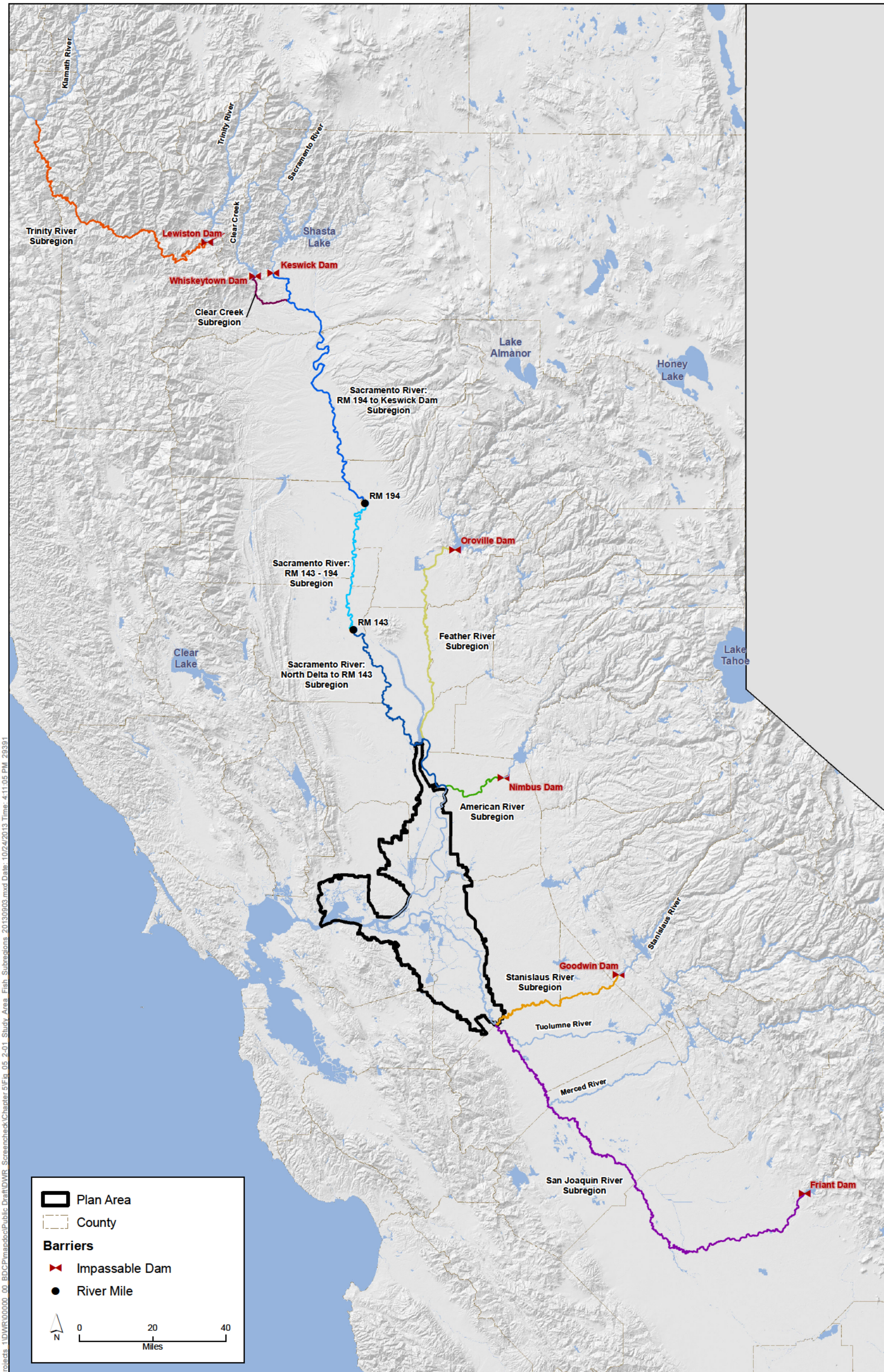
As discussed in Section 5.2.7.10, *Approach for Determining Net Effects on Covered Fish Species,* the effects analysis evaluates the combined effects of all covered activities, including the conservation measures, to determine the net effect of implementing the Plan. As with fish species, it is necessary to determine three outcomes for each covered wildlife and plant species: the adverse effects of covered activities on organisms and populations, the beneficial effects expected to result from the conservation strategy, and net effects of these outcomes on the species.

HCPs are required (Section 10(a)(2)(A)(i) of the ESA) to describe the impact of the take on each covered species. The impact of the take is defined as the effect of all take on species and their populations. In the effects analysis, it considers the species' overall range, the importance of the Plan Area to the species as a whole, and the extent to which BDCP-related take will affect the species' long-term survival and conservation.

The beneficial effects analysis addresses effects on each species expected to result from implementation of the conservation strategy described in Chapter 3, *Conservation Strategy*. It includes a quantitative analysis of habitat restoration and protection acreages (Appendix 5.J, Attachment 5J.B, *Natural Community Restoration and Protection Contributing to Covered Species Conservation*) and, where applicable, protection or establishment of species occurrences. It also includes a qualitative assessment of anticipated benefits to the species based on quality of habitat to be protected and restored (habitat quality factors differ by species), and expected benefits of habitat management and enhancement actions.

The net effects analysis addresses the net effects on the species resulting from the adverse effects of covered activities and the beneficial effects of implementing conservation measures. This includes a quantitative analysis of net change in available habitat and, where applicable, species occurrences. In addition, the net effects analysis evaluates temporal loss related to any delays between habitat loss and habitat restoration. To the extent that information is available, the analysis also describes the quality difference between habitat lost and habitat restored and protected.

For each species, a determination was made as to whether the net effects on the species will result in the conservation of a species in the Plan Area. The Plan's contribution to species conservation was guided by the proportion of a species' range and life cycle within the Plan Area and the level of effect on that species. For example, all else being equal, the Plan's obligation to provide for the conservation and management of a species that has a small portion of its range in the Plan Area is less than the Plan's obligation to provide for the conservation and management of a species that has a large portion of its range in the Plan Area. For listed species, conservation in the Plan Area means to contribute to factors that result in the species' no longer needing to be state- or federally listed. For nonlisted species, conservation as defined in the BDCP refers to the BDCP's contribution to factors that prevent the species' need to become state- or federally listed in the future.



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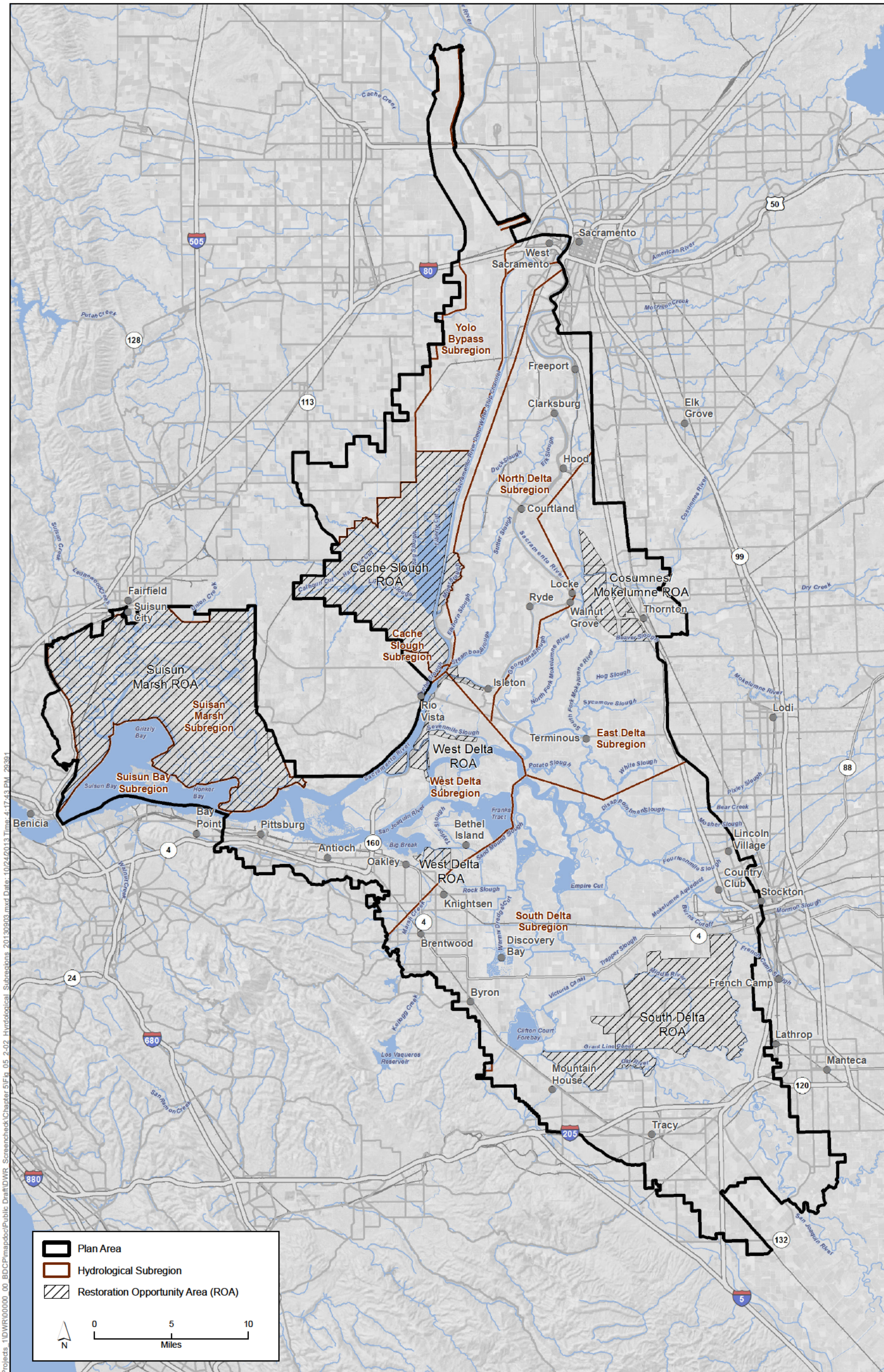
GIS Data Sources:Fish Barriers, DWR 2012;
Subregion Flowlines, DWR 2012

Figure 5.2-1
Study Area



GIS Data Source: Restoration Opportunity Area, SAIC 2011.

Figure 5.2-2
Plan Area, Geographic Subregions, and Restoration Opportunity Areas

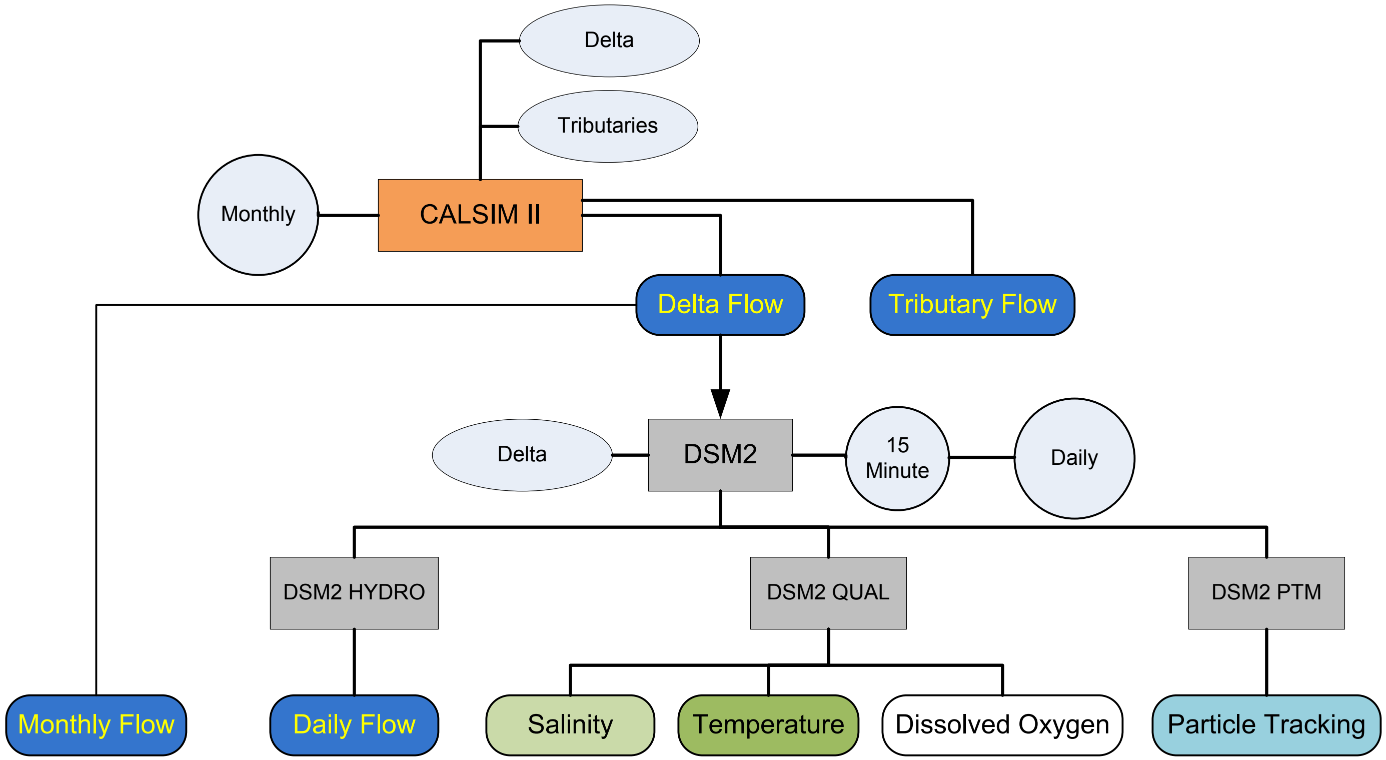
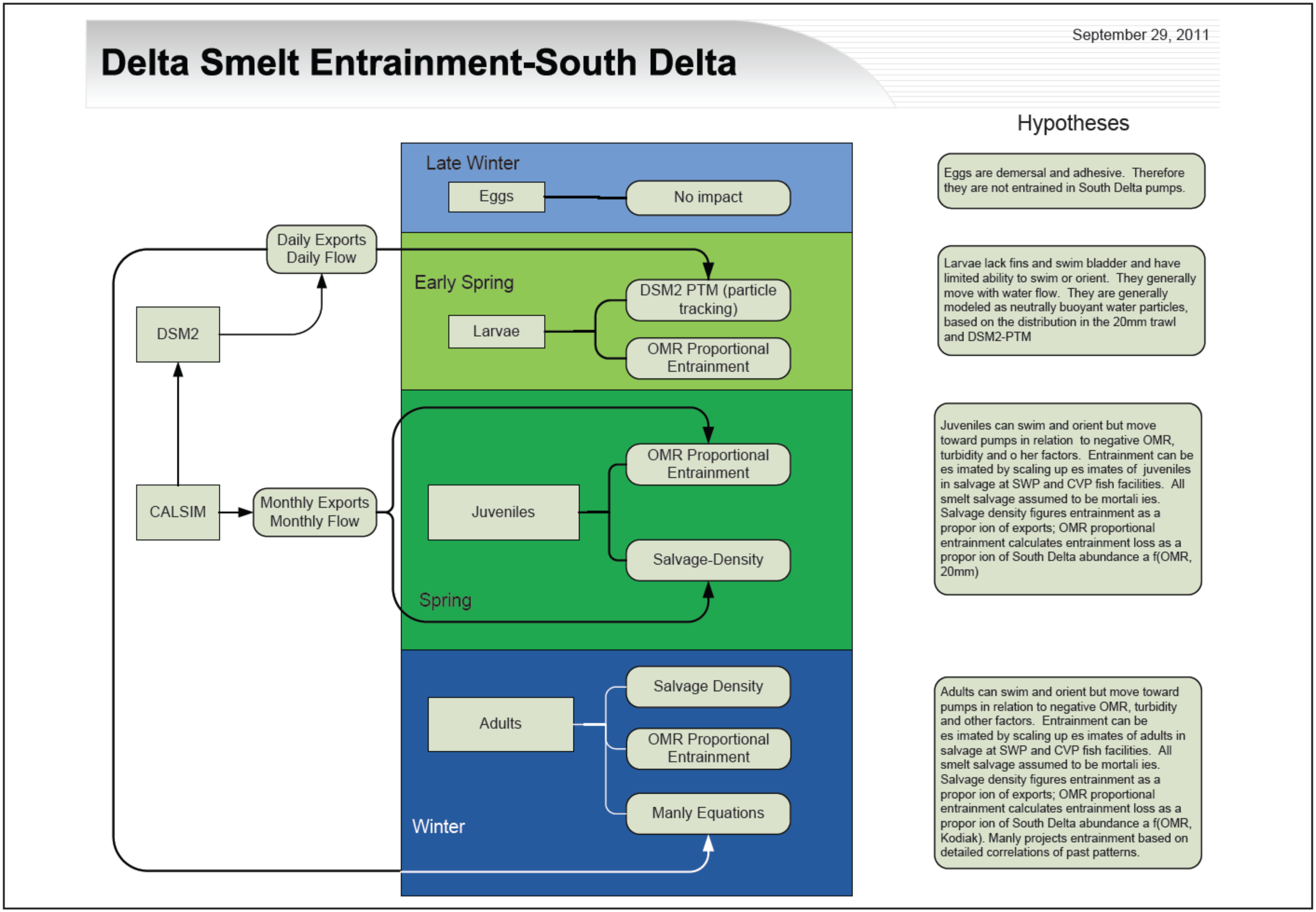
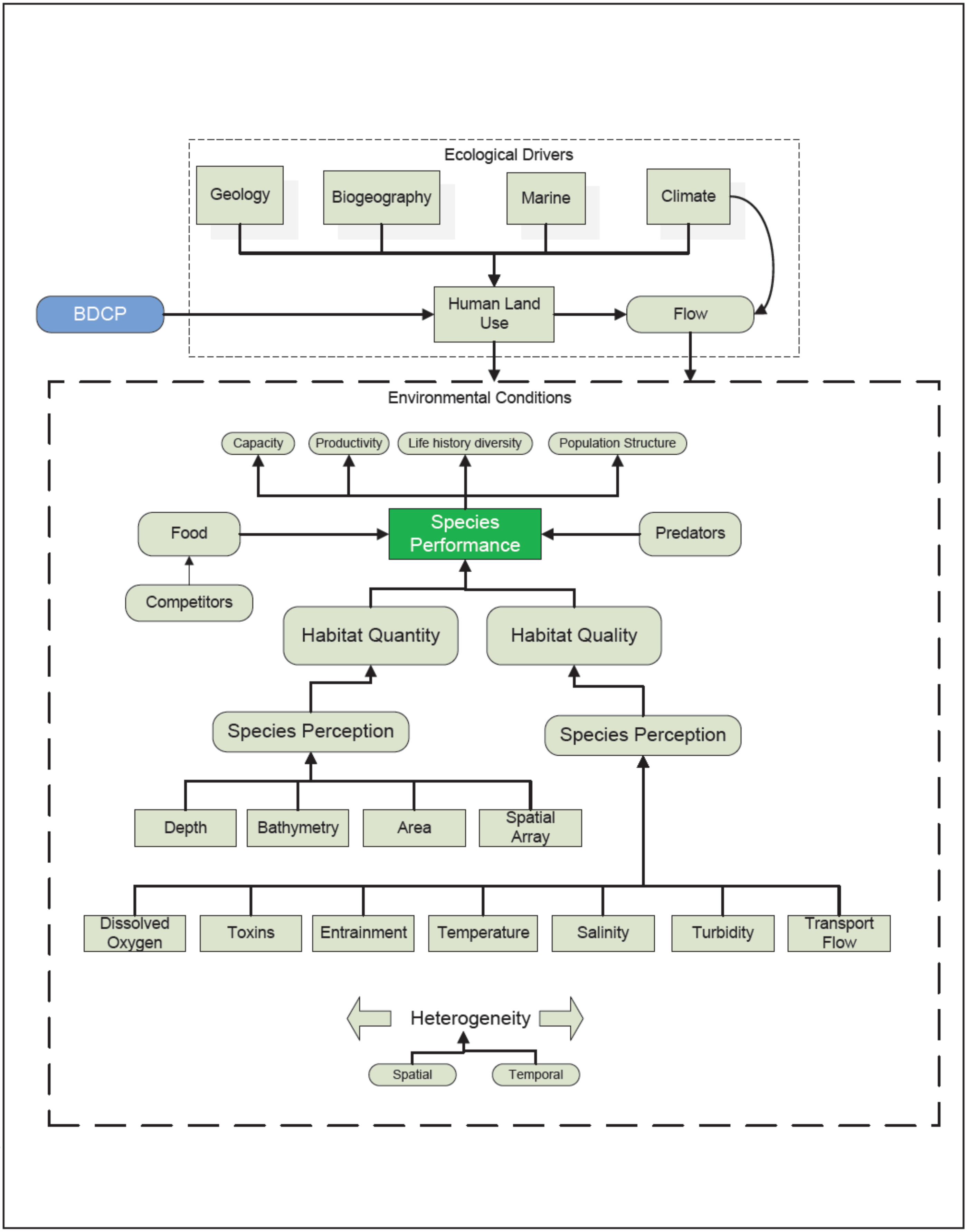


Figure 5.2-3
Relationship between Environmental Models and Their Major Outputs



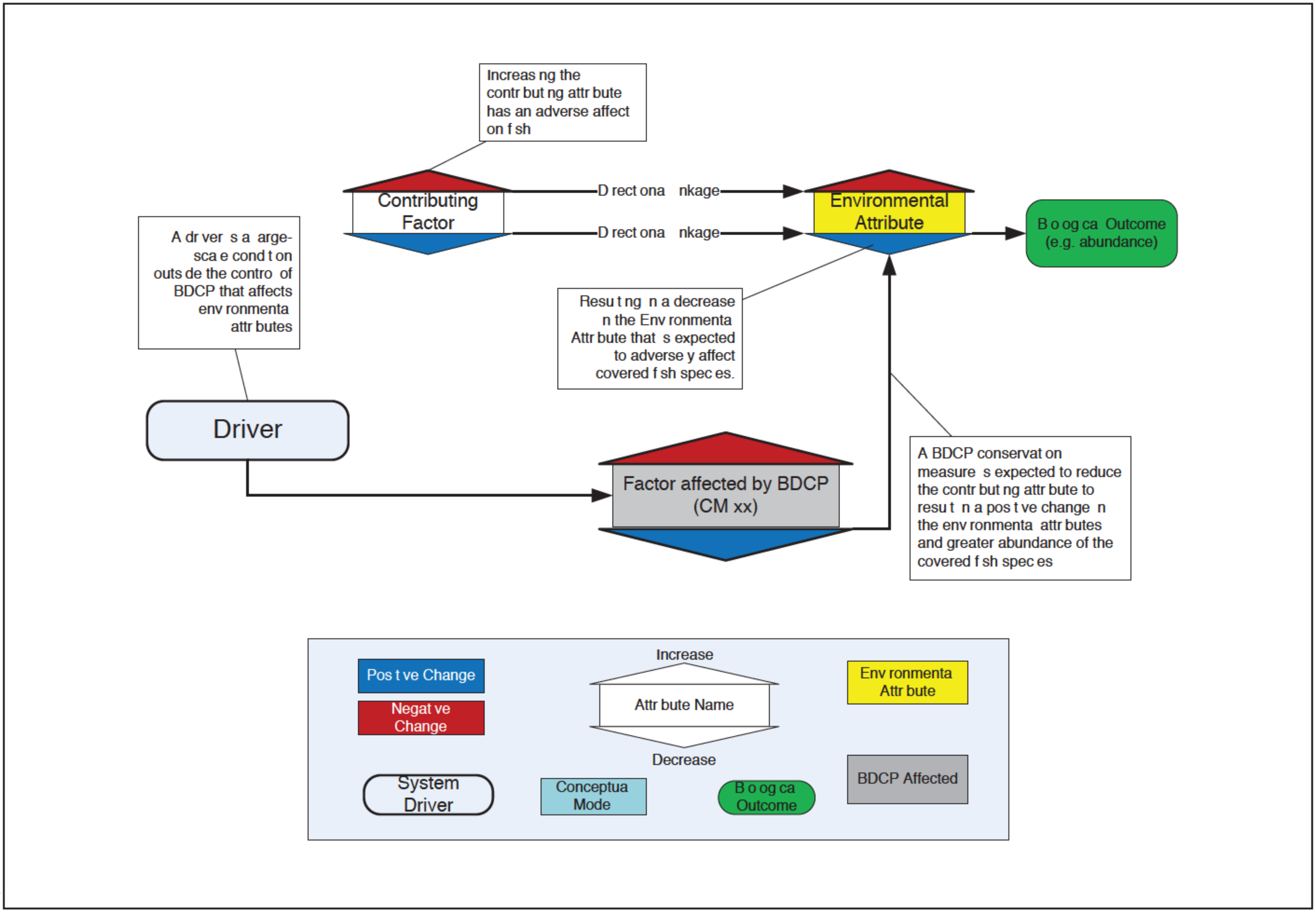
BDCP Effects Analysis (2-22-2012) TG

Figure 5.2-4
Relationship between Biological Models Used to Evaluate Entrainment and Environmental Models



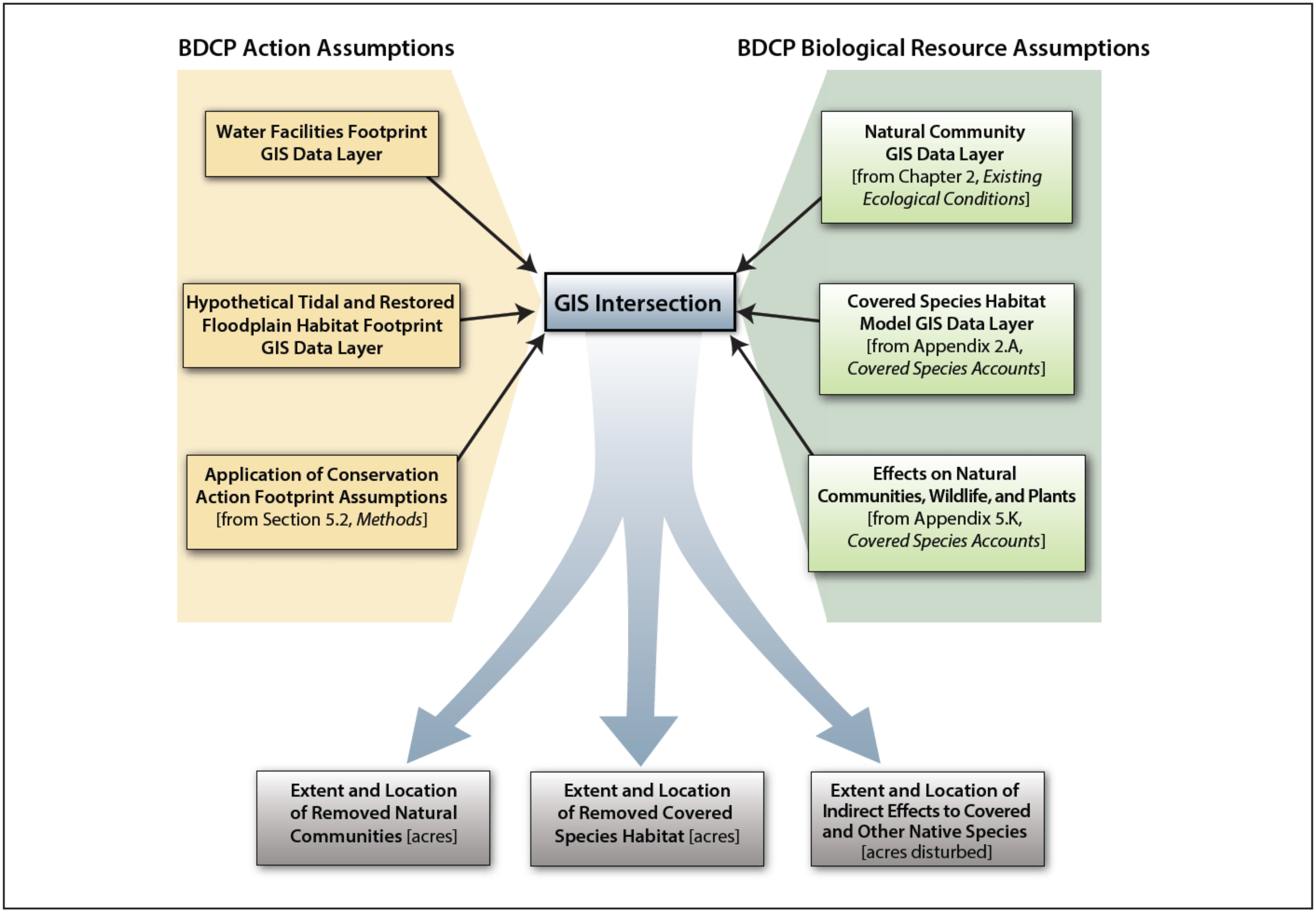
BDCP Effects Analysis (2-22-2012) TG

Figure 5.2-5
Conceptual Model of the Effects Analysis



Graphics… 00343.12 BDCP (1/28/13) AB rev. 20130225

Figure 5.2-6
Illustrative Example of the Components of BDCP Conceptual Models



Graphics/… BDCP EA/SAIC (created: 01/20/11) (Rev. 20130225 TM)

Figure 5.2-7
Process for Calculating Extent of Covered Activity and Conservation Action Footprint Effects on Natural Communities and Covered Species Habitats

5.3 Ecosystem and Landscape Effects

Ecosystem and landscape effects are those that affect general ecological processes and phenomena. Such effects can be, but not necessarily are, expressed at large spatial scales. For example, suspended sediment generated during dredging is a highly localized source, yet may have ecosystem effects by increasing the turbidity of the river or surrounding Delta channels. This section describes the indirect and ecosystem-level effects on covered species during construction and operation of the water facilities, and following restoration of various aquatic natural communities. It describes the results of physical modeling of hydrology and hydrodynamics, modeling of water temperatures, evaluation of various water quality parameters and toxic contaminants, and an assessment of the effects of in-water construction activities at the ecosystem and landscape levels. This section summarizes the detailed results of the analyses of these parameters, and along with the appendices listed below, supports the more specific analyses and evaluation of results for each covered species provided in Section 5.4, *Effects on Natural Communities*, Section 5.5, *Effects on Covered Fish,* and Section 5.6, *Effects on Covered Wildlife and Plant Species*.

Overall, the BDCP will result in substantial ecosystem and landscape-level effects through two primary mechanisms: restoration, enhancement, and/or protection of over 110,000 acres of terrestrial and aquatic natural communities in the Plan Area that represent substantial habitat for all of the covered species; and shifting the location, amount, and timing of diversion of SWP/CVP water from the Delta during most water-year types. These landscape and ecosystem-level effects are intended to result in the following.

- Beneficial or neutral changes in hydrodynamics.
- Increased access to habitat for covered species, including floodplains, tidal wetlands, and other natural communities.
- Increased aquatic food production and availability.

These changes result from the conservation measures, described in Chapter 3, Section 3.4, *Conservation Measures*, which provide landscape-scale, natural community, and species-specific benefits. These beneficial effects are described in this chapter and in the following technical appendices.

- Appendix 5.A.1, *Climate Change Implications for Natural Communities and Terrestrial Species*
- Appendix 5.A.2, *Climate Change Approach and Implications for Aquatic Species*
- Appendix 5.B, *Entrainment*
- Appendix 5.C, *Flow, Passage, Salinity, and Turbidity*
    - Attachment 5C.A, *CALSIM and DSM2 Modeling Results for the Evaluated Starting Operations Scenarios*
    - Attachment 5C.D, *Water Clarity—Suspended Sediment Concentration and Turbidity*
- Appendix 5.D, *Contaminants*
- Appendix 5.E, *Habitat Restoration*
- Appendix 5.F, *Biological Stressors on Covered Fish*

- Appendix 5.G, *Fish Life Cycle Models*
- Appendix 5.H, *Aquatic Construction and Maintenance Effects*

This section provides a summary of BDCP effects on flow, water quality, aquatic habitat and foodwebs, and other ecosystem drivers. In addition, this section provides an overview of BDCP benefits related to climate change adaptation.

5.3.1 Flow

5.3.1.1 Overview of BDCP Effects on Flow

As discussed in Chapter 2, *Existing Ecological Conditions*, the hydrology of the Plan Area is influenced primarily by freshwater inflows from the Sacramento River from the north and the San Joaquin River from the south, tidal action from the Pacific Ocean, and by SWP/CVP pumping in the south Delta. Figure 5.3-1 is the BDCP conceptual model of flow, depicting drivers, covered activities, controls, and VSP attributes, and how they interact. Eastside streams, particularly the Mokelumne River, also contribute inflows to the Plan Area. Numerous upstream dams and diversions greatly influence the timing and volume of water flowing into the Delta. Multiple upstream tributaries to the Sacramento and San Joaquin Rivers influence flow into the Plan Area. The Feather and American Rivers and many large creeks drain directly into the Sacramento River, and Cache and Putah Creeks drain into the Yolo Bypass, which joins the Sacramento River in the Cache Slough area. The Yuba and Bear Rivers drain into the Feather River before its confluence with the Sacramento River. The Calaveras, Stanislaus, Tuolumne, and Merced Rivers, and some flood flows from the Kings Rivers drain into the San Joaquin River upstream (but south) of the Delta. The Cosumnes River drains directly into the Mokelumne River, and both drain into the San Joaquin River after entering the Delta.

The BDCP will modify the hydrodynamics (i.e., tidal flows) in the Delta channels. Covered activities will reduce the movement of water from the north (Sacramento River) to the south (exports), restoring a more natural pattern of flow through the Delta. The BDCP will improve normative flows east to west (outflow to Bay) by shifting a large portion of exports to the north Delta. Additionally, the timing of Delta exports and outflows is adjusted to specifically benefit the aquatic ecosystem and covered fish species. While this reduces some Sacramento River flows, the frequency and magnitude of reverse flows in Old and Middle River (OMR) will be substantially reduced because of the reduced use of the south Delta export facilities in most water-year types. In the north Delta, flow patterns will be altered by the increased diversions to the Yolo Bypass (*CM2 Yolo Bypass Fisheries Enhancement*) with a modified Fremont Weir, allowing an additional 6,000 cfs diversion from the Sacramento River into the Yolo Bypass when Verona flows are above 35,000 cfs, and operations of the new north Delta intake facilities (*CM1 Water Facilities and Operation*). These changes in flow patterns in the north Delta present ecosystem-level tradeoffs between habitat in the Yolo Bypass and the Sacramento River during the winter-spring migration period, resulting in both positive and negative effects on the migration and passage of fish through and within the Delta, as described in Appendix 5.C, *Flow, Passage, Salinity, and Turbidity,* Section 5.C.5.3, *Passage, Movement, and Migration Results*.

The changes in Delta flows are not expected to result in any substantial changes in dissolved oxygen (DO), as described below. However, removal of suspended sediment by the new north Delta intake facilities has the potential to reduce turbidity and increase water clarity throughout the Plan Area.

The physical and biological effects of this action are difficult to estimate, because changes in the Delta due to tidal natural communities restoration will also affect sediment erosion and deposition. The overall changes in turbidity and water clarity are likely to be localized and dependent on subregional and local characteristics.

Changes in Delta outflow under the BDCP will not increase salinity enough under any outflow scenario to result in biological effects because Delta outflow will only be reduced by higher exports during periods of moderately high outflow. There may be changes in salinity at some Delta locations caused by tidal flow mixing effects from restoration actions and from sea level rise caused by climate change.

Changes outside the Plan Area (i.e., upstream, indirect effects) from covered activities were minimized or avoided to ensure the species-specific biological goals could be achieved within the Plan Area. As such, the changes in upstream flow and temperature resulting from BDCP are limited. When the effects of climate change are factored out, the BDCP will result in minimal changes in most upstream flows or reservoir operations compared to existing biological conditions (EBC2) that have no predicted biological effects. The exception is in the Feather River. Due to changes in the seasonal timing of releases from Oroville Dam, the Feather River will have lower flows and higher temperatures in summer months of wetter years. These changes to the environment (flows and temperatures) and the related effects on fish are described in Appendix 5.C, Section 5.C.5.2 *Upstream Habitat Results*.

Although the BDCP does not affect the coldwater pool in Shasta or Folsom Reservoirs (water temperature below 60°F), coldwater pool management is predicted to be challenging for the SWP and CVP reservoirs in the ELT and LLT. This is due to changes in the timing of runoff due to climate change both with and without the BDCP. Reservoir and downstream river temperatures will be higher because of the assumed climate change effects on inflows, increased air temperatures, and increased Delta outflow needed for salinity control with assumed sea level rise conditions in the ELT and LLT. Climate change effects on upstream flows and temperatures strongly influence the expected future condition of covered species and natural communities. These effects are detailed in Appendix 5.A.2, *Climate Change Implications and Assumptions for Aquatic Species*, and are summarized where relevant below.

The following sections discuss the general trends of changes in flows in specific locations throughout the Plan Area. Additional detail is provided in Appendix 5.C, Attachment 5C.A, *CALSIM and DSM2 Modeling Results for the Evaluated Starting Operations Scenarios*. These documents include substantially more information and detail about high outflow scenario (HOS) and low outflow scenario (LOS) operations, including CALSIM modeling results for each case. Where major differences between ESO and LOS or HOS are expected, all three BDCP outcomes are described.

5.3.1.2 Sacramento River Flows at Freeport

Other than flows exiting the Yolo Bypass, the Sacramento River flow at Freeport provides the largest Delta inflow and represents the water available for diversion at the proposed north Delta intakes. The average modeled annual inflow at Freeport for the ESO was reduced by about 650 thousand acre-feet (TAF) compared to EBC2, primarily as a result of the increased Fremont Weir spills into the Yolo Bypass that will occur under the BDCP. Monthly median flows at Freeport were similar to EBC2 but were shifted in some months as a result of small changes in upstream flows and increased diversions at the Fremont Weir.

Table 5.3-1 shows the CALSIM-simulated monthly cumulative distributions of Freeport flows for the BDCP cases. Comparison to the EBC1 and EBC2 conditions are provided in Appendix 5.C, Attachment 5C.A. The Freeport flows for the HOS and LOS cases are compared to the ESO flows for the ELT and LLT conditions. The months with the greatest changes in Freeport flows for the HOS cases are increased flows in April and May, with reduced flows in June and July, caused by reduced reservoir storage from high spring releases and the goal of maintaining the EBC carryover storage. The months with the major changes in Freeport flows for the LOS cases were reduced flows in September of about half of the years, with smaller reductions in November in fewer years. These shifts in upstream reservoir operations are more thoroughly discussed in Attachment 5C.A.

The modeled Sacramento River at Freeport median flows were similar in October, November, and December for the EBC2 and ESO, and HOS cases. The flows in these months are lower than EBC2 flows for the LOS cases because there is no Fall X2 action included in the LOS. The LOS flows in the fall months are similar to the EBC1 flows. The Freeport median flows in January, February, and March for the ESO cases were about 3,000 cfs less than EBC2 flows, reflecting the increased spills at the Fremont Weir into the Yolo Bypass. The April and May median flows at Freeport were similar for the ESO, LOS, and EBC2 cases. The March to May flows for the HOS cases are higher than those in the ESO, LOS, EBC1, and EBC2 cases because it includes targeted higher spring outflows. The June median flows were increased considerably for the ESO cases compared to the EBC1 and EBC2 cases. The Freeport median flows for the ESO cases in July and August were reduced by about 3,000 cfs compared to EBC2 flows because of changes in upstream reservoir releases. The ESO north Delta intakes allowed higher exports in April, May, and June and subsequently allowed reduced reservoir releases and reduced exports in July and August.

Table 5.3-1. CALSIM-Simulated Monthly Distribution of Sacramento River at Freeport Flows (1922–2003) for BDCP Scenarios[a]

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
A. ESO_ELT													
Min	5,361	5,879	6,900	8,210	8,960	8,545	7,833	5,503	8,134	8,535	6,298	6,002	6,233
10%	7,539	7,691	9,436	12,368	12,263	11,593	9,923	8,877	10,344	11,243	8,425	7,901	8,235
20%	9,053	8,630	12,682	13,453	14,965	15,274	10,964	10,128	11,689	15,560	10,361	8,626	9,577
30%	10,032	10,050	13,513	14,922	18,127	18,379	11,855	10,785	12,836	17,187	11,815	9,252	10,653
40%	10,863	10,750	13,852	18,067	22,967	20,493	13,013	11,530	15,796	17,952	12,507	9,552	11,977
50%	11,347	12,105	15,312	21,839	30,189	24,078	15,633	12,792	16,942	19,661	13,462	11,334	13,142
60%	11,930	12,775	18,388	25,968	43,730	29,054	19,851	14,754	18,213	21,381	14,335	16,845	17,441
70%	12,145	14,236	22,238	38,298	48,197	39,735	22,838	17,536	19,993	22,165	16,043	22,026	18,844
80%	12,513	15,492	34,749	55,148	60,611	50,513	31,852	25,400	20,781	23,427	17,301	23,632	20,754
90%	13,392	21,982	49,387	65,015	69,720	62,051	46,267	39,230	22,308	24,162	18,416	24,983	24,051
Max	29,534	57,482	80,914	78,073	77,818	80,189	74,449	57,436	53,440	26,084	21,268	28,340	31,199
Avg	11,191	14,085	22,916	30,698	36,484	31,483	22,094	18,388	17,561	18,922	13,690	15,225	15,203
B. Changes under HOS_ELT Compared to ESO_ELT													
Min	-23	811	58	323	-1,057	-369	-325	15	-505	-243	1,426	25	-188
10%	498	-15	28	-12	81	14	185	-350	-303	-1,455	548	-58	-51
20%	427	-53	-1,745	-16	24	42	-39	-439	-810	-2,643	558	168	40
30%	-159	-298	-33	58	-358	-105	-28	-49	-1,332	-1,522	-228	-89	-254

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
40%	-701	-57	-14	226	-139	445	5,308	1,245	-3,982	-979	-222	40	-366
50%	-403	-166	6	32	-6	375	6,690	3,327	-4,445	-1,759	-571	-132	171
60%	-725	139	-7	782	-308	291	4,014	3,878	-4,524	-2,201	-992	58	-186
70%	-267	372	-8	1,215	1,179	-2,868	4,421	4,564	-4,043	-1,994	-1,690	2	-162
80%	-168	417	284	721	1,384	-19	1,901	4,076	-3,876	-2,048	-1,418	-54	50
90%	605	58	607	453	0	-24	9	423	-2,491	-1,407	-1,617	437	-283
Max	1,772	3	0	0	2	-1	1	-4	5	-1,779	-2,767	-235	338
Avg	-71	-1	114	187	-56	-69	2,120	1,634	-2,516	-1,631	-729	-70	-65
C. Changes under LOS_ELT Compared to ESO_ELT													
Min	0	39	107	305	-87	-104	1	17	-6	11	0	-2	-47
10%	6	-6	579	181	97	6	225	0	-33	-903	155	297	51
20%	247	246	-81	610	-116	-42	187	1	249	-886	19	533	124
30%	141	-199	-48	1,193	392	447	112	47	-134	272	-204	704	118
40%	411	-172	-10	710	-61	423	-156	25	93	789	-47	1,005	61
50%	484	-843	377	574	36	353	-1	-74	107	493	-398	-375	13
60%	195	-643	82	1,988	270	-42	6	64	1,042	-195	-231	-5,372	-593
70%	350	-897	152	2,942	1,180	201	-5	-1	66	-61	-99	-9,535	-318
80%	504	-259	306	872	374	-4	10	1,219	150	53	349	-9,802	-669
90%	538	256	3,498	19	16	22	2	2	5	-28	695	-8,600	-99
Max	-93	1	0	-4	1	0	0	3	1	-22	15	-5,087	313
Avg	316	-340	611	658	207	152	77	9	201	41	15	-3,427	-85
D. ESO_LLT													
Min	4,901	5,688	6,349	8,735	6,298	7,801	8,320	5,327	8,127	8,828	7,780	7,047	6,585
10%	8,158	7,141	9,440	12,471	12,363	11,464	10,699	8,674	10,941	10,389	8,373	7,775	8,394
20%	9,283	8,331	12,426	13,741	15,532	15,490	11,204	10,690	12,151	12,743	10,143	8,752	9,485
30%	10,858	9,812	13,603	15,758	19,264	18,403	12,191	11,809	13,276	14,532	11,385	9,426	10,662
40%	11,385	10,872	14,357	18,894	23,192	20,648	13,213	12,595	15,520	16,650	12,036	10,198	11,720
50%	11,859	11,952	15,874	21,948	30,009	23,697	16,021	13,530	17,586	18,805	12,375	12,310	12,988
60%	12,441	12,633	18,001	24,888	43,168	29,230	20,046	15,076	19,523	20,491	13,500	17,197	17,501
70%	13,113	14,515	20,790	39,247	48,812	39,937	22,611	20,088	21,190	21,769	14,502	22,253	19,059
80%	13,813	14,880	31,652	56,986	63,420	51,636	32,225	23,965	23,239	23,464	16,614	25,457	20,553
90%	14,961	20,481	47,114	65,109	70,478	62,099	45,720	33,673	24,086	24,135	17,696	27,249	23,928
Max	29,533	53,220	81,077	80,443	80,031	79,178	74,335	50,028	47,484	26,683	23,129	29,035	29,744
Avg	11,862	13,483	22,156	31,296	37,070	31,666	22,231	17,669	17,959	18,084	13,157	15,923	15,188
E. Changes under HOS_LLT Compared to ESO_LLT													
Min	-45	-17	-10	-1,525	1,608	127	-826	210	-154	-442	-79	191	-515
10%	-55	478	-378	-359	-664	49	-468	-10	-971	4	-106	416	-90
20%	-3	95	-1,887	-243	-153	-440	-238	-209	-924	174	42	226	150
30%	-428	-85	-386	-1,094	-321	-354	-255	-250	-1,316	-413	111	-13	-148
40%	-237	309	-361	-760	-316	-221	1,770	-118	-2,659	-1,119	175	434	-412
50%	-381	-54	-214	-843	503	444	5,743	546	-3,740	-1,484	784	1,022	-128

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
60%	-355	4	79	1,169	212	448	4,740	1,636	-4,306	-2,080	623	1,034	-224
70%	-424	-236	621	31	496	-1,663	4,781	1,106	-4,861	-1,835	266	333	-162
80%	-173	165	-972	-1,977	-553	-49	1,134	-17	-4,019	-2,758	-1,143	-143	-88
90%	449	463	324	2,112	30	7	19	1,182	-894	-1,630	-1,123	191	-408
Max	112	1,319	0	-2	2	-1	2	5	24	2,173	-4,615	33	19
Avg	-176	108	-117	-379	-19	-4	1,845	495	-2,465	-1,204	-264	416	-108
F. Changes under LOS_LLT Compared to ESO_LOS													
Min	0	39	139	-2,448	595	-45	-40	-371	-3	11	0	204	155
10%	23	346	18	-148	24	306	-17	8	-47	-152	97	262	112
20%	678	203	174	160	387	-352	234	25	502	-137	169	454	273
30%	90	-421	-74	1,528	1,611	262	424	-255	680	377	-114	436	156
40%	-206	-924	505	1,215	-153	201	345	121	248	131	7	76	62
50%	106	-1,324	786	652	-44	728	-298	103	-18	-254	471	-1,518	206
60%	197	-1,318	458	2,043	912	371	247	-210	33	-220	154	-5,943	-652
70%	442	-2,060	964	-290	1,340	1,352	19	-596	-266	142	571	-10,156	-532
80%	370	-508	1,323	616	-450	319	6	-135	-166	66	24	-12,782	-580
90%	238	306	2,013	1,607	270	2	5	302	-89	206	324	-13,455	-545
Max	-7	2,168	0	-4	0	0	1	-22	10	-82	-185	-8,289	-114
Avg	172	-585	911	717	285	374	95	-36	35	-22	145	-4,784	-157
[a] For descriptions of scenarios, see Table 5.2-3.													

5.3.1.3 Yolo Bypass Flows

The Yolo Bypass flows are the sum of Fremont Weir spills and Cache Creek and Putah Creek flows. Although the BDCP will divert additional flows (at lower Sacramento River at Verona flows) into the Yolo Bypass at the Fremont Weir, the monthly sequences of Yolo Bypass flows were similar because the Yolo Bypass flows are dominated by very high spills from the Sacramento River and Sutter Bypass. A few more months with the BDCP (ESO, LOS, or HOS) will have flows of 2,000 to 6,000 cfs (notch capacity), and the high-flow months have slightly more flow (6,000 cfs) than the EBC1 or EBC2 cases. The HOS case will increase flows in March, April, and May of about 40% of the years and cause a small increase in Yolo Bypass flows in these years compared to the ESO or LOS cases.

5.3.1.4 North Delta Intake Pumping

The proposed north Delta intakes will be located along the Sacramento River between Freeport and Courtland (opposite Sutter Slough). The greatest tidal flows and largest range of tidal elevations are observed at relatively low Sacramento River flows. The tidal variations are reduced at higher river flows because the river surface gradient is greater, dampening the tidal flows. The general effect of each intake is the reduction of the downstream flow by about 3,000 cfs (when operated at capacity). Because there is always a downstream “bypass flow” requirement (e.g., 5,000 cfs in July through September, 7,000 cfs in October through November, and 10,000 cfs in December through June), there almost always will be a net downstream tidal flow (i.e., sweeping velocity) below the operating north Delta intakes. (Bypass flow criteria are described in detail in Chapter 3, *Conservation Strategy*.) However, there can be upstream flows and velocities during flood tide periods when the net river flow is reduced to less than half of the tidal flow magnitude. Based on these bypass rules, it is not expected that juvenile fish will move downstream past the intake structure and then be brought back adjacent to it with incoming (flood) tides. The detailed DSM2 tidal modeling of the intakes included a downstream sweeping velocity criteria of 0.4 foot per second; the intakes were not operated when the tidal velocity was less than 0.4 foot per second, as measured downstream of the intake. The upstream intake would normally be operated first, and the second and third intakes would be operated at higher Sacramento River flows when the tidal velocities are always much greater than the criteria.

The CALSIM-simulated Sacramento River diversions into the proposed north Delta intakes, located along the Sacramento River between Freeport and Hood, are the primary cause of BDCP changes in Delta flows. There are no existing intakes at these locations, so there are no north Delta intake diversions for EBC1 or EBC2 cases. Although the intakes would have a combined capacity of 9,000 cfs, the simulated north Delta diversions for the ESO cases are generally less than 5,000 cfs. The north Delta diversions are often limited by the monthly inflow hydrology and the D-1641 outflow objectives. Although the maximum export-to-inflow ratio was assumed not to apply to the north Delta diversions, the proposed BDCP operating rules include monthly minimum bypass flows for the north Delta intakes to reduce the effects of these diversions on migrating Sacramento River fish. These daily bypass rules were applied within CALSIM using daily estimated Freeport flows.

Table 5.3-2 gives the CALSIM-simulated monthly cumulative distributions of north Delta intake pumping (cfs) for the ESO cases, with the changes in north Delta pumping for the HOS and LOS cases for 1922 through 2003. The changes in the north Delta pumping for the HOS and LOS indicate that the pumping was reduced in the months of March, April, and May to provide increased outflow, and was also reduced in June in response to reduced Freeport inflows. The changes in north Delta pumping for the LOS case were moderate, with increases in pumping in the fall months, likely caused by reservoir flood control releases that were no longer needed for Delta outflow.

The simulated north Delta diversions would be very similar for the ELT and LLT, with some north Delta diversions in almost every month. The CALSIM-simulated north Delta diversions were 9,000 cfs in at least 10% of the years in the months of January through June. For both the ESO cases, the median diversions were about 2,000 cfs in October, 2,000 cfs in November; 1,000 cfs in December, 3,000 cfs in January, 6,000 cfs in February, 6,250 cfs in March, 3,500 cfs in April, 2,000 cfs in May, 4,500 cfs in June, 2,000 cfs in July, 3,000 cfs in August, and 2,500 cfs in September. The average annual total exports for ESO_ELT were 5,265 TAF with average north Delta diversions of 2,603 TAF (49% of total exports). The average annual total exports for ESO_LLT were 4,945 TAF with north Delta diversions of 2,435 TAF (49% of total exports). The CALSIM model assumed that there would be some south Delta exports in all months. The BDCP adaptive management program can be used to refine the north and south Delta exports to maximize benefits to fish.

Table 5.3-2. CALSIM-Simulated Monthly Distribution of North Delta Diversions (cfs) near Hood (1922–2003) for BDCP Scenarios[a]

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
A. North Delta Exports under ESO_ELT													
Min	-	-	-	6	474	513	470	218	-	-	-	-	231
10%	0	-	257	680	748	696	636	534	641	235	140	-	654
20%	977	279	701	810	977	1,449	691	608	751	341	450	738	1,041
30%	1,171	1,100	807	912	2,163	3,462	811	678	1,371	783	1,348	1,469	1,540
40%	1,980	1,461	827	1,303	4,714	4,532	1,592	1,197	2,740	1,747	2,161	1,894	1,960
50%	2,470	1,934	935	2,853	6,114	6,270	3,487	1,988	4,453	2,132	2,878	2,531	2,391
60%	2,998	2,232	1,341	4,946	7,119	7,538	4,772	3,034	5,666	2,761	3,161	3,705	3,172
70%	3,343	3,277	1,872	7,476	8,999	8,987	6,979	5,300	6,750	3,270	3,663	4,887	3,672
80%	3,828	4,751	4,923	8,739	9,000	9,000	8,368	8,341	7,626	4,124	4,620	6,127	4,198
90%	4,907	6,533	7,012	9,000	9,000	9,000	9,000	8,999	8,857	6,553	5,261	7,194	4,702
Max	8,321	9,000	8,216	9,000	9,000	9,000	9,000	9,000	9,000	9,000	7,994	9,000	5,362
Avg	2,567	2,633	2,277	4,117	5,320	5,577	4,141	3,554	4,361	2,590	2,785	3,359	2,603
B. Changes in North Delta Exports under HOS_ELT Compared to ESO_ELT													
Min	0	0	0	-6	1	-37	-470	-116	0	0	0	0	19
10%	411	0	295	2	-33	-1	-97	-46	-10	-15	-46	102	-34
20%	12	134	-24	4	-78	-283	-56	-72	-23	292	-235	175	-124
30%	17	-106	-3	-11	4	-1,962	-127	-87	-565	259	-757	-70	-329
40%	-444	-181	15	37	-274	-3,032	-721	-535	-1,520	-373	-1,028	-95	-482
50%	-410	131	5	-250	0	-3,001	-1,987	-796	-2,674	-451	-1,150	103	-307
60%	-539	46	2	-152	230	-1,685	-3,210	-1,534	-3,294	-489	-947	559	-499
70%	-454	-90	34	274	0	-425	-1,510	-2,382	-3,365	-423	-382	242	-545
80%	-232	208	167	0	0	0	-635	-2,186	-2,635	-485	-960	239	-511
90%	536	903	142	0	0	0	-702	-82	-2,448	-671	-1,272	289	-437
Max	95	0	0	0	0	0	0	0	0	-1,053	218	0	143
Avg	-81	78	55	9	-30	-1,106	-873	-772	-1,591	-243	-758	114	-315
C. Changes in North Delta Exports under LOS_ELT Compared to ESO_ELT													
Min	0	0	0	-6	47	-12	0	3	0	0	0	0	10
10%	0	0	223	-57	0	1	0	0	0	-66	-48	277	1
20%	-279	76	8	-21	66	-439	17	0	1	117	264	740	148
30%	125	207	-11	5	165	310	1	14	35	156	329	415	-50
40%	419	399	-2	-76	-224	561	37	23	-95	-122	63	458	186
50%	508	595	2	1	1	71	3	0	407	1	65	404	210
60%	299	1,208	77	412	220	100	12	249	324	-90	361	-248	83
70%	226	832	102	274	1	-126	-3	-250	242	263	435	-1,073	131
80%	813	569	357	-9	0	0	-655	-22	56	-25	194	-824	-137
90%	1,174	-91	302	0	0	0	-52	-13	-13	-380	404	693	30
Max	297	0	0	0	0	0	0	0	0	0	328	0	8
Avg	356	384	50	14	37	52	-74	-5	142	13	165	43	71

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
D. North Delta Pumping under ESO_LLT													
Min	-	-	-	-	-	466	499	184	-	-	-	-	178
10%	0	-	183	707	702	699	643	522	658	235	4	0	570
20%	203	37	582	812	1,038	1,423	698	643	775	418	300	191	954
30%	726	997	800	965	2,153	3,468	828	763	1,082	604	581	343	1,137
40%	1,030	1,197	842	1,421	4,499	4,409	1,667	1,040	2,631	1,023	1,368	1,161	1,665
50%	1,675	1,599	919	2,604	6,275	6,489	3,291	1,980	5,089	1,319	2,134	1,986	2,220
60%	2,175	1,917	1,179	5,078	7,894	7,890	4,841	3,199	6,549	1,502	2,916	3,504	3,145
70%	2,703	2,816	1,553	7,873	9,000	8,982	7,008	6,020	7,388	2,189	3,535	4,347	3,520
80%	3,195	3,875	3,814	8,692	9,000	9,000	8,359	8,275	8,247	2,911	4,028	5,831	3,940
90%	4,252	5,744	6,468	9,000	9,000	9,000	9,000	8,810	8,934	3,669	4,645	7,270	4,412
Max	7,685	8,730	8,216	9,000	9,000	9,000	9,000	9,000	9,000	7,143	7,253	9,000	4,946
Avg	1,949	2,219	1,997	4,174	5,393	5,551	4,100	3,589	4,617	1,710	2,277	2,954	2,435
E. Changes in North Delta Pumping under HOS_LLT Compared to ESO_LLT													
Min	0	0	0	0	474	10	-499	-184	0	0	0	0	85
10%	0	0	345	-46	50	0	-122	-180	-10	-98	-4	0	-48
20%	227	5	53	-12	-72	-495	-58	-99	-11	-7	-181	-59	-119
30%	255	68	-42	11	-197	-1,968	-155	-115	-246	52	-366	-122	-94
40%	227	143	-19	-138	-126	-2,909	-816	-290	-1,441	-31	-675	-319	-314
50%	-210	238	-18	-245	-362	-3,175	-1,791	-1,095	-2,921	-36	-847	-502	-378
60%	-103	131	-36	607	-593	-1,943	-3,341	-1,699	-3,420	298	-846	340	-632
70%	-353	-78	42	55	0	-284	-1,840	-3,770	-2,921	142	-663	452	-523
80%	-254	302	46	0	0	0	-1,228	-3,102	-2,421	-83	-480	871	-421
90%	-285	167	180	0	0	0	-515	-468	-844	873	-438	579	-228
Max	99	0	261	0	0	0	0	0	0	-820	-352	0	-50
Avg	-58	96	56	-41	-123	-1,023	-954	-1,033	-1,413	106	-496	69	-291
F. Changes in North Delta Pumping under LOS_LLT Compared to ESO_LLT													
Min	0	0	0	0	0	-1	-2	-122	0	0	0	0	-68
10%	0	0	65	3	66	0	3	2	-2	0	48	6	-67
20%	-116	334	29	-7	-9	-236	17	22	0	-89	59	59	-22
30%	-331	-144	-3	-28	239	183	164	0	541	-49	234	61	202
40%	-238	174	28	-251	5	276	100	224	1,168	-76	416	672	194
50%	-441	453	-8	298	65	-221	65	23	-320	-39	474	284	89
60%	-185	676	230	774	-469	-249	116	-103	-413	104	325	-727	-91
70%	46	751	278	73	0	0	46	-217	-211	202	370	-645	44
80%	265	808	357	0	0	0	-20	-2	-5	-4	100	-1,488	49
90%	-184	273	180	0	0	0	-146	-90	-8	44	398	-1,939	17
Max	261	270	0	0	0	0	0	0	0	-467	138	0	-76
Avg	-105	373	159	88	29	59	12	-24	25	27	270	-451	28

[a] For descriptions of scenarios, see Table 5.2-3.

5.3.1.5 Sutter Slough and Steamboat Slough Flows

Sutter and Steamboat Sloughs divert about 40% of the Sacramento River flow. The monthly median predicted diversion flows into Sutter and Steamboat Sloughs were similar for the EBC2 cases because the Sacramento River flows were similar. The median diversions into Sutter and Steamboat Sloughs were lower for the ESO, LOS, and HOS cases because the Fremont Weir notch increases the diversions to the Yolo Bypass and because north Delta intakes reduce the Sacramento River flow at Sutter and Steamboat Sloughs. In addition, tidal restoration in the Cache Slough complex was simulated to shift the tidal elevations and reduce the Sutter and Steamboat diversion fractions. Nevertheless, the median diversions in most months were similar. The BDCP median diversion flows (ESO, LOS, or HOS) were reduced by about 1,000 cfs in January, about 5,000 cfs in February, and about 3,500 cfs in March compared to the EBC1 and EBC2 cases. The reductions in the Sutter and Steamboat Slough diversions were about 40% of the simulated north Delta intake diversions. The annual average diversions into Sutter and Steamboat Sloughs were about 6,500 TAF (42% of the Sacramento River flow at Freeport) for the EBC2 cases, and were reduced to about 5,500 TAF (36% of the Sacramento River flow at Freeport) for the ESO, LOS, or HOS scenarios.

5.3.1.6 Delta Cross Channel and Georgiana Slough Flows

Similar to Steamboat and Sutter Sloughs, CALSIM predicted reduced monthly median diversion flows to Delta Cross Channel and Georgiana Slough for the ESO, LOS, or HOS cases because the north Delta intakes reduced the Sacramento River flow. The average annual diversions into the Delta Cross Channel and Georgiana Slough were about 3,750 TAF (24% of the Sacramento River flow at Freeport) for the EBC2 cases and were reduced to about 3,150 TAF (21% of the Sacramento River flow at Freeport) for the ESO cases. *CM16 Nonphysical Fish Barriers* includes the operation of a nonphysical barrier at Georgiana Slough to reduce diversion of fish into the slough during their downstream migration in the spring.

5.3.1.7 Sacramento River Flows at Rio Vista

The minimum flows in September through December for Rio Vista (3,000 to 4,500 cfs, depending on water-year type) were increased by the Fall X2 requirements in October and November of wet and above-normal years (about 50% of the years). The median monthly flows at Rio Vista for the ESO, LOS, or HOS cases were reduced from the EBC1 or EBC2 flows because the north Delta intake pumping; the Rio Vista flow is reduced by about 80% of the north Delta pumping (the remaining 20% of the Sacramento River flow reduction is “missing” in the Delta Cross Channel and Georgiana Slough diversions). But the minimum Rio Vista flows are protected by the required Delta outflow. The annual average Sacramento River flows at Rio Vista were about 14,000 TAF for the EBC2 cases, and were reduced to about 12,000 TAF for the ESO cases, because the simulated north Delta intake diversions were an average of 2,500 TAF.

5.3.1.8 Threemile Slough Flows

The DSM2 modeling indicates that Threemile Slough flows are about 3% of the Rio Vista flows and were reduced slightly for the ESO cases because the Rio Vista flows were reduced by about 80% of the north Delta intake diversions, as described above. The predicted annual average Threemile Slough flows were about 1,000 TAF for EBC2 cases and were reduced to about 700 TAF for the ESO cases. There is a much larger tidal exchange of water between the Sacramento River and the San Joaquin River through Threemile Slough; this large tidal exchange would remain similar for the

EBC2 and ESO, although the tidal natural communities restoration (*CM4 Tidal Natural Communities Restoration*) is predicted to slightly reduce the tidal exchange in Threemile Slough.

5.3.1.9 San Joaquin River Inflow and Diversions to Old River

The BDCP will not result in changes in the San Joaquin River flows at Old River from BDCP, but some changes are expected as a result of climate change (for ELT and LLT). The average annual San Joaquin River inflow was about 3,000 TAF for the ELT cases and was reduced slightly to about 2,900 TAF for the LLT cases. The predicted median head of Old River flow (e.g., diversion from the San Joaquin River) for December through May was about half of the San Joaquin River flow at Vernalis for the EBC2. The median head of Old River flows in June through September for EBC2 were about 40% of the San Joaquin River flow at Vernalis. The BDCP includes an operable gate at the head of Old River. The gate would be operated to reduce the diversions into Old River in some months to protect migrating fish. The BDCP flows were reduced to about 25% of the San Joaquin River flow in January through June because the tidal gate was assumed to be closed for half of each day. The annual average head of Old River diversion flow for the EBC2 cases was equal to about 40% of the San Joaquin River at Vernalis flow; this was reduced to about 35% of the Vernalis flow for the BDCP cases. Actual operations of the head of Old River barrier would be adaptively managed.

5.3.1.10 South Delta Pumping

All of the Delta exports are pumped from the south Delta for the EBC1 and EBC2 cases. For the ESO, HOS, and LOS cases, the south Delta pumping was reduced by about half, and about half of the total exports were diverted at the north Delta intakes. The EBC2_ELT annual average exports were 4,728 TAF, and the EBC2_LLT annual average exports were 4,441 TAF. The reductions in the simulated EBC2 south Delta exports for the ELT and the LLT cases were likely the result of increased Delta outflows assumed to be necessary for X2 and salinity control with sea level rise. The annual average south Delta exports were 2,662 TAF for the ESO_ELT, and were 2,510 TAF for the ESO_LLT. The average ESO south Delta exports were about 56% of the EBC2 south Delta exports. The HOS cases reduced the south Delta exports because more outflow was required during the months of March through May in about 40% of the years. The annual average south Delta exports were 2,417 TAF for the HOS ELT and were 2,270 TAF for the HOS LLT; the average HOS south Delta exports were about 51% of the EBC2 south Delta exports. The LOS cases increased the south Delta exports because less outflow was required during the months of September through November in about half of the years. The annual average south Delta exports were 2,917 TAF for the LOS ELT and were 2,792 TAF for the LOS LLT; the average LOS south Delta exports were about 62% of the EBC2 south Delta exports.

The monthly patterns of south Delta exports are important for evaluating fish entrainment impacts. The CALSIM model accounts for all D-1641 objectives and USFWS (2008) and NMFS (2009) BiOp actions, as well as the Delta inflows and export-to-inflow objectives to calculate the south Delta exports. Table 5.3-3 gives the CALSIM-simulated monthly cumulative distributions of south Delta exports (cfs) for the EBC2 and ESO cases for 1922 through 2003. The median south Delta exports for the ESO cases were about 2,500 cfs in October, 4,250 in November, 7,000 cfs in December, 4,250 cfs in January, 2,500 cfs in February, and 2,000 cfs in March. The median exports were about 1,500 cfs in April and May and 2,000 cfs in June. The median exports were about 7,000 cfs in July, 5,000 cfs in August, and 4,000 cfs in September for the ESO_ELT case, and the median exports were about 6,000 cfs in July, 5,000 cfs in August, and 2,000 cfs in September for the ESO_LLT case. The CALSIM results for the ESO cases reflect the specified north Delta bypass rules and other simulation rules used to maintain some south Delta pumping for water quality (salinity) control.

Table 5.3-3 also shows the shifts in monthly south Delta exports for the HOS and LOS cases compared to the ESO cases (ELT and LLT). The HOS cases caused large reductions from the ESO south Delta exports of about 500 cfs to 1,500 cfs in March through July. The reductions in March through May were required to provide additional outflow, and the reduction in June and July were caused by reduced upstream reservoir storage releases to maintain carryover storages that were similar to the EBC2 and ESO cases. The LOS cases caused increases compared to the ESO south Delta exports of about 1,000 cfs to 4,000 cfs in September through November of about half of the years. The increased south Delta exports in these months (following above normal and wet years) were caused by the reduced outflow requirements.

Table 5.3-3. CALSIM-Simulated Monthly Distribution of South Delta Exports (cfs) (1922–2003) for BDCP Scenarios[a]

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
A. EBC2_ELT													
Min	1,544	1,891	2,782	900	1,307	1,100	900	900	1,005	900	900	2,823	1,713
10%	3,982	4,408	5,532	4,242	3,744	2,158	1,482	1,500	1,442	6,668	2,184	4,457	3,186
20%	4,490	4,791	7,169	5,086	4,846	4,315	1,500	1,500	1,680	7,948	7,668	4,818	3,915
30%	5,077	5,135	7,551	6,033	5,647	4,576	1,500	1,500	2,856	9,231	8,346	6,661	4,283
40%	5,455	5,771	7,953	6,409	6,599	5,324	1,650	1,517	3,202	9,994	10,848	8,467	4,397
50%	5,798	6,013	8,402	6,586	6,807	6,490	1,768	1,647	3,723	10,880	11,495	8,952	4,837
60%	6,115	6,769	9,766	6,784	7,651	7,173	1,929	1,769	5,081	11,137	11,630	9,405	5,158
70%	6,371	7,810	10,453	6,933	8,265	8,641	2,164	1,932	5,316	11,328	11,780	10,362	5,470
80%	6,702	9,020	11,545	8,171	9,386	9,396	2,490	2,336	5,904	11,570	11,780	11,098	5,599
90%	8,360	10,853	11,727	9,330	10,454	10,760	3,505	3,666	8,437	11,605	11,780	11,280	5,995
Max	11,280	11,280	12,278	13,100	13,100	12,161	8,851	10,777	11,280	11,621	11,780	11,280	6,977
Avg	5,890	6,753	8,812	6,720	7,148	6,588	2,181	2,307	4,420	9,652	9,433	8,326	4,728
B. ESO_ELT													
Min	0	0	959	0	0	0	0	0	328	303	1,926	0	995
10%	1,199	0	5,100	1,509	1,024	696	968	905	1,127	2,039	3,038	0	2,028
20%	1,820	0	5,827	1,514	1,814	1,472	1,097	1,073	1,476	3,147	3,523	0	2,201
30%	2,182	832	6,286	2,007	2,466	1,575	1,236	1,158	1,661	4,752	3,956	276	2,405
40%	2,552	2,640	6,640	3,039	2,926	1,783	1,419	1,274	1,676	6,296	4,614	810	2,597
50%	2,672	4,378	6,980	4,259	3,638	2,202	1,539	1,415	2,397	7,001	5,092	4,187	2,699
60%	2,715	4,875	7,213	4,558	4,430	2,574	1,641	1,584	3,088	8,154	5,759	4,563	2,771
70%	2,739	5,115	7,822	4,842	4,925	3,830	1,728	1,649	3,346	9,496	6,915	4,719	2,852
80%	2,781	5,828	9,418	5,310	5,180	4,188	2,420	1,794	3,505	11,139	7,833	5,042	3,006
90%	2,846	6,065	9,623	5,864	5,541	4,432	2,781	2,220	3,651	12,224	10,480	5,370	3,296
Max	3,083	6,766	10,851	6,324	6,679	6,792	3,127	3,874	6,020	14,400	12,748	10,332	4,231
Avg	2,303	3,289	7,124	3,608	3,503	2,559	1,668	1,491	2,445	7,135	5,910	2,897	2,662
C. Changes under HOS_ELT Compared to ESO_ELT													
Min	0	0	7	0	0	0	0	0	-328	-14	74	0	443

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
10%	-278	0	-166	-6	-444	-696	-968	-905	-942	-938	232	0	-201
20%	-56	0	-8	2	-260	-1,472	-802	-698	-972	-831	404	0	-190
30%	21	395	30	-176	-71	-1,195	-435	-403	-487	-1,222	382	-276	-252
40%	-2	-192	-57	764	-130	-901	-503	-365	-191	-1,654	279	-400	-279
50%	-1	-61	-55	73	45	-678	-552	-406	-729	-843	568	-192	-298
60%	0	-193	-130	99	39	-774	-444	-397	-1,382	-1,141	510	-54	-219
70%	0	-105	-464	410	-8	-1,436	-300	-257	-1,048	-1,661	-109	3	-164
80%	-4	-524	-375	210	-17	-430	-767	-221	-595	-1,910	-63	-180	-170
90%	0	-69	22	0	6	-220	-422	-506	-289	-948	-1,594	-2	-355
Max	585	89	-237	0	1,514	-560	0	13	-557	-213	-1,746	-2,643	-885
Avg	-28	-48	-143	124	-47	-807	-551	-453	-700	-1,095	-45	-249	-245
D. Changes under LOS_ELT Compared to ESO_ELT													
Min	1,089	225	0	0	0	0	0	0	-114	-26	0	838	14
10%	1,148	4,365	-449	-8	-376	-88	20	-5	156	-270	58	4,135	173
20%	848	4,817	-40	19	-255	-431	30	-36	83	-7	-27	4,574	301
30%	534	4,259	-19	-383	-313	-21	22	-30	13	271	-52	4,473	247
40%	185	2,769	-43	77	-325	-142	11	-16	18	-93	-435	4,075	186
50%	86	1,359	-54	-257	-25	-367	-9	0	324	120	-346	880	237
60%	80	1,044	19	-139	-33	-180	-2	-24	27	-7	-322	849	225
70%	91	962	263	-46	-50	-420	0	0	19	188	-729	1,064	277
80%	81	416	-74	-30	-108	-263	-1	-2	0	-224	313	995	257
90%	76	310	-142	8	-27	-90	-47	98	0	-110	372	1,066	426
Max	0	714	-185	0	-239	-402	0	2	-7	0	-128	1,239	-14
Avg	382	2,145	-51	-88	-183	-234	3	-12	38	33	-139	2,391	255
E. EBC2_LLT													
Min	546	1,846	82	1,500	900	959	900	846	760	57	580	2,841	1,520
10%	2,554	3,355	4,138	4,493	3,341	2,150	1,359	1,500	1,480	3,663	3,453	4,337	2,861
20%	3,660	4,478	6,178	4,910	4,377	3,222	1,500	1,500	1,633	5,853	6,558	4,795	3,592
30%	4,214	4,861	7,250	5,463	5,506	4,566	1,598	1,500	2,392	8,269	7,933	5,615	3,851
40%	4,613	5,086	7,882	6,179	6,251	5,250	1,712	1,606	2,995	8,818	9,625	6,546	4,331
50%	5,016	5,641	8,211	6,505	6,643	6,507	1,830	1,691	3,544	9,731	11,059	7,595	4,605
60%	5,384	6,351	9,062	6,744	7,266	7,202	2,071	1,785	4,094	10,426	11,437	8,956	4,832
70%	5,768	7,130	10,444	6,857	8,220	8,178	2,230	1,964	5,085	10,849	11,662	9,418	5,075
80%	6,219	8,289	10,946	7,731	9,231	9,202	2,461	2,449	5,616	11,432	11,780	11,088	5,354
90%	6,640	11,279	11,704	9,525	10,456	10,469	3,590	3,369	6,155	11,605	11,780	11,280	5,728
Max	11,280	11,280	12,278	13,100	13,100	12,161	8,851	10,670	11,280	11,780	11,780	11,366	7,207
Avg	4,938	6,348	8,358	6,562	6,901	6,406	2,235	2,303	3,934	8,751	9,071	7,681	4,441
F. ESO_LLT													
Min	0	0	835	0	0	0	0	0	0	0	1,447	0	1,230
10%	12	0	3,213	1,566	1,131	601	924	748	1,044	1,277	2,880	0	1,916
20%	499	0	5,345	1,566	1,785	1,391	1,104	946	1,411	2,393	3,455	0	2,072

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
30%	1,014	0	6,106	2,031	2,420	1,575	1,261	1,072	1,616	3,961	3,780	98	2,270
40%	2,097	1,975	6,509	2,849	2,836	1,818	1,437	1,241	1,674	4,838	4,254	338	2,385
50%	2,541	4,328	6,862	4,256	3,618	2,493	1,545	1,366	1,680	6,109	4,864	2,275	2,481
60%	2,632	4,780	7,217	4,595	4,752	2,848	1,627	1,431	2,085	7,547	5,357	3,770	2,567
70%	2,712	5,098	8,320	5,193	5,039	3,713	1,728	1,569	3,095	9,191	5,978	4,633	2,686
80%	2,749	5,689	9,473	5,525	5,404	4,188	2,373	1,649	3,360	10,543	7,850	5,181	2,949
90%	2,790	6,054	9,670	5,907	5,533	4,696	2,749	2,105	3,575	11,735	10,022	5,685	3,199
Max	5,062	7,228	10,354	6,783	8,371	6,194	3,108	3,870	4,231	14,400	13,012	8,868	4,055
Avg	1,883	3,098	6,854	3,665	3,549	2,645	1,621	1,361	2,161	6,513	5,477	2,620	2,510
G. Changes under HOS_LLT Compared to ESO_LLT													
Min	0	0	-813	0	0	0	0	0	0	0	241	0	-34
10%	-9	0	904	0	-1,050	-601	-924	-748	-1,043	-208	295	0	-168
20%	-101	0	-38	0	-222	-1,391	-1,055	-822	-1,393	-123	-56	0	-156
30%	68	0	32	-90	-122	-1,193	-762	-445	-1,365	-808	197	-98	-246
40%	20	-976	-191	754	-30	-1,007	-653	-425	-912	-406	542	150	-229
50%	22	100	-35	44	-71	-936	-687	-409	-386	-1,132	668	137	-217
60%	20	-113	-102	74	-306	-1,169	-551	-195	-454	-1,762	1,299	706	-134
70%	-18	-57	-694	-31	-92	-1,310	-390	-163	-1,417	-2,182	1,316	331	-146
80%	0	-328	-862	-10	-209	-596	-873	-149	-1,324	-2,360	73	216	-334
90%	13	85	-158	0	-3	-550	-1,026	-473	-561	-1,558	-1,511	599	-391
Max	0	1,306	-194	-113	-1	-13	7	24	397	-1,458	-2,465	-818	-721
Avg	8	-67	-122	60	-175	-905	-680	-375	-878	-1,182	215	122	-241
H. Changes under LOS_LLT Compared to ESO_LLT													
Min	0	876	-728	0	0	0	0	0	0	0	309	0	-4
10%	2,207	3,789	688	-106	-535	-4	0	-1	-13	10	-60	2,822	62
20%	2,066	4,644	84	0	-303	-410	0	11	-193	-314	-97	4,209	357
30%	1,642	4,839	-26	173	-430	-8	-43	2	-180	-554	-52	4,509	277
40%	626	3,272	-154	491	-87	-146	-61	10	-13	-24	-245	4,686	308
50%	212	1,290	41	63	-69	-246	-49	-14	-5	161	-400	3,071	317
60%	155	1,137	-51	-89	-300	112	-34	5	50	170	-246	1,781	337
70%	111	1,001	-507	-131	-81	12	0	-29	-30	511	34	1,097	353
80%	98	544	-786	-2	-209	-81	-319	0	-59	-255	-759	891	309
90%	102	263	-161	-8	6	-184	7	19	-59	451	-1,105	1,174	341
Max	-1,169	-1	0	-176	0	-694	0	0	-357	0	379	488	35
Avg	743	2,176	-193	54	-163	-123	-36	9	-49	7	-158	2,451	282
[a] For descriptions of scenarios, see Table 5.2-3.													

5.3.1.11 Old and Middle River Flows

The CALSIM modeling assumed that some OMR reverse flow restrictions will apply for each of the applicable months (December through June). The restrictions were assumed to vary somewhat with runoff conditions (e.g., water-year type). The assumed OMR restrictions were generally negative (reverse) flows of -5,000 cfs from January to June for the EBC2, but were increased (less negative, more restrictive) for the ESO. These changes in the simulated OMR limits were used to shift pumping to the north Delta intakes. Because negative (e.g., reverse) OMR flow is toward the south Delta pumps, the greatest negative values indicate higher pumping. The minimum OMR values indicate the maximum pumping from the central Delta. For example, the January through March and June minimum flows were -5,000 cfs because the assumed OMR limits were restricting pumping to this level in many of the years in these months. The actual OMR restrictions are adaptively managed by the smelt working group experts in delta smelt biology from USFWS, the U.S. Department of the Interior, Bureau of Reclamation (Reclamation), U.S. Environmental Protection Agency, DWR, NMFS, and CDFW.

in response to real-time monitoring of fish and turbidity and temperature conditions. The assumed restrictions provide a representative simulation compared to D-1641 conditions without any OMR restrictions.

The OMR flows were generally higher in all months for the ESO, because north Delta diversions allowed the south Delta pumping to be reduced in many years. For April and May, the median ESO pumping was increased slightly, so the minimum OMR flows were reduced (more pumping) by about 250 cfs to 500 cfs, although the minimum April and May OMR flows were not less than -2,000 cfs for the ESO cases. The median OMR flows in July through September were about -10,000 cfs for the EBC2 and ESO cases, with the majority of the total exports pumped from the south Delta, because the fish entrainment risks were assumed to be small for covered species.

The ESO cases shifted pumping from the south Delta to the north Delta intakes and thereby increased the OMR flows (reduced negative OMR flows) in most months. The median predicted OMR flows for the ESO cases were about 3,000 cfs higher in October, 2,000 cfs higher in November, 1,000 cfs higher in December, 2,000 cfs higher in January, 2,000 cfs higher in February, 2,500 cfs higher in March, similar in April and May, 500 cfs higher in June, 4,000 cfs higher in July, 6,000 cfs higher in August, and 6,000 cfs higher in September. The simulated split between the dual north Delta intake pumping and south Delta export facilities will likely be adjusted under the BDCP adaptive management program to increase fish protection benefits.

5.3.1.12 San Joaquin River Flows at Antioch

San Joaquin River flows at Antioch were increased for the ESO because the reduction in south Delta exports will increase OMR flows and San Joaquin River flows at Antioch by the same amount as the reduced south Delta exports. For the EBC2 cases, monthly median flows at Antioch were about 2,500 cfs in October, 1,500 cfs in November, and 500 cfs in December. The San Joaquin River flows at Antioch were about 4,000 cfs in January, 6,500 cfs in February; 4,500 cfs in March, 6,000 cfs in April, 5,500 cfs in May, 3,000 cfs in and June, 0 cfs in July, -1,500 cfs in August, and 6,000 cfs in September. The monthly median San Joaquin River flows at Antioch were generally increased for the ESO because of the north Delta intake diversions, which reduced the south Delta pumping. The annual average San Joaquin at Antioch flows were about 3,000 TAF for the EBC2 cases, and were increased to about 4,300 TAF for the ESO cases. Although the south Delta exports were reduced from about 4,400 TAF to 2,500 TAF for the ESO, which would increase the Antioch flow, the north Delta intake pumping reduced the Delta Cross Channel, Georgiana Slough and Threemile Slough diversions to the San Joaquin River, which reduced the Antioch flow. As described above, the north Delta intake pumping will likely be adjusted under the adaptive management program; the adjustments in south Delta exports and north Delta intake pumping will change the Antioch flows.

5.3.1.13 Delta Outflow and Estuarine Salinity Gradient

Delta outflow is the primary driver of salinity in the Delta and of the X2 position (the location, expressed in kilometers from the Golden Gate Bridge, at which channel-bottom water salinity is 2 parts per trillion). Figure 5.3-2 shows the BDCP conceptual model for salinity. The variation in BDCP outcomes (ESO, LOS, or HOS) are defined by the outflow in spring and fall as described in Chapter 3, Section 3.4.1.4.4, *Decision Trees*. Compared to the ESO, the HOS includes higher spring outflows while the LOS includes lower fall outflows. The LOS outflow is based on D-1641 requirements. D-1641 has specified Delta outflow in all months; during the February through June period, the required Delta outflow is calculated from the required number of days that X2 must be downstream of three electrical conductivity measurements (Collinsville at 81 kilometers, Chipps Island at 75 kilometers, and Port Chicago at 64 kilometers). The CALSIM model uses information from the DSM2 modeling results to determine the outflow necessary to satisfy the X2 requirements. Monthly outflow X2 values provide a reasonable summary of the seasonal variations in the salinity gradient for the Bay-Delta habitat. The HOS includes the Fall X2 action and increased spring outflow, both described in detail in Chapter 3.

Table 5.3-4 gives the CALSIM-simulated monthly cumulative distributions of Delta outflow for the EBC2 and ESO cases. The changes in ESO outflows for the HOS and LOS cases are shown as well. This table summarizes the major simulated results for Delta outflow. The ESO cases are very similar to the EBC2 cases for the ELT and LLT timeframes. The major changes in Delta outflow for the HOS case are easily identified in the months of March, April, and May in about half of the years. The major changes in Delta outflow for the LOS case are also easily identified in the months of September through November in about half of the years.

The ESO outflows were slightly less than the EBC2 outflows, because the north Delta intakes allowed higher exports in some months when reverse OMR flow restrictions were limiting EBC2 south Delta exports. The average annual CALSIM-simulated outflow was 16,157 TAF for EBC2_ELT and was 16,282 TAF for EBC2_LLT. The average annual CALSIM-simulated outflow was 15,590 TAF for ESO_ELT and was 15,767 TAF for ESO_LLT. The monthly median outflows in October through December were generally controlled by the required Delta outflow in most years; higher outflows (more than 15,000 cfs) were simulated in only a few years. The highest monthly outflows were simulated in January through March, with many years having more than 50,000 cfs outflow in at least one month. Median outflow for the ESO cases was about 15,500 cfs in April, 13,500 cfs in May, and 8,500 cfs in June. The simulated ESO outflows in July, August, and September were generally controlled by the required Delta outflow. There were only a few years with July outflows of more than 10,000 cfs, August outflows of more than 5,000 cfs, or September outflows of more than 15,000 cfs (required for Fall X2).

Table 5.3-4. CALSIM-Simulated Monthly Distribution of Delta Outflow (cfs) (1922–2003) for BDCP Scenarios[a]

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
A. EBC2_ELT													
Min	3,000	3,500	3,500	5,615	7,487	7,239	6,778	4,000	4,000	4,000	3,000	3,000	3,976
10%	3,413	3,648	4,500	8,979	8,970	9,325	9,673	7,270	5,550	4,623	4,000	3,000	5,503
20%	4,000	4,500	4,500	10,182	13,061	12,150	10,148	8,207	6,530	5,000	4,000	3,000	6,541
30%	4,000	4,520	4,730	12,889	16,005	17,530	12,029	9,420	6,850	5,270	4,000	3,000	7,363
40%	4,000	6,121	5,603	17,730	22,646	20,599	15,322	11,398	7,100	7,211	4,000	3,050	9,057
50%	5,361	9,766	8,957	21,394	35,392	25,488	18,731	14,068	7,243	8,000	4,000	3,756	10,691
60%	6,813	10,156	11,846	28,605	52,433	33,345	25,312	16,690	7,726	8,017	4,041	11,094	16,751
70%	9,375	13,634	18,137	50,813	64,146	45,822	28,869	19,925	8,525	9,353	4,252	17,630	20,679
80%	9,688	14,583	34,739	73,082	89,138	67,748	45,806	28,578	10,494	11,071	4,521	19,063	25,266
90%	10,148	15,000	72,480	111,700	137,264	87,701	68,822	48,228	20,580	12,641	5,066	19,375	33,399
Max	27,880	86,453	195,153	305,523	248,113	273,702	146,802	79,224	61,582	22,296	8,687	20,156	60,157
Avg	6,638	11,515	23,546	44,889	55,330	43,911	29,833	21,103	10,945	8,232	4,308	9,473	16,157
B. ESO_ELT													
Min	3,000	3,500	3,500	5,282	7,476	6,854	6,651	4,000	4,000	4,000	3,000	3,000	3,878
10%	5,888	3,500	4,500	9,171	9,340	9,583	8,972	7,101	5,779	4,000	3,500	3,000	5,458
20%	6,492	4,500	4,502	12,333	12,868	11,860	9,696	8,123	6,966	5,000	3,500	3,000	6,390
30%	7,043	4,500	4,521	14,162	16,302	15,711	10,785	9,172	7,133	5,000	3,911	3,000	7,278
40%	7,413	4,500	6,886	16,914	21,043	18,203	14,169	11,868	7,486	6,500	4,000	3,000	8,991
50%	7,652	8,438	9,492	22,942	33,065	23,150	15,875	13,414	8,111	8,000	4,000	3,000	10,157
60%	8,039	9,469	12,763	28,258	50,322	32,335	18,835	14,695	8,921	8,000	4,000	11,250	15,272
70%	8,438	13,633	17,281	43,796	61,912	42,065	23,969	16,918	9,285	8,116	4,000	18,297	19,441
80%	9,038	14,500	34,663	72,701	86,002	66,025	39,200	21,203	11,557	9,376	4,000	19,688	24,685
90%	9,672	16,330	63,579	106,332	137,372	85,369	61,911	41,223	19,133	10,233	4,087	20,313	31,782
Max	26,659	86,986	195,172	307,821	251,077	273,553	145,298	79,212	58,864	21,779	7,513	21,563	60,200
Avg	7,889	11,085	23,042	44,053	54,312	42,524	26,355	18,888	11,138	7,376	3,926	9,708	15,590
C. Changes under HOS_ELT Compared to ESO_ELT													
Min	679	0	0	26	-190	385	178	0	0	0	0	0	2
10%	77	0	0	0	190	711	0	181	-178	0	0	0	173
20%	165	0	2	263	18	1,895	520	-153	-375	0	94	0	301
30%	128	0	90	-5	503	1,731	1,788	536	-13	0	89	0	48
40%	-11	308	-344	22	250	4,515	4,510	1,810	-167	0	0	0	331
50%	-62	217	20	45	-8	5,003	9,229	3,174	-532	-53	0	230	1,100
60%	-115	0	401	1,523	-1,316	1,802	8,850	5,074	-224	0	0	94	783
70%	0	-97	147	988	-109	4,064	8,683	6,585	434	-116	0	47	823
80%	24	-125	614	-377	526	54	3,531	11,354	-711	-846	0	281	2,246
90%	9	111	-2,804	6,555	2,952	1,101	823	8,081	-44	-869	316	313	633
Max	2,113	-1,113	4	14	-8,511	171	220	-489	640	562	-73	0	26
Avg	42	-55	446	146	-160	1,950	4,068	2,868	-192	-250	67	88	548

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
D. Changes under LOS_ELT Compared to ESO_ELT													
Min	0	0	0	4	-9	-20	2	0	0	0	0	0	-9
10%	-292	0	0	287	-19	198	104	14	158	0	0	0	-93
20%	-247	0	0	1,618	-5	-119	81	-268	19	0	14	0	-129
30%	-10	0	158	1,216	207	329	214	423	61	0	-58	0	-209
40%	-73	0	320	498	194	9	259	-101	-73	0	0	0	-195
50%	-153	-3,938	4	960	1,112	875	11	0	-98	0	0	0	-396
60%	-384	-4,969	531	2,169	595	3	-6	-9	7	0	0	-8,250	-713
70%	-579	-9,132	472	2,876	-902	990	-52	-95	33	49	0	-15,297	-473
80%	-993	-9,397	1,134	1,020	16	706	31	145	-662	-165	0	-16,687	-665
90%	-1,374	-360	1,988	-1,242	-560	4,544	6	-38	3	-306	43	-14,704	-918
Max	-86	5	5	-15	-98	7	1	-303	1,796	6	5	-2,550	530
Avg	-388	-2,910	981	1,067	554	483	146	25	16	-5	3	-5,922	-351
E. EBC2_LLT													
Min	3,233	3,500	3,861	4,500	6,657	7,239	7,100	4,000	4,000	4,000	3,000	3,000	4,320
10%	4,675	3,867	4,500	8,795	9,837	9,752	9,922	7,114	6,616	5,000	4,000	3,000	5,941
20%	5,416	4,500	4,802	10,583	12,804	12,757	10,558	9,666	7,100	5,353	4,000	3,000	6,740
30%	6,651	4,506	5,502	14,279	18,411	17,306	11,588	10,187	7,383	6,500	4,000	3,000	7,773
40%	7,263	5,398	7,365	18,568	22,394	19,021	14,930	11,203	8,150	7,694	4,000	3,000	9,105
50%	7,763	10,182	9,176	22,068	36,623	25,464	18,289	13,070	8,353	8,281	4,154	3,470	10,729
60%	8,125	10,938	12,033	29,372	51,011	33,034	24,619	14,380	8,874	9,988	4,637	11,875	16,853
70%	10,578	12,905	16,907	48,241	64,656	49,395	29,251	18,934	10,265	10,830	5,270	17,016	20,961
80%	10,938	14,343	32,181	75,213	92,435	70,389	44,438	25,887	11,104	12,779	5,570	20,750	25,327
90%	11,234	15,469	68,167	106,474	135,965	93,131	68,298	39,760	18,601	13,558	6,297	21,250	33,411
Max	24,664	74,097	192,448	317,787	253,373	281,371	145,542	68,558	53,980	18,471	10,997	21,875	58,712
Avg	8,276	10,844	22,113	46,372	56,338	45,097	29,603	19,121	10,560	8,984	4,754	9,754	16,282
F. ESO_LLT													
Min	3,000	3,500	4,500	5,349	4,455	7,239	7,100	4,001	4,000	4,000	3,298	3,000	4,869
10%	5,873	3,500	4,500	10,991	9,923	9,772	9,766	7,123	6,679	5,000	3,595	3,000	6,087
20%	7,179	4,500	4,504	12,809	12,703	13,266	10,288	10,041	7,159	5,000	4,000	3,000	6,898
30%	7,600	4,500	5,624	14,128	18,237	15,095	11,417	10,908	7,600	5,571	4,000	4,002	7,491
40%	8,641	4,500	7,585	16,938	21,307	17,826	13,292	11,850	8,445	6,690	4,000	4,537	8,998
50%	10,117	10,162	10,807	22,789	33,380	22,492	15,716	13,243	9,125	8,000	4,000	6,738	10,270
60%	10,465	11,438	12,945	27,476	48,669	32,545	19,480	14,599	9,748	8,000	4,000	13,344	15,931
70%	10,752	12,905	16,605	42,626	60,788	41,393	23,405	16,868	10,960	8,674	4,230	18,859	19,873
80%	11,220	14,514	30,270	73,944	91,327	67,586	37,925	21,025	11,327	9,547	4,560	21,875	24,846
90%	12,773	16,844	60,010	103,246	134,414	94,765	60,789	32,920	19,706	11,192	5,024	22,500	31,482
Max	26,755	73,050	192,580	316,004	255,260	279,907	144,263	68,727	52,008	14,616	6,860	22,813	58,899
Avg	9,510	10,728	21,867	44,827	55,165	43,308	26,460	17,821	10,751	7,616	4,218	10,995	15,767

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
G. Changes under HOS_LLT Compared to ESO_LLT													
Min	0	0	-1,000	7	3,060	0	0	-1	0	0	-72	0	-556
10%	-310	364	0	-1,152	41	471	141	160	-236	0	122	0	103
20%	-402	0	3	-146	129	6	43	-64	18	0	0	197	57
30%	43	0	-747	-69	74	2,639	542	107	-281	-177	0	112	54
40%	-32	56	37	-998	-204	4,776	4,327	688	-629	-190	0	1,021	413
50%	-78	-220	-730	-686	51	4,103	9,044	1,845	-320	0	0	676	1,155
60%	-28	125	493	179	2,074	1,358	9,590	3,315	-30	0	0	-219	555
70%	-127	0	521	67	2,182	3,844	10,453	4,294	-26	-608	-207	141	351
80%	32	0	464	-3,660	-1,174	1,382	5,613	4,009	89	292	-110	0	1,968
90%	92	0	1,792	9,267	4,101	523	1,311	10,572	-139	-500	251	-156	828
Max	106	-176	-12	4	-8,625	312	71	-205	-369	-998	-706	156	58
Avg	-104	106	86	207	195	2,046	4,010	1,917	-149	-119	9	242	510
H. Changes under LOS_LLT Compared to ESO_LLT													
Min	0	0	0	-131	938	0	0	-1	0	0	-65	0	-22
10%	-150	72	0	-116	73	-65	-8	-1	-142	0	67	0	-190
20%	-87	0	1,209	-207	204	-1,207	127	126	81	0	0	0	-220
30%	-18	0	1,812	1,261	-76	484	120	22	-25	-223	0	-1,002	-35
40%	-744	0	758	2,895	69	306	258	59	54	-103	0	-1,537	32
50%	-1,784	-5,662	-277	190	-7	1,840	113	26	165	-26	0	-3,738	-156
60%	-1,536	-6,937	1,110	2,278	325	62	-51	86	85	0	0	-9,869	-1,296
70%	-734	-8,301	206	395	1,031	2,660	20	-68	3	-39	22	-14,761	-459
80%	219	-9,162	3,602	3,715	-1,834	1,882	77	2	135	-143	65	-16,744	-501
90%	397	-1,775	4,190	5,001	7,028	-648	-613	1	3	-188	85	-15,800	-598
Max	-10	5,681	-22	-277	-90	2,573	-1,821	-669	990	-25	-159	-8,041	455
Avg	-481	-3,056	1,329	1,654	740	641	115	-25	66	-78	27	-6,854	-348
[a] For descriptions of scenarios, see Table 5.2-3.													

5.3.2 Water Quality

Water quality affects both the physical properties of water (temperature, turbidity) and the chemical properties(salinity, pollutant concentrations) that elicit biological responses, ranging from higher primary productivity to mortality in covered fish species. Temperature, for example, may have a lethal effect, and affects the metabolism of fish, which then require more food and more oxygen to survive. Figure 5.3-3 is the BDCP conceptual model of temperature depicting drivers, covered activities, controls, and VSP attributes and how they interact. Salinity elicits direct responses from organisms depending on their ability to adapt to salinity gradients. The saturation concentration of DO is reduced at warmer temperatures, and fish must move water over their gills at a faster rate when water has a lower DO concentration. Excessive turbidity can have direct effects on organisms, causing irritation or in some instances suffocation. Turbidity also has indirect effects such as providing cover from predators or providing a visual background (contrast) that makes prey items easier to acquire. This section summarizes the results of the analysis for water temperature, salinity, DO, and turbidity as they relate to the BDCP.

Contaminants, such as methylmercury and selenium, within sediment and the water column also can elicit biological responses from covered fish species. Therefore, this section also summarizes the ecosystem-scale effects of methylmercury, selenium, copper, ammonia[1], pyrethroids, pesticides, endocrine disrupters, and other contaminants. Findings from Appendix 5.D, *Contaminants,* are summarized and include a discussion of loads from outside the Plan Area, loads from within the Plan Area, and summaries of the chemical and ecological effects of covered activities and conservation measures.

5.3.2.1 Water Temperature

Water temperature effects caused by the BDCP are limited to the upstream Sacramento and San Joaquin Rivers and their tributaries. With the exception of the Feather River, changes are minimal. Comparisons of water temperature differences between EBC and ESO scenarios were not conducted for the Plan Area. The reasoning behind this is provided in the USFWS (2008:194) BiOp.

> The [state and federal] water projects have little if any ability to affect water temperatures in the Estuary (Kimmerer 2004). Estuarine and Delta water temperatures are driven by air temperature. Water temperatures at Freeport can be cooled up to about 3°C by high Sacramento River flows, but only by very high river flows that cannot be sustained by the projects. Note also that the cooling effect of the Sacramento River is not visible in data from the west Delta at Antioch (Kimmerer 2004) so the area of influence is limited.

Appendix 5.C, Attachment 5C.A, *CALSIM and DSM2 Modeling Results for the Evaluated Starting Operations Scenarios*, provides the DSM2-QUAL comparison of water temperatures under existing biological conditions with BDCP's preliminary proposal (Alternative 1A as described in the EIR/EIS for the BDCP [California Department of Water Resources et al. 2012]). Although the preliminary proposal has been superseded by the ESO (Alternative 4 of the BDCP EIR/EIS, one potential outcome of the decision tree process), the comparison between EBC scenarios and preliminary proposal scenarios is provided to illustrate that there is very little difference in Plan Area water temperatures between these scenarios. Water temperature differences between scenarios are attributable to climate change, as discussed in Appendix 2.C, *Climate Change Implications and Assumptions*.

Water temperatures in rivers below the SWP and CVP reservoirs may be affected in the future by the combination of Delta operations and by climate change effects on air temperatures. The physical factors that control the seasonal water temperature patterns in upstream tributary streams and the potential biological effects of increased temperature on various fish life stages are discussed below. Climate change also will affect precipitation and runoff; these expected changes in reservoir inflows will interact with reservoir operations (flood control releases and water supply storage) to also change the release temperatures from the major SWP and CVP reservoirs.

Water temperature in the Sacramento River immediately downstream of Shasta and Keswick Dams is determined by a number of factors that include the availability of cold water stored in the upstream reservoirs, seasonal atmospheric conditions, and the level of instream flow released to the river. Table 5.3-5 summarizes differences in upstream temperatures. Table 5.3-6 shows the monthly and annual mean temperature changes at four key locations in the upper Sacramento River. There will be minimal changes in Sacramento River temperatures as a result of BDCP. As described above, the BDCP will not result in changes in San Joaquin River flows and therefore will not contribute to any changes in temperature.

[1] Ammonia in water generally forms some amount of ammonium. Therefore, the use of the term ammonia implies that both ammonia and ammonium may be present.

Table 5.3-5. Summary of Upstream Temperature Results under the Scenarios[a]

Place	Mean Monthly Results	Mean Annual Results
Keswick	Mean monthly water temperatures are predicted to be lower and higher under ESO_LLT, LOS_LLT, and HOS_LLT relative to EBC2_LLT in all months by up to −0.6% (LOS_LLT in October) and +0.6% (ESO_LLT in August).	Mean annual water temperature levels in the are predicted to be +0.1%, 0.0%, and −0.1% higher and lower in the ESO, LOS, and HOS LLT respectively, than the EBC2_LLT.
Bend Bridge	Mean monthly water temperatures are predicted to be lower and higher under ESO_LLT, LOS_LLT, and HOS_LLT relative to EBC2_LLT in all months by up to −0.8% (LOS_LLT in November) and +1.3% (ESO_LLT in September).	Mean annual water temperature levels in the are predicted to be 0.0%, 0.0%, and −0.1% higher and lower in the ESO, LOS, and HOS LLT respectively, than the EBC2_LLT.
Feather River at the Fish Barrier	Mean monthly water temperatures are predicted to be lower and higher under ESO_LLT, LOS_LLT, and HOS_LLT relative to EBC2_LLT in all months by up to −3.0% (LOS_LLT in October) and +1.0% (HOS_LLT in August).	Mean annual water temperature levels in the are predicted to be −0.1%, −0.5%, and 0.0% higher and lower in the ESO, LOS, and HOS LLT respectively, than the EBC2_LLT.
Feather River at Honcut	Mean monthly water temperatures are predicted to be lower and higher under ESO_LLT, LOS_LLT, and HOS_LLT relative to the EBC2_LLT in all months by up to −2.1% (ESO_LLT in June) and +3.0% (HOS_LLT in July).	Mean annual water temperature levels in the are predicted to be +0.1%, +0.2%, and +0.3% higher and lower in the ESO, LOS, and HOS LLT respectively, than the EBC2_LLT.

[a] For descriptions of scenarios, see Table 5.2-3.

Table 5.3-6. Summary of the Average Monthly Upstream Temperature Data at Four Key Locations under the Scenarios[a]

	Sacramento River Keswick								Sacramento River Bend Bridge							
	EBC2		ESO		LOS		HOS		EBC2		ESO		LOS		HOS	
Month	ELT	LLT	ELT	LLT	ELT	LLT	ELT	LLT	ELT	LLT	ELT	LLT	ELT	LLT	ELT	LLT
Jan	47.0	47.8	47.0	47.8	47.0	47.9	47.1	47.9	45.6	46.6	45.6	46.5	45.7	46.6	45.7	46.6
Feb	46.4	47.2	46.4	47.2	46.4	47.3	46.5	47.2	47.0	47.9	47.0	47.8	47.0	47.9	47.1	47.9
Mar	47.4	48.3	47.5	48.3	47.5	48.3	47.5	48.3	49.9	50.8	49.9	50.7	49.9	50.7	49.9	50.8
Apr	48.9	49.8	48.9	49.7	48.9	49.8	48.9	49.8	53.2	54.2	53.2	54.1	53.2	54.1	53.2	54.2
May	50.2	51.0	50.2	51.0	50.2	51.0	50.2	51.0	56.3	57.1	56.1	56.8	56.0	56.8	56.2	57.0
Jun	50.9	51.7	50.9	51.7	50.9	51.7	50.9	51.7	56.4	57.2	56.2	56.9	56.2	56.8	56.4	57.2
Jul	52.3	53.4	52.3	53.7	52.3	53.6	52.1	53.3	57.0	58.2	57.0	58.5	57.0	58.4	56.9	58.1
Aug	54.3	55.9	54.4	56.2	54.5	56.2	53.9	55.7	58.9	60.5	58.9	60.9	59.0	60.9	58.5	60.3
Sep	56.1	57.9	56.3	58.2	56.2	58.2	55.8	57.7	59.2	61.0	59.5	61.2	59.7	61.8	59.2	60.8
Oct	56.0	57.7	56.0	57.9	55.8	57.4	55.7	57.8	56.3	57.9	56.3	58.0	56.2	57.7	56.1	57.9
Nov	54.0	55.2	53.9	55.3	53.8	55.0	53.9	55.2	52.1	53.3	51.9	53.2	51.8	52.9	51.9	53.2
Dec	50.5	51.4	50.4	51.3	50.4	51.3	50.5	51.4	47.3	48.3	47.3	48.3	47.4	48.4	47.3	48.3
Year	51.2	52.3	51.2	52.4	51.2	52.3	51.1	52.2	53.3	54.4	53.2	54.4	53.3	54.4	53.2	54.3
	Feather River Fish Barrier								Feather River Honcut							
	EBC2		ESO		LOS		HOS		EBC2		ESO		LOS		HOS	
Month	ELT	LLT	ELT	LLT	ELT	LLT	ELT	LLT	ELT	LLT	ELT	LLT	ELT	LLT	ELT	LLT
Jan	49.1	50.7	49.0	50.8	49.0	50.9	49.1	50.8	47.6	49.1	47.5	49.2	47.6	49.2	47.6	49.2
Feb	49.8	51.3	49.8	51.3	49.9	51.4	49.8	51.4	51.2	52.7	51.2	52.6	51.3	52.7	51.3	52.6
Mar	50.9	52.4	51.0	52.5	50.9	52.5	51.0	52.5	54.5	55.9	54.6	56.0	54.5	55.9	54.5	56.0
Apr	52.0	53.3	52.0	53.3	52.0	53.4	51.8	53.1	59.2	60.5	59.2	60.5	59.2	60.5	58.1	59.5
May	55.8	56.0	55.7	55.9	55.8	55.9	55.4	55.7	65.5	66.6	65.4	66.2	65.4	66.3	64.3	65.6
Jun	58.0	58.2	57.6	57.9	57.6	57.9	58.1	58.1	70.4	71.6	69.1	70.1	68.9	70.2	70.2	71.2
Jul	61.2	61.5	61.4	61.8	61.5	61.8	61.6	62.0	71.1	72.2	71.9	73.5	71.9	73.5	72.8	74.4
Aug	60.8	61.3	60.8	61.4	60.8	61.3	61.1	61.9	71.3	72.6	71.8	73.7	71.7	73.5	72.7	74.5
Sep	56.0	58.1	56.3	57.9	56.9	58.2	56.7	58.4	65.5	67.5	66.1	68	67.3	69.3	66.6	68.6
Oct	55.0	58.5	54.7	58.2	54.5	56.7	55.8	58.5	60.9	63.3	60.7	63.2	60.7	62.7	61.2	63.3
Nov	53.8	58.3	53.9	58.1	53.4	56.7	54.2	57.4	54.3	57.1	54.4	57.1	54.2	56.6	54.4	56.8
Dec	50.9	53.9	51.0	53.8	50.5	53.5	50.8	53.8	48.3	50.6	48.3	50.5	48.2	50.5	48.2	50.5
Year	54.4	56.1	54.4	56.1	54.4	55.8	54.6	56.1	60.0	61.6	60.0	61.7	60.1	61.7	60.2	61.9

[a] For descriptions of scenarios, see Table 5.2-3.

5.3.2.2 Dissolved Oxygen

DO is a measure of how much oxygen is available in the water column for support of aquatic species that rely on oxygen for survival. Different species have varying tolerances of DO levels, but in general many of the fish species in the Delta require high DO levels (5 to 7 milligrams per liter [mg/L]). When DO levels fall, species become stressed and move toward areas of higher DO if pathways exist. Low DO levels can create passage barriers and increase species mortality. Figure

5.3-4 is the BDCP conceptual model of DO depicting drivers, covered activities, controls, and VSP attributes and how they interact.

The simulations of DO concentrations in the eight regions of the Delta for the six different scenarios using DSM-QUAL found only minor differences among the scenarios. The results of the simulations are presented in Appendix 5.C, *Flow, Passage*, *Salinity, and Turbidity,* Section 5.C.5.4, *Delta Habitat (Plan Area) Results*. The greatest difference in the mean DO value for any day of the year was 0.95 mg/L in Suisun Marsh during March. For most of the regions, differences due to climate change were larger than those due to the effects of the ESO. Furthermore, except for the ESO in the San Joaquin River region, differences due to climate change were consistently negative while those due to the ESO were positive or close to zero.

The Stockton Deep Water Ship Channel has been identified as an impaired waterway by the State Water Resources Control Board because of low DO concentrations during late summer and early fall and often fails to meet water quality objectives established by the Central Valley Regional Water Quality Control Board (2005, 2007) for DO. Available data indicate that low DO (less than 6 mg/L) may affect salmonids in September and October during the upstream adult migration period, and in June during the downstream juvenile migration period. This makes Chinook salmon more likely to be exposed to low DO levels than steelhead because peak migration for steelhead occurs outside of June, September, and October. Juvenile salmonids may be exposed to low DO periods during the end of their downstream migration period (primarily in June). In addition, juvenile white sturgeon, which rear in the San Joaquin River, exhibit reduced foraging and growth rates at DO levels below 58% saturation (5.8 mg/L at 15°C) (Cech and Crocker 2002).

Recent results for the DO aeration system in the Deep Water Ship Channel suggest that the aeration facility is effective at raising DO levels in much of the channel. Under *CM14 Stockton Deep Water Ship Channel Dissolved Oxygen Levels*, shared funding of the long-term operation and maintenance costs associated with an aeration facility will occur. Studies conducted by DWR show that the aeration system can be effective at meeting the Basin Plan objectives for DO of 5 mg/L (or 6 mg/L from September through November) as long as the inflowing biochemical oxygen demand does not exceed the 8,000 pounds per day capacity of the aeration facility to add oxygen (California Department of Water Resources 2010). During periods when biochemical oxygen demand is higher than the capacity of the aeration facility, the Basin Plan objectives may not be met, but the number of days that the objectives could be met is increased with the aeration facility. CM14 also includes adaptive management and monitoring to allow future adjustments to the aeration facility operations to improve its effectiveness at meeting the Basin Plan objectives for DO in the Deep Water Ship Channel.

5.3.2.3 Sediment and Turbidity

Water clarity in the Delta is determined primarily by the amount of suspended sediment transported in the water column (Kimmerer 2004). As rivers enter estuaries, sediment eroded from upstream areas is deposited in the estuary in varying degrees, depending on factors such as flow rate, tidal forcing, and local conditions. The patterns of geomorphic change occur on time scales varying from episodic, as storm flows can transport large volumes of sediment, to decadal; for example, due to changes in climate patterns, the damming of rivers, and land usage. Figure 5.3-5 is the BDCP conceptual model of turbidity depicting drivers, covered activities, controls, and VSP attributes and how they interact.

The major source of sediment to the Delta is the Sacramento River plus the Yolo Bypass, which accounted for up to 85% of the sediment supply over the period 1999 to 2002 (Wright and Schoellhamer 2005). The San Joaquin River accounted for about 13%, with the eastside inflows (Cosumnes, Calaveras, and Mokelumne Rivers) accounting for the remaining 2% over the same period. The great majority of Sacramento River sediment (more than 80%) enters the Delta episodically during high-flow events in the wet periods, with sediment concentrations generally higher during first flush events (Schoellhamer et al. 2007). Although in recent history (since 1957) sediment supply to the Delta has been decreasing, the Delta remains depositional (Wright and Schoellhamer 2005; Schoellhamer et al. 2007). Water clarity has been increasing in the Delta, particularly in the central and south Delta (Miller pers. comm.)

The construction of reservoirs has resulted in an upstream accumulation of sediment within the reservoirs. In addition, previous stores of hydraulic mining-derived sediments have been depleted, and there have been various changes associated with channel adjustments downstream of dams and bank protection measures that decrease sediment supply. However, other factors such as land use changes (e.g., logging, grazing) and urbanization can increase sediment supply. The current balance between the factors regulating sediment supply to the Sacramento River is unknown (Wright and Schoellhamer 2004), so it is not possible to predict the evolution of sediment supply in the coming decades with any certainty. Thus, it is hard to predict whether sufficient sediment will enter the Delta to be available for all restoration opportunity areas (ROAs). In addition, sea level rise requires sediment deposition to maintain the elevation of current wetlands above tidal water levels.

Sediment is a critical resource in habitat creation. Tidal marsh and floodplain restoration efforts may require a sediment source as the substrate for the restoration effort, so knowledge of sediment transport patterns can enable the optimal siting of restoration areas for maximum sediment trapping from local waterborne sources (Ganju et al. 2004). Sediments are advected downstream into transitional areas where tidal forcing can mobilize the mass of fine sediments in an oscillation, the net direction of which (landward or seaward) is dictated by a variety factors such as net outflow, tidal strength (e.g., timing in the spring-neap cycle), and timing within the diurnal tidal cycle (Ganju et al. 2004). Deposition typically occurs at slack after ebb and flood tides. More generally, deposition occurs as flow velocity decreases, and coarser, heavier sediments fall out of the water column.

Implementation of dual conveyance under *CM1 Water Facilities and Operation* was estimated to result in around 8 to 9% less sediment entering the Plan Area in the LLT from the Sacramento River, the main source of sediment for the Delta and downstream subregions (Appendix 5.C, Attachment 5C.D, *Water Clarity—Suspended Sediment Concentration and Turbidity*). Although there would be less south Delta exports and therefore less removal of sediment entering the Plan Area from the San Joaquin River, this is a relatively minor contribution to Plan Area sediment, especially compared to the Sacramento River contribution. Less sediment entering the Plan Area may cause greater water clarity, although the extent of the effect is uncertain. Capture of sediment in upstream ROAs (particularly Cache Slough ROA and West Delta ROA) could also lead to greater water clarity in downstream areas such as Suisun Bay. However, factors related to tidal natural communities restoration and changes in net flows also point to the potential for lower water clarity in the LLT under the BDCP in portions of the Suisun Bay and West Delta subregions. Also, the potential exists for wind-wave resuspension of sediment within the ROAs based on an analysis of typical prevailing wind speed, fetch, and water depth; the Cache Slough and West Delta ROAs have the best potential for such resuspension. Overall, actual biological effects will depend on site-specific characteristics in existing and restored areas.

Table 5.3-7 summarizes the potential effects of two of the major contributors to water clarity in the Delta under the preliminary proposal LLT scenario due to the establishment of the ROAs, whether each subregion is likely to become a depositional or an erosional environment and the specific effect of seasonal summer winds on sediment resuspension within the ROAs. In areas of deposition, sediment that is suspended settles, creating clearer water conditions. A good example of this is the south Delta where submerged aquatic vegetation (SAV) collects sediment from the water column, making the water clearer. Areas of erosion are eroding sediment into the water column, making the water less clear.

The Delta will remain regionally depositional in the LLT timeframe, in both the EBC2 and the ESO scenarios, although the location of the depositional regions will differ, and overall it will become clearer. The effects of sea level rise will depend on the balance between sediment supply from the watersheds and the rate of sea level rise, so it is unclear whether sediment supply will be sufficient to maintain the current extent of tidal marsh. The initial effect of tidal restoration is to decrease sediment supply downstream of the Plan Area, but the longer-term effects are uncertain as the areas of restoration reach a dynamic equilibrium.

Table 5.3-7. Potential Effects[a] of Restoration in the Subregions under the BDCP Compared to Future Conditions without the BDCP

Subregions	Depositional or Erosional Change as a Result of Restoration	Effect of Deposition and Erosion on Water Clarity
North Delta	Uncertainty is too high to estimate the characteristics	Uncertainty is too high to estimate the effect
Cache/Yolo	Depostional change	Mix of depositional and erosional change
West Delta	Mix of depositional and erosional change	Increase in water clarity
Suisun Marsh	Depostional change	Increase in water clarity
East Delta	Mix of depositional and erosional change/U	Increase in water clarity
South Delta	Depostional change	Increase in water clarity

[a] Subregional water clarity is influenced by the depositional or erosional characteristics within the region.

5.3.2.4 Salinity

The concentration of dissolved salts in a body of water is salinity. Usually measured in parts per trillion (ppt), the salinity gradient transitioning from the ocean to a freshwater stream can vary between 0.5 ppt (fresh water) to approximately 32 to 37 ppt (sea water). Historically in the Delta, the point in the salinity gradient that has been tracked and managed is the 2-ppt channel-bottom salinity, referred to as X2, or the 2-ppt isohaline. Many fish species have a preferred range of salinity and a range of physiological tolerance to salinity, both of which can influence their distribution.

The salinity analysis assesses the potential for changes to habitat, which results from changes in both flows under the BDCP and changes in the configuration of wetted areas, to cause changes in salinity. Figure 5.3-2 is the BDCP conceptual model of salinity depicting drivers, covered activities, controls, and VSP attributes and how they interact. Increased tidal mixing associated with the addition of tidal marsh restoration areas under the BDCP may allow more salt into the western Delta. The estuarine salinity gradient is controlled by Delta outflow. Higher Delta outflow moves the salinity gradient west and lowers the X2 (decreases the distance from the Golden Gate Bridge). Under the BDCP scenarios, outflows will be nearly the same during the low-flow months of July through October in many years, so that X2 will remain unchanged. However, outflows under LOS would be lower than under ESO or HOS in September through November of wet and above-normal years (about 50% of the years). Under the LOS, outflow would be operated to meet the D-1641 objectives, so the salinity in the western Delta would be higher than the ESO or HOS cases. The changes in outflow are given in Table 5.3-7. The X2 will move upstream to the historical positions under D-1641. As described in Appendix 5.C, Attachment 5C.A, *CALSIM and DSM2 Modeling Results for the Evaluated Starting Operations Scenarios*, the outflow salinity relationships may shift with sea level rise, so that the X2 position for an outflow of 3,000 cfs or 4,000 cfs may be more upstream than historically observed. The monitoring and decision-tree process for Fall X2 will provide more guidance for the required Fall X2 and outflow for delta smelt habitat protection, including more accurate estimates of the outflow necessary to maintain the X2 position with sea level rise.

Relatively small changes in salinity (electrical conductivity) were simulated for the ROAs. Electrical conductivity from seawater intrusion was increased slightly at most Delta stations. The incremental changes in electrical conductivity from historical conditions depend on the assumed locations of the ROAs and their connections to the existing channels. Restoration in Suisun Marsh generally reduced the tidal flows at Chipps Island and upstream, thereby reducing the seawater intrusion effects at upstream locations. However, tidal trapping on Grizzly Island increased the salinity at Chipps Island and upstream. Reductions in the net diversions from the Sacramento River to the San Joaquin River (through Delta Cross Channel, Georgiana Slough, and Threemile Slough) reduced the freshening effects from the Sacramento River (lowest electrical conductivity) and increased the electrical conductivity at the San Joaquin River stations. South Delta ROAs tended to increase the tidal mixing of seawater into the south Delta (OMR) and to the south Delta exports.

5.3.2.5 Contaminants

The BDCP will not introduce new contaminants or increase the concentrations of contaminants in the Plan Area directly, with the exception of herbicides, which will be applied in limited and safe concentrations to control invasive aquatic weeds. However, the conservation strategy includes restoration and changes in water operations that have the potential to change how contaminants already present in the Plan Area are mobilized and transported. Conceptual models were developed that included all factors that influence the environmental fate and transport, mobility in an aquatic system, and bioavailability to covered fish species for each toxin. Quantitative analyses are applied where they were useful in describing factors in the conceptual models, and if data inputs and available analytical and modeling tools were deemed sufficient to provide reliable results. Figure 5.3-6 is the BDCP conceptual model of contaminants depicting drivers, covered activities, controls, and VSP attributes and how they interact. In general, the following conclusions can be drawn from the analysis presented in Appendix 5.D, *Contaminants*.

- Water operations will have few to no effects on toxins in the Delta.
- Restoration will increase bioavailability of certain toxins, especially methylmercury, but the overall effects on covered fish species are expected to be localized and of low magnitude.
- Available data suggest that species exposure to contaminants will be below sublethal and lethal levels.

- The long-term benefits of restoration will reduce exposure to existing toxins in the environment and eliminate sources.

Table 5.3-8 summarizes the conclusions for each constituent. Details of these conclusions are provided in Appendix 5.D, *Contaminants*.

Table 5.3-8. Summary of Contaminant Conclusions

Contaminant	Conclusion
Methylmercury	• Modeling showed small, insignificant changes in total mercury and methylmercury levels in water and fish tissues due to the BDCP. • Methylmercury likely would be generated by inundation of BDCP restoration areas, resulting in increased bioavailability to covered species; however *CM12 Methylmercury Management* will minimize methylmercury production and mobilization.
Selenium	• The BDCP will result in a less than 10% annual average selenium increase in San Joaquin River water in the south Delta relative to other source waters (including the Sacramento River). • In the long term, selenium inputs to the Delta should decrease as the proportion of cultivated lands decreases as a result of land use changes, including restoration tidal marsh under the BDCP. Selenium no longer will be concentrated by irrigation and leaching of these formerly cultivated areas.
Copper	• The BDCP will result in decreased flow in the Sacramento River under certain conditions. • Copper concentrations are consistently low throughout the Sacramento River and copper concentrations in the Sacramento River watershed have been tied to flow rates. An appreciable effect on copper concentrations is not expected. • Restoration actions will take some land out of agricultural use, and end the application of pesticides (some of which contain copper) to those areas, thus reducing overall loading of copper to the Delta and resulting in beneficial effects on covered fish species.
Ammonia[a]	• Quantitative analysis indicates that the Sacramento River will have sufficient assimilation capacity under the BDCP to dilute ammonia in Sacramento wastewater treatment plant effluent to avoid adverse effects from these contaminants on the covered fish. • Few to no effects are expected from the BDCP on ammonia.
Pesticides—Pyrethroid	• Quantitative analysis indicates that the Sacramento River will have sufficient assimilation capacity under the BDCP to dilute pyrethroids in Sacramento wastewater treatment plant effluent to avoid adverse effects from these contaminants on the covered fish. • Under restoration actions, flooding of formerly agricultural land is expected to result in mobilization of pyrethroids in agricultural soils into the aquatic system, increasing bioavailability to aquatic organisms. • Current information does not allow estimation of resultant mobilization of pyrethroids due to ESO restoration. • Restoration actions will take some land out of agricultural use, and end the application of pesticides (including pyrethroids) to those areas, thus reducing overall loading of these chemicals to the Delta and resulting in a beneficial effect.
Endocrine Disruptors	• Since endocrine disruptors are a diverse group of chemicals, it is not possible to evaluate fully the potential effects on the distribution and bioavailability of these chemicals resulting from the restoration actions.

Contaminant	Conclusion
Pesticides—Organochlorine	• The BDCP is not expected to affect organochlorine concentrations in the Delta. • Under restoration actions, flooding of formerly agricultural land is expected to result in mobilization of pesticides in agricultural soils into the aquatic system, increasing bioavailability to aquatic organisms; specifically, benthic organisms. • Concentrations in the water column should be relatively short-lived because these pesticides settle out of the water column in low-velocity flow.
Pesticides—Organophosphates	• BDCP operations are not expected to affect organophosphate concentrations in the Delta. • Under restoration actions, flooding of formerly agricultural land is expected to result in mobilization of pesticides in agricultural soils into the aquatic system, increasing bioavailability to aquatic organisms. • The solubility, tendency to adhere to soils and particulates, and degradation rates for these compounds vary; however, organophosphate pesticides are metabolized by fish and do not tend to bioaccumulate. • Restoration actions will take some land out of agricultural use, and end the application of pesticides (including organophosphates) to those areas, thus reducing overall loading of these chemicals to the delta and resulting in a beneficial effect.
[a] Ammonia in water generally forms some amount of ammonium. Therefore, the use of the term ammonia implies that both ammonia and ammonium may be present.	

5.3.2.6 Construction Effects

Appendix 5.H, *Aquatic Construction and Maintenance Effects*, analyzes the water quality effects on covered fish species during construction of different conservation measures. The potential effects of turbidity, suspension of potentially toxic sediments, and accidental spills associated with these activities are summarized in Table 5.3-9. In addition to the avoidance and minimization measures related to permit requirements, the BDCP includes implementation of *CM22 Avoidance and Minimization Measures*, which is a suite of avoidance and minimization measures that complement those likely to be required by permits.

Table 5.3-9. Potential for Construction Activities to Affect Water Quality

Activity	Conservation Measures	Location	Potential Water Quality Effects	Avoidance and Minimization Measures
Channel dredging/ excavation	• CM1 Water Facilities and Operation • CM4 Tidal Natural Communities Restoration • CM5 Seasonally Inundated Floodplain Restoration • CM15 Localized Reduction of Predatory Fishes	In water	• Increased turbidity • Resuspension of toxins attached to sediments • Disturbance/removal of channel sediments • Injury or loss of benthic invertebrates	• Section 404 and Section 10 permits will require BMPs to minimize suspension of bottom sediments • Basin Plan requirements limit turbidity levels • CM22
Installation of piles or sheet pile for cofferdam	• CM1 Water Facilities and Operation • CM16 Nonphysical Fish Barriers • CM21 Nonproject	In water	• Increased suspension of bottom sediments and turbidity • Suspension of toxic-contaminated sediment	• Section 404 and Section 10 permits will require BMPs to minimize suspension of bottom sediments • Basin Plan

Activity	Conservation Measures	Location	Potential Water Quality Effects	Avoidance and Minimization Measures
	Diversions			requirements limit turbidity levels • CM22
Discharge of treated water from dewatering activities	• CM1 Water Facilities and Operation	In water	• None	• Water will be treated prior to discharge and will meet National Pollutant Discharge Elimination Service permit requirements • CM22
Stormwater discharge or accidental spills (from upland construction areas or equipment)	• CM1 Water Facilities and Operation • CM2 Yolo Bypass Fisheries Enhancement • CM4 Tidal Natural Communities Restoration • CM5 Seasonally Inundated Floodplain Restoration • CM6 Channel Margin Enhancement • CM7 Riparian Natural Community Restoration • CM14 Stockton Deep Water Ship Channel Dissolved Oxygen Levels • CM15 Localized Reduction of Predatory Fishes • CM16 Nonphysical Fish Barriers • CM18 Conservation Hatcheries • CM19 Urban Stormwater Treatment • CM21 Nonproject Diversions	In water	• Small discharges from upland construction areas	• Subject to National Pollutant Discharge Elimination Service Permit requirements • CM22
Excavation for restoration	• CM2 Yolo Bypass Fisheries Enhancement • CM4 Tidal Natural Communities Restoration • CM5 Seasonally Inundated Floodplain Restoration • CM6 Channel Margin Enhancement • CM7 Riparian Natural Community Restoration	In water	• Increased suspended sediment • Mobilization of toxic-contaminated sediment	• Section 404 and Section 10 permits will require BMPs to minimize suspension of bottom sediments • Basin Plan requirements limit turbidity levels • CM22
Basin Plan = water quality control plan; BMPs = best management practices.				

5.3.2.6.1 Contaminants and Turbidity

In-water construction activities will disturb bottom sediments and could result in turbidity levels that could affect covered fish species. In-water construction activities will have minimal effects on covered fish species and will depend on the location and presence of the fish species. The in-water construction activities that could generate increased turbidity will be temporary and localized. As such, the expected increases in turbidity and suspended sediment will be of short duration, limited in extent, and monitored for compliance with regulatory standards. In addition, any localized increases in suspended sediment and turbidity likely will be diluted quickly as a result of the mixing potential associated with channel currents. Potential effects on covered fish species likely will be limited to indirect effects resulting from the behavioral response of fish to turbid water and suspended sediment in the affected portion of aquatic habitats. Such responses include avoidance of high turbidity, changes in foraging ability, increased predation risk, and reduced territoriality (Meehan and Bjornn 1991; Bash et al. 2001). However, most increases in turbidity and suspended sediment will occur in the summer period when fewer individuals of migratory species (e.g., Chinook salmon, steelhead, splittail, sturgeon) are likely to be present in the south Delta.

Sediment disturbance caused by in-water construction may cause localized and temporary suspension of potentially contaminated sediments. These effects will be minimized by implementation of *CM22 Avoidance and Minimization Measures*, compliance with required local permits, clearances, and National Pollutant Discharge Elimination Service permits or other waste discharge requirements from the Central Valley Regional Water Quality Control Board and implementation of appropriate best management practices to protect water resources from contamination. In addition, turbidity, and in turn suspension of sediments, will be minimized by requirements of the U.S. Army Corps of Engineers Section 404 permit and the Section 10 Water Quality Permit, along with the water quality control plan (Basin Plan) requirements to maintain low turbidity during construction. Exposure of covered fish species to any disturbed contaminated sediments will be minimized by restrictions on in-water work to between June 1 and October 31, when the potential for many of the covered species to be near construction will be at a minimum. Although sturgeon are assumed to be potentially present year-round and therefore could be affected by water quality, they are bottom feeders so disturbance of sediments will not change their potential exposure to them; therefore, effects are considered low.

5.3.2.6.2 Spills

Because the in-water construction periods for the construction measures will be short-term and the in-water construction equipment will be generally limited to barges, pile-driving equipment, and dredges, the potential for direct accidental spills to the aquatic environment is short-term, and any spills that may occur will be of very limited quantities. The most likely types of accidental spills will be fuel, oil, and hydraulic fluids. These types of spills are readily contained by booms, and all personnel will be trained to identify and rapidly respond to such accidents. There is also a potential for spills in upland areas to flow into the aquatic system, but the probability of these types of effects is also low, given the spill prevention and response programs required by permitting requirements.

5.3.3 Aquatic Habitat and Foodweb

This section provides a summary of the ecosystem-scale effects of the BDCP on aquatic foodwebs. The proposed tidal marsh, channel margin, floodplain, and riparian restoration measures will increase availability to suitable habitat for all covered fish species and restore important ecological functions of the Delta. Uses of this restored habitat include, depending on specific life histories, adult holding, foraging, and spawning; egg and larval development; and juvenile rearing. The restoration is expected to provide increased production of periphyton, phytoplankton, zooplankton, macroinvertebrates, insects, and small fish that contribute to the local and regional trophic foodweb associated with each restoration area. The extensive restoration will promote linkages between various habitat types, mimicking historical conditions. Overall, the restoration of tidal natural communities has the potential to provide a large net benefit to each covered fish species, although fully achieving this potential will require careful design, and, when appropriate, management of restored areas.

Conservation measures for restoring aquatic habitat are based, in large part, on objectives for geographic diversity of habitat, diversity of habitat types (seasonal floodplain, intertidal and shallow subtidal areas, and channel margin habitat), and heterogeneity and diversity of habitat characteristics within and among areas that are compatible with existing topography, hydrology, and water quality conditions. The areas for tidal restoration are geographically distributed throughout the Delta (see Chapter 3, *Conservation Strategy*, for a full description of locations, including a map of ROAs).

The design of each restoration area will consider a number of factors.

- The area that meets the design water depth conditions.
- Location and size of levee breaches.
- Tidal hydrodynamics in the area.
- Proximity to migration corridors and spawning areas.
- Compatibility with existing land uses and infrastructure.
- Current patterns and circulation within the restored habitat.
- Avoidance of areas that will increase the risk of stranding, exposure to increased predation, and adverse water quality conditions.

The design also will consider the likelihood that the area will be colonized by tules and other emergent vegetation, SAV, and floating aquatic vegetation such as *Egeria*; colonization by nonnative clams (e.g., *Potamocorbula*, *Corbicula*); areas of high velocity and turbulence such as levee breaches where juvenile fish will have increased risk of predation; and diversity of spatial habitat features such as variable water depths and channels under existing and future conditions assuming sea level rise.

Although there is scientific information collected from the Delta, Yolo Bypass, and Suisun Marsh areas of the Delta that shows evidence of benefits of aquatic habitat restoration (Sommer et al. 2001a, 2001b; Simenstad et al. 2000), as well as results from a number of restoration projects conducted in the Pacific Northwest that focused on juvenile salmon rearing (Miller and Simenstad 1997; Gray et al. 2002; Bottom et al. 2005a, 2005b), a number of areas of uncertainty remain (Brown 2003a, 2003b, 2003c, 2003d; Davis et al. 2003; Orr et al. 2003). Areas of uncertainty include, but are not limited to the following areas:

- The ability of the restored habitat to meet the objectives and expected outcomes, including the time it takes to meet the biological objectives.

- The risk that the restored habitat will be colonized by invasive species such as nonnative submerged vegetation, nonnative predatory fish, and/or clams.
- The change in magnitude of predation mortality on covered fish.
- Foodweb responses to habitat restoration actions on both a local and a regional scale.
- The risk of adverse effects resulting from unsuitable changes in water quality and exposure to toxic contaminants.
- The proportion of the covered species population that actively inhabit restored habitats and the change in growth rate, survival, abundance, life-history strategies, and population dynamics.

Regardless of these uncertainties, large-scale restoration of the magnitude proposed under the Plan has never been attempted in the Delta, and, based on the information collected from smaller restoration efforts in the Plan Area, there is potential for substantial benefits to covered fish species by providing additional habitat as well as enhancement of the foodweb. Habitat restoration projects will be designed with a phased approach to serve as a large-scale experimental program that documents changes in ecosystem function, both beneficial and adverse, in terms of each of the covered fish species. If results of monitoring identify adverse effects that will not support meeting the expected biological outcomes, the existing and future restoration actions will be modified and refined as part of adaptive management. In the event that a restored habitat is found to have substantial adverse effects on the reproductive success, growth, survival, or population dynamics of the covered fish, substantial modifications will be made to address and mitigate these adverse effects.

The following sections provide general information about the Bay-Delta foodweb and trophic pathways, and the expected outcomes of habitat restoration actions under the BDCP with respect to hydrodynamics, residence time, and increased food productivity.

5.3.3.1 Bay-Delta Foodweb and Trophic Pathways

This section provides background on the Bay-Delta foodweb and trophic pathways, along with a summary of current information on the diets of covered fish species. Figure 5.3-7 is the BDCP conceptual model of food depicting drivers, covered activities, controls, and VSP attributes and how they interact. There are three basic trophic pathways in estuarine foodwebs: the phytoplankton-based pathway. the detrital pathway, and the littoral SAV and epiphytic macroalgae pathway (Grimaldo et al. 2009). The Bay-Delta is unusual in that community metabolism is driven by microbial consumption of organic detritus (Sobczak et al. 2005), but phytoplankton is the main source of organic matter for zooplankton and the foodweb supporting pelagic fish (Jassby and Cloern 2000; Jassby et al. 2002, 2003; Müller-Solger et al. 2002, 2006; Sobczak et al. 2002, 2005; Kimmerer et al. 2005). The following sections summarize the main features of the phytoplankton-based foodweb and the detrital pathway based on current understanding.

5.3.3.1.1 Overview of Phytoplankton-Based Foodweb

Phytoplankton

Phytoplankton production in the Bay-Delta has undergone a number of major changes over the past 150 years. During the gold rush era, high turbidity resulting from upstream hydraulic mining kept phytoplankton at low levels (Alpine and Cloern 1992; Cloern 1996; Cole and Cloern 1984, 1987; Cloern and Dufford 2005; Cloern et al. 2007; Jassby et al. 2002; Kimmerer 2004). Between 1975 and

1995, phytoplankton production dropped dramatically, declining by more than 40% because of a combination of new stressors (Jassby et al. 2002), including excessive grazing by two introduced clams—the overbite clam (*Potamocorbula amurensis*) in brackish waters and the Asian clam (*Corbicula*) in fresh water (Kimmerer et al. 1994; Kimmerer and Orsi 1996; Orsi and Mecum 1996). Recent research indicates that another major factor has been Sacramento Regional Wastewater Treatment Plant discharges of high levels of ammonium, which inhibits diatom production (Glibert 2010; Glibert et al. 2011; Wilkerson et al. 2006; Dugdale et al. 2007).

The decreased diatom production and invasive clams have altered the species composition of the phytoplankton, as well as overall phytoplankton abundance (Jassby 2008). Flagellates, green algae, and cyanobacteria have increased as diatom populations have declined. These species are poor food sources for the zooplankton that are the preferred prey of native fish species. For example, studies show that the survival of copepods, the main prey of delta smelt and other native fish species, is depressed with increasing abundance of the cyanobacterium *Microcystis aeruginosa* (microcystis) relative to more palatable phytoplankton (Ger 2008). Microcystis is now widespread in the Delta in late summer and fall (Lehman et al. 2005, 2008, 2010).

Since the mid-1990s, phytoplankton production has recovered to some extent in the Delta, although production remains low (Jassby 2008). At the same time, no trend has been apparent in phytoplankton in Suisun Bay, even though grazing by *Potamocorbula* remains a factor. Scientists hypothesize that export of phytoplankton production from the upper estuary is helping to maintain Suisun Bay's zooplankton (Baxter et al. 2010).

Zooplankton

With the decline in diatoms, there have been parallel declines in the Delta's zooplankton populations, many of which are known to be limited by phytoplankton production (Müller-Solger et al. 2002; Sobczak et al. 2002). The decline in mesozooplankton, particularly calanoid copepods (*Eurytemora affinis, Pseudodiaptomus forbes*), cladocerans (*Daphnia* spp.), and mysids (*Neomysis mercedis*), is a major factor contributing to recent declines of native fishes (Cloern 2007; Sommer et al. 2007; Glibert 2010; Glibert et al. 2011; Maunder and Deriso 2011; Miller et al. 2012; Winder and Jassby 2010).

Historically, calanoid copepods and cladocerans formed the zooplankton prey base for most fish species in the Delta because of their large size and visibility. However, the introductions of *Potamocorbula* and *Corbicula* led to major alterations in the zooplankton community by decimating phytoplankton populations (Jassby 2008). High filtration rates of early instars by *Potamocorbula* have been implicated in the decline of both *Eurytemora* and the native mysid shrimp *Neomysis mercedis* (Feyrer 1999; Winder and Jassby 2011). *Neomysis* is an important food for many native fish species, including delta smelt (Herbold et al. 1992; Kimmerer 1992). Since 1995, the introduced mysid, *Hyperacanthomysis longirostris* (formerly *Acanthomysis bowmani*), has been the most abundant mysid in the upper estuary (Kimmerer et al. 1994; Kimmerer and Orsi 1996; Orsi and Mecum 1996). This species has less nutritional value than *Neomysis* (Moyle 2002).

At present, the calanoid copepods *Eurytemora* and *Pseudodiaptomus* and the introduced cyclopoid copepod *Limnoithona tetraspina* are the primary zooplankton species in the brackish portions of the Bay-Delta. Introduced in 1993, *Limnoithona* on average rapidly became the most abundant copepod in these areas (Orsi and Mecum 1996). Because of its small size, sedentary behavior, and ability to avoid predators, it is thought that *Limnoithona* may be an inferior food for fish, and therefore may contribute to the decline in food quantity and quality for delta smelt and other pelagic fishes (Bouley and Kimmerer 2006; Gould and Kimmerer 2010).

In the freshwater portions of the Delta, cladocerans and the calanoid copepods *Diaptomus* and *Limnocalanus* are the dominant zooplankton (Kimmerer and Orsi 1996; Kimmerer 2004). Amphipod crustaceans, including the introduced *Hyperacanthomysis longirostris*, provide alternative prey for fish that formerly fed extensively on *Neomysis* (Feyrer et al. 2003) but they are not currently monitored sufficiently to understand their importance in the foodweb (Kimmerer et al. 2008).

Macroinvertebrates and Fish

The changes in the phytoplankton and zooplankton communities have greatly reduced the food resources for *Neomysis* and native fishes (Winder and Jassby 2011). *Neomysis* and other mysids feed primarily on phytoplankton, providing an energetic link between plankton and planktivorous fishes such as delta smelt, longfin smelt, and Chinook salmon. The benthic-feeding sturgeon feed on epibenthic organisms such as amphipods, bay shrimp, and bivalves, including the introduced clams (Israel and Klimley 2008; Israel et al. 2008, 2009).

Potamocorbula has decreased the total amount of plankton available for native planktivores, and diverted much of the estuary's production to the benthos (Winder and Jassby 2010), resulting in an energetic "dead end." The decline in the phytoplankton-based pelagic foodweb is thought to be one of the major reasons for the pelagic organism decline (POD) that began in 2002 (Sommer et al. 2007; Thomson et al. 2010; Mac Nally et al. 2010; Baxter et al. 2010). Delta smelt, longfin smelt, striped bass, and threadfin shad are pelagic fishes that have experienced sharp declines over the past decade.

5.3.3.1.2 Export of Food Resources from Restored Habitats

Export of Marsh-Derived Production

The findings of Howe and Simenstad (2011) suggest that a potential benefit of tidal habitat restoration is the export of marsh-derived production, including both detritus and phytoplankton. In the Bay-Delta, there is evidence that tidal marshes export food resources to adjacent channels and downstream systems (Cloern et al. 2007; Lehman et al. 2008). Studies in both southern California (Kwak and Zedler 1997) and the Bay-Delta (Howe and Simenstad 2007, 2011) show that tidal wetlands export food resources both to adjacent channels and the wider estuary (Kneib et al. 2008; Maier and Simenstad. 2009). Marsh export may include advection and tidal exchange, as well as export of productivity in the form of macroinvertebrates and small fishes (Kneib et al. 2008). The BDCP includes substantial restoration of tidal natural communities (65,000 acres, including transitional uplands to accommodate sea level rise) that has the potential to produce and export detritus and phytoplankton into the open estuary where fish can consume it. The magnitude of this benefit depends on site-specific conditions of the restored areas, hydrodynamics in and around the restored areas, the distribution of fish, and constraints on productivity available to covered species such as the abundance and distribution of invasive clams in restoration sites. Careful design of restored areas, including application of adaptive management, can increase the likelihood that this benefit will be realized.

Export of Phytoplankton and Zooplankton from the Delta

Phytoplankton, zooplankton, and other food resources produced on inundated floodplains in the upper estuary provide subsidies to foodwebs downstream (Schemel et al. 1996; Jassby and Cloern 2000; Mitsch and Gosselink 2000; Moyle et al. 2007; Moss 2007; Lehman et al. 2008). The export of resources from the diversity of habitats in the Cache Slough ROA also has great potential to increase downstream productivity. According to Baxter et al. (2010), Durand of the University of California at Davis (UC Davis) found that transport from upstream areas was essential for maintaining the *P. forbesi* copepod population in Suisun Bay. Müller-Solger et al. (2006) noted that areas rich in high-quality phytoplankton and other nutritious food sources, including the southern Delta and small tidal marsh sloughs, may be critical source areas for important fish prey organisms such as *P. forbesi* and *E. affinis*. Opperman (2008) has described the importance of export of food to downstream foodwebs, and Sobczak et al. (2005) and Ahearn et al. (2006) discussed the links between carbon produced on floodplains and the downstream foodweb.

5.3.3.2 Physical Effects

The habitat restoration and enhancement conservation measures will result in changes to physical parameters such as hydrodynamics and residence time that will influence productivity and food export. The expected changes under the BDCP are described below.

5.3.3.2.1 Hydrodynamics

The proposed tidal restoration will add a substantial increment to the existing Delta surface area at high tide (+4 feet) and low tide (-2 feet). The mean higher high water (MHHW) surface area upstream of Martinez will increase from about 90,000 acres to 140,000 acres, an increase of more than 55%. The mean lower low water (MLLW) surface area will increase from about 83,000 acres to 115,000 acres, an increase of more than 39%.

The simulated tidal flow changes from the restoration of tidal habitat areas were generally low in the Delta channels, except for some existing channels near the restoration areas. Restoration in the Suisun Marsh ROA resulted in significant simulated increases in tidal flow at the mouth of Montezuma Slough (+100%). Tidal flow at the head of Montezuma Slough was increased by about 60%. At Chipps Island (West Delta ROA), the tidal flows were reduced by about 5%. These reductions in Chipps Island tidal flows were the result of Suisun Marsh restoration. More of the tidal prism (tidal flows) went into the expanded Suisun Marsh tidal habitat, and less went upstream into the Delta channels and expanded tidal habitat. The tidal restoration also caused tidal muting (reduced tidal amplitude and reduced tidal flows) throughout the Delta. Tidal flows in the lower Sacramento River (West Delta ROA) were reduced by the downstream restoration in Suisun Marsh and were increased by the upstream restoration in Cache Slough ROA. The net effect on tidal flows was an increase of about 3% in the lower Sacramento River (West Delta ROA) flows. Tidal flows in the lower San Joaquin River (West Delta ROA) were reduced by about 10%. Simulated tidal elevations were muted and tidal flows were reduced in the Sacramento River. The tidal range (high tide to low tide elevation) was reduced from about 2 feet to about 1.5 feet. The flows were always positive, but the tidal variation was reduced from 6,000 cfs to about 5,000 cfs.

5.3.3.2.2 Residence Time

Increased residence time can lead to both positive and negative effects on the Delta ecosystem depending on its location and length. It is generally believed that an increase in residence time will cause an increase in primary production because the phytoplankton population will spend more time integrating light and nutrients within Delta channels and growing. However, increases in residence time can also allow nonnative clams to graze a larger proportion of the primary productivity if the residence time occurs within an area with high densities of clams (Lopez et al. 2006; Lucas et al. 2002). In addition, an increase in residence time potentially could increase exposure of aquatic organisms to pesticides and heavy metals. Residence time is calculated using a DSM2 particle-tracking model. Residence time is calculated up to the time at which 50% of the particles leave the Delta (by exiting the west end at Martinez, SWP/CVP exports, or agricultural diversions).

These results indicate that residence time will increase by 3 to 4 days (9 to 19%) as a result of the lower Sacramento River flow downstream of the north Delta intakes and the lower south Delta pumping under ESO for the hydrologic modeling scenarios used in the DSM2 analyses (WY 1976 through 1991). There is large variation among hydrologic scenarios in these results, which reduces the certainty of the conclusions (compounding the existing uncertainty of DSM2 outputs). The small average increases of 3 to 4 days predicted by this analysis are unlikely to cause major changes in primary production, particularly with respect to the large level of uncertainty and large variation in results. It is not known what the effect of 3 to 4 days more of exposure to pesticides or metals will have on different aquatic organisms.

5.3.3.3 Habitat Productivity

The Habitat Productivity Analysis was used to assess potential foodweb enhancements that may result from proposed tidal habitat restoration activities. Increased food productivity is expected in all ROAs as a result of the BDCP, but the Suisun Marsh, Cache Slough, and South Delta ROAs are expected to see the greatest increases in productivity. While the Suisun Marsh and Cache Slough ROAs will immediately provide increased productivity because restoration is planned first on those ROAs, the South Delta ROA will provide benefits in the LLT. Food produced in the ROAs is expected to directly benefit covered fish in the ROAs as well as in areas to the extent that food is exported from ROAs. Accordingly, the restoration of these areas and the associated food production are expected to create better linkages between upstream spawning areas and downstream rearing areas for juvenile Chinook salmon, splittail, sturgeon, delta smelt, and longfin smelt. The analysis examined two main sources of foodweb support: phytoplankton production and marsh-derived production.

5.3.3.3.1 Phytoplankton Production

The relationship between phytoplankton growth rate and depth developed by Lopez et al. (2006) was used to characterize how habitat restoration could contribute to the phytoplankton-based foodweb (Figure 5.E.4-85, *Relationship between Phytoplankton Growth Rate and Depth*, in Appendix 5.E, *Habitat Restoration*). The analysis focused solely on the relationship between phytoplankton and depth, while recognizing that other factors may influence phytoplankton production in particular locations. Lopez et al. (2006) note that the relationship between phytoplankton and zooplankton is only weakly correlated in some locations in the Bay-Delta because of grazing by invasive clams and weak hydraulic connections. In habitats that are heavily grazed and have high residence time there will probably be little export of phytoplankton production.

The relationship between phytoplankton growth rate and depth was applied to the estimated depths for each tidal-area stratum. In addition, a consideration of the area of habitat of an average depth was added to the estimates of phytoplankton growth rate. It was assumed that a larger area of a given phytoplankton growth rate has a greater value than a smaller area with the same rate. To capture this notion, the phytoplankton growth rate was calculated from the estimated average water depth of each tidal-area stratum, and then multiplied by the area of the stratum, resulting in a metric termed *prod-acres* (phytoplankton growth rate multiplied by area). The analysis provided estimates of phytoplankton growth rate and calculated prod-acres by ROA for existing conditions and conditions under the BDCP as shown in Table 5.3-10.

Table 5.3-10. Depth-Averaged Phytoplankton Growth Rate and Prod-Acres under Two Scenarios[a]: Existing Conditions and Future Conditions with the BDCP

Restoration Opportunity Area	Scenario[a]	Phytoplankton Growth Rate	Prod-Acres
Cache Slough	EBC2	0.89	10,111
	ESO_LLT	0.97	29,569
North Delta	EBC2	0.71	2,661
	ESO_LLT	0.76	3,172
West Delta	EBC2	0.78	22,591
	ESO_LLT	0.82	26,673
Suisun Marsh	EBC2	1.12	13,935
	ESO_LLT	0.99	24,422
Suisun Bay	EBC2	0.70	14,222
	ESO_LLT	0.67	13.701
East Delta	EBC2	0.81	4,818
	ESO_LLT	0.94	8,936
South Delta	EBC2	0.76	15,061
	ESO_LLT	0.89	38,090

[a] For descriptions of scenarios, see Table 5.2-3.

5.3.3.3.2 Restoration Opportunity Areas and Conservation Measures

The habitat restoration and habitat enhancement conservation measures are predicted to produce and export food for covered fish species. Different types of habitat restoration will occur under the conservation measures in the different ROAs. Figure 5.3-8 is the BDCP conceptual model of habitat depicting drivers, covered activities, controls, and VSP attributes and how they interact. The contribution of the conservation measures and each ROA and for each habitat restoration and enhancement is discussed below.

Tidal Natural Community Restoration

CM4 Tidal Natural Communities Restoration will restore tidal wetlands throughout the restoration areas. Studies in locations throughout the United States indicate substantial ecological benefits from restoring tidal wetlands, including foodweb support for fish species (Boesch and Turner 1984; Baltz et al. 1993) and the export of nutrients and prey organisms to adjacent channels (Shreffler et al. 1992; Lucas et al. 2002; Schemel et al. 2004; Sommer et al. 2004a, 2004b; Lopez et al. 2006). Studies conducted in the lower Bay-Delta estuary and elsewhere along the Pacific coast also provide evidence of tidal marsh benefits for fish, especially salmonids (Simenstad et al. 1982; West and

Zedler 2000; Bottom et al. 2005a; Maier and Simenstad 2009; Simenstad et al. 2000; Howe and Simenstad 2011).

Of the Delta habitats, the tidal marsh sloughs have the highest particulate organic matter and phytoplankton concentrations and support the greatest zooplankton growth rates (Mueller-Solger et al. 2002; Sobczak et al. 2002). The shallow littoral edges of marsh systems often are associated with high standing stocks of fishes in California (e.g., Allen 1982; Moyle et al. 1986; Nobriga et al. 2005) and elsewhere (e.g., Kneib 1997, 2003). When tidal mudflat is inundated, it serves as shallow open-water habitat for fish species, including splittail, salmonids, and sturgeon, and provides forage on benthic invertebrates.

Tidal wetlands also have the capacity to export food resources to adjacent channels and to downstream systems (Cloern et al. 2007; Lehman et al. 2008). The export of food may include movement of phytoplankton and zooplankton by advection and tidal exchanges as well as the export of productivity in the form of macroinvertebrates, small fishes, and other larger organisms (Kneib 1997, 2003).

Cache Slough Restoration Opportunity Area

The phytoplankton growth model estimates that the measure of production (prod-acres) in the Cache Slough ROA is currently high and will increase by approximately threefold by the end of the permit term. This increase in phytoplankton growth and assumed increases in zooplankton will provide benefits to delta smelt in two major ways: the resident population of delta smelt in Cache Slough will benefit directly from increases in copepod and mysid abundance in the Cache Slough ROA, and larvae and juveniles will derive an indirect benefit to the extent that food resources are exported downstream to rearing areas. Likewise, Sacramento splittail will benefit directly from increased production in restored Cache Slough wetlands, as well as from production that is exported downstream to areas such as Suisun Bay and Suisun Marsh, where it will support splittail rearing. Young Chinook salmon and steelhead forage in tidal habitat and will benefit from the increase in zooplankton, chironomids, amphipods and drift insects commonly found in tidal habitats. Sturgeon, which feed on benthic invertebrates, including those found on marsh mudflats, will benefit from the transfer of increased production to mudflat fauna in restored marshes.

Suisun Marsh Restoration Opportunity Area

The phytoplankton growth model indicates that the Suisun Marsh ROA, like Cache Slough, has significantly more prod-acres under the baseline scenario than the other ROAs and will increase by approximately double by the end of the permit term. An increase in phytoplankton at the base of the pelagic foodweb will enhance food production for delta smelt. Juvenile fish will benefit directly from increased production in marsh channels and indirectly from production exported to deeper, open-water areas. Larval longfin smelt frequently are found in marsh environments, but soon after they reach free-swimming post-larval stages, they concentrate in deepwater environments. Therefore, the primary benefit to longfin smelt of restoration in the Suisun Marsh ROA will be the export of food resources to deeper waters. Increased production of phytoplankton and marsh derived detritus will support production of benthos, on which splittail juveniles and adults, who spend most their lives in Suisun Marsh, Suisun Bay, and the Delta, can feed. Likewise, Chinook salmon and steelhead fry and juveniles forage in tidal marshes, channels, and sloughs, and emergent vegetation communities support invertebrate prey populations. Juvenile salmonids also benefit indirectly from exported food resources. The export of food may include movement of phytoplankton and zooplankton by means of advection and tidal exchanges, as well as the export of productivity in the form of detrital carbon, macroinvertebrates and small fishes.

West Delta Restoration Opportunity Area

The phytoplankton model estimates that primary production in the West Delta ROA is currently the second lowest of the ROAs. The BDCP is modeled to increase production in this ROA substantially but production will remain lower than the average of the other ROAs. Tidal habitat restoration in the West Delta ROA could increase local food production for rearing salmonids and splittail, and increase the availability and production of food in the western Delta and Suisun Bay by export via tidal flow. The restored habitats will provide a potentially important linkage between upstream spawning and rearing habitat for splittail and the major splittail habitat downstream in Suisun Marsh and Bay. Similarly, rearing salmonids in the west Delta migrating from the Cosumnes and Mokelumne Rivers, and these individuals will benefit from food production in the West Delta ROA.

East Delta Restoration Opportunity Area

The phytoplankton model indicates that the number of prod-acres in the East Delta ROA under the baseline scenario will approximately double with BDCP. With tidal wetland restoration, production will increase but will remain modest. Transport of production from tidal habitat restoration in the Cosumnes/Mokelumne ROA could benefit juvenile salmonids, splittail, delta smelt, and sturgeon in the east and central Delta and steelhead, delta smelt, and splittail migrating to and from the Cosumnes and Mokelumne Rivers.

South Delta Restoration Opportunity Area

The phytoplankton model estimates that there are no prod-acres in the South Delta ROA under baseline conditions. With restoration, prod-acres will increase dramatically, with the highest total increase estimated for this ROA. Most (75%) of the increase occurs in the deep zone. Although delta smelt and longfin smelt are not generally found year round in the south Delta early life-history stages will benefit directly from increased phytoplankton and zooplankton production resulting from tidal habitat restoration. The increase in phytoplankton will enhance the foodweb supporting splittail, helping to promote growth and survival of both juveniles and adults, particularly those migrating to and emigrating from the San Joaquin River. Permanent tidal marshes in the South Delta ROA will contribute new holding and rearing areas for juvenile fish and improved survival in the San Joaquin River system for salmonids.

Channel Margin Enhancement

CM6 Channel Margin Enhancement will improve the physical elements (e.g., woody debris, rocks) and vegetation (emergent plants, woody riparian, SAV) associated with channel margin habitat, shallow water, and banks, and enhance their capacity to serve as substrates for invertebrate communities that support foraging fish. The use of channel margin habitat by fish depends on species- and age-specific dietary preferences and foraging behavior. Isotope studies indicate that the majority of fishes in littoral habitats have diets dominated by nearshore invertebrates such as amphipod grazers from SAV and epiphytic macroalgae. In the Delta, juvenile Chinook salmon rely predominantly on zooplankton and chironomids, with some amphipods derived from channel margin habitat and other littoral sources (Grimaldo et al. 2009). Studies of littoral habitats in the Pacific Northwest have found that sub-yearling juvenile Chinook salmon feed primarily on amphipods (*Corophium* spp.), dipteran insects, and some zooplankton (*Daphnia* spp.), with a shift in diet from insects to amphipods and larval fish as juveniles increase in length and move toward the estuary mouth (McCabe et al. 1986 and Bottom and Jones 1990 as cited in Lott 2004). Delta smelt and other pelagic species are expected to benefit from food resources in channel margins to the extent that food resources associated with channel margin habitat are exported to open channel habitat.

Channel margin habitat will be located along the major migration routes and linked to other important habitats through the Delta. Evidence from the northwest United States suggests that connectivity of foraging habitat (e.g., the length, condition, and complexity of pathways) affects the importance of habitats to juvenile Chinook salmon. For instance, juvenile Chinook salmon were less abundant in dendritic tidal channel systems as distance from the main distributary channels increased (Beamer et al. 2005 cited in Fresh 2006). However, recent work in the San Francisco estuary, including the Plan Area, has shown occupation by fish of very small intertidal dendritic channels (Gewant and Bollens 2011).

There is some indication that channel margin habitat could be extremely important rearing habitat for foraging Chinook salmon in years with low precipitation when floodplains are not functioning. A study by McLain and Castillo (2009) found that densities of Chinook salmon fry in the Sacramento River and Steamboat Slough were higher compared to Miner Slough and Liberty Island Marsh during a low outflow year.

Floodplain Restoration

CM5 Seasonally Inundated Floodplain Restoration is anticipated to increase food resources for juvenile salmon and splittail and increase the productivity of foodwebs that support Delta fish species (Jeffres et al. 2008; Sommer et al. 2001a, 2001b). Floodplains can export food resources, especially algae, to support foodwebs in downstream communities. Periodically, pulsing small “floodplain activation floods” may pump higher concentrations of algae than found in adjacent river channels to downstream waters (Ahearn et al. 2006). The restoration aims to support juvenile Chinook salmon and splittail and to export of floodplain-produced algae to downstream aquatic ecosystems during flood events).

Restoration potentially could increase the quantity and quality of riverine phytoplankton biomass available to the aquatic foodweb by passing river water through a floodplain such as proposed on the San Joaquin River during the flood season. Central Valley floodplains should produce increased levels of phytoplankton and other algae, particularly during long-duration flooding that occurs in the spring. The shallow water depth and long residence time in floodplains will facilitate settling of suspended solids, resulting in reduced turbidity and increased total irradiance available for phytoplankton growth in the water column(Lehman et al. 2008). At the Cosumnes River Preserve, the inundated floodplain progressed from a physically driven system when connected to the river floods, to a biologically driven, pond-like system with increasing temperature and productivity (Ahearn et al. 2006). Periodic small floods often boost productivity of phytoplankton by delivering new pulses of nutrients, mixing waters, and exchanging organic materials with their adjacent river. In floodplain sites that have multiple connections and disconnections like the Cosumnes floodplain zooplankton biomass should increase rapidly following each flood event after water warms and microalgae production is increased.

Providing river–floodplain connectivity should enhance production of lower trophic levels at relatively rapid time scales. In the Yolo Bypass, some foodweb organisms should respond within days and attain high densities soon after inundation, including smaller fast-growing algae, vagile organisms such as drift insects, and organisms associated with wetted substrate such as chironomids (Benigio and Summer 2008). These organisms, particularly chironomids and drift insects, will provide a food source to fish that is available prior to the development of foodweb productivity.

Yolo Bypass Fisheries Enhancement

CM2 Yolo Bypass Fisheries Enhancement is expected to improve spawning, substrate, rearing habitat, and food production benefits to covered fish species. Specifically, the most important spawning habitat for splittail occurs in the seasonally inundated floodplains of the Sutter and Yolo Bypasses of the Sacramento River(Sommer et al. 2007). Analysis of floodplain habitat availability for splittail is directed primarily at the egg/embryo, larval, and juvenile stages because production of these life stages is especially important in determining year class abundance (Sommer et al. 1997). Results of the analyses show that the frequency and duration of inundation events are greater under the BDCP than under either of the existing biological conditions (EBC1 and EBC2), especially for dry and critical year types. For wet year types in particular, the BDCP results in a reduced frequency of shorter-duration events and an increased frequency of longer-duration events. This change is attributable to the influence of the Fremont Weir notch at lower flows. In addition to the numerous splittail benefits expected, benefits to juvenile salmon also are expected. Benefits to juvenile salmon associated with floodplain habitats are well-documented and result in increased growth and condition (Sommer et al. 2001b; Jeffres et al. 2008).

Riparian Restoration

CM7 Riparian Natural Community Restoration is expected to restore ecological functions in the riparian zone. Modern ecological theory suggests that natural disturbances (e.g., flooding) contribute physical and biological energy that links the terrestrial and aquatic environments in the riparian zone, similar to that outlined by the River Continuum theory (Vannote et al. 1980). These hydrologic pulses (Junk 1999; Tockner et al. 2000) support recruitment of diverse tree and shrub species, and together these species create a heterogeneous landscape. This riparian vegetation in turn promotes a diversity of associated terrestrial and aquatic species. In the Cosumnes River Preserve, researchers found that flood-induced disturbance is an important factor in promoting heterogeneous riparian habitats, including woody and herbaceous species diversity (Viers et al. 2006). Biodiversity is a key parameter for all BDCP habitat restoration actions because the number of species in a habitat directly relates to the complexity and connectivity of the foodweb (Martinez 1993, 1994; Martinez and Lawton 1995).

Although the covered fish species do not rely primarily on riparian habitat, they are directly and indirectly supported by the habitat services and food sources provided by the highly productive riparian ecosystem, particularly during flood flows when riparian habitats are inundated. Riparian vegetation is a source of organic material (e.g., falling leaves), insect food, and woody debris in waterways and can influence the course of water flows and structure of instream habitat. This debris is an important habitat and food source for fish, amphibians, and aquatic insects (Opperman et al. 2005).

5.3.3.4 Construction Effects

As discussed in Appendix 5.H, *Aquatic Construction and Maintenance Effects*, construction activities in the ROAs will include in-water work such as pile driving and dredging, which will temporarily disturb or modify habitat, including benthic habitat and on-bank and channel habitat. Benthic organism removal from dredging, and burying deposit feeders, suspension/deposit feeders, and suspension feeders, will occur in portions of the dredged area. Removing these organisms through dredging or disposal may cause short-term effects on fish species residing in the dredge area by limiting food resources (U.S. Army Corps of Engineers 1978). Benthic substrate that is excavated contains macroinvertebrates that provide prey for covered fish species. Covered fish species that consume benthic macroinvertebrates include white and green sturgeon and Sacramento splittail. While it is speculative to assign numbers or values to how much construction activities will affect food production, over the scale of the ROAs, it will have a local effect and most likely is not measurable.

Construction activities could affect channel habitat that provides detritus to the foodweb and rearing habitat. The affected habitat associated with the intake facilities for *CM1 Water Facilities and Operation* is currently armored levee bank with limited riparian vegetation and of low value for species rearing. Cofferdams will be used to isolate the entire work area from the wetted channel of the Sacramento River during construction of each of the three intake facilities. At each intake, between 2.9 and 5.1 acres of river area will be temporarily isolated by the cofferdams during the entire construction period, for a total area of about 22.6 acres. Additionally, approximately 4 miles of channel habitat will be permanently converted because of the construction of the intakes. Some riparian trees and shrubs that grow on the levee banks will be lost, slightly reducing instream cover and shade and the contribution of leaves, small debris, and insects falling into the river from overhanging vegetation. However, bank armoring and lack of physical structure currently limit the quality of this kind of habitat. Other conservation measures will include modifications of habitat such as the realignment of Putah Creek (*CM2 Yolo Bypass Fisheries Enhancement*). It will permanently remove existing grassland, managed wetlands, and cultivated lands. Although this habitat modification will be permanent, it is designed to provide better habitat for covered fish species, including herbaceous riparian vegetation in the upstream half of the realignment and freshwater tidal marsh in the downstream half of the realignment. Therefore, the effects on covered fish species of construction activities related to the realignment and construction of other conservation measures are expected to be minor and temporary.

5.3.4 Climate Change Adaptation

The BDCP will have numerous benefits for adapting to ongoing climate change and its effects on the Bay-Delta region (see recent review of projected climate changes by Cloern et al. 2011). Studies suggest that northern California will experience a continuing change from snow to rain in winter, leading to reduced snowpack, earlier snowmelt, and reduced river flows and reservoir storage in summer (Knowles and Cayan 2002; Miller et al. 2003; Mote et al. 2005). Air temperatures will continue to rise, increasing water temperatures and the movements of aquatic species in search of cool water refuges. Accelerated rates of relative sea level rise will increase the intrusion of seawater into the upper estuary (Cayan et al. 2009). Sea level rise combined with an increase in coastal storms, storm surge, and river runoff will increase shoreline flooding and erosion.

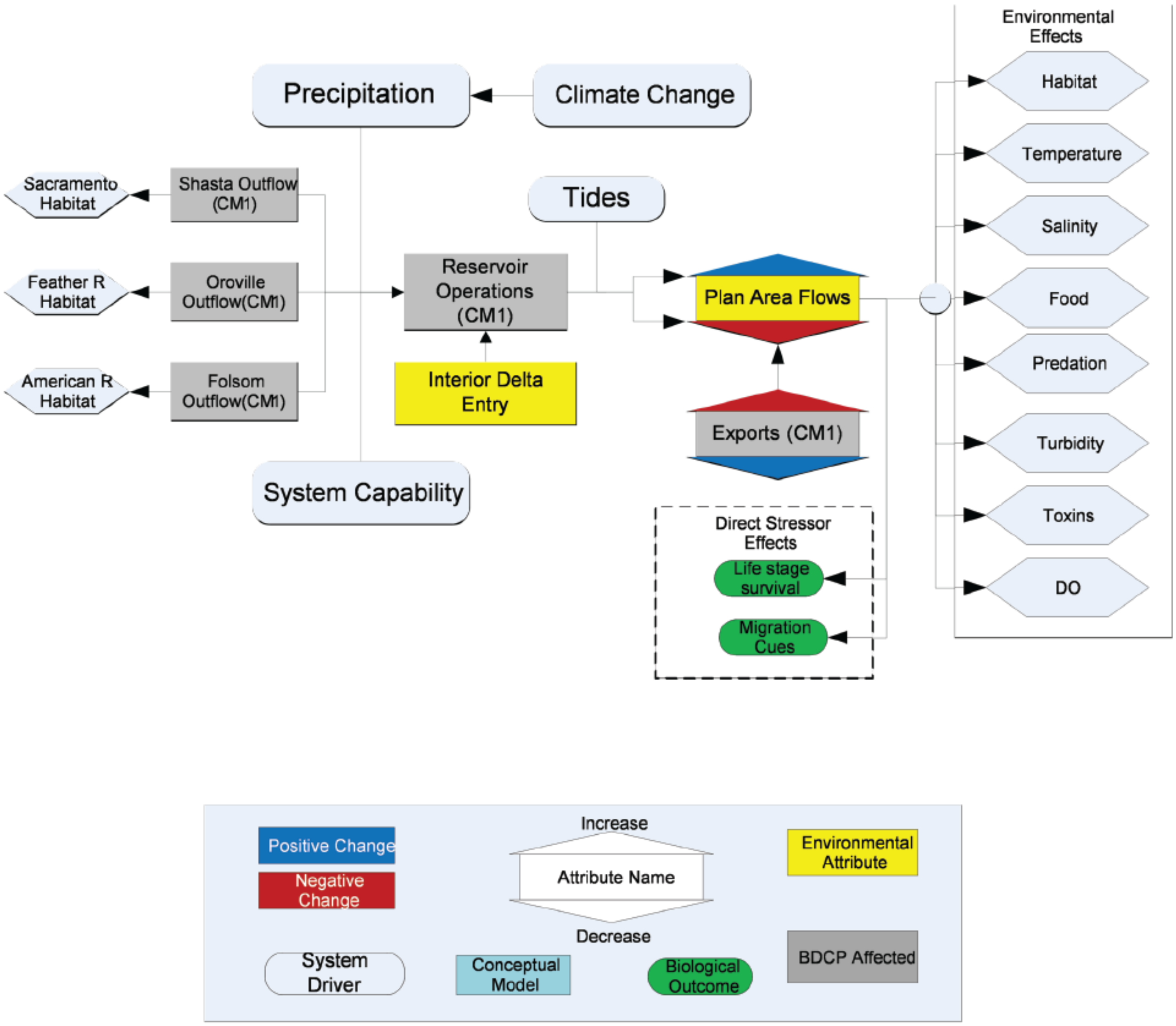
These physical changes are expected to be widespread and long-lasting, even if meaningful reductions in greenhouse gas emissions (i.e., climate change mitigation) are made now. The BDCP will not counter or reverse these physical trends. However, conservation measures will provide numerous benefits to the Bay-Delta ecosystem, natural communities, and covered species that is expected to reduce their vulnerability to the adverse physical and biological effects of climate change. Table 5.3-11 below identifies the expected benefits of the BDCP for climate change adaptation.

Table 5.3-11. Summary of Expected Climate Change Adaptation Benefits of the BDCP

Benefit	Description
Enhanced ecosystem services	Restoration of wetlands, floodplains, and riparian habitats will restore ecosystem services that benefit humans as well as ecosystems, including flood control, water purification, sediment retention, carbon sequestration, and the provision of habitats and biota (Mitsch and Gosselink 2000).
Protection from sea level rise	Increased wetland plant biomass, including belowground production, helps to promote accretion and the ability of the marsh to keep pace with sea level rise (Callaway et al. 2011; Parker et al. 2011). A wider and more extensive marsh plain in tidal wetlands and a wider floodplain in river systems increases protection of upland habitat and human structures from flooding and storm surges, which are predicted to get worse with climate change (Cayan et al. 2009).
Carbon sequestration and climate change mitigation	Marsh grasses, microalgae, and phytoplankton and woody biomass included in riparian restoration remove carbon dioxide from the atmosphere and marsh soils store carbon from marsh organisms, helping to control CO_2 emissions that contribute to climate change (Marsh et al. 2005; Trulio et al. 2007).
Protection of migrating birds	The brackish marshes in the North Bay and Suisun Marsh provide an important resting place for birds along the Pacific Flyway. These birds will experience increasing loss of mudflats used for forage and resting during long-distance migration (Point Reyes Bird Observatory Conservation Science 2011).
Increased upland transition zones	The tidal wetland restoration will have a wide upland transition area, providing refuge for wetland animals during extreme high tides (predicted to increase with climate change) and opportunities for wetland migration upslope in response to sea level rise (Callaway et al. 2011; Parker et al. 2011).
Reduction in risks of levee failure	When wetlands behind levees dry out, the organic matter in the soil oxidizes, which can increase subsidence. This can reduce the stability of levees and increase the risk of levee failure during flooding, resulting in saltwater intrusion into aquifers and farmlands (Mount and Twiss 2005).Restoration will increase inundation and reduce subsidence.
Natural water management	Improved floodplain connections to rivers will restore the ability of floodplains to absorb flood flows and provide a reservoir of water to help aquatic species withstand droughts.
Increased resilience to invasive species	Seasonally inundated floodplains provide more resilience to invasive species by increasing numbers and health of native species and excluding invasive species (Moyle et al. 2007).
Increased habitat variability	Supports species diversity by providing a mosaic of habitats that can be used by different species that have evolved to use specific habitats.
Increased habitat complexity	Wetland restoration will include networks of channels within marshes that are used by fish for foraging, refuge, and movement in and out of the marsh. Currently, such channels are rare (Parker et al. 2011).
Increased habitat patch size and connectivity	Protection and restoration of a variety of natural communities will increase the patch size and connectivity of these habitats. Increasing patch size will tend to increase population sizes of native species, which provides more resiliency against a changing climate. Increasing connectivity allows more genetic exchange among populations and movement to more suitable habitats as environmental conditions change.

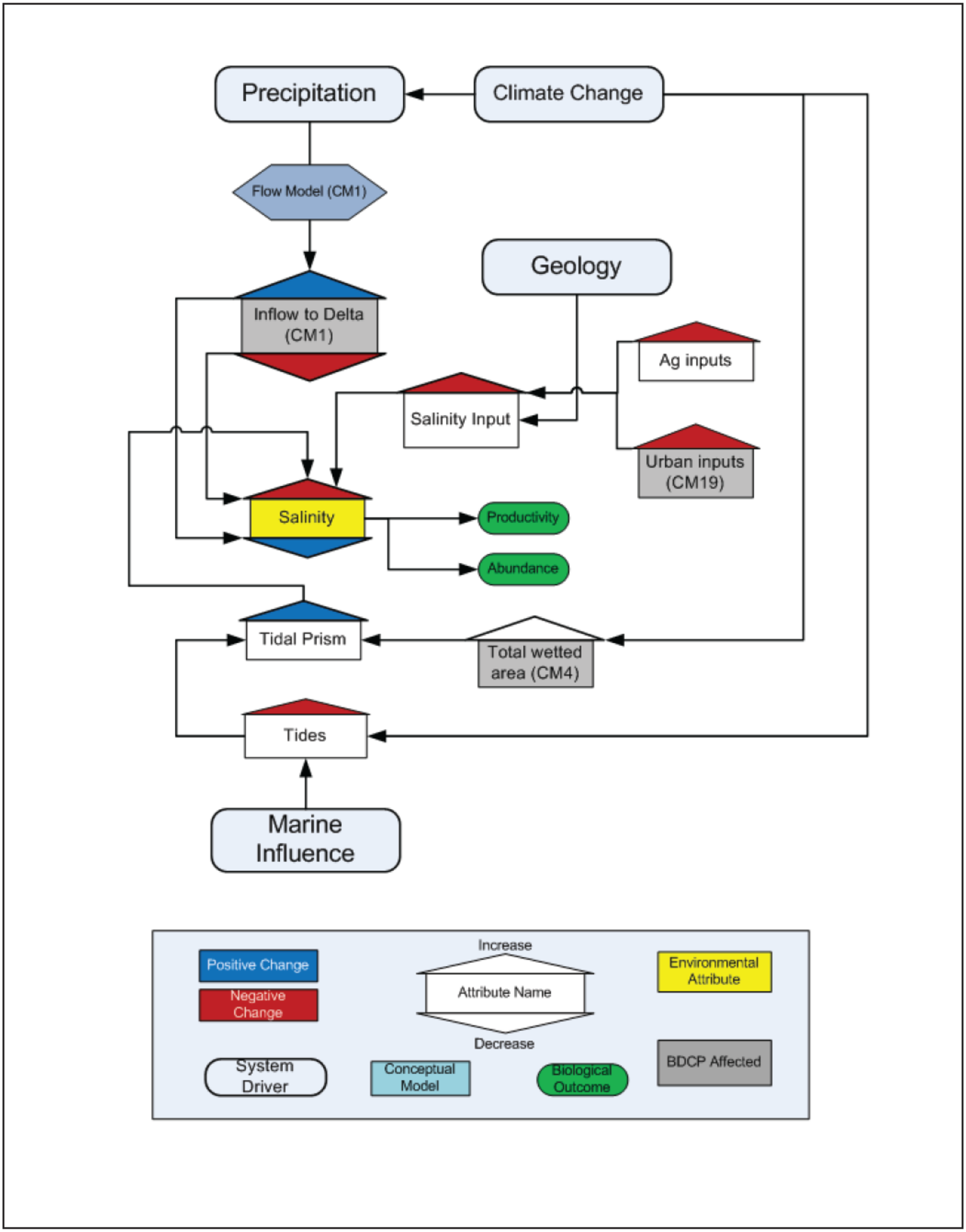
In addition to the benefits described above, reductions in ecosystem stressors to covered species are expected to occur as a result of implementing the BDCP. It is expected that covered species will be better able to adapt to climate change by a reduction in these stressors. Stressors include predation, entrainment, food, and invasive aquatic vegetation (IAV). The conservation strategy is expected to lessen predation associated with the different habitat restoration and enhancement efforts. For example, Moyle et al. (2007) showed that floodplains can be managed to favor native fishes and exclude invasive species. The covered activities are expected to keep entrainment at current low levels and is expected to result in additional food production. Restoration of tidal marsh will help increase phytoplankton and marsh-derived production to enhance primary and secondary food production, which will benefit covered fish species. Chinook salmon fry feed primarily on chironomids, which are associated with emergent marsh vegetation in wetlands in the Plan Area (Simenstad et al. 2000). Tidal marsh sloughs have the highest levels of dissolved organic carbon, particulate organic carbon, and phytoplankton-derived carbon among various Bay-Delta habitats (Jassby and Cloern 2000; Müller-Solger et al. 2002; Sobczak et al. 2002; Sobczak et al. 2005). Finally, the covered activities are expected to reduce IAV. Specifically, *Egeria* and associated nonnative fish (primarily centrarchid species) will be excluded from the habitat restoration and enhancement sites (Nobriga and Feyer 2007). For terrestrial covered species, the adverse effects of fragmentation will be reduced through improved habitat connectivity.

Operational and adaptive management considerations of the covered activities also will support climate change adaptation. These considerations include increased flexibility in water operations to address higher variation in hydrology expected by climate change; monitoring to address data gaps that will address changing conditions and uncertainties associated with climate change; and physical and biological models developed for the covered activities to support adaptive management and shoreline planning.



Graphis/Projects/00343.12 BDCP Chp 5 (02-15-13) SS

Figure 5.3-1
BDCP Conceptual Model for Flow in the Plan Area



Graphis/Projects/00343.12 BDCP Chp 5 (02-15-13) SS

Figure 5.3-2
BDCP Conceptual Model for Salinity in the Plan Area

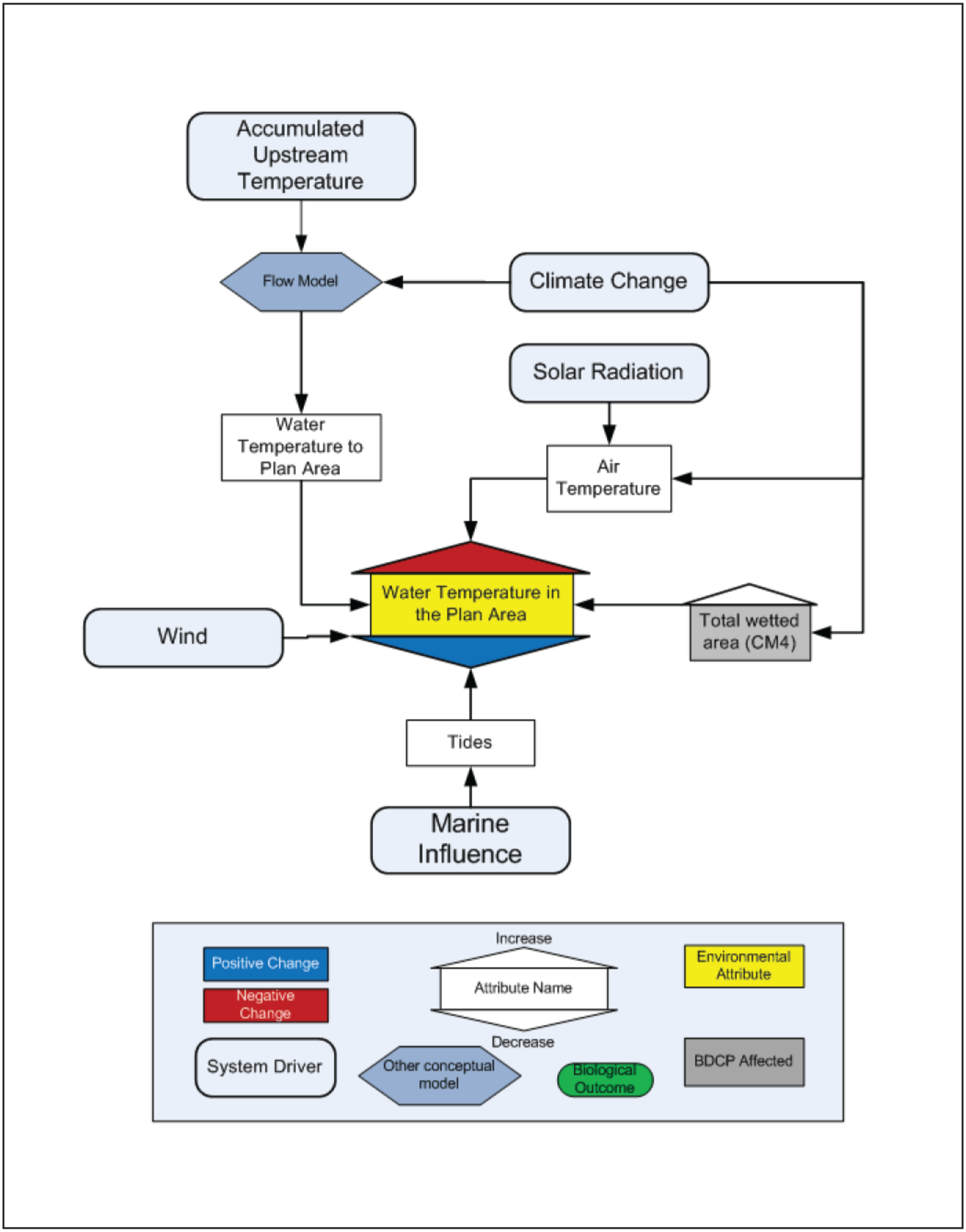


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Figure 5.3-3
BDCP Conceptual Model for Temperature in the Plan Area

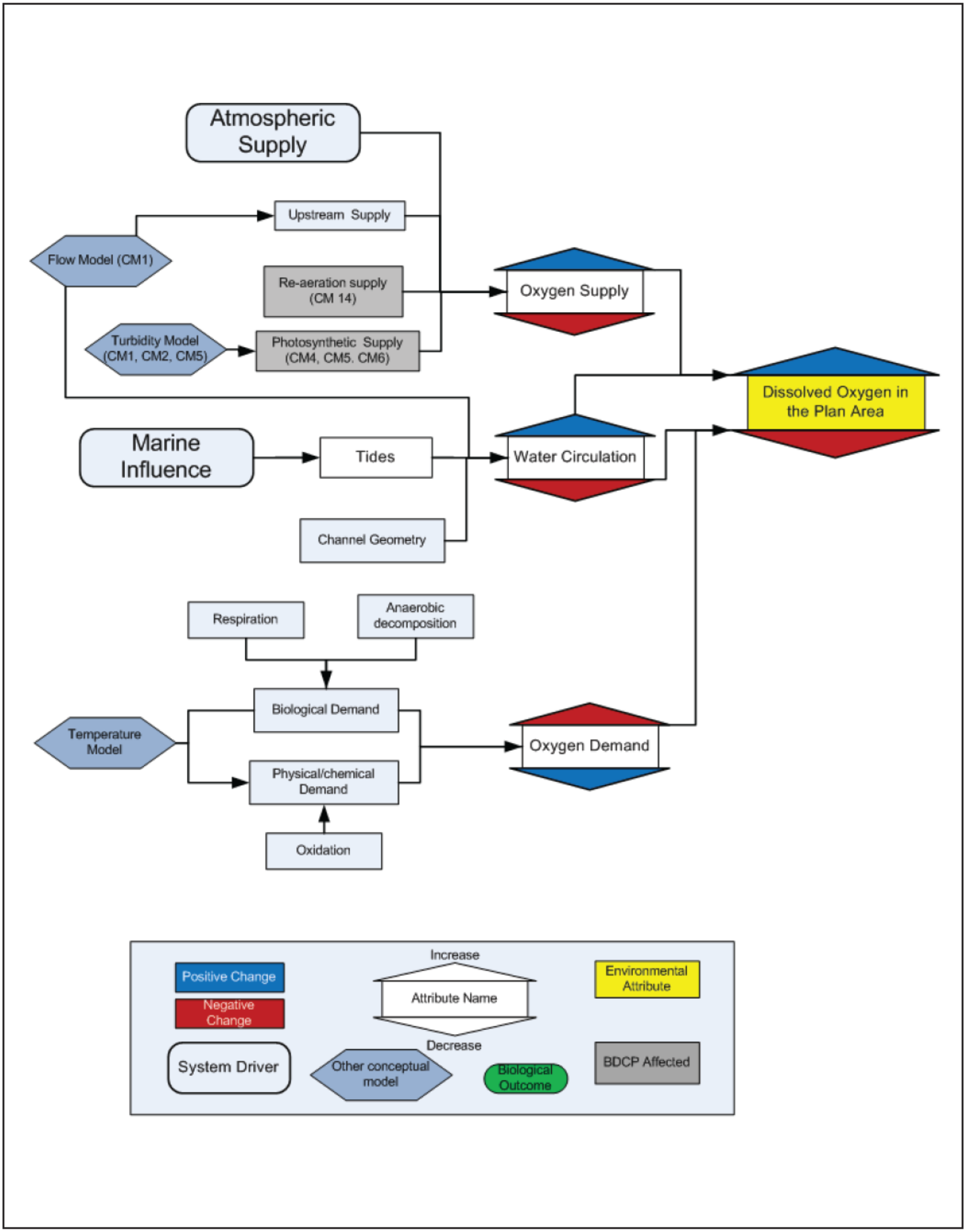

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Figure 5.3-4
BDCP Conceptual Model for Dissolved Oxygen in the Plan Area

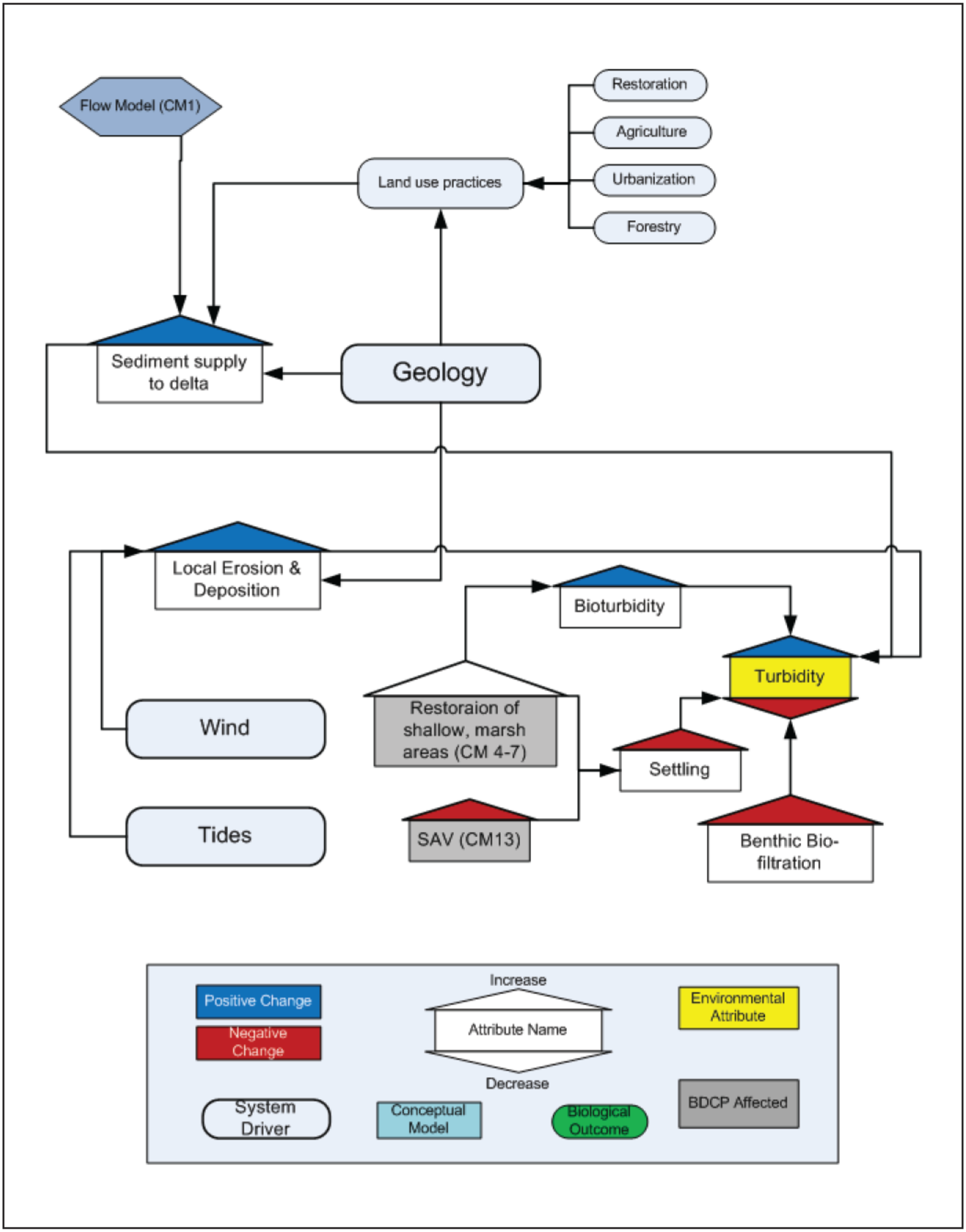

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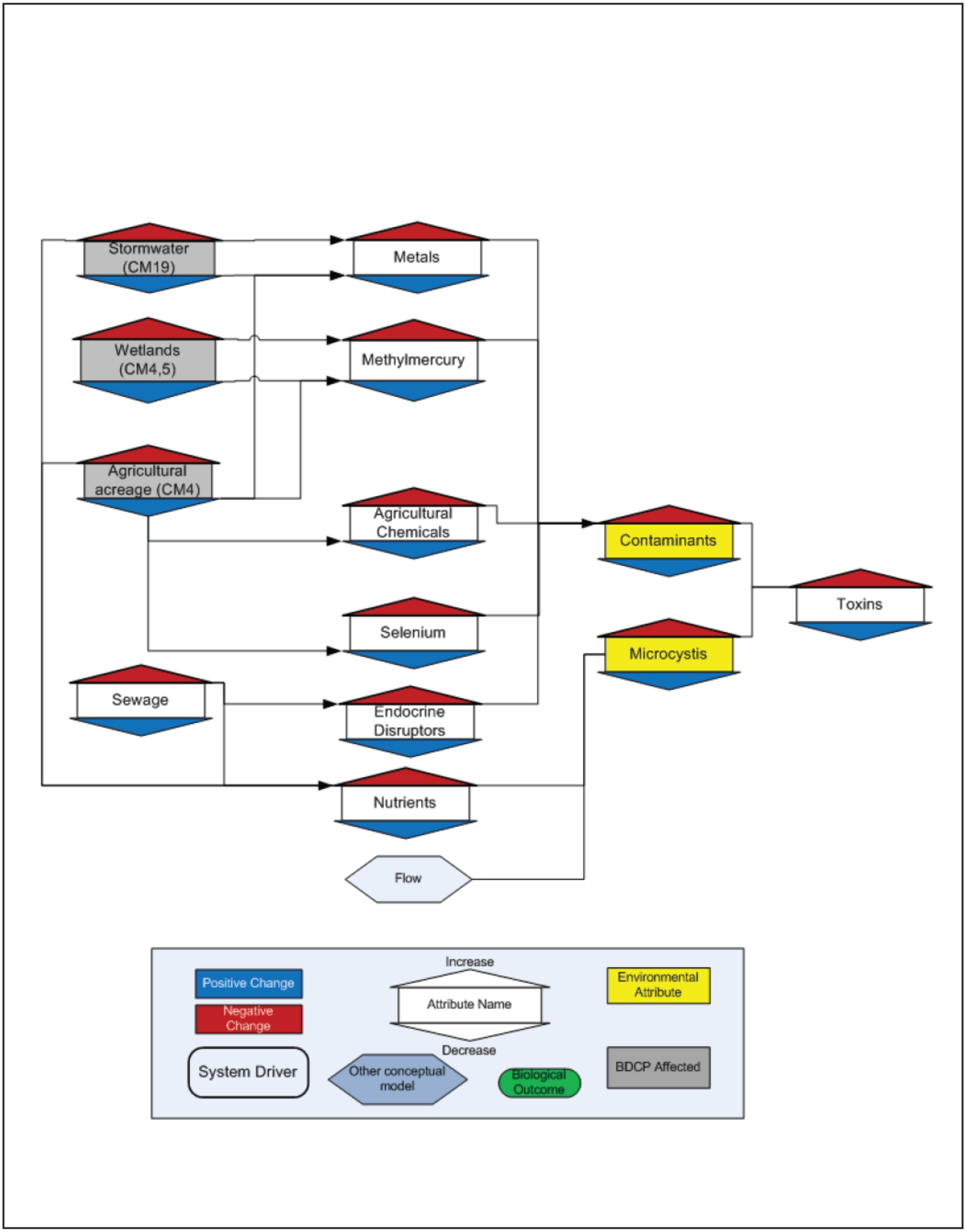
Figure 5.3-5
BDCP Conceptual Model for Sediment and Turbidity in the Plan Area



Graphis/Projects/00343.12 BDCP Chp 5

Figure 5.3-6
BDCP Conceptual Model for Contaminants in the Plan Area

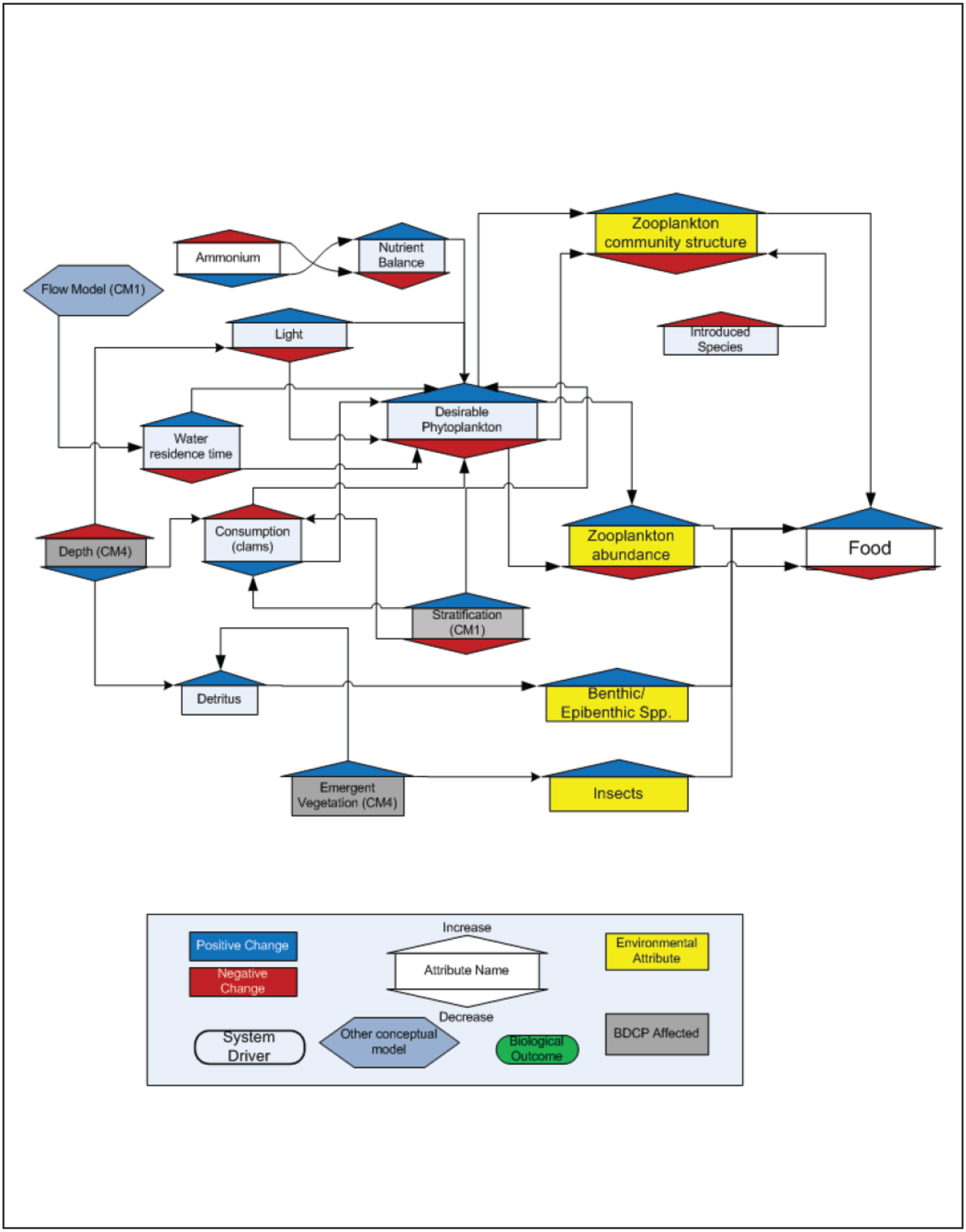


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Figure 5.3-7
BDCP Conceptual Model for Food in the Plan Area

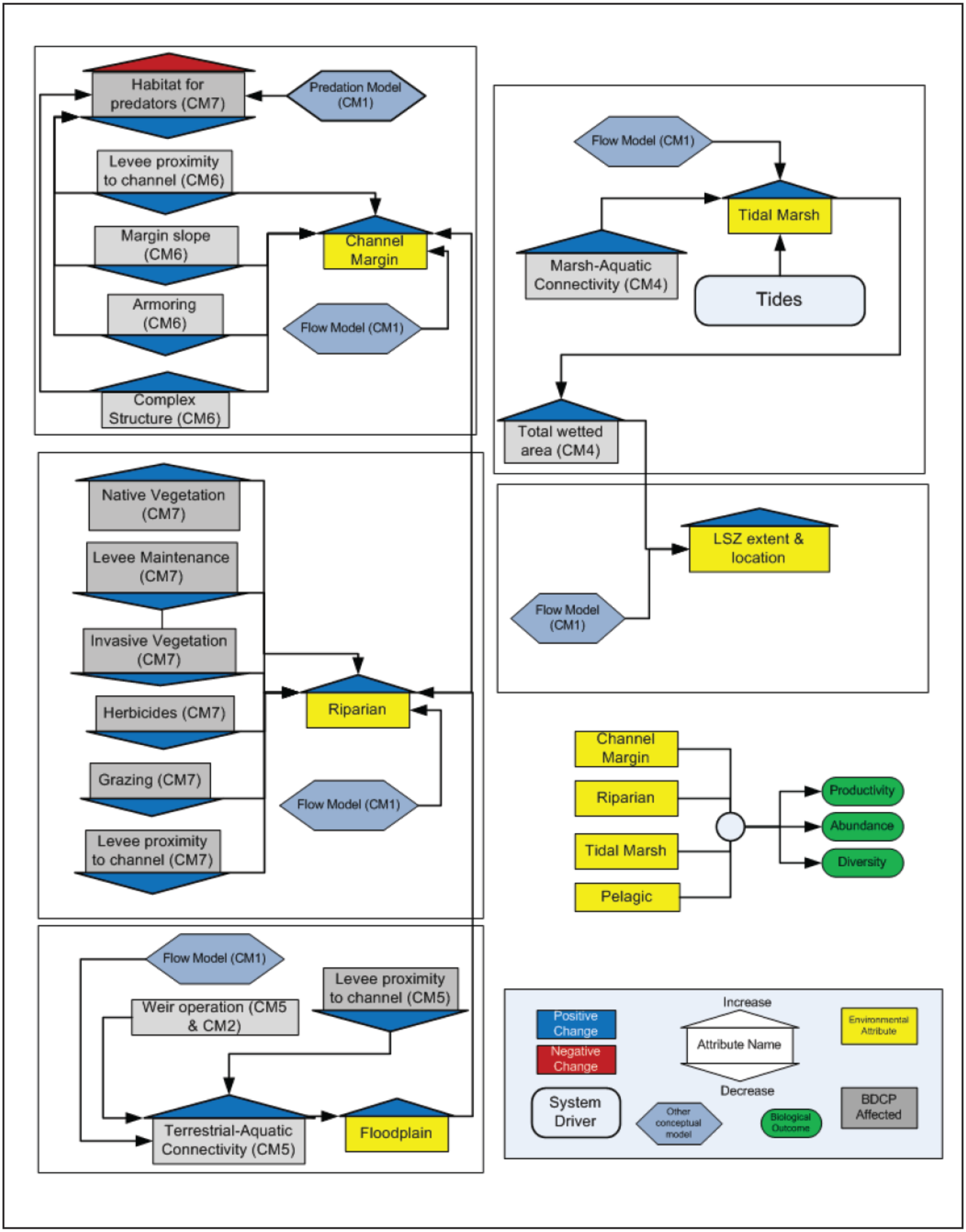

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Figure 5.3-8
BDCP Conceptual Model for Habitat in the Plan Area

5.4 Effects on Natural Communities

This section provides the results of the effects analysis for natural communities. Section 5.2.6, *Effects Analysis for Natural Communities*, described the methods used to conduct this analysis. Table 5.4-1 quantifies the acreage of habitat that will be removed through each covered activity. Table 5.4-2 summarizes the periodic effects on natural communities. Table 5.4-3 summarizes the net effects on each natural community.

5.4.1 Tidal Perennial Aquatic

The tidal perennial aquatic natural community occurs throughout the Plan Area in all conservation zones and consists of open water habitat associated with tidal brackish emergent wetland, tidal freshwater emergent wetland, valley/foothill riparian, and grassland communities. It can occur as large open water bodies such as Suisun Bay, inundated Delta Islands such as Franks Tract and Liberty Island, reservoirs such as Clifton Court Forebay, perennial water courses such as the Sacramento, San Joaquin, and Mokelumne Rivers, and also as smaller open water areas in the many distributaries, sloughs, and channels of the Plan Area.

5.4.1.1 Adverse Effects

5.4.1.1.1 Permanent Loss and Fragmentation

In general, covered activities are not expected to adversely affect tidal perennial aquatic habitat because the ecological functions and biological resource values of tidal perennial aquatic habitat in the Plan Area are expected to benefit from the restoration of large areas of tidal aquatic habitat and the protection, restoration, and management of associated wetland and upland communities.

The Plan Area currently contains approximately, 86,263 acres of tidal perennial aquatic habitat, and an estimated 207 acres will be permanently lost as a result of covered activities.[1] Of these 207 acres, an estimated 178 acres will be lost as a result of water conveyance facility construction (*CM1 Water Facilities and Operation*), an estimated 18 acres from tidal natural communities restoration (*CM4 Tidal Natural Communities Restoration*), an estimated 8 acres from Fremont Weir and Yolo Bypass improvements (*CM2 Yolo Bypass Fisheries Enhancement*), and an estimated 2 acres from levee construction associated with floodplain restoration (*CM5 Seasonally Inundated Floodplain Restoration*) (Table 5.4-1).

Channel margin enhancement could result in filling of small amounts of tidal perennial aquatic habitat along 20 miles of river and sloughs. The extent of this loss cannot be quantified at this time, but the majority of the enhancement activity will occur on tidal perennial aquatic habitat margins, including levees and channel banks. The improvements could occur on sections of the Sacramento, San Joaquin, and Mokelumne Rivers and along Steamboat and Sutter Sloughs.

[1] Habitat or natural community loss acreage estimates are based on hypothetical footprints and models rather than detailed project-level design and represent the maximum allowed under the permit. Actual losses will be tracked through compliance monitoring to ensure that they do not exceed estimates.

5.4.1.1.2 Periodic Inundation

Periodic inundation is not expected to adversely affect the tidal perennial aquatic natural community, because this community is already inundated.

5.4.1.1.3 Construction-Related Effects

Permanent effects of construction are described above in Section 5.4.1.1.1, *Permanent Loss and Fragmentation*. Other construction-related effects on the tidal perennial aquatic natural community include temporary habitat loss as a result of grading and ground disturbance and dredging activities. Construction-related activities will result in temporary loss of an estimated 2,116 acres of tidal perennial aquatic natural community. An estimated 2,101 acres will be temporarily lost as a result of dredging Clifton Court Forebay, as a component of water conveyance facility construction (*CM1 Water Facilities and Operation*); 11 acres as a result of Fremont Weir and Yolo Bypass improvements (*CM2 Yolo Bypass Fisheries Enhancement*); and 5 acres as a result of levee construction for floodplain restoration (*CM5 Seasonally Inundated Floodplain Restoration*).

5.4.1.1.4 Effects of Ongoing Activities

Operation, Maintenance, Enhancement, and Management

Restoration, management, and operation actions associated with covered activities and tidal perennial aquatic habitat that could affect salinity gradients will result in complex interactions inseparable from the effects of water operations (e.g., Sacramento River outflow and changes in the operation of the Suisun Marsh salinity control gates in the fall) and the effects of tidal habitat restoration (reduced tidal prism and compression of tidal range) that make it impossible to completely separate/isolate and discern their independent effects on the tidal perennial aquatic community.

Tidal habitat restoration actions will increase the extent of the area inundated and influenced by tidal action through the breaching of levees and dikes. Such actions will result in the dampening of the tidal prism as the extent of area exposed to tidal influence increases and thus fluctuations in tidal influence may not be as significant as current fluctuations.

Changes in flow, salinity, water temperature, dissolved oxygen, and turbidity are expected to occur in the Plan Area as a result of the BDCP. Additionally, changes in how contaminants that are already present in the Plan Area are mobilized and transported may influence the exposure to and effects of contaminants on covered fish species. As mentioned above, it is difficult to isolate the effects of tidal aquatic habitat restoration and changes in outflow associated with water facilities and operations. Appendix 5.C, *Flow, Passage, Salinity and Turbidity*, provides further discussion and an overview of the effects of the BDCP associated with flow and habitat restoration actions. Appendix 5.D, *Contaminants,* provides further discussion and an overview of how habitat restoration and changes in flow conditions resulting from implementation of the BDCP may in turn affect the mobilization and transport of contaminants and the potential effect on covered species.

In summary, the following effects will occur.

- **Salinity.** Under the covered activities, including ESO scenarios for spring and fall outflow, X2 moves upstream (lower outflow) in some months, depending on water-year type, with the reduced inflows or higher exports that were allowed with the north Delta intake. However, the covered activities will meet the required D-1641 X2 locations from February through June.

- **Water temperature and dissolved oxygen.** Water temperatures and dissolved oxygen in the Delta are primarily affected by atmospheric conditions (air temperature, winds, solar radiation, and climate change). Water temperatures are typically in thermal equilibrium with the atmospheric conditions and therefore are not expected to be influenced strongly by changes in river flows affected by covered activity operations. Similarly, dissolved oxygen concentrations in the river channels and bays are typically in equilibrium with atmospheric conditions, and covered activities are not anticipated to result in biologically significant changes in the Delta. As a result of these factors, covered activities are not expected to result in adverse changes in either water temperatures or dissolved oxygen concentrations in the Delta that will affect the target species.

- **Turbidity.** The analysis focused on whether the different subregions will become erosional, which will increase turbidity, or depositional, which will decrease turbidity. The analysis also evaluated whether seasonal wind resuspension in ROAs is likely to be greater with the BDCP, thereby increasing turbidity. Factors such as submerged aquatic vegetation, benthic filter feeders, organic materials, and the potential substantial effects on the critical shear stress of erosion from changes in benthic algae and macrofauna have not been considered in the present analysis of turbidity because of a lack of data, a lack of modeling tools, or both. These factors likely have relatively significant influence on turbidity levels; thus, the analysis does not quantify effects but provides a relative expectation of whether turbidity will increase or decrease under the BDCP. The Delta will remain regionally depositional in the late long-term time frame, with or without the BDCP, although the location of the depositional regions will differ. The effects of sea level rise will depend on the balance between sediment supply from the watersheds and the rate of sea level rise, so it is unclear whether sediment supply will be sufficient to maintain the current extent of tidal marsh. The initial effect of restoration in the ROAs is to decrease sediment supply downstream, but the long-term effects are uncertain as the ROAs reach a dynamic equilibrium.

- **Contaminants.** Two pathways of effects on contaminants are examined in Appendix 5.D, *Contaminants*, in connection with water operations; an increase in the proportional amount of flow from the San Joaquin River and a reduction in flow in the Sacramento River. The first pathway is the potential for increased loading of selenium from increased contributions of water from the San Joaquin watershed as Sacramento River inputs were diverted by north Delta intakes. Based on the evaluation of current and expected future reductions in selenium from the San Joaquin watershed, and source-water fingerprinting that indicates no increase of San Joaquin water contribution at Suisun Marsh and a only a slight increase in the south Delta, minimal effects on selenium or associated effects on covered fish species are expected.

- **Dilution capacity.** The second issue connected to water operations is the potential for decreased dilution capacity of the Sacramento River, especially for Sacramento Regional Wastewater Treatment Plant effluent, and more specifically for ammonia[2] and pyrethroids. Modeling results presented in Appendix 5.C, *Flow, Passage, Salinity, and Turbidity* indicate that reduced dilution capacity in the Sacramento River at the treatment plant will result from changes in upstream reservoir operations associated with the covered activities, not from diversion of water to the Yolo Bypass or from north Delta intakes located downstream of the treatment plant. Quantitative analysis indicates that the Sacramento River will have sufficient

[2] Ammonia in water generally forms some amount of ammonium. Therefore, the use of the term *ammonia* implies that both ammonia and ammonium may be present.

dilution capacity under the covered activities for both ammonia to avoid exceedance of ambient water quality criteria. Resultant pyrethroid levels are more difficult to estimate, but a simple dilution calculation indicates little difference in dilution under the covered activities.

- **Restoration.** Covered activities will result in some level of mobilization and increased bioavailability of methylmercury, copper, and pesticides (including organophosphate, organochlorine and pyrethroid pesticides). Given current information, it is not possible to estimate the concentrations of these constituents that will become available to covered fish species, but review of the conceptual models for each of these contaminants indicates that the effects should be limited both temporally and spatially. The most problematic of these potential contaminants is methylmercury. *CM12 Methylmercury Management* provides for the site-specific assessment of restoration areas, integration of design measures to minimize methylmercury production, and site monitoring and reporting. The areas with the highest potential for methylmercury generation are the Yolo Bypass, and to a lesser extent, the Mokelumne-Cosumnes River. With the implementation of CM12, effects of methylmercury mobilization on covered fish at the tidal wetland restoration sites are expected to be minimized.

In general, the following conclusions can be drawn regarding contaminants.

- Water operations under the BDCP are expected to have few to no effects on contaminants in the Delta.
- Restoration actions are expected to increase bioavailability of certain contaminants, especially methylmercury, but the overall effects on covered fish species are expected to be localized and of low magnitude.
- Available data suggest that species exposure to contaminants is expected to be below sublethal and lethal levels.
- The long-term benefits of restoration are expected to reduce exposure to existing contaminants in the environment and eliminate sources.

5.4.1.2 Beneficial Effects

While there is no minimum restoration requirement for the tidal perennial aquatic natural community, an estimated approximately 27,000 acres of tidal perennial aquatic natural community will be restored based on tidal restoration modeling (estimated from Table 5, *Tidal Habitat Areas by Time Step and by Region With and Without Project (Acres)*, in Appendix 3.B, by subtracting late long-term acreage without BDCP from late long-term acreage with BDCP). However, the tidal restoration will focus on maximizing restoration of emergent wetland natural communities, and the tidal perennial aquatic natural community will only be restored to the extent necessary as a result of restoring tidal emergent wetlands. Nevertheless, a substantial amount of tidal perennial aquatic natural community is expected to be restored, which would more than offset losses as a result of covered activities. Restoring the tidal perennial aquatic natural community is expected to benefit covered fish species by contributing to an increase in primary productivity, which is essential to maintain a robust food base for covered fish species; an increase in the extent of suitable rearing habitat for juvenile covered fish species, and an increase in the extent of potentially suitable spawning habitat for some covered fish species.

The restoration actions have two principal objectives.

- To increase the amount of available habitat for covered fish species. This objective relates to the direct habitat needs unique to each species and life-history stage.
- To enhance the ecological function of the Delta.

For the expected benefits of restoring tidal perennial aquatic habitat, refer to Chapter 3, Section 3.3.7, *Species Biological Goals and Objectives*, for discussion of the benefits of the restoration of tidal perennial aquatic habitat for each of the covered species (i.e., discussions of the benefits of Objectives TPANC1.1 and TPANC2.1). Further discussion of the effects of restoring tidal perennial aquatic natural community habitats is presented in Appendix 5.E, *Habitat Restoration*.

5.4.1.3 Net Effects

Assuming permanent loss of 207 acres of tidal perennial aquatic natural community and over 27,000 acres of restoration, the BDCP will result in a net increase of 26,793 acres (31%) of tidal perennial aquatic habitat in the Plan Area in Conservation Zones 1, 2, 4, 5, 7, and 11. This will be a substantial increase in the amount of tidal habitat contributing to primary productivity and food resources important to covered fish species. Specific restoration projects have not been designated. However, restoration sites will be designed to support habitat mosaics and an ecological gradient of shallow subtidal aquatic, tidal mudflat, tidal marsh, transitional uplands, and riparian habitats, as well as uplands (e.g., grasslands, cultivated lands) to accommodate anticipated future sea level rise, as appropriate to specific restoration sites.

Although specific locations for restoration actions have not been identified, general areas for expected restoration have been delineated as ROAs. ROAs are areas in BDCP subregions that have been identified as having particularly high potential for restoration. ROAs form the geographic scale of the evaluation of restoration potential that appears in Appendix 5.E, *Habitat Restoration.* Appendix 5.E also provides a brief description of the different ROAs, including location, connectivity to adjacent water bodies, predominant land use and existing vegetation, topographic and bathymetric data, and salinity ranges. Also summarized in Appendix 5.E are the desired post-restoration conditions for each ROA. These postrestoration conditions are expected to produce physical and ecological functions in each ROA.

This substantial increase in tidal perennial aquatic habitat will help to offset the permanent and temporary effects and periodic effects mentioned above, as well as offset the historical loss of such habitat in the Plan Area.

5.4.2 Tidal Mudflat

The tidal mudflat natural community occurs in all conservation zones at the interface of tidal brackish and freshwater emergent wetlands and tidal perennial aquatic communities, and along river channels and slough margins. Tidal mudflat is not mapped in the Plan Area; it occurs in areas of disturbance or sediment deposition associated with various intertidal elevations of tidal brackish and tidal freshwater emergent wetlands, and with the upper elevations of the tidal perennial aquatic natural community. To a lesser degree, it also occupies microhabitats in areas of sediment deposition along natural and artificial levees in the valley/foothill riparian natural community, and seasonal floodplain and channel margin natural communities. Tidal mudflat often shifts in distribution over time and is sustained through disturbances to other nearby communities or through the deposition of mineral soil in the intertidal zone.

5.4.2.1 Adverse Effects

5.4.2.1.1 Permanent Loss and Fragmentation

Because the tidal mudflat natural community is not mapped in the Plan Area, the acreage and distribution of loss cannot be estimated in the same manner it is for other natural communities. Based on modeling efforts conducted by ESAPWA, tidal restoration is not expected to remove existing tidal mudflats in the Plan Area (Appendix 3.B, *BDCP Tidal Habitat Evolution Assessment*). Tidal restoration will result in changes in the tidal range, which may increase the height of the MLLW and reduce the height of the MHHW, narrowing the protective band of tules, bulrushes, and cattails and leading to higher rates of erosion and consequent increases in tidal mudflat natural community. The local persistence of tidal mudflat habitat will then depend on the persistence of the dominant species and the rates of sediment supply, making even qualitative predictions of potential effects on the natural community uncertain.

The removal of levees to restore seasonally inundated floodplains is expected to result in an indeterminate loss of narrow bands of tidal mudflat community that are often present at the interface of the water surface and the levee banks. Construction of low benches and other enhancement features along channel margins is also expected to result in the loss of narrow bands of tidal mudflat habitat that are often present at the interface of the water surface and levee banks.

5.4.2.1.2 Periodic Inundation

The tidal mudflat natural community is not expected to be adversely affected by periodic inundation.

5.4.2.1.3 Construction-Related Effects

Permanent effects of construction are described above in Section 5.4.2.1.1, *Permanent Loss and Fragmentation*. Other construction-related effects on the tidal mudflat natural community include temporary removal and temporary noise, visual, and other construction-related disturbances to wildlife and vegetation. The construction of intake facilities will result in the temporary removal of an indeterminate extent of the tidal mudflat community that occurs as narrow bands along river channel margins. These removed areas of tidal mudflat community are expected to be reestablished through natural processes along the altered channel margins following the completion of intake facility construction. Noise and visual disturbances during the construction and subsequent maintenance of the intake facilities (including human activities at work sites, staging areas, spoils sites, and other work areas along the construction corridor) could temporarily disturb covered and other native wildlife that use the surrounding tidal mudflat community. These effects will be minimized with the implementation of the avoidance and minimization measures described in Appendix 3.C, *Avoidance and Minimization Measures*.

5.4.2.1.4 Effects of Ongoing Activities

Facilities Operation and Maintenance

No adverse effects on the tidal mudflat natural community are expected to result from facilities operation and maintenance.

Natural Communities Enhancement and Management

Activities associated with natural communities enhancement and management in protected areas supporting tidal mudflat natural community, such as ground disturbance to control nonnative vegetation, could result in local, temporary adverse natural community effects. These effects are expected to be minimal, and will be avoided and minimized with implementation of measures described in Appendix 3.C.

Other Indirect Effects

The water salinity effects on the tidal mudflat community cannot be quantified. Increases or decreases in channel water salinity could temporarily increase or reduce local dominance of some species until a new dynamic equilibrium is established, but the potential changes are indeterminate.

5.4.2.2 Beneficial Effects

The restoration of 65,000 acres of tidal natural communities (*CM4 Tidal Natural Communities Restoration*) is expected to benefit tidal mudflat. Tidal restoration along an elevation gradient will result in a range of intertidal zones, within which tidal mudflat is expected to develop between shallow subtidal aquatic (tidal perennial aquatic) areas and emergent marsh plains (tidal and freshwater emergent wetland). At least 20 linear miles of transitional intertidal areas, including tidal mudflat natural community and patches of subtidal and lower marsh, will be restored in the tidal natural communities. Tidal restoration will result in an estimated 932-acre increase in tidal mudflats in the Plan Area (Appendix 3.B, *BDCP Tidal Habitat Evolution Assessment*).

Activities under *CM5 Seasonally Inundated Floodplain Restoration* and *CM6 Channel Margin Enhancement* are expected to promote development of the types of mudflats that occur adjacent to riparian natural communities along channel margins. These mudflats develop as a result of fluvial processes and sediment deposition, and provide substrate that supports covered plant species including delta mudwort, Delta tule pea, Mason's lilaeopsis and Suisun Marsh aster. Furthermore, fluvial processes are instrumental in the production of tidal mudflat through sediment transport to intertidal areas. Nonnative invasive plants can encroach into tidal mudflats and thereby diminish the extent of this natural community. Invasive plants will be managed as needed to protect tidal mudflats (*CM11 Natural Communities Enhancement and Management*).

5.4.2.3 Net Effects

The extent and distribution of tidal mudflat natural community that will be adversely affected by covered activities cannot be determined with existing information, because this natural community was not mapped and it is a dynamic component of tidal and fluvial systems in the Plan Area as microhabitats that shift over time in tidal and riparian natural communities in response to a complexity of environmental variables. However, tidal restoration will result in an estimated net 932-acre increase in this natural community (Appendix 3.B). The BDCP will also benefit the tidal mudflats through floodplain restoration (CM5) and channel margin enhancement (CM6) to provide tidal mudflat for rare plant species along rivers and channels.

5.4.3 Tidal Brackish Emergent Wetland

The extent of this natural community in the Plan Area (8,501 acres) is entirely in Conservation Zone 11 (Suisun Marsh).

5.4.3.1 Adverse Effects

5.4.3.1.1 Permanent Loss and Fragmentation

Covered activities will result in the permanent loss of one acre of the tidal brackish emergent wetland natural community in Suisun Marsh (Conservation Zone 11) (Table 5.4-1). The 1 acre of loss will result from *CM4 Tidal Natural Communities Restoration*.[3]

5.4.3.1.2 Periodic Inundation

Periodic inundation related to Yolo Bypass operations and floodplain restoration will not affect this natural community.

5.4.3.1.3 Construction-Related Effects

Permanent effects of construction are described above in Section 5.4.3.1.1, *Permanent Loss and Fragmentation*. Temporary loss of this natural community during construction will be avoided. Other construction-related effects on the tidal brackish emergent wetland natural community include noise, visual, and direct disturbance of wildlife from construction equipment, and the spread of invasive plants. Construction equipment for tidal habitat restoration could disturb, injure, or kill native wetland wildlife. Noise and visual disturbances during these construction activities could result in temporary disturbances that will affect native wildlife use of tidal brackish marsh habitat. Ground disturbance from construction or maintenance and the transport of construction crews, equipment, and materials could result in the introduction and spread of invasive nonnative plants. These effects will be minimized with the implementation of the avoidance and minimization measures described in Appendix 3.C, *Avoidance and Minimization Measures*.

5.4.3.1.4 Effects of Ongoing Activities

Facilities Operation and Maintenance

Ongoing operation and maintenance activities are not expected to result in adverse effects on tidal brackish emergent wetlands.

Occasional repair of access roads and levees associated with covered activities has the potential to require removal of adjacent vegetation and could entail earth and rock work in the tidal brackish emergent wetland natural community. This activity could lead to increased soil erosion, turbidity, and runoff entering this natural community. The activities will be subject to normal erosion,

[3] Habitat or natural community loss acreage estimates are based on hypothetical footprints and models rather than detailed project-level design and represent the maximum allowed under the permit. Actual losses will be tracked through compliance monitoring to ensure that they do not exceed estimates.

turbidity and runoff control management practices, including those developed as part of *AMM2 Construction Best Management Practices and Monitoring* and *AMM4 Erosion and Sediment Control Plan* (Appendix 3.C, *Avoidance and Minimization Measures*). Any vegetation removal or earthwork adjacent to or within aquatic habitats will require use of sediment and turbidity barriers, soil stabilization, and revegetation of disturbed surfaces. Proper implementation of these measures will avoid permanent adverse effects on this community.

Natural Communities Enhancement and Management

Habitat enhancement and management activities in tidal brackish marsh could result in temporary vegetation changes, but effects on desirable native plants will be minimal as enhancement and management actions will be targeted to control undesirable or nonnative plant species that are limiting the tidal marsh restoration goals. Vegetation management, in the form of physical removal and chemical treatment, will be a periodic activity associated with the long-term maintenance of restoration sites as described in *CM11 Natural Communities Enhancement and Management*. Use of herbicides to control nuisance vegetation could pose a long-term hazard to tidal brackish emergent wetland natural community at or adjacent to treated areas. The hazard could be created by uncontrolled drift of herbicides, uncontrolled runoff of contaminated stormwater onto the natural community, or direct discharge of herbicides to wetland areas being treated for invasive species removal. Implementation of *AMM3 Stormwater Prevention Pollution Plan, AMM5 Spill Prevention, Containment, and Countermeasure Plan, and AMM32 Hazardous Materials Management* (Appendix 3.C) will reduce effects on the tidal brackish emergent wetland natural community from use of various chemicals during maintenance activities, including the use of herbicides. Best management practices (BMPs) (AMM2), including control of drift and runoff from treated areas will, also reduce effects on the tidal brackish emergent wetland natural community where they occur adjacent to levees associated with tidal wetland restoration activities.

5.4.3.1.5 Other Indirect Effects

Invasive Plants

Ground disturbance associated with tidal restoration will increase opportunities for colonization for invasive species such as nonnative cordgrass (*Spartina alterniflora*), which could exclude establishment of native tidal brackish emergent wetland species.

Methylmercury

Increased methylmercury associated with tidal brackish emergent wetland restoration may indirectly affect native species that inhabit the tidal brackish emergent wetland natural community (Appendix 5.D, *Contaminants*). Tidal marsh restoration has the potential to increase exposure to methylmercury. Mercury is transformed into the more bioavailable form of methylmercury in aquatic systems, especially areas subjected to regular wetting and drying such as tidal marshes. Thus, restoration activities that create newly inundated areas could increase bioavailability of mercury (see Chapter 3, *Conservation Strategy*, for details of restoration). In general, the highest methylation rates are associated with high tidal marshes that experience intermittent wetting and drying and associated anoxic conditions (Alpers et al. 2008). The potential mobilization or creation of methylmercury in the Plan Area varies with site-specific conditions and will need to be assessed at the project level. The Suisun Marsh Plan (Bureau of Reclamation et al. 2010) anticipates that tidal wetlands restored under the plan will generate less methylmercury than the existing managed wetlands. Measures described under *CM12 Methylmercury Management* include provisions for project-specific mercury management plans. Along with minimization and mitigation measures and adaptive management and monitoring, CM12 is expected to reduce the effects of methylmercury on the tidal brackish emergent wetland natural community resulting from the BDCP.

Temperature

Tidal natural communities restoration will potentially affect water temperatures, although this effect has not been quantified. Restoring tidal exchange to broad, shallow areas will subject the water column to temperature influences from the atmosphere that will be based on the timing and duration of the inundation and ambient weather conditions (e.g., air temperature, insolation, and wind mixing effects). The occurrence of extreme high tides at night may contribute to a cooling effect from restored tidal habitats. Effects of tidal habitat restoration on water temperature have not been modeled or predicted in detail but are expected to result in localized changes that could include increased or decreased temperature of water exported to adjacent channels. These changes will affect aquatic life if they occurred at/near critical temperature thresholds for various life stages and/or functions. Temperature effects are expected to be more dramatic for tidal emergent habitats than for subtidal habitats, based on water depths.

Nitrogen Emissions

The tidal brackish emergent wetland natural community is one of five natural communities identified as potentially affected by nitrogen emissions as a result of covered activities (Appendix 5.J, Attachment 5J.A, *Construction-Related Nitrogen Deposition on BDCP Natural Communities*). BDCP construction activities will require the use of cars, trucks, and machinery that release small amounts of atmospheric nitrogen through the combustion and emissions process associated with motorized vehicles. Emissions will be largely limited to the construction phase of development, which is anticipated to last approximately 9 years. Following combustion, reactive nitrogen is blown downwind and deposited on the landscape, where it acts as a fertilizer. This depositional nitrogen can affect biogeochemical processes and species composition in terrestrial ecosystems, most of which are nitrogen limited (Pardo et al. 2011; Bay Area Open Space Council 2011). Nitrogen can be directly absorbed by plant leaves or taken up by roots through the process of dry deposition, the most common form of deposition in the Central Valley. Increased nitrogen favors nonnative annual grasses and other weeds that crowd out native plants, change fire regimes, and displace rare species adapted to low-nitrogen conditions.

Appendix 5.J, Attachment 5J.A, includes an analysis of the potential effects of nitrogen emissions on tidal brackish emergent wetlands in the Plan Area. The analysis concludes that nitrogen emissions from covered activities will not harm the tidal brackish emergent wetland natural community in the Plan Area for the following reasons.

- The covered activities will make a negligible contribution to projected emissions in the region (less than 0.2%).
- The construction activities will be temporary (less than 9 years).
- Most of the tidal brackish emergent wetlands are west of the proposed conveyance facilities and powerlines and are unlikely to experience significant negative effects from temporary, construction-related nitrogen deposition.

Moreover, planned management of the reserve system (*CM11 Natural Communities Enhancement and Management*), which includes invasive vegetation control measures, is expected to minimize the potential adverse effects of nitrogen deposition on protected tidal brackish emergent wetlands in the Plan Area.

5.4.3.2 Beneficial Effects

At least 6,000 acres of tidal brackish emergent wetland community will be restored in Conservation Zone 11 (Objective TBEWNC1.1) under *CM4 Tidal Natural Communities Restoration*. Tidal natural communities restoration will decrease habitat fragmentation by providing additional connectivity between isolated patches of tidal brackish emergent wetland (Objective TBEWNC1.3). Changes in water operations will restore parts of Suisun Marsh to more natural salinity levels and tidal regimes, resulting in changes in plant composition in the natural community, at some locations (e.g., increased saltgrass (*Distichlis spicata*) and pickleweed (*Salicornia pacifica*) where less inundation results in increased salinity). Restored tidal marshes are expected to provide increased phytoplankton production, which will benefit zooplankton such as copepods that are an important prey item for listed fish (e.g., delta smelt, longfin smelt, and splittail), other estuarine fish, and other aquatic organisms. Substrates in restoration areas will provide habitat for macroinvertebrates which will also result in beneficial food web effects. Vegetation in these areas is expected to provide diverse functions including food web/detritus production, refuge and nursery areas for aquatic species, and water quality renovation and nutrient cycling functions.

Tidal brackish emergent wetland will benefit from the BDCP climate change adaptation strategy. Currently unprotected upland areas around the fringe of existing tidal brackish emergent wetland will be protected, to provide opportunities for this community to migrate upslope in response to sea level rise (Objective L1.3).

Much of the tidal brackish emergent wetlands on the upper elevation fringes in Suisun Marsh are susceptible to wave erosion in storms because wave energy hits levees. Restoring a complete marsh plain will help tidal brackish emergent wetland be more resilient to storm events, which are expected to increase in frequency and severity with climate change. The BDCP will provide a large, unfragmented expanse of tidal brackish emergent wetland natural community that will have a diversity of plant species and vegetation structure, as well as topographic heterogeneity (Objective TBEWNC1.4), providing habitat value for covered species and a diversity of native wildlife.

Implementation of *CM11 Natural Communities Enhancement and Management* will limit the risk of spreading invasive species through invasive species control and wetland management and through enhancement activities to support native species. Perennial pepperweed, one of the most serious invasive species in this natural community, will be limited to no more than 10% cover in tidal brackish emergent wetland natural community within the reserve system (Objective TBEWNC2.1).

Habitat value is expected to increase as a result of tidal marsh restoration and changes in salinity levels and tidal regimes from water operations. The potential for any adverse effects of mercury methylation will be minimized with the implementation of methylmercury management avoidance and minimization measures. The Suisun Marsh Plan (Bureau of Reclamation et al. 2010) anticipates that tidal wetlands restored under that plan will generate less methylmercury than the existing managed wetlands. For the BDCP, management measures may result in a 10% reduction in methylmercury production in restoration areas. This value could be substantially higher depending on final determinations of need for fill and/or regrading to achieve targeted elevations in restoration areas. Additionally, long-term monitoring for methylmercury effects will lead to increased understanding of the propensity for methylation to occur in various habitats/substrate types, and the factors affecting transport and bioaccumulation.

The general overall effect of water operations will be a return to more natural salinity and tidal range conditions. However, both the rate of change from current conditions to future conditions and changes in the extent and location of the tidal emergent wetland community are highly uncertain, especially with sea level rise due to climate change.

Restored tidal marsh emergent wetlands will have the following conditions:

- Growth of tules (*Schoenoplectus californicus* and *S. acutus*) and cattails (*Typha*) lining the larger channels with *S. californicus* growing outward into the channels to elevations of 35 centimeters below MLLW.
- Growth of bulrushes (*S. americanus* and *Bolboschoenus maritimus*) from the upper margin of the channel to the marsh plain, as soil conditions become increasingly saline.
- Conversion of tall emergent vegetation to low vegetation consisting initially of saltgrass and then to pickleweed with increases in soil salinity and decreases in inundation duration.

5.4.3.3 Net Effects

Implementation of the BDCP will result in overall benefits for the tidal brackish emergent wetland natural community through restoration of at least 6,000 acres of this community. Covered activities are not expected to permanently remove any tidal brackish marsh habitats (Table 5.4-3). This is because the tidal restoration focuses on converting managed wetlands to tidal marsh.

Following implementation of tidal marsh restoration actions, there will be an increase of 5,999 acres (71%) in the total extent of tidal brackish marsh habitats in the Plan Area, and an increase of 6,000 acres (72%) in the extent of this natural community protected (Table 5.4-3). This change does not include any potential losses that might result from sea level rise. Restored tidal brackish emergent wetland natural community is expected to support higher long-term habitat values for associated covered and other native wildlife species than the managed wetlands where restoration will occur because it will be sustainable, managed, and enhanced and future restoration, and will connect isolated patches of existing tidal brackish marsh habitat in the Plan Area. Restored and existing sites will also function more naturally relative to salinity levels and tidal regimes with changes in water operations. Restored habitat is also expected to reduce contaminants by producing less methylmercury than managed wetlands. Restoration and subsequent management of this community to maintain its ecological functions is expected to benefit aquatic foodweb processes in support of the covered and other native fish species and covered and other native wildlife and plant species dependent on Suisun Marsh tidal habitats.

5.4.4 Tidal Freshwater Emergent Wetland Natural Community

Tidal freshwater emergent natural community is present in all conservation zones in the Plan Area, but is most prominent in the central Delta.

5.4.4.1 Adverse Effects

5.4.4.1.1 Permanent Loss and Fragmentation

Covered activities will result in the permanent loss of up to 14 acres[4] (less than 1%) of the tidal freshwater emergent wetland natural community in the Plan Area (Table 5.4-1). Most (85 %) of this loss will result from construction activities associated with tunnel, pipeline, weir, bypass structure, and levee construction. Most of this loss will occur in small patches in the highest reaches of tidal influence such as in the Cosumnes and Mokelumne River confluences (Conservation Zone 4). Most of the loss from conveyance facility construction will occur along rivers and canals in the central Delta from barge unloading facility construction (Old River on the east side of Woodward Island and Connection Slough at the north end of Bacon Island), and from transmission line construction (San Joaquin River and Potato Slough at the south and north ends of Venice Island, Connection Slough at the north end of Bacon Island, and Railroad Slough at the north end of Woodward Island). An estimated 1 acre of the 14 acres will be lost as reusable tunnel material, which will likely be moved to other sites for use in levee build-up and restoration, and the affected area will likely be restored. While this effect is categorized as permanent, because there is no assurance that the material will eventually be moved, the effect will likely be temporary. Furthermore, the amount of storage area needed for reusable tunnel material is flexible and the footprint used in the effects analysis is based on a worst-case scenario; the actual area to be affected by reusable tunnel material storage will likely be less than the estimated acreage.

5.4.4.1.2 Periodic Inundation

Yolo Bypass Operations

Appendix 5.J, *Effects on Natural Communities, Wildlife, and Plants*, provides the method used to estimate periodic inundation effects in the Yolo Bypass. Based on this method, periodic inundation could affect tidal freshwater emergent wetland community ranging from an estimated 24 acres during a notch flow of 1,000 cfs to an estimated 58 acres during a notch flow of 4,000 cfs (Table 5.4-2). Periodic inundation is not expected to have an adverse effect on the tidal freshwater emergent wetland natural community, as the constituent species are adapted to periodic inundation conditions.

Floodplain Restoration

This activity will result in seasonal periodic inundation of an estimated 3 acres of tidal freshwater emergent wetland natural community. Periodic inundation is not expected to have an adverse effect on the tidal freshwater emergent wetland natural community, as the constituent species are adapted to periodic inundation conditions.

5.4.4.1.3 Construction-Related Effects

Permanent effects of construction are described above in Section 5.4.4.1.1, *Permanent Loss and Fragmentation*. Other construction-related effects on the tidal freshwater emergent wetland natural community include temporary natural community loss; noise, visual, and direct disturbance of

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[4] Habitat or natural community loss acreage estimates are based on hypothetical footprints and models rather than detailed project-level design and represent the maximum allowed under the permit. Actual losses will be tracked through compliance monitoring to ensure that they do not exceed estimates.

wildlife from construction equipment; and spread of invasive plants. Construction activities will result in the temporary loss of 11 acres of tidal freshwater emergent wetland natural community. All areas of vegetation removal associated with construction activities, such as staging areas, temporary roads, and pipeline corridors, will be revegetated to promote restoration of the area with the expectation of recovery to preproject conditions in a few years. Construction equipment for tidal habitat restoration could disturb, injure, or kill native wetland wildlife. Noise and visual disturbances during these construction activities could result in temporary disturbances that will affect native wildlife use of tidal brackish marsh habitat. Ground disturbance from construction or maintenance and the transport of construction crews, equipment, and materials could result in the introduction and spread of invasive nonnative plants. Implementation of AMM1 through AMM5 and AMM10 (Appendix 3.C, *Avoidance and Minimization Measures*) will minimize these effects.

5.4.4.1.4 Effects of Ongoing Activities

Facilities Operation and Maintenance

Occasional repair of access roads, water conveyance facilities, and levees associated with covered has the potential to require temporary removal of adjacent vegetation and could entail earth and rock work in or adjacent to the tidal freshwater emergent wetland natural community. These activities could lead to increased soil erosion, turbidity, and runoff entering the natural community. The activities will be subject to normal erosion, turbidity, and runoff control management practices, including those developed as part of *AMM2 Construction Best Management Practices and Monitoring* and *AMM4 Erosion and Sediment Control Plan* (Appendix 3.C). Any vegetation removal or earthwork adjacent to or within emergent wetland habitats will require use of sediment and turbidity barriers, soil stabilization, and revegetation of disturbed surfaces. Proper implementation of these measures will avoid permanent adverse effects on this community.

Natural Communities Enhancement and Management

Habitat enhancement and management may at times result in the removal of vegetation in this community. Vegetation management, in the form of physical removal and chemical treatment, will be an occasional activity associated with the long-term maintenance of restoration sites as described in *CM11 Natural Communities Enhancement and Management*. Use of herbicides to control invasive vegetation could pose a long-term adverse effect on the tidal freshwater emergent wetland natural community at or adjacent to treated areas. The effect could result from uncontrolled drift of herbicides, uncontrolled runoff of contaminated stormwater onto the natural community, or direct discharge of herbicides to wetland areas being treated for invasive species removal. Implementation of *AMM3 Stormwater Pollution Prevention Plan, AMM5 Spill Prevention, Containment, and Countermeasure Plan, and AMM32 Hazardous Material Management* (Appendix 3.C) will reduce effects on the tidal freshwater emergent wetland natural community from use of various chemicals during maintenance activities, including the use of herbicides. BMPs (AMM2), including control of drift and runoff from treated areas, will also reduce effects on the tidal freshwater emergent wetland natural community where it occurs adjacent to levees associated with tidal wetland restoration activities.

However, because the removal will target plant species considered detrimental to the natural communities health or conservation, the overall effects are not considered adverse.

5.4.4.1.5 Other Indirect Effects

Salinity

Water operations are generally not expected to affect the dominant plant species of this community, with the possible exception of the western Delta where there is a transition from fresh to brackish water. The changed salinity conditions in the western Delta are expected to be small, subtle, and complex, which leads to uncertainty in determining their effects on the tidal freshwater emergent wetland community (Appendix 5.E, *Habitat Restoration*). There is the potential that some tidal freshwater marsh may become brackish. A shift of higher salinity water from Suisun Bay up the Sacramento and San Joaquin Rivers from changes in water operations may reduce the composition of woody species, such as willow, that codominate this community with cattails and tules. These changes may affect covered species that use woody riparian habitat (e.g., riparian passerine birds), but not those that are typically found in emergent wetlands (e.g., the California black rail). The severity and extent of these salinity changes are complicated by anticipated sea level rise and the effects of BDCP tidal restoration over the permit term. These potential changes may result in gradual and small reductions in the acreage and quality of tidal freshwater emergent wetland natural community in the Plan Area. However, the location and magnitude of these changes cannot be predicted at this time. The overall magnitude of the effect on native species is expected to be very low.

Nitrogen Emissions

The tidal freshwater emergent wetland natural community is one of five natural communities identified as potentially affected by nitrogen emissions as a result of covered activities (Appendix 5.J, Attachment 5J.A, *Construction-Related Nitrogen Deposition on BDCP Natural Communities*). BDCP construction activities will require the use of cars, trucks, and machinery that release small amounts of atmospheric nitrogen through the combustion and emissions process associated with motorized vehicles. Emissions will be largely limited to the construction phase of development, which is anticipated to last approximately 9 years. Following combustion, reactive nitrogen is blown downwind and deposited on the landscape, where it acts as a fertilizer. This depositional nitrogen can affect biogeochemical processes and species composition in terrestrial ecosystems, most of which are nitrogen limited (Pardo et al. 2011; Bay Area Open Space Council 2011). Nitrogen can be directly absorbed by plant leaves or taken up by roots through the process of dry deposition, the most common form of deposition in the Central Valley. Increased nitrogen favors nonnative annual grasses and other weeds that crowd out native plants, change fire regimes, and displace rare species adapted to low-nitrogen conditions.

Attachment 5J.A includes an analysis of the potential effects of nitrogen emissions on tidal freshwater emergent wetlands in the Plan Area. The analysis concludes that nitrogen emissions from covered activities will not harm the tidal freshwater emergent wetland natural community in the Plan Area for the following reasons.

- The covered activities will make a negligible contribution to projected emissions in the region (less than 0.2%).
- The construction activities will be temporary (less than 9 years).
- Most of the tidal freshwater emergent wetlands are from 5 to 20 kilometers west of the proposed conveyance facilities and powerlines and are unlikely to experience significant negative effects from temporary, construction-related nitrogen deposition.

Moreover, planned management of the reserve system (*CM11 Natural Communities Enhancement and Management*), which includes invasive vegetation control measures, is expected to minimize the potential adverse effects of nitrogen deposition on protected tidal freshwater emergent wetlands in the Plan Area.

Methylmercury

Increased methylmercury associated with tidal freshwater emergent wetland restoration may indirectly affect native species that inhabit the tidal freshwater emergent wetland natural community (Appendix 5.D, *Contaminants*). Tidal marsh restoration has the potential to increase exposure to methylmercury. Mercury is transformed into the more bioavailable form of methylmercury in aquatic systems, especially areas subjected to regular wetting and drying such as tidal marshes. Thus, restoration activities that create newly inundated areas could increase bioavailability of mercury (see Chapter 3, *Conservation Strategy*, for details of restoration). In general, the highest methylation rates are associated with high tidal marshes that experience intermittent wetting and drying and associated anoxic conditions (Alpers et al. 2008). The potential mobilization or creation of methylmercury in the Plan Area varies with site-specific conditions and will need to be assessed at the project level. Measures described under *CM12 Methylmercury Management* include provisions for project-specific mercury management plans. Along with minimization and mitigation measures and adaptive management and monitoring, CM12 is expected to reduce the effects of methylmercury on the tidal freshwater emergent wetland natural community resulting from the BDCP.

5.4.4.2 Beneficial Effects

The implementation of *CM4 Tidal Natural Communities Restoration* will restore at least 24,000 acres of tidal freshwater emergent wetland community (Objective TFEWNC1.1) in Cache Slough (Conservation Zone 1, 2, and 3), the Cosumnes/Mokelumne (Conservation Zone 4), West Delta (Conservation Zone 5 and 6), and South Delta (Conservation Zone 7) ROAs. Achieving this objective will promote vegetation diversity and structural complexity (as incorporated into the restoration design) in restored tidal freshwater marsh. High plant diversity and vegetation structure creates a variety of ecological niches to support high wildlife diversity. The diversity of plant types in freshwater tidal marshes provides complex structure that supports a greater diversity of animals, especially birds and insects, than in saline marshes (Nobriga 2008). A diversity of marsh vegetation will be restored and sustained to reflect historical species compositions and high structural complexity (Objective TFEWNC2.1). Moreover, topographic heterogeneity will be created in restored tidal freshwater emergent wetlands to provide a variety of inundation characteristics and vegetation composition (Objective TFEWNC2.2).

The 65,000 acres of tidal natural communities and transitional uplands will include sufficient transitional uplands along the fringes of restored tidal freshwater emergent wetlands to accommodate up to 3 feet of sea level rise where possible and allow for the future upslope establishment of the tidal freshwater emergent wetland natural community (Objective L1.7).

Tidal freshwater emergent wetlands will be restored in areas that increase connectivity among conservation lands (Objective TFEWNC1.2). This is expected to further enhance the value of this natural community in the Plan Area. Additionally, reducing the introduction and proliferation of nonnative plant species will benefit native plants and wildlife using the tidal freshwater emergent wetland natural community. The tidal marsh will be monitored and nonnative invasive species will be controlled if they pose a threat to covered species populations or native plant diversity, as described in *CM11 Natural Communities Enhancement and Management*.

5.4.4.3 Net Effects

Implementation of the BDCP will result in an increase of 23,987 acres (271%) (24,000-acre gain versus 13-acre loss) of the tidal freshwater marsh natural community in the Plan Area (Table 5.4-3). This change does not include any potential losses that might result from sea level rise. The restored tidal freshwater emergent wetland community is expected to provide higher habitat value for associated covered and other native plants and wildlife species because it is expected to be much larger in size and provide greater habitat diversity and structural complexity than the existing tidal freshwater emergent wetlands that primarily occur in small and isolated patches of tules. Follow-up enhancement and management measures will help to ensure restoration success over the long term. Tidal restoration will be timed to ensure that it stays ahead of the loss of tidal natural communities (Figure 5.4-1).

5.4.5 Valley/Foothill Riparian

There are 17,644 acres of valley/foothill riparian natural community distributed widely across the Plan Area, in all conservation zones.

5.4.5.1 Adverse Effects

5.4.5.1.1 Permanent Loss and Fragmentation

Covered activities will result in the permanent loss of up to 717 acres[5] of the valley/foothill riparian natural community (4% of this natural community in the Plan Area), including 34 acres from water conveyance facility construction, 89 acres from Fremont Weir/Yolo Bypass improvements, 552 acres from tidal natural communities restoration, and 43 acres from levee construction for floodplain restoration (Table 5.4-1). An estimated 18 of the 34 acres removed through conveyance facility construction will be lost through placement of reusable tunnel material, which will likely be moved to other sites for use in levee build-up and restoration, and the affected area will likely be restored. While this effect is categorized as permanent, because there is no assurance that the material will eventually be moved, the effect will likely be temporary. Furthermore, the amount of storage area needed for reusable tunnel material is flexible and the footprint used in the effects analysis is based on a worst-case scenario; the actual area to be affected by reusable tunnel material storage will likely be less than the estimated acreage. Additionally, AMM6 (Appendix 3.C, *Avoidance and Minimization Measures*) requires that reusable tunnel material be placed in locations that avoid direct loss of valley/foothill riparian natural community. Although the greatest loss (77%) is from tidal natural communities restoration, the estimate of loss resulting from tidal restoration is based on projections of where restoration may occur, and actual loss is expected to be lower because of the ability to select sites that minimize effects on valley/foothill riparian natural community. Actual loss will be tracked through compliance monitoring to ensure that it does not exceed this estimate.

[5] Habitat or natural community loss acreage estimates are based on hypothetical footprints and models rather than detailed project-level design and represent the maximum allowed under the permit. Actual losses will be tracked through compliance monitoring to ensure that they do not exceed estimates.

The valley/foothill riparian natural community that will be removed consists mostly of small, fragmented patches and narrow strips of trees along waterways. These areas are not likely to provide significant, intact wildlife movement corridors and are vulnerable to edge effects such as runoff from adjacent development and agriculture, human disturbance, and encroachment of invasive plants and nonnative predators.

The value of the natural community to be removed was evaluated by categorizing each mapped polygon of riparian vegetation that will be removed, based on the hypothetical footprints, as supporting low, moderate, or high habitat functions for riparian-associated and other native wildlife based on the following criteria.

- Polygon size (size of the patch of riparian vegetation within which loss will occur).
- Type of vegetation (woodland, scrub, or herbaceous).
- Extent and structural qualities of riparian vegetation (dense multistoried vegetation versus a few trees with no understory) within the polygon.
- Hydrology and connectivity (on the banks of an active, unarmored stream or in a floodplain, or an isolated patch with no connection to a channel.
- The ability of the vegetation to rapidly restore (e.g., a site that consists of willow or blackberry scrub can recover quickly compared with a mature woodland, and so it was given a lower rating).

Based on this analysis, over two-thirds of all riparian polygons overlapping with the hypothetical covered activity footprints are smaller than 1 acre (Figure 5.4-2). Out of 361 habitat patches, only 12 (3%) were greater than 10 acres in size. One limitation of this analysis, however, is that patches that consisted of different vegetation alliances but that were connected to each other were counted separately instead of lumped together. Based on the analysis and as shown in Figure 5.4-3, most of the habitat lost is of low and moderate value.

5.4.5.1.2 Periodic Inundation

Yolo Bypass Operations

Appendix 5.J, *Effects on Natural Communities, Wildlife, and Plants*, provides the method used to estimate periodic inundation effects in the Yolo Bypass. Based on this method, periodic inundation could affect valley/foothill riparian natural community ranging from an estimated 51 acres of during a notch flow of 6,000 cfs to an estimated 92 acres during a notch flow of 4,000 cfs (Table 5.4-2). However, BDCP-associated inundation of areas that would not otherwise have been inundated is expected to occur in no more than 30% of all years, because Fremont Weir is expected to overtop the remaining estimated 70% of all years, and during those years notch operations will not typically affect the maximum extent of inundation. In more than half of all years under existing conditions, an area greater than the project-related inundation area already inundates in the bypass. Increased inundation frequencies could potentially promote the germination and establishment of riparian plants, but habitat conditions in the bypass are not expected to change substantially as a result of Yolo Bypass operations and effects on the valley/foothill riparian natural community are expected to be minimal.

Floodplain Restoration

This activity will result in seasonal inundation of an estimated 266 acres of valley/foothill riparian natural community. The restored floodplains will transition from areas that flood frequently (e.g., every 1 to 2 years) to areas that flood infrequently (e.g., every 10 years or more. While frequent flooding in the lower elevation portions of the floodplain may result in scouring of riparian vegetation, this is expected to have a beneficial rather than an adverse effect on the natural community (Section 5.4.5.2, *Beneficial Effects*).

5.4.5.1.3 Construction-Related Effects

Permanent effects of construction are described above in Section 5.4.5.1.1, *Permanent Loss and Fragmentation*. Other construction-related effects on the valley/foothill riparian natural community include temporary natural community loss; noise, visual, and direct disturbance of wildlife from construction equipment; and spread of invasive plants.

Approximately 152 acres of valley/foothill riparian natural community will be temporarily removed as a result of development of water conveyance facilities (30 acres), Yolo Bypass fisheries enhancement construction (88 acres), and construction of setback levees (35 acres). All areas of vegetation removal associated with construction activities, such as staging areas, temporary roads, and pipeline corridors, will be revegetated to promote restoration of the area with the expectation of recovery to preproject conditions. Temporarily affected areas will be restored as riparian habitat within 1 year following the completion of construction activities, but are not expected to mature to preproject conditions for several years or more, depending on the successional stage of the affected area. The time it will take for the restored riparian habitat to develop such that the habitat functions of the affected habitat are replaced may range from 5 years to several decades, depending on the type of affected riparian habitat. Under *AMM18 Swainson's Hawk and White-Tailed Kite*, a program to plant mature trees will be implemented in riparian habitat to offset temporal habitat loss (Appendix 3.C). Revegetation will include the planting of mature trees, including transplanting trees scheduled for removal, and supplemented with additional saplings.

However, most of the affected habitat consists of riparian scrub, and habitat functions for this type of vegetation can typically be replaced in 5 years. Habitat for species that require early- to midsuccessional riparian, such as the yellow-breasted chat and the least Bell's vireo, can be restored within 5 years (Kus 2002).

Construction equipment used for valley/foothill riparian restoration could disturb, injure, or kill native wetland wildlife. Noise and visual disturbances during these construction activities could result in temporary disturbances that will affect native wildlife use of the valley/foothill riparian natural community. Ground disturbance from construction or maintenance and the transport of construction crews, equipment, and materials could result in the introduction and spread of invasive nonnative plants. Implementation of AMM1 through AMM5, AMM10, and AMM11 (Appendix 3.C) will avoid and minimize these effects.

5.4.5.1.4 Effects of Ongoing Activities

Facilities Operation and Maintenance

Operation or construction equipment for water conveyance operation and maintenance (including access roads) or Yolo Bypass fisheries enhancement may injure or kill native riparian wildlife. Noise and visual disturbances during these operation and maintenance activities could result in temporary disturbances that will affect native wildlife use of the valley/foothill riparian community. Ground disturbance from maintenance and the transport of construction crews, equipment, and materials could result in the introduction and spread of invasive nonnative plants. Vegetation management, in the form of physical removal and chemical treatment, will be an ongoing occasional activity associated with the long-term maintenance of water conveyance facilities. Use of herbicides to control nuisance vegetation could have a long-term adverse effect on valley/foothill riparian natural community at or adjacent to treated areas. This effect could result from uncontrolled drift of herbicides, uncontrolled runoff of contaminated stormwater onto the natural community, or direct discharge of herbicides to riparian areas being treated for invasive species removal. Implementation of *AMM3 Stormwater Pollution Prevention Plan, AMM5 Spill Prevention, Containment, and Countermeasure Plan*, and *AMM32 Hazardous Material Management* (Appendix 3.C) will reduce the effects of covered activities and include the commitment to prepare and implement spill prevention, containment, and countermeasure plans and stormwater pollution prevention plans. BMPs (AMM2), including control of drift and runoff from treated areas and application of herbicides approved for use in terrestrial environments, are also expected to reduce the risk of affecting natural communities adjacent to water conveyance features and levees associated with restoration activities.

Long-term operation of the new intakes on the Sacramento River will include periodic dredging of sediments that might accumulate in front of intake screens. The dredging could occur adjacent to the valley/foothill riparian natural community. This activity is not expected to adversely affect riparian plants as long as dredging equipment is kept out of riparian areas and dredge spoil is disposed of outside of riparian corridors. Implementation of AMM1 through AMM4 and AMM10 (Appendix 3.C) will minimize the operations and maintenance effects described above.

The periodic changes in flows in the Sacramento River, Feather River, and American River associated with the increased diversion of Sacramento River flows at north Delta intakes may affect salinity in these rivers and Delta waterways. Increases in salinity are predicted for the west Delta and Suisun Marsh as a result of changed water operations. These salinity changes may change the plant composition of riparian habitats along the lower Sacramento and San Joaquin Rivers and west Delta islands. The severity and extent of these salinity changes are complicated by anticipated sea level rise and the effects of downstream tidal restoration over the permit term. There is the potential that some valley/foothill riparian natural community may be degraded immediately adjacent to river channels. The riparian communities in the west Delta are dominated by willows, cottonwood, and mixed brambles. These potential changes are not expected to result in an appreciable reduction in the acreage and value of valley/foothill riparian natural community in the Plan Area.

Natural Communities Enhancement and Management

Activities associated with implementation of natural communities enhancement and management in the protected valley/foothill riparian natural community, such as ground disturbance to control nonnative vegetation, could result in local, temporary adverse natural community effects. Potential effects of vegetation management are also described under *Facilities Operations and Maintenance*, above. Enhancement and management actions may also include fire management. Enhancement and management effects on this natural community are expected to be minimal, and will be avoided and minimized through implementation of AMM1 through AMM4 and AMM10 (Appendix 3.C).

Recreation

Passive recreation in the from of hiking and wildlife viewing will be allowed in and adjacent to riparian areas in the reserve system, where that recreation is compatible with the biological goals and objectives. Implementation of restrictions on recreational use contained in *CM11 Natural Communities Enhancement and Management* and *AMM37 Recreation* will ensure that recreation-related effects on the riparian natural community are minimal. Use of existing trails and levees will be prioritized over building new trails. Trails through riparian areas will avoid tree removal or substantial pruning to the extent possible. If tree removal is required, unhealthy, exotic tree species or trees unlikely to reach maturity due to site conditions (e.g., being shaded out by larger trees) will be targeted for removal.

5.4.5.1.5 Other Indirect Effects

Water operations will result in salinity changes that could affect the valley/foothill riparian natural community. However, data is lacking on the salinity tolerances of riparian plants. Changes in channel water salinity may cause plant species shifts in the lower Delta, but the effect cannot be predicted even qualitatively due to the inherent variability of the system. Changes in tidal stages that increase MLLW and reduce MHHW may cause a corresponding shift in riparian vegetation, but this potential effect is also difficult to predict. Muted tidal ranges will complicate this scenario by narrowing the protective band of tules, bulrushes, and cattails independent of channel water salinity, leading to higher rates of erosion. Riparian restoration projects will be focused in areas least likely to be adversely affected by salinity changes (e.g., north of the intakes, and in Conservation Zones 7, which has freshwater influence from the San Joaquin River). Salinity effects on restored valley/foothill riparian natural community will be monitored and riparian restoration efforts will be adaptively managed to ensure that restoration targets are met in areas that do not experience stress due to high salinity that might reduce the diversity and habitat functions of the community.

5.4.5.2 Beneficial Effects

The Implementation Office will restore or create 5,000 acres of riparian valley/foothill riparian natural community in Conservation Zones 1, 2, 4, 5, 6, and 7 (*CM7 Riparian Natural Community Restoration*), with at least 3,000 acres occurring on restored seasonally inundated floodplain. The Implementation Office will protect 750 acres of existing valley/foothill riparian natural community (*CM3 Natural Communities Protection and Restoration*) in Conservation Zone 7. Approximately 2,000 acres of riparian restoration will be distributed in tidal and channel margin restoration areas and will occur generally as long narrow strips. The majority of restoration, at least 3,000 acres, will occur in the south Delta seasonal floodplain restoration site in Conservation Zone 7, where the lack of existing constraints allows restoration of larger tracts of riparian natural community. Large tracts of this vegetation are an important component of habitat for covered species such as the yellow-billed cuckoo, which only breed in large patches (minimum 100 acres) of habitat. The establishment of large tracts of riparian community will also establish large core areas that are better buffered from encroachment of humans, invasive plants, and nonnative animals as well as from noise and other disturbances associated with surrounding agricultural and urban land uses. Restoration of riparian community in Conservation Zone 7 will also provide habitat for the riparian brush rabbit and the riparian woodrat, which have a very limited distributions and are restricted only to areas within and adjacent to Conservation Zone 7.

Riparian restoration in the Plan Area will create the potential for many species to recolonize some of their historical range. Several covered species, such as the yellow-billed cuckoo, least Bell's vireo, riparian brush rabbit, side-flowering skullcap, and valley elderberry longhorn beetle are riparian obligates and are found almost exclusively in this natural community. Other species, such as the Swainson's hawk and the white-tailed kite, forage in open country, but nest in tall trees, often in patches of riparian forest. For many of the covered species, as well as numerous other native riparian species, population declines and/or range contractions have been linked to loss of riparian habitat. The restoration or creation of 5,000 acres and protection of 750 existing acres in the Plan Area will be an important step toward the conservation of those species.

The structural heterogeneity of riparian vegetation, including understory (low shrubs), midstory (large shrubs and small trees) and overstory (upper canopy formed from large trees), will be enhanced and maintained. Both early- to midsuccessional and late-successional riparian vegetation will be maintained (*CM7 Riparian Natural Community Restoration* and *CM11 Natural Communities Enhancement and Management*). This will provide habitat requirements for a diversity of wildlife species. Different bird species nest and forage at different vegetation heights, necessitating the presence of multiple vegetation layers. Low shrubs provide cover for many wildlife species, tall trees provide perching opportunities, and canopy cover provides shading. Horizontal overlap among vegetation components and over adjacent riverine channels, freshwater emergent wetlands, and grasslands increases opportunities for insects produced in riparian vegetation to be distributed into channels and other communities to provide food supply for wildlife.

5.4.5.3 Net Effects

Implementation of the BDCP will result in an estimated increase of 4,282 acres (24%) of the valley/foothill riparian natural community in the Plan Area (Table 5.4-3) and an increase of 5,219 acres (95%) of valley/foothill riparian natural community protected in conservation lands.

The valley/foothill riparian natural community that will be removed consists mostly of small, fragmented patches and narrow strips of trees along waterways. These areas are not likely to provide significant, intact wildlife movement corridors and are vulnerable to edge effects such as runoff from adjacent development and agriculture, human disturbance, and encroachment of invasive plants and nonnative predators. The valley/foothill natural community that will be restored will consist of some narrow strips and small patches along channel margins and adjacent to tidally restored areas, but most of the restored natural community and all of the 750 acres of protected natural community will consist of large, interconnected riparian areas that will exhibit structural heterogeneity and will be managed and enhanced to provide high habitat value for covered species and other native riparian species in the Plan Area. As shown on Figure 5.4-3, riparian restoration will stay ahead of riparian loss throughout the permit term.

5.4.6 Nontidal Perennial Aquatic and Nontidal Freshwater Perennial Emergent Wetland Natural Community

5.4.6.1 Adverse Effects

There are 6,874 acres of nontidal perennial aquatic natural community and nontidal perennial emergent wetland natural communities (nontidal marsh) distributed throughout the Plan Area in all conservation zones. These natural communities occur in the Plan Area mostly as small, isolated patches and along drainage and irrigation ditches in a cultivated landscape.

5.4.6.1.1 Permanent Loss and Fragmentation

Covered activities will result in the permanent loss of up to 426 acres[6] of the nontidal marsh (6% of total in Plan Area) (Table 5.4-1). Covered activities resulting in permanent loss of nontidal marsh include conveyance facilities construction (*CM1 Water Facilities and Operation*), Fremont Weir and Yolo Bypass improvements (*CM2 Yolo Bypass Fisheries Enhancement*), tidal natural communities restoration (*CM4 Tidal Natural Communities Restoration*), and floodplain restoration. Most of the permanent loss (68%) will result from tidal natural communities restoration. The nontidal marsh that will be lost is of low value, consisting of small patches and narrow, linear ditches and canals in a cultivated landscape.

5.4.6.1.2 Periodic Inundation

Yolo Bypass Operations

Appendix 5.J, *Effects on Natural Communities, Wildlife, and Plants*, provides the method used to estimate periodic inundation effects in the Yolo Bypass. Based on this method, periodic inundation could affect nontidal perennial freshwater emergent wetland natural community ranging from an estimated 6 acres during notch flows of 1,000 cfs to an estimated 8 acres during notch flows of 6,000(A)[7] and 6,000(B)[8] cfs (Table 5.4-2). Periodic inundation is not expected to affect nontidal perennial aquatic natural community because this community is already flooded. BDCP-associated inundation of the nontidal freshwater emergent wetland natural community that would not otherwise have been inundated is expected to occur in no more than 30% of all years, since Fremont Weir is expected to overtop the remaining estimated 70% of all years, and during those years notch operations will not typically affect the maximum extent of inundation. In more than half of all years under existing conditions, an area greater than the BDCP-related inundation area already inundates in the bypass. Furthermore, the nontidal marsh natural communities are adapted to inundation conditions. Therefore, habitat conditions in the bypass are not expected to change substantially as a result of Yolo Bypass operations and effects on nontidal marsh, if any, are expected to be minimal.

Floodplain Restoration

This activity will result in seasonal inundation of an estimated 8 acres of nontidal marsh. The floodplains will transition from areas that flood frequently (e.g., every 1 to 2 years) to areas that flood infrequently (e.g., every 10 years or more). Nontidal marsh in frequently flooded areas is not expected to be adversely affected, and nontidal marsh in frequently flooded area is expected to be beneficially affected by inundation, as these conditions are expected to promote nontidal marsh germination and growth.

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[6] Habitat or natural community loss acreage estimates are based on hypothetical footprints and models rather than detailed project-level design and represent the maximum allowed under the permit. Actual losses will be tracked through compliance monitoring to ensure that they do not exceed estimates.

[7] Scenario A = 6,000 cfs notch flow, existing flow = 4,037 cfs; and proposed flow = 10,037 cfs

[8] Scenario B = 6,000 cfs notch flow; existing flow = 6,289 cfs; and proposed flow = 12,289 cfs

5.4.6.1.3 Construction-Related Effects

Permanent effects of construction are described above in Section 5.4.6.1.1, *Permanent Loss and Fragmentation*. Other construction-related effects on nontidal marsh include temporary natural community loss; noise, visual, and direct disturbance of wildlife from construction equipment; and spread of invasive plants. These are described below.

Construction of conveyance facilities, Fremont Weir/Yolo Bypass Improvements, and levees for floodplain restoration will result in temporary loss of an estimated 41 acres of nontidal marsh (0.6% of total in Plan Area) natural communities. Temporarily disturbed areas will be restored to preproject conditions within 1 year after construction is completed.

Nontidal marsh could be affected in the vicinity of tidal restoration construction activities. Construction equipment for tidal natural communities restoration could disturb, injure, or kill native wetland wildlife. Noise and visual disturbances during these construction activities could result in temporary disturbances that could affect native wildlife use of nontidal marsh habitat. Ground disturbance from construction or maintenance and the transport of construction crews, equipment, and materials could result in the introduction and spread of invasive nonnative plants. Other effects could include hydrologic alteration, runoff and sedimentation from construction sites, or petroleum and contamination spills. Implementation of AMM1 through AMM4, AMM10, and AMM11 (Appendix 3.C, *Avoidance and Minimization Measures*) will minimize these effects.

5.4.6.1.4 Effects of Ongoing Activities

Operations and Maintenance

Future operations and maintenance activities could result in ongoing temporary periodic noise and visual disturbances that could affect native wildlife use of the surrounding nontidal marsh natural community. In addition, while maintenance activities are not expected to remove nontidal marsh communities, operation of equipment could temporarily disturb small areas of vegetation around maintained structures. Occasional repair of access roads, water conveyance facilities, and levees associated with covered activities has the potential to require removal of adjacent vegetation and may entail earth and rock work in nontidal marsh. This activity could lead to increased soil erosion, turbidity, and runoff entering nontidal marsh. These activities will be subject to normal erosion, turbidity, and runoff control management practices, including those developed as part of *AMM2 Construction Best Management Practices and Monitoring*, *AMM3 Stormwater Pollution and Prevention Plan*, and *AMM4 Erosion and Sediment Control Plan.* Any vegetation removal or earthwork adjacent to or within aquatic areas will require use of sediment and turbidity barriers, soil stabilization, and revegetation of disturbed surfaces. AMM10 requires restoration of temporarily affected natural communities. Proper implementation of these measures will avoid permanent adverse effects on this community. Implementation of AMM1 will also minimize these effects.

Vegetation management, in the form of physical removal and chemical treatment, will be an ongoing occasional activity associated with the long-term maintenance of water conveyance facilities. Use of herbicides to control nuisance vegetation could have a long-term adverse effect on nontidal marsh at or adjacent to treated areas. This effect could result from uncontrolled drift of herbicides, uncontrolled runoff of contaminated stormwater onto the natural community, or direct discharge of herbicides to nontidal marsh being treated for invasive species removal. Implementation of *AMM3 Stormwater Pollution Prevention Plan, AMM5 Spill Prevention, Containment, and Countermeasure Plan*, and *AMM32 Hazardous Material Management* will reduce the effects of covered activities on nontidal marsh and include the commitment to prepare and implement spill prevention, containment, and countermeasure plans and stormwater pollution prevention plans. BMPs (AMM2), including control of drift and runoff from treated areas and application of herbicides approved for use in terrestrial environments, are also expected to reduce the risk of affecting natural communities adjacent to water conveyance features and levees associated with restoration activities.

Long-term operation of the new intakes on the Sacramento River will include periodic dredging of sediments that might accumulate in front of intake screens. The dredging could occur in or adjacent to nontidal marsh. This activity is not expected to adversely affect nontidal marsh as long as dredging equipment is kept out of nontidal marsh areas and dredge spoil is disposed of outside of nontidal marsh areas.

Management and Enhancement

Activities associated with implementation of natural communities enhancement and management within the protected and enhanced nontidal perennial aquatic and nontidal freshwater perennial emergent natural communities, such as ground disturbance to control nonnative vegetation, could result in local, temporary adverse natural community effects. Actions will include control of invasive nonnative plant and animal species, fire management, and restrictions on vector control and application of herbicides. Vegetation management may occur in and adjacent to nontidal marsh in the reserve system; effects of this activity are similar to those described under *Operations and Maintenance*, above. These effects are expected to be minimal, and will be avoided and minimized through implementation of AMM1 through AMM4 and AMM10 (Appendix 3.C).

5.4.6.2 Beneficial Effects

BDCP implementation will result in the restoration of 1,200 acres of nontidal marsh. The restoration will occur in blocks that will be contiguous with the larger reserve system. The nontidal marsh will be restored in the vicinity of giant garter snake subpopulations identified in the recovery plan for this species (U.S. Fish and Wildlife Service 1998): one in Conservation Zone 2 in the vicinity of the Yolo Bypass/Willow Slough population and one in Conservation Zone 4 or 5 in the vicinity of the Coldani Marsh/White Slough population. The restored nontidal marsh will be managed to maintain native biodiversity and to sustain giant garter snake and western pond turtle populations.

5.4.6.3 Net Effects

Implementation of the BDCP will result in an estimated increase of 774 acres (9%) of nontidal marsh in the Plan Area (Table 5.4-3). The natural communities to be lost consist of small, fragmented patches and linear canals and ditches in a cultivated landscape. The restored natural communities will consist of relatively large, unfragmented patches that will be located in areas most beneficial to giant garter snake and will be managed to support western pond turtle and to sustain native biodiversity. The BDCP will result in a net benefit to this natural community. Nontidal marsh restoration will be timed to ensure that it stays ahead of the loss of nontidal aquatic and wetland natural communities (Figure 5.4-4).

5.4.7 Alkali Seasonal Wetland

There are 3,723 acres of alkali seasonal wetland complex natural community scattered throughout the Plan Area in all conservation zones except Conservation Zone 3. Most (74%) of the alkali seasonal wetland complex consists of relatively large patches in Conservation Zone 2, on Type 1 conservation lands[9] on and near Tule Ranch. The remainder consists of small patches in a matrix of grassland and vernal pool complex natural communities. Factors considered in assessing the value of alkali seasonal wetland natural community, to the extent that information is available, include patch size, connectivity with other natural communities, proximity to existing conservation lands (Types 1 and 2), and presence of covered species occurrences in the vicinity.

5.4.7.1 Adverse Effects

5.4.7.1.1 Permanent Loss and Fragmentation

Covered activities will result in the permanent loss of up to 72 acres[10] of the alkali seasonal wetlands natural community (2% of this community in the Plan Area), including 45 acres from Fremont Weir/Yolo Bypass improvements (*CM2 Yolo Bypass Fisheries Enhancement*), and 27 acres from tidal natural communities restoration (*CM4 Tidal Natural Communities Restoration*) (Table 5.4-2).

Based on the hypothetical restoration footprint, tidal restoration will convert an estimated 27 acres of this community to tidal natural communities in Conservation Zone 1, in the Cache Slough ROA, where this natural community occurs in a transitional area between tidal freshwater emergent wetlands in Lindsey Slough and adjacent grasslands and vernal pool complex. The alkali seasonal wetland complex that will be removed is considered of moderate to high value: although it is present in small patches and consists of the more common, saltgrass dominated alkali seasonal wetland rather than the less common woody iodine bush scrub type, it occurs in a matrix of other natural community types, is in and near Type 1 conservation lands, and is contiguous with high-value grasslands and vernal pool complex with many covered species occurrences in the Jepson Prairie area. Tidal restoration will not result in fragmentation of this natural community because the affected areas are on the edges of alkali seasonal wetland complex in Conservation Zone 1.

Fremont Weir/Yolo Bypass improvements will remove 45 acres of alkali seasonal wetland natural community in Conservation Zone 2, as a result of Putah Creek realignment. The alkali seasonal wetland complex that will be removed is considered of moderate to high value: although it consists of the more common saltgrass-dominated alkali seasonal wetland rather than the less common woody iodine bush-scrub type and there are few covered species occurrences in the vicinity, it is part of a relatively large, contiguous patch of alkali seasonal wetland and is in Type 1 conservation lands. Putah Creek realignment will not result in fragmentation of this natural community because the affected areas are on the edges of alkali seasonal wetland complex in this area.

[9] See Section 3.2.4.2.2, *Conservation Lands*, for definitions of conservation land types.

[10] Habitat or natural community loss acreage estimates are based on hypothetical footprints and models rather than detailed project-level design and represent the maximum allowed under the permit. Actual losses will be tracked through compliance monitoring to ensure that they do not exceed estimates.

5.4.7.1.2 Periodic Inundation

The only covered activity that will result in periodic inundation of alkali seasonal wetlands is Yolo Bypass operation.

Yolo Bypass Operations

Appendix 5.J, *Effects on Natural Communities, Wildlife, and Plants*, provides the method used to estimate periodic inundation effects in the Yolo Bypass. Based on this method, periodic inundation could affect alkali seasonal wetland complex natural community ranging from an estimated 264 acres of during a notch flow of 1,000 cfs to an estimated 744 acres during a notch flow of 4,000 cfs (Table 5.4-2). The alkali seasonal wetland complex that will be inundated is considered of moderate to high value: although it consists of the more common, saltgrass-dominated alkali seasonal wetland rather than the less common woody iodine bush-scrub type and there are few covered species occurrences in the vicinity, it is part of a relatively large, contiguous patch of alkali seasonal wetland and is in Type 1 conservation lands. This natural community is adapted to seasonal inundation and adverse effects from inundation are expected to be minimal, if any: plant composition may shift if the duration of inundation is increased, but not to the extent that it is expected to convert to a different natural community type. Furthermore, BDCP-associated inundation of areas that would not otherwise have been inundated is expected to occur in no more than 30% of all years, since Fremont Weir is expected to overtop the remaining estimated 70% of all years, and during those years notch operations will not typically affect the maximum extent of inundation. In more than half of all years under existing conditions, an area greater than the BDCP-related inundation area already inundates in the bypass. Therefore, habitat conditions in the bypass are not expected to change substantially as a result of Yolo Bypass operations and effects on alkali seasonal wetlands, if any, are expected to be minimal.

5.4.7.1.3 Construction-Related Effects

Permanent effects of construction are described above in Section 5.4.7.1.1, *Permanent Loss and Fragmentation*. Other construction-related effects on the alkali seasonal wetland natural community include temporary natural community loss; noise, visual, and direct disturbance of wildlife from construction equipment; and spread of invasive plants. These are described below.

Construction-related activity will not result in temporary loss of alkali seasonal wetland complex natural community. Although the transmission line footprint crosses alkali seasonal wetland complex, the line will be above ground, and *AMM30 Transmission Line Siting and Design* requires that the final alignment be designed to avoid any temporary loss of alkali seasonal wetlands. Alkali seasonal wetland complex could also be affected in the vicinity of Putah Creek realignment. These effects could include hydrologic alteration, runoff and sedimentation from construction sites, or petroleum and contamination spills. Implementation of AMM1 through AMM4 (Appendix 3.C, *Avoidance and Minimization Measures*) will avoid these impacts.

5.4.7.1.4 Effects of Ongoing Activities

Operations and Maintenance

Future operations and maintenance activities could result in ongoing temporary periodic noise and visual disturbances that could affect native wildlife use of adjacent alkali seasonal wetland natural community. These indirect effects would be limited to locations where alkali seasonal wetlands are in close proximity to the SWP or CVP facilities such as adjacent to Clifton Court Forebay or the intakes to the south Delta pumps. In addition, while maintenance activities are not expected to remove alkali seasonal wetland natural communities, operation of equipment could temporarily disturb small areas of vegetation around maintained structures. Occasional repair of access roads, water conveyance facilities, and levees associated with covered activities has the potential to require removal of adjacent vegetation and may entail earth and rock work in the vicinity of the alkali seasonal wetland complex natural community. These activities could lead to increased soil erosion and runoff entering the alkali seasonal wetland natural community. The activities will be subject to normal erosion and runoff control management practices, including those developed as part of *AMM2 Construction Best Management Practices and Monitoring*, *AMM3 Stormwater Pollution and Prevention Plan*, and *AMM4 Erosion and Sediment Control Plan.* AMM10 requires restoration of temporarily affected natural communities. Proper implementation of these measures will avoid permanent adverse effects on this community. These effects are expected to be minimal, and will be avoided and minimized with implementation of the AMMs described above and *AMM1 Worker Awareness Training* (Appendix 3.C).

Vegetation management, in the form of physical removal and chemical treatment, will be an occasional ongoing activity associated with the long-term maintenance of water conveyance facilities and associated transmission lines, although the transmission lines to be constructed in the vicinity of alkali seasonal wetlands are temporary and will be removed when construction is completed. Use of herbicides to control nuisance vegetation could pose a long-term hazard to the alkali seasonal wetland natural community at or adjacent to treated areas. The hazard could be created by uncontrolled drift of herbicides, uncontrolled runoff of contaminated stormwater onto the natural community, or direct discharge of herbicides to alkali seasonal wetland complex being treated for invasive species removal. *AMM5 Spill Prevention, Containment, and Countermeasure Plan* will reduce effects on this natural community that could result from use of various chemicals during maintenance activities, including the use of herbicides. BMPs (AMM2), including control of drift and runoff from treated areas and application of herbicides approved for use in aquatic environments, will also reduce the risk of affecting natural communities adjacent to water conveyance features and levees associated with restoration activities.

Management and Enhancement

Activities associated with implementation of natural communities enhancement and management within the protected and enhanced alkali seasonal wetland natural community, such as ground disturbance to control invasive vegetation, could result in local, temporary adverse natural community effects. Actions will include control of invasive nonnative plant and animal species, fire management, and restrictions on vector control and application of herbicides. Vegetation management may occur in and adjacent to alkali seasonal wetlands in the reserve system. Effects of this activity are similar to those described under *Operations and Maintenance*, above. These effects are expected to be minimal, and will be avoided and minimized with implementation of AMM1 through AMM4 and AMM10 (Appendix 3.C).

Recreation

Passive recreation in the from of hiking and wildlife viewing may be allowed in and adjacent to alkali seasonal wetland complexes in the reserve system, where that recreation is compatible with the biological goals and objectives. Implementation of the restrictions on recreational use described in *CM11 Natural Communities Enhancement and Management* and *AMM37 Recreation* will ensure that recreation-related effects on the alkali seasonal wetland complex natural community are minimal. Recreational trails will be limited to existing trails and roads. New trail construction is prohibited within the alkali seasonal wetland complex reserves. Recreation within the alkali seasonal wetland complex reserves will be limited to docent-led wildlife and botanical tours.

5.4.7.1.5 Other Indirect Effects

Nitrogen Emissions

The alkali seasonal wetland natural community is one of five natural communities identified as potentially affected by nitrogen emissions as a result of covered activities (Appendix 5.J, Attachment 5J.A, *Construction-Related Nitrogen Deposition on BDCP Natural Communities*). BDCP construction activities will require the use of cars, trucks, and machinery that release small amounts of atmospheric nitrogen through the combustion and emissions process associated with motorized vehicles. Emissions will be largely limited to the construction phase of development, which is anticipated to last approximately 9 years. Following combustion, reactive nitrogen is blown downwind and deposited on the landscape, where it acts as a fertilizer. This depositional nitrogen can affect biogeochemical processes and species composition in terrestrial ecosystems, most of which are nitrogen limited (Pardo et al. 2011; Bay Area Open Space Council 2011). Nitrogen can be directly absorbed by plant leaves or taken up by roots through the process of dry deposition, the most common form of deposition in the Central Valley. Increased nitrogen favors nonnative annual grasses and other weeds that crowd out native plants, change fire regimes, and displace rare species adapted to low-nitrogen conditions.

Alkali seasonal wetland complexes occur in the vicinity of proposed construction of conveyance facilities in Conservation Zone 8. Based on proximity to the facilities, this area could be affected by the temporary increases in nitrogen deposition associated with conveyance construction. However, weed control and targeted grazing on protected lands are anticipated to control invasive plants, which might proliferate in an ungrazed system.

Attachment 5J.A*,* includes a detailed analysis of the potential effects of nitrogen emissions on alkali seasonal wetland complexes in the Plan Area. The analysis concludes that nitrogen emissions from covered activities will not harm the alkali seasonal wetland complex natural community in the Plan Area for the following reasons.

- The covered activities will make a negligible contribution to projected emissions in the region (less than 0.2%).
- The construction activities will be temporary (less than 9 years).
- Nitrogen emissions will be transported away from most of the alkali seasonal wetland complex natural community in the Plan Area because of prevailing wind conditions.

Moreover, planned management of the BDCP reserve system (*CM11 Natural Communities Enhancement and Management*), which includes invasive vegetation control measures, is expected to minimize the potential adverse effects of nitrogen deposition on protected alkali seasonal wetland complexes in the Plan Area.

5.4.7.2 Beneficial Effects

With implementation of the BDCP, 150 acres of alkali seasonal wetland will be protected in Conservation Zones 1, 8, or 11, in a mosaic of protected grasslands and vernal pool complex (*CM3 Natural Communities Protection and Restoration*). This will protect currently unprotected high-value alkali seasonal wetland complex in the Plan Area. Alkali seasonal wetlands in Conservation Zones 1, 8, and 11 occur in a matrix of grasslands and vernal pool complex in a large, unfragmented natural landscape supporting a diversity of native plant and wildlife species. Protection of alkali seasonal wetland complex in Conservation Zone 8 provides the only opportunity in the Plan Area to protect the rarer woody iodine bush scrub type alkali seasonal wetland natural community. Protected alkali seasonal wetland complex will be managed and enhanced to maintain appropriate seasonal inundation with overland flow and some ephemeral ponding: conditions necessary to sustain native species adapted to seasonally wet conditions in alkaline soils (*CM11 Natural Communities Enhancement and Management*). The protected alkali seasonal wetlands will also be managed and enhanced to increase the cover of native alkali seasonal wetland plants relative to invasive nonnative species, to minimize competition posed by invasive plants to native plant species, and improve overall habitat suitability for native wildlife, through activities such as control of invasive plants and fencing alkali seasonal wetland areas to protect them from adverse effects of grazing livestock (CM11). Additionally, loss of alkali seasonal wetland will be offset through restoration to achieve no net loss of wetted acres.

5.4.7.3 Net Effects

Implementation of the BDCP will result in no net loss of alkali seasonal wetlands in the Plan Area (Table 5.4-3) and an increase of 150 acres (3%) of this natural community in conservation lands.

The alkali seasonal wetland that will be adversely affected is of moderate value, in that it is consists of portions of relatively large patches of alkali seasonal wetland, or occurs in a matrix of grasslands and vernal pool complex, in an intact natural landscape in or near existing conservation lands, and has covered species occurrences in the vicinity. The rarer iodine scrub type of alkali seasonal wetland complex will be adversely affected by covered activities. The alkali seasonal wetland that will be protected will be of high value, occurring in a matrix of grasslands and vernal pool complex that forms an unfragmented landscape with many covered species occurrences and near existing conservation lands (*CM3 Natural Communities Protection and Restoration*). The rarer iodine bush scrub type of alkali seasonal wetland will be protected in Conservation Zone 8. The protected alkali seasonal wetlands will be managed and enhanced to sustain or increase native biodiversity (*CM11 Natural Communities Enhancement and Management*). Implementation of the BDCP will result in a net benefit to the alkali seasonal wetland complex natural community. Alkali seasonal wetland protection will be timed to ensure that it stays ahead of the loss of the alkali seasonal wetland natural community (Figure 5.4-5).

5.4.8 Vernal Pool Complex

There are 11,284 acres of vernal pool complex natural community in the Plan Area (8,708 acres of vernal pool complex and 2,576 acres of degraded vernal pool complex), in Conservation Zones 1, 2, 4, 5, 8, 9, and 11. Core recovery areas identified in the vernal pool recovery plan (U.S. Fish and Wildlife Service 2005) overlap with portions of Conservation Zone 1 (Jepson Prairie core recovery area), Zone 11 (Jepson Prairie and Suisun core recovery area), and Zone 8 (Altamont Hills core recovery area). Most of the community present in Conservation Zones 2 and 4 are in conservation lands (Type 1 or 2 conservation lands[11]), and vernal pool complex in Conservation Zone 9 consists of small patches that are isolated among developed areas and cultivated land.

5.4.8.1 Adverse Effects

5.4.8.1.1 Permanent Loss and Fragmentation

The hypothetical footprint for covered activities overlaps with 387 acres of the vernal pool complex natural community (3.4% of this community in the Plan Area), including 15 acres from conveyance facility construction (*CM1 Water Facilities and Operation*) and 372 acres from tidal natural communities restoration (*CM4 Tidal Natural Communities Restoration*) (Table 5.4-2). The 387 acres consist of 9 acres of intact vernal pool complex and 378 acres of degraded vernal pool complex. However, *AMM12 Vernal Pool Crustaceans* (Appendix 3.C, *Avoidance and Minimization Measures*) requires that projects be designed to avoid loss of vernal pool complex to the extent possible, and that no more than 10 wetted acres will be removed as a result of covered activities throughout the permit term. Assuming 15% density of wetted acres within the vernal pool complex, the loss of 10 wetted acres as a result of covered activities will result in an estimated loss of 67 acres of the vernal pool complex natural community.

Conveyance facility construction will result in loss of vernal pool complex south and west of Clifton Court Forebay. The area most likely to be affected by tidal natural communities restoration consists of degraded vernal pool complex in the vicinity of Duck Slough and Lindsey Slough. Some degraded vernal pool complex also has potential to be lost along the eastern margin of Suisun Marsh, in an area that lacks vernal pool topography but supports soil and vegetation conditions characteristic of the vernal pool natural community.

5.4.8.1.2 Periodic Inundation

The only covered activity that will result in periodic inundation of the vernal pool complex natural community is Yolo Bypass operation.

Yolo Bypass Operations

This activity may result in increased periodic inundation of up to 4 acres of vernal pool complex in the Yolo Bypass (Table 5.4-2). This natural community is adapted to seasonal inundation and adverse effects from inundation are expected to be minimal, if any: plant composition may shift if the duration of inundation is increased, but not to the extent that it is expected to convert to a different natural community type. Furthermore, BDCP-associated inundation of areas that would not otherwise have been inundated is expected to occur in no more than 30% of all years, since Fremont Weir is expected to overtop the remaining estimated 70% of all years, and during those years notch operations will not typically affect the maximum extent of inundation. In more than half of all years under existing conditions, an area greater than the project-related inundation area already inundates in the bypass. Therefore, habitat conditions in the bypass are not expected to change substantially as a result of Yolo Bypass operations and effects on the vernal pool complex natural community, if any, are expected to be minimal.

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[11] See Section 3.2.4.2.2, *Conservation Lands*, for definitions of conservation land types.

5.4.8.1.3 Construction-Related Effects

Permanent effects of construction are described above in Section 5.4.8.1.1, *Permanent Loss and Fragmentation*. Based on the hypothetical footprint, construction will result in temporary loss of 16 acres of vernal pool complex, 2 acres of which are degraded vernal pool complex. However, *AMM12 Vernal Pool Crustaceans* requires that projects be designed to avoid temporary and permanent loss of vernal pool complex, and that temporary and permanent loss of wetted acres not exceed 10 acres throughout the permit term. Temporary construction-related indirect effects, such as hydrologic alteration, runoff and sedimentation from construction sites, and petroleum and contamination spills, will be minimized with implementation of AMM1 through AMM4 (Appendix 3.C). AMM12 requires projects to be designed to ensure that no more than 20 wetted acres of vernal pools are indirectly affected (as defined in AMM12) throughout the permit term.

5.4.8.1.4 Effects of Ongoing Activities

Facilities Operation and Maintenance

Future operations and maintenance activities could result in ongoing temporary occasional noise and visual disturbances that could affect native wildlife use of adjacent vernal pool complex natural community. In addition, while maintenance activities are not expected to remove vernal pool complex natural communities, operation of equipment could temporarily disturb small areas of vegetation around maintained structures. Occasional repair of access roads, water conveyance facilities, and levees associated with covered activities have the potential to require removal of adjacent vegetation and may entail earth and rock work in the vicinity of the vernal pool complex natural community. This activity could lead to increased soil erosion and runoff entering the natural community. These activities will be subject to normal erosion and runoff control management practices, including those developed as part of *AMM2 Construction Best Management Practices and Monitoring*, *AMM3 Stormwater Pollution and Prevention Plan*, and *AMM4 Erosion and Sediment Control Plan.* AMM10 requires restoration of temporarily affected natural communities. These effects are expected to be minimal, and proper implementation of these measures will avoid permanent adverse effects on this community. Implementation of AMM1 will also avoid and minimize effects (Appendix 3.C).

Vegetation management, in the form of physical removal and chemical treatment, will be an occasional ongoing activity associated with the long-term maintenance of water conveyance facilities and associated transmission lines, although the transmission lines to be constructed in the vicinity of vernal pools are temporary and will be removed when construction is completed. Use of herbicides to control nuisance vegetation could have an adverse effect on the vernal pool complex natural community at or adjacent to treated areas. This effect could be created by uncontrolled drift of herbicides, uncontrolled runoff of contaminated stormwater onto the natural community, or direct discharge of herbicides to vernal pool complexes being treated for invasive species removal. Implementation of *AMM5 Spill Prevention, Containment, and Countermeasure Plan* will reduce effects on this natural community that could result from use of various chemicals during maintenance activities, including the use of herbicides. BMPs (AMM2), including control of drift and runoff from treated areas and use of herbicides approved for use in aquatic environments, will also reduce the risk of affecting natural communities adjacent to water conveyance features and levees associated with restoration activities.

Natural Communities Enhancement and Management

Activities associated with implementation of natural communities enhancement and management within the protected and restored vernal pool complex natural community, such as ground disturbance to control invasive vegetation, could result in local, temporary adverse natural community effects. Actions will include control of invasive nonnative plant and animal species, fire management, and restrictions on vector control and application of herbicides. Vegetation management may occur in and adjacent to vernal pool complexes in the reserve system; effects of this activity are similar to those described under *Operations and Maintenance*, above. These effects are expected to be minimal, and will be avoided and minimized with implementation of AMM1 through AMM4 and AMM10 (Appendix 3.C).

Recreation

Passive recreation in the from of hiking and wildlife viewing may be allowed in and adjacent to vernal pool complexes in the reserve system, where that recreation is compatible with the biological goals and objectives. Implementation of the restrictions on recreational use described in *CM11 Natural Communities Enhancement and Management* and *AMM37 Recreation* will ensure that recreation-related effects on the vernal pool complex natural community are minimal. Recreational trails will be limited to existing trails and roads. New trail construction is prohibited within the vernal pool complex reserves. Recreation within the vernal pool reserves will be limited to docent-led wildlife and botanical tours.

5.4.8.1.5 Other Indirect Effects

Nitrogen Emissions

The vernal pool complex natural community is one of five natural communities identified as potentially affected by nitrogen emissions as a result of covered activities (Appendix 5.J, Attachment 5J.A, *Construction-Related Nitrogen Deposition on BDCP Natural Communities*). BDCP construction activities will require the use of cars, trucks, and machinery that release small amounts of atmospheric nitrogen through the combustion and emissions process associated with motorized vehicles. Emissions will be largely limited to the construction phase of development, which is anticipated to last approximately 9 years. Following combustion, reactive nitrogen is blown downwind and deposited on the landscape, where it acts as a fertilizer. This depositional nitrogen can affect biogeochemical processes and species composition in terrestrial ecosystems, most of which are nitrogen limited (Pardo et al. 2011; Bay Area Open Space Council 2011). Nitrogen can be directly absorbed by plant leaves or taken up by roots through the process of dry deposition, the most common form of deposition in the Central Valley. Increased nitrogen favors nonnative annual grasses and other weeds that crowd out native plants, change fire regimes, and displace rare species adapted to low-nitrogen conditions.

Vernal pool complexes occur along the margins of the Plan Area, including the Stone Lakes National Wildlife Refuge, adjacent to and east of proposed construction of conveyance facilities. The North Stone Lake unit of the Stone Lake Wildlife Refuge contains one of the only remaining undeveloped grassland units in the eastern Delta region (U.S. Fish and Wildlife Service 2007a), as well as large complexes of vernal pools. Based on proximity to the facilities and its location downwind of construction, this area could be affected by the temporary increases in nitrogen deposition associated with conveyance construction. However, weed control and targeted grazing in the refuge are anticipated to control invasive plants, which might proliferate in an ungrazed system. Grazing throughout the refuge is conducted from November through June to reduce competition between vernal pool plants and nonnative species such as annual ryegrass and yellow starthistle, in accordance with the *Stone Lake Comprehensive Conservation Plan* (U.S. Fish and Wildlife Service 2007a).

Attachment 5J.A includes a detailed analysis of the potential effects of nitrogen emissions on vernal pool complexes in the Plan Area. The analysis concludes that nitrogen emissions from covered activities will not harm the vernal pool complex natural community in the Plan Area for the following reasons.

- The covered activities will make a negligible contribution to projected emissions in the region (less than 0.2%).
- The construction activities will be temporary (less than 9 years).
- There is a substantial distance between the nitrogen sources and vernal pool complexes.
- Nitrogen emissions will be transported away from most of the vernal pool complex natural community in the Plan Area because of prevailing wind conditions.

Moreover, planned management of the BDCP reserve system (*CM11 Natural Communities Enhancement and Management*), which includes invasive vegetation control measures, is expected to minimize the potential adverse effects of nitrogen deposition on protected vernal pool complexes in the Plan Area.

5.4.8.2 Beneficial Effects

With implementation of the BDCP, 600 acres of vernal pool complex will be protected in Conservation Zones 1, 8, and 11 (*CM3 Natural Communities Protection and Restoration*) and additional vernal pool complex will be restored to achieve no net loss (*CM9 Vernal Pool and Alkali Seasonal Wetland Complex Restoration*). The protected vernal pool complex natural community will be managed and enhanced to increase native biodiversity, maintain native pollinators, and maintain appropriate seasonal ponding characteristics (*CM11 Natural Communities Enhancement and Management*).

The 600 acres of protected vernal pool complex and additional restored vernal pool complex will be components of a large, interconnected reserve system incorporating a mosaic of grasslands, vernal pool complex, and alkali seasonal wetlands to optimize protection of plant pollinators, provide for the dispersal of plants and animals, sustain important predators of herbivores such as rodents and rabbits (U.S. Fish and Wildlife Service 2005), and minimize effects of adjacent urbanization. Protection will be concentrated in core recovery areas identified in the vernal pool recovery plan (U.S. Fish and Wildlife Service 2005). These targeted conservation areas are situated at elevations that are suitable as wildlife upland habitats adjacent to restored tidal habitats, and can be protected to build on existing and planned preserves in Solano County between Conservation Zones 1 and 11. Protection of vernal pool complex natural community in Conservation Zones 1 and 11 will protect an important connection between Suisun Marsh and the Cache Slough area.

The strategic distribution of vernal pool protection in Conservation Zones 1, 8, and 11 will ensure that the reserve system in the Plan Area (including currently protected areas and areas to be protected and restored under the BDCP) conserves a range of landforms, hydrogeomorphic conditions, and vegetation alliances, as described in Chapter 3, *Conservation Strategy.* The full range of vernal pool types in the Plan Area and a range of vernal pool inundation characteristics will be protected, including larger, deeper pools with long inundation periods and smaller, shallower pools with short inundation periods, to increase the probability of sustaining species during both long-term high and low rainfall periods, and to contribute to biodiversity, since many vernal pool species depend on a narrow range of inundation periods.

5.4.8.3 Net Effects

Implementation of the BDCP will result in no net loss of wetted vernal pool acres in the Plan Area, and an estimated increase of 667 acres (11%) of this natural community in conservation lands, assuming 600 acres of vernal pool complex will be protected (minimum requirement) and 67 acres will be restored with a 15% density of vernal pools, to offset loss of 10 wetted acres (Table 5.4-3). Vernal pool complex likely to be removed is degraded. The vernal pools to be protected and restored will be of high value: they will be located in core recovery areas, in locations that support the highest concentrations of covered and other native vernal pool species and adjacent to existing conservation lands. The protected and restored vernal pool complexes will be managed and enhanced to increase native biodiversity and sustain populations of covered and other native species. The BDCP will result in a net benefit to this natural community. Vernal pool complex restoration and protection will be timed to ensure that it stays ahead of the loss of vernal pool complex natural community (Figure 5.4-6).

5.4.9 Managed Wetland

There are 70,698 acres of managed wetlands in the Plan Area, 71% (49,999 acres) of which are in Suisun Marsh (Conservation Zone 11), and the remainder of which are distributed throughout the Plan Area in all conservation zones.

5.4.9.1 Adverse Effects

5.4.9.1.1 Permanent Loss and Fragmentation

Covered activities will result in the permanent loss of up to 13,778 acres[12] (19%) of managed wetlands (Table 5.4-1). Of the 13,778 acres of loss, an estimated 7 acres (less than 1%) will result from conveyance facility construction, 24 acres (less than 1%) from construction of conveyance channels as part of Fremont Weir/Yolo Bypass improvements, and the remaining 13,746 acres (over 99%) from tidal natural communities restoration. The majority will be removed from Suisun Marsh in Conservation Zone 11 (Table 5.4-1).

Tidal restoration that will result in the loss of managed wetlands will occur at primarily six locations in Suisun Marsh. Some of the areas to be affected (Simmons Island, Montezuma Slough, and the east side of Suisun Slough) are currently managed as seasonal wetlands that are inundated during the winter months). Other areas to be affected (Nurse Slough, Hill Slough, West Suisun, and the west side of Suisun Slough) are managed primarily as semi-permanent wetlands, providing inundated wildlife habitat for longer periods of the year. All these affected areas are currently connected by managed wetlands that will not be affected by tidal restoration, and the managed wetlands that will be lost to tidal restoration will continue to provide connectivity to other managed wetlands for most

[12] Habitat or natural community loss acreage estimates are based on hypothetical footprints and models rather than detailed project-level design and represent the maximum allowed under the permit. Actual losses will be tracked through compliance monitoring to ensure that they do not exceed estimates.

of the covered species that use managed wetlands. Tidal restoration will not contribute significantly to fragmentation of managed wetland which is ubiquitous in Suisun Marsh.

The estimated 7 acres of managed wetlands that will be permanently lost as a result of conveyance facility construction consist of a small patch on Mandeville Island. This loss is not expected to adversely affect connectivity for the managed wetland natural community. The estimated 24 acres that will be permanently lost through construction of conveyance channels as part of Fremont Weir/Yolo Bypass improvements consist of several areas near the middle of the bypass along the edges of managed wetland patches, and this loss is not expected to fragment the managed wetland natural community.

5.4.9.1.2 Periodic Inundation

Yolo Bypass Operations

Publicly and privately owned managed wetlands in the Yolo Bypass are primarily managed to provide recreational opportunities for the viewing and hunting of overwintering waterfowl, which are primarily dabbling ducks (95% of waterfowl in the Delta are dabbling ducks). Publicly owned managed wetlands in the bypass also provide viewing opportunities for other migratory bird species, including shorebirds and raptors. Water levels on seasonal managed wetlands are managed to attract overwintering waterfowl in the early to mid-fall and to maximize waterfowl food biomass and food value, with the primary food being seeds from annual herbs and forbs (e.g., swamp timothy [*Crypsis schoenoides*]). On semipermanent wetlands, water is maintained later into the summer (through June or July) to support nesting and brooding waterfowl. Permanent managed wetlands maintain some number of wetted acres year-round, also to support nesting and brooding.

All three types of managed wetlands (seasonal, semipermanent, and permanent) are filled with water in the fall to "hunt" or "shoot" water levels. Water levels on seasonal wetlands are managed to maximize to foraging depths for dabbling ducks. Dabbling ducks can forage at depths no greater than 18 inches and prefer depths less than 10 inches. On public lands in the Yolo Bypass Wildlife Area, swamp timothy is the primary forage type (Ducks Unlimited 2012). Water levels on public lands are thus maintained actively through the end of February when water levels are allowed to slowly recede through evaporation. Water is typically removed in mid-April to maximize swamp timothy seed production. Privately managed wetlands more typically use a mix of watergrass (*Echinocloa crus-galli)* and smartweed (*Polygonum hydropiperoides*) and typically flood wetland cells for 2 to 4 weeks in May to maximize seed production.

Yolo Bypass operations under *CM2 Yolo Bypass Fisheries Enhancement* will alter the magnitude, frequency, and duration of flooding and expand the extent of the flooded footprint to the west where elevations are higher. Increased water depths will make the more typically flooded portions of the bypass too deep for dabbling ducks. However, areas to the west that are not typically flooded will likely become available, possibly replacing some or all of the lost foraging value depending on the underlying land use type (e.g., corn, rice, pasture). The longer the duration of the flood event, the more likely food at accessible depths will become depleted. February is the most sensitive time period for waterfowl forage, because waterfowl populations are highest and demand on food resources is greatest. Ducks Unlimited (2012) created an analytical tool to assess impacts of CM2 operations on waterfowl populations. Two hypothetical flood scenarios were run, one of which was a winter-long flood event with Fremont Weir overtopping from November 15 to April 15. The models indicated that controlled floods temporarily remove food supply from waterfowl populations, but do not affect the annual carrying capacity of the Yolo Basin (Ducks Unlimited 2012).

The increase in flooding duration on public lands in the Yolo Bypass has potential to affect seed germination of the primary forage type on public lands, swamp timothy. Water needs to be removed by mid-April to allow for maximization of swamp timothy seed germination. Flooding frequency can also be an important effect, as multiple years of flooding have been shown to have compounding effects on swamp timothy seed germination, with seed germination decreasing slightly the first year of flooding, but in greater amounts the following year (Rahilly et al. 2010). In the TRUEMET seed loss model performed by Ducks Unlimited (2012), seasonal wetlands that grow swamp timothy had a 25% reduced food value following 2 years of delayed drawdown. Privately managed wetlands in Yolo Bypass are much more tolerant of late-season flooding, as maximization of seed germination for watergrass and smartweed requires water levels to be held steady for 2 to 4 weeks in May (Ducks Unlimited 2012). Appendix 5.J, *Effects on Natural Communities, Wildlife, and Plants*, provides the method used to estimate periodic inundation effects in the Yolo Bypass. Based on this method, periodic inundation could affect managed wetlands ranging from an estimated 931 acres during a notch flow of 6,000 (B)[13] cfs to an estimated 2,612 acres during a notch flow of 4,000 cfs (Table 5.4-2). However, BDCP-associated inundation of areas that would not otherwise have been inundated is expected to occur in no more than 30% of all years, since Fremont Weir is expected to overtop the remaining estimated 70% of all years, and during those years notch operations will not typically affect the maximum extent of inundation. In more than half of all years under existing conditions, an area greater than the project-related inundation area already inundates in the bypass.

Floodplain Restoration

Up to 6 acres of managed wetland will be periodically inundated (about every 5 to 7 years) in newly restored floodplains. Affected managed wetland will convert to shallow open water habitat during this short time period. Following drawdown, the managed wetland habitat functions are expected to return. While inundation will provide benefits to fish, waterfowl, and other aquatic organisms, inundation will temporarily remove habitat for managed wetlands species that make less use of aquatic habitats.

5.4.9.1.3 Construction-Related Effects

Permanent effects of construction are described above in Section 5.4.9.1.1, *Permanent Loss and Fragmentation*. Other construction-related effects on managed wetlands include temporary natural community loss; noise, visual, and direct disturbance of wildlife from construction equipment; and spread of invasive plants. These are described below.

Construction activities will result in the temporary loss of an estimated 72 acres of managed wetlands. Construction of the water conveyance facilities will result in the temporary removal of approximately 28 acres of managed wetland, and construction of fisheries enhancements at Yolo Bypass will temporarily remove 44 acres. Temporarily disturbed areas will be restored within 1 year following completion of construction. Noise and visual disturbances during construction activities could result in temporary disturbances that will affect native wildlife use of managed wetland habitat. Ground disturbance from construction or maintenance and the transport of construction crews, equipment, and materials could result in the introduction and spread of invasive

[13] Scenario B = 6,000 cfs notch flow; existing flow = 6,289 cfs; and proposed flow = 12,289 cfs

nonnative plants. Implementation of AMM1 through AMM5 and AMM10 (Appendix 3.C, *Avoidance and Minimization Measures*) will avoid and minimize these effects.

5.4.9.1.4 Effects of Ongoing Activities

Facilities Operation and Maintenance

Occasional repair of access roads, water conveyance facilities, and levees associated with covered activities has the potential to require temporary removal of adjacent vegetation and could entail earth and rock work in or adjacent to the managed wetland natural community. This activity could lead to increased soil erosion, turbidity, and runoff entering the natural community. These activities will be subject to normal erosion, turbidity, and runoff control management practices, including those developed as part of *AMM2 Construction Best Management Practices and Monitoring* and *AMM4 Erosion and Sediment Control Plan* (Appendix 3.C). Any vegetation removal or earthwork adjacent to or within wetlands will require use of sediment and turbidity barriers, soil stabilization, and revegetation of disturbed surfaces. Proper implementation of these measures will avoid permanent adverse effects on this community.

Vegetation management, in the form of physical removal and chemical treatment, will be an ongoing occasional activity associated with the long-term maintenance of water conveyance facilities. Use of herbicides to control nuisance vegetation could have a long-term adverse effect on the managed wetland natural community at or adjacent to treated areas. This effect could result from uncontrolled drift of herbicides, uncontrolled runoff of contaminated stormwater onto the natural community, or direct discharge of herbicides to wetland areas being treated for invasive species removal. Implementation of *AMM3 Stormwater Pollution Prevention Plan, AMM5 Spill Prevention, Containment, and Countermeasure Plan*, and *AMM32 Hazardous Material Management* will reduce the effects of covered activities and include the commitment to prepare and implement spill prevention, containment, and countermeasure plans and stormwater pollution prevention plans. BMPs (AMM2), including control of drift and runoff from treated areas and application of herbicides approved for use in terrestrial environments are also expected to reduce the risk of affecting natural communities adjacent to water conveyance features and levees associated with restoration activities.

Natural Communities Enhancement and Management

Activities associated with implementation of natural communities enhancement and management in the protected managed wetland natural community, such as ground disturbance to control nonnative vegetation, could result in local, temporary adverse natural community effects. Potential effects of vegetation management are also described under *Facilities Operations and Maintenance*, above. Enhancement and management actions may also include fire management. Enhancement and management effects on this natural community are expected to be minimal, and will be avoided and minimized with implementation of AMM1 through AMM4 and AMM10 (Appendix 3.C).

Recreation

Recreation will be allowed in and adjacent to managed wetlands in the reserve system, where that recreation is compatible with the biological goals and objectives. Hunting will be the primary recreational use of these lands. When the hunting season is closed, hiking and fishing may also be allowed. The restrictions on recreational use described in *CM11 Natural Communities Enhancement* *and Management* and *AMM37 Recreation* will ensure that recreation-related effects on the managed wetland natural community are minimal.

5.4.9.2 Beneficial Effects

With implementation of the BDCP, 8,100 acres of managed wetlands will be protected, of which at least 1,500 acres will be located within the Grizzly Island Marsh Complex, consistent with the *Draft Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California* (U.S. Fish and Wildlife Service 2010) (*CM3 Natural Communities Protection and Restoration*). Although the primary purpose of the at least 1,500 acres of protection is to protect and enhance habitat for the salt marsh harvest mouse, it is also expected to benefit the managed wetland natural community and the diversity of species that use it, including migratory waterfowl and the western pond turtle. The remaining 6,600 acres will be protected and managed for waterfowl and native biodiversity. These 6,600 acres of protected managed wetlands will be managed to significantly improve existing conditions by maximizing food biomass and food value for overwintering waterfowl and improving habitat for breeding waterfowl. By acquiring 8,100 acres of managed wetland for protection, the Implementation Office will be able to manage and enhance these lands as needed to achieve the biological goals and objectives, such as the control of invasive species measures to increase the diversity of native species.

5.4.9.3 Net Effects

Implementation of the BDCP will result in a decrease of 13,278 acres (19%) of managed wetland and a loss of 4,956 acres (7%) of protected managed wetlands in the Plan Area in the conversion to restored tidal natural communities (Table 5.4-3). Managed wetlands in Suisun Marsh are already protected *in perpetuity* and managed primarily as waterfowl habitat; the management status and existing habitat condition vary considerably. However, additional protection will be provided on 8,100 acres of managed wetlands through placement of conservation easements on these existing conservation lands, allowing for enhancement and management to increase habitat values for salt marsh harvest mouse and waterfowl, and to increase biodiversity above baseline conditions consistent with the biological goals and objectives.

Nearly all (99.8%) of the loss of managed wetland will result from tidal restoration, in which the managed wetlands will be converted to tidal marsh that is expected to provide habitat values for covered species and other native wildlife that use managed wetlands, including but not limited to the salt marsh harvest mouse, California clapper rail, California black rail, and white-tailed kite. The restored tidal brackish emergent wetland and tidal freshwater emergent will provide habitat values similar to those of the managed wetlands they will replace. Managed wetlands currently support pickleweed and other marsh vegetation that provide suitable habitat for the salt marsh harvest mouse, California clapper rail, California black rail, and a diversity of other native wetland species; these habitat functions will be maintained or improved with conversion to tidal brackish emergent wetlands. Similarly, tidal freshwater emergent wetlands are expected to provide habitat values for many native wildlife species that use the managed wetlands to be replaced.

The 8,100 acres of managed wetlands to be protected and enhanced will provide higher habitat values for covered species than the managed wetlands that will be removed (e.g., greater structural diversity of vegetation and refugia for Suisun Marsh wildlife species during high tide events; maximized food biomass, food value, and breeding habitat for waterfowl species). Although the

BDCP will result in a net loss of managed wetlands, it will result in net benefits to covered species and a diversity of native species that use managed wetlands.

5.4.10 Other Natural Seasonal Wetland

There are 276 acres of other natural seasonal wetland natural community in the Plan Area, in Conservation Zones 2 (5 acres), 4 (185 acres), 5 (2 acres), 7 (15 acres), 8 (4 acres), and 11 (66 acres). Covered activities will not affect this natural community. Of the 276 acres of other natural seasonal wetlands in the Plan Area, 227 acres (82%) are currently in protected status, including approximately 185 acres on Cosumnes River Preserve, and approximately 85 acres east of Suisun Marsh, and lands owned and managed by CDFW and a private hunting preserve. Up to 2 acres of other natural seasonal wetland will be periodically inundated (about every 5 to 7 years) in newly restored floodplains. Affected other natural seasonal wetland will convert to shallow open-water habitat during this short time period. Following drawdown, wetland habitat functions are expected to return. While inundation will provide benefits to aquatic organisms, inundation will temporarily remove habitat for other natural seasonal wetland species that make less use of aquatic habitats.

This natural community is adequately conserved and managed in the Plan Area for the purpose of maintaining ecological integrity of large habitat blocks, ecosystem function, and biological diversity.

5.4.11 Grassland

There are 76,315 acres of grassland natural community distributed throughout the Plan Area in all conservation zones. The largest, contiguous grassland areas are in Conservation Zones 1, 8, and 11. Grasslands in the remainder of the conservation zones consist primarily of isolated patches surrounded by cultivated lands.

5.4.11.1 Adverse Effects

5.4.11.1.1 Permanent Loss and Fragmentation

Covered activities will result in the permanent loss of up to an estimated 2,516 acres[14] of the grassland natural community (Table 5.4-1). An estimated 460 acres will be removed through construction of above ground water conveyance facilities in Conservation Zones 4, 5, 6, and 8. Grasslands to be permanently lost as a result of conveyance facility construction consist of relatively small patches interspersed among cultivated lands in the Delta. The largest patch that will be affected by conveyance facility construction is on DWR land on either side of Twin Cities Road; this land will be used for storage of reusable tunnel material. Of the 460 acres of grasslands categorized as permanently lost through conveyance facility construction, an estimated 249 acres consist of storage sites for reusable tunnel material. The reusable tunnel material will likely be moved to other sites for use in levee build-up and restoration, and the affected areas will likely be restored. While this effect is categorized as permanent, because there is no assurance that the material will eventually be moved, the effect will likely be temporary. Furthermore, the amount of storage area needed for reusable tunnel material is flexible and the footprint used in the effects analysis is based

[14] Habitat or natural community loss acreage estimates are based on hypothetical footprints and models rather than detailed project-level design and represent the maximum allowed under the permit. Actual losses will be tracked through compliance monitoring to ensure that they do not exceed estimates.

on a worst-case scenario; the actual area to be affected by reusable tunnel material storage will likely be less than the estimated acreage.

Construction of conveyance channels and levee improvements in the Yolo Bypass will remove an estimated 388 acres of grassland: this grassland loss will take place along linear footprints in relatively large but scattered, disjunctive patches of grasslands in Conservation Zone 2. Tidal natural communities restoration will permanently remove up to 1,122 acres of grassland community from multiple locations throughout Conservation Zones 1, 2, 4, 5, 6, 7, 8, and 11: the grasslands to be removed mostly consist of scattered, isolated patches. Construction of setback levees for floodplain restoration will remove up to 51 acres of grassland community in Conservation Zone 7, and riparian restoration in the new floodplains will displace an additional 399 acres of grasslands: these grasslands consist of small patches and narrow strips on the edges of cultivated lands and irrigation ditches and canals. Riparian restoration as part of tidal natural communities restoration will result in the permanent loss of 11 acres. The development of conservation hatcheries will affect 35 acres of grassland natural community. Construction of trails and other facilities related to passive recreational activities will remove an estimated 50 acres of grassland natural community.

The high-value grasslands in the Plan Area, consisting of large, unfragmented areas that support many covered species occurrences and are in or near conservation lands (Type 1 and 2 conservation lands[15]), are located in the southwestern portion of Conservation Zone 1 (Jepson Prairie and surrounding area) along the western edge Conservation Zones 8 (west of Clifton Court Forebay) and around the perimeter of Suisun Marsh in Conservation Zone 11. Tidal restoration will remove some (467 acres) of this high-value grassland near Jepson Prairie in Conservation Zone 1. Grassland loss in Conservation Zone 8 will consist of fragmented patches surrounded by cultivated lands, located east of the high-value grasslands, and none of the high-value grasslands in Conservation Zone 8 will be permanently removed through covered activities. Up to 20 acres of grasslands will be removed from the perimeter of Suisun Marsh in Conservation Zone 11: this represents less than 1% of the grasslands surrounding Suisun Marsh. Therefore, most of the 2,517 acres of grassland loss will take place outside these high-value grassland areas in Conservation Zones 1, 8, and 11.

Construction of conveyance channels associated with Yolo Bypass improvements may create a localized barrier that impedes the movement of native grassland-associated amphibians, reptiles, and small mammals to and from habitat areas on each side of the channels. This effect could result in local changes in the abundance and distribution of affected native species.

5.4.11.1.2 Periodic Inundation

Yolo Bypass Operations

Appendix 5.J, *Effects on Natural Communities, Wildlife, and Plants*, provides the method used to estimate periodic inundation effects in the Yolo Bypass. Based on this method, periodic inundation could affect the grassland natural community ranging from an estimated 385 acres during a notch flow of 1,000 cfs to an estimated 1,277 acres during a notch flow of 4,000 cfs (Table 5.4-2). However, BDCP-associated inundation of areas that would not otherwise have been inundated is expected to occur in no more than 30% of all years, since Fremont Weir is expected to overtop the remaining estimated 70% of all years, and during those years notch operations will not typically affect the maximum extent of inundation. In more than half of all years under existing conditions, an area

[15] See Section 3.2.4.2.2, *Conservation Lands*, for definitions of conservation land types.

greater than the BDCP-related inundation area already inundates in the bypass. During periods when grasslands are inundated, the affected grassland will convert to shallow open water habitat. Following drawdown, the grassland habitat functions are expected to return as they do under the existing Yolo Bypass inundation regime, although longer and more frequent inundation could change the grassland plant species composition and render the grasslands unsuitable for some grassland wildlife species. While more frequent and inundation of longer durations will provide benefits to fish, waterfowl and other water birds, and other aquatic organisms, increased inundation frequency and duration make the grasslands periodically unavailable to some terrestrial species. For example, longer springtime inundation could preclude use by foraging Swainson's hawks, white-tailed kites, tricolored blackbirds, and other native species that forage in grassland habitats.

Floodplain Restoration

Up to 514 acres of grassland community will be periodically inundated in newly restored floodplains. The floodplains will transition from areas that flood frequently (e.g., every 1 to 2 years) to areas that flood infrequently (e.g., every 10 years or more). During seasonal inundation, affected grassland habitat will convert to shallow open water habitat. Following drawdown, the grassland habitat functions are expected to return. While inundation will provide benefits to fish, waterfowl and other waterbirds, and other aquatic organisms increased inundation frequency and duration make the grasslands periodically unavailable to some terrestrial species. For example, spring inundation could preclude use by Swainson's hawks, white-tailed kites, tricolored blackbirds, and other native species that forage in grassland habitats. However, most of the inundation is expected to take place during the winter, when breeding birds will not be affected. Adjacent uplands will be protected for any wildlife that may be affected by seasonal inundation: consequently, wildlife that may be displaced by seasonal inundation, including prey species for Swainson's hawks and other raptors, is expected to repopulate affected habitats between inundation events.

5.4.11.1.3 Construction-Related Effects

Permanent effects of construction are described above in Section 5.4.11.1.1, *Permanent Loss and Fragmentation*. Other construction-related effects on grassland natural community loss; noise, visual, and direct disturbance of wildlife from construction equipment; and spread of invasive plants. These are described below.

Construction-related activity will temporarily disturb 431 acres of the grassland natural community. Temporarily disturbed areas will be restored within 1 year following construction. Construction of the water conveyance facilities may temporarily fragment grassland habitat, primarily in Conservation Zones 4 and 5. This temporary fragmentation could impede the ability of native amphibians, reptiles, and small mammals to move among habitat areas. Because the majority of the conveyance facility will be underground, this is a temporary effect and will be localized as construction activities move along the project corridor.

Noise and visual disturbances during construction activities could result in temporary disturbances that will affect native wildlife use of grassland habitat. Ground disturbance from construction or maintenance and the transport of construction crews, equipment, and materials could result in the introduction and spread of invasive nonnative plants. Implementation of AMM1 through AMM5, AMM10, and AMM11 (Appendix 3.C, *Avoidance and Minimization Measures*) will avoid and minimize these effects.

5.4.11.1.4 Effects of Ongoing Activities

Facilities Operation and Maintenance

Occasional repair of access roads, water conveyance facilities and levees associated with the covered activities has the potential to require temporary removal of adjacent vegetation and could entail earth and rock work in or adjacent to the grassland natural community. These activities could lead to increased soil erosion and runoff entering the natural community. The activities will be subject to normal erosion and runoff control management practices, including those developed as part of *AMM2 Construction Best Management Practices and Monitoring* and *AMM4 Erosion and Sediment Control Plan* (Appendix 3.C). Proper implementation of these measures will avoid permanent adverse effects on this community.

Vegetation management, in the form of physical removal and chemical treatment, will be an ongoing occasional activity associated with the long-term maintenance of water conveyance facilities. Use of herbicides to control nuisance vegetation could have a long-term adverse effect on the grassland natural community at or adjacent to treated areas. This effect could result from uncontrolled drift of herbicides, uncontrolled runoff of contaminated stormwater onto the natural community, or direct discharge of herbicides to grassland areas being treated for invasive species removal. Implementation of *AMM3 Stormwater Pollution Prevention Plan, AMM5 Spill Prevention, Containment, and Countermeasure Plan*, and *AMM32 Hazardous Material Management* will reduce the effects of covered activities and include the commitment to prepare and implement spill prevention, containment, and countermeasure plans and stormwater pollution prevention plans. BMPs (AMM2), including control of drift and runoff from treated areas and the application of herbicides approved for use in terrestrial environments, are also expected to reduce the risk of affecting natural communities adjacent to water conveyance features and levees associated with restoration activities.

Additionally, implementation of AMM1 and AMM10 will minimize these operation and maintenance effects.

Natural Communities Enhancement and Management

Activities associated with implementation of natural communities enhancement and management in the protected grassland natural community, such as ground disturbance to control nonnative vegetation, could result in local, temporary adverse natural community effects. Potential effects of vegetation management are also described under *Facilities Operations and Maintenance*, above. Enhancement and management actions may also include fire management. Enhancement and management effects on this natural community are expected to be minimal, and will be avoided and minimized with implementation of AMM1 through AMM4 and AMM10 (Appendix 3.C).

Recreation

Passive recreation in the from of hiking and wildlife viewing will be allowed in and adjacent to grassland areas in the reserve system, where that recreation is compatible with the biological goals and objectives. Potential effects on the grassland natural community include trampling of vegetation and erosion of trails as a result of foot traffic, which could lead to erosion and sedimentation of adjacent grasslands. Implementation of the restrictions on recreational use described in *CM11 Natural Communities Enhancement and Management* and *AMM37 Recreation* will ensure that recreation-related effects on the grassland natural community are minimal.

5.4.11.1.5 Other Indirect Effects

Nitrogen Emissions

The grassland natural community is one of five natural communities identified as potentially affected by nitrogen emissions as a result of covered activities (Appendix 5.J, Attachment 5J.A, *Construction-Related Nitrogen Deposition on BDCP Natural Communities*). BDCP construction activities will require the use of cars, trucks, and machinery that release small amounts of atmospheric nitrogen through the combustion and emissions process associated with motorized vehicles. Emissions will be largely limited to the construction phase of development, which is anticipated to last approximately 9 years. Following combustion, reactive nitrogen is blown downwind and deposited on the landscape, where it acts as a fertilizer. This depositional nitrogen can affect biogeochemical processes and species composition in terrestrial ecosystems, most of which are nitrogen limited (Pardo et al. 2011; Bay Area Open Space Council 2011). Nitrogen can be directly absorbed by plant leaves or taken up by roots through the process of dry deposition, the most common form of deposition in the Central Valley. Increased nitrogen favors nonnative annual grasses and other weeds that crowd out native plants, change fire regimes, and displace rare species adapted to low-nitrogen conditions. However, grasslands in the Plan Area are already dominated by non-native species under existing conditions. Grasslands occur in the vicinity of proposed construction of conveyance facilities primarily in Conservation Zone 8. Based on proximity to the facilities, this area could be affected by the temporary increases in nitrogen deposition associated with conveyance construction. However, weed control and targeted grazing on protected lands are anticipated to control invasive plants, which might proliferate in an ungrazed system.

Attachment 5J.A includes an analysis of the potential effects of nitrogen emissions on grasslands in the Plan Area. The analysis concludes that nitrogen emissions from covered activities will not harm the grasslands natural community in the Plan Area for the following reasons.

- The covered activities will make a negligible contribution to projected emissions in the region (less than 0.2%).
- The construction activities will be temporary (less than 9 years).
- Nitrogen emissions will be transported away from most of the grassland natural community in the Plan Area because of prevailing wind conditions.
- Grasslands in the Plan Area are dominated by non-native invasive species under existing conditions.

Moreover, planned management of the reserve system (*CM11 Natural Communities Enhancement and Management*), which includes invasive vegetation control measures, is expected to minimize the potential adverse effects of nitrogen deposition on protected grasslands in the Plan Area.

5.4.11.2 Beneficial Effects

With implementation of the BDCP, 8,000 acres of grasslands will be protected in Conservation Zones 1, 2, 4, 5, 7, 8, and 11, and 2,000 acres of grassland will be restored. Grassland protection and restoration will improve connectivity among habitat areas in and adjacent to the Plan Area, improve genetic interchange among native species' populations, and contribute to the long-term conservation of grassland-associated covered species.

Grasslands and associated vernal pool and alkali seasonal wetland complex will be protected in large contiguous landscapes encompassing the range of vegetation, hydrologic, and soil conditions that characterize these communities. Restored grassland will be sited and designed to increased grassland connectivity. Grasslands and associated vernal pool complex and alkali seasonal wetland complex in Conservation Zones 1 and 11 will be protected to increase habitat linkages between Suisun Marsh, Jepson Prairie, and the Cache Slough Complex for the California tiger salamander and other grassland- and vernal pool-dependent wildlife. Thus, lands will be protected along the upland fringe of Suisun Marsh to maintain connectivity with much larger protected (e.g., Jepson Prairie Preserve) and unprotected grassland landscapes that are immediately adjacent to the Plan Area. The protected grasslands in Conservation Zones 1 and 11 will form a component of a continuous gradient of protected natural communities that will range from grassland upland communities down slope to existing and restored tidal wetland communities in Suisun Marsh. Additionally, grasslands and associated vernal pool and alkali seasonal wetland complex in Conservation Zone 8 will be protected to maintain habitat connectivity with protected grassland and vernal pool landscapes at the southwest end of the Plan Area where it overlaps with the East Contra Costa County HCP/NCCP, providing habitat contiguity for the San Joaquin kit fox and other grassland and vernal pool-associated wildlife.

In addition to the large expanses of grassland and associated vernal pool and alkali seasonal wetland complexes that will be protected and enhanced in Conservation Zones 1, 8, and 11, the 8,000 acres of protected grasslands will include some smaller patches of grassland associated with maintained agricultural habitats (e.g., vegetated levee slopes) throughout the Plan Area. These grassland patches are expected to serve as upland habitat for giant garter snakes and western pond turtles, and foraging habitat for Swainson's hawks and white-tailed kites.

Although the majority of grassland protection and restoration will occur in Conservation Zones 1, 8, and 11, grassland protection or restoration will also occur in Conservation Zones 2, 4, or 5 where upland habitat for giant garter snakes is needed adjacent to restored tidal and nontidal freshwater emergent wetland. Grasslands will also be protected and restored in Conservation Zone 7 as needed to provide upland refugia on the landward side of levees adjacent to protected and restored habitat for the riparian brush rabbit.

Grasslands in the reserve system will be managed to sustain or increase native biodiversity and wildlife habitat values. They will be managed to sustain a mosaic of grassland vegetation alliances and increase the extent, distribution, and density of native perennial grasses intermingled with other native species, including annual grasses, geophytes, and other forbs. They will also be managed to increase opportunities for movement by broad-ranging animals through grasslands, increase burrow availability for burrow-dependent species, and increase prey, especially small mammals and insects, for grassland-foraging species.

5.4.11.3 Net Effects

Implementation of the BDCP will result in an estimated decrease of 517 acres (less than 1%) of the grassland natural community in the Plan Area (Table 5.4-3) and an estimated 42% increase of this natural community in conservation lands. The grasslands that will be adversely affected are widely scattered throughout the Plan Area and range from low to high value. The protected and restored grasslands will be of high value, consisting primarily of large, contiguous expanses that will be located in areas with high concentrations of covered grassland and vernal pool complex associated species in Conservation Zones 1, 8, and 11 and will provide essential habitat connectivity for the California tiger salamander, the San Joaquin kit fox, and other covered species (Section 5.4.11.2, *Beneficial Effects*). The BDCP will therefore result in a net benefit to the grassland natural community. Grassland restoration and protection will be timed to ensure that it stays ahead of the loss of the grassland natural community (Figure 5.4-7).

5.4.12 Inland Dune Scrub

There are 19 acres of inland dune scrub natural community in the Plan Area, in Conservation Zone 10. Covered activities will not affect this natural community, and all 19 acres are protected and managed by the USFWS in the Antioch Dunes National Wildlife Refuge and through a Memorandum of Agreement with PG&E. Because the area surrounding the refuge is developed, there is no opportunity for restoring dunes outside the refuge, within the Plan Area. The existing acreage of this natural community is adequately conserved and managed in the Plan Area for the purpose of maintaining ecological integrity, ecosystem function, and biological diversity.

5.4.13 Cultivated Lands

There are 481,909 acres of cultivated lands distributed throughout the Plan Area, in all conservation zones. Cultivated lands make up 56% of all natural community acreage in the Plan Area.

5.4.13.1 Adverse Effects

5.4.13.1.1 Permanent Loss and Fragmentation

Covered activities will result in the permanent loss of up to 55,372 acres[16] (11%) of the cultivated lands (Table 5.4-1). Of this, 4,588 acres (8%) will result from conveyance facility construction, 39,565 acres (71%) will result from tidal natural communities restoration, 629 acres (1%) will result from Fremont Weir/Yolo Bypass inundation, 2,087 acres (4%) will result from levee construction for floodplain expansion, 3,593 acres (6%) will result from seasonal floodplain restoration, 960 acres (2%) from tidal natural communities restoration, 2,000 acres (4%) from grassland restoration, and 1,950 acres (4%) will result from nontidal marsh restoration. An estimated 36% of the loss consists of alfalfa and irrigated pasture, which has high habitat value for some wildlife and covered species, while an estimated 7% consists of orchards and vineyards, which have little to no value to native wildlife or covered species. An estimated 57% of the cultivated lands that will be removed consist of other cultivated crops and lands with varying levels of wildlife value. Rice, which has high habitat value for many wildlife species, will not be permanently removed as a result of covered activities.

Of the 4,588 acres of cultivated lands to be removed as a result of conveyance facility construction, 3,140 acres will consist of storage sites for reusable tunnel material. This material will likely be moved to other sites for use in levee build-up and restoration, and the affected area will likely be restored. While this effect is categorized as permanent, because there is no assurance that the material will eventually be moved, the effect will likely be temporary. Furthermore, the amount of storage area needed for reusable tunnel material is flexible and the footprint used in the effects

[16] Habitat or natural community loss acreage estimates are based on hypothetical footprints and models rather than detailed project-level design and represent the maximum allowed under the permit. Actual losses will be tracked through compliance monitoring to ensure that they do not exceed estimates.

analysis is based on a worst-case scenario; the actual area to be affected by reusable tunnel material storage will likely be less than the estimated acreage.

5.4.13.1.2 Periodic Inundation

Yolo Bypass Operations

Appendix 5.J, *Effects on Natural Communities, Wildlife, and Plants*, provides the method used to estimate periodic inundation effects in the Yolo Bypass. Based on this methodology, periodic inundation could affect cultivated lands ranging from an estimated 2,894 acres during a notch flow of 1,000 cfs to an estimated 5,100 acres during a notch flow of 6,000 cfs (Table 5.4-2). However, BDCP-associated inundation of areas that would not otherwise have been inundated is expected to occur in no more than 30% of all years, since Fremont Weir is expected to overtop the remaining estimated 70% of all years, and during those years notch operations will not typically affect the maximum extent of inundation. In more than half of all years under existing conditions, an area greater than the BDCP-related inundation area already inundates in the bypass.

Although the area to be inundated currently experiences periodic inundation within the same footprint, if inundation continues later in the spring, this could delay ground preparation and planting operations for crops in the Yolo Bypass. After the flow ceases, it may take as many as 4 weeks for the waters to recede and for the land to dry sufficiently to start farming. Assuming a 4-week time period between the end of water inundation and the point when ground preparation activities can begin, and an additional 4-week period for ground preparation prior to planting, planting begins 8 weeks from the end of inundation. Based on a May 1 planting date for tomatoes, inundation must end by March 1 for tomato planting to occur; based on a May 15 planting date for safflower, inundation must end by March 15 for safflower planting to occur; based on a June 1 planting date for corn and rice, inundation must end by April 1 for corn and rice planting to occur; and based on a June 15 planting date for sudan grass, inundation must end by April 15 for sudan grass planting to occur (EDAW 2008; U.C. Cooperative Extension 2009). The new inundation schedule could substantially prevent agricultural use of these lands, decreasing the amount of cultivated lands in the bypass during some years. However, the extent of these effects is currently unknown and will be analyzed in forthcoming documents for *CM2 Yolo Bypass Fisheries Enhancement.*

Floodplain Restoration

This activity will periodically inundate an estimated 8,915 acres of the cultivated lands. While these lands are inundated, affected cultivated land will convert to shallow open water wildlife habitat. Following drawdown, previous cultivated land uses are expected to be reestablished. While inundation will provide benefits to fish, waterfowl and other waterbirds, and other aquatic organisms, inundation will temporarily remove habitat for cultivated land-associated native species. Inundation of restored floodplains is expected to drown and temporarily reduce the abundance of small mammals and other native species on cultivated lands. The floodplains will transition from areas that flood frequently (e.g., every 1 to 2 years) to areas that flood infrequently (e.g., every 10 years or more). Affected species are expected to repopulate affected habitats between inundation events if upland refugia are available during inundation events.

5.4.13.1.3 Construction-Related Effects

Permanent effects of construction are described above in Section 5.4.13.1.1, *Permanent Loss and Fragmentation*. Other construction-related effects on cultivated lands include temporary natural community loss; noise, visual, and direct disturbance of wildlife from construction equipment; and spread of invasive plants. These are described below.

Up to 2,753 acres of cultivated lands will be temporarily removed during construction activities, and restored to preproject conditions within 1 year after completion of construction. Additionally, an estimated 199 acres of cultivated lands will be removed for spoils and borrow sites during construction: these areas will be restored within the permit term but in an undetermined timeframe.

Noise and visual disturbances during construction activities could result in temporary disturbances that could affect native wildlife use of cultivated lands. However, cultivated lands experience frequent human disturbance, and most species using this natural community type are accustomed to this disturbance. Ground disturbance from construction or maintenance and the transport of construction crews, equipment, and materials could result in the introduction and spread of invasive nonnative plants. Again, because the cultivated lands natural community experiences frequent ground disturbance, this will not be a newly introduced factor. Implementation of AMM1 through AMM5, AMM10, and AMM11 (Appendix 3.C, *Avoidance and Minimization Measures*) will avoid and minimize these effects.

5.4.13.1.4 Effects of Ongoing Activities

Facilities Operation and Maintenance

Cultivated lands are not expected to be adversely affected by ongoing operation and maintenance activities. Cultivated lands are already a heavily maintained landscape, and operation and maintenance activities on these lands are not expected to appreciably affect the native species habitat values or ecosystem functions of these lands.

Natural Communities Enhancement and Management

Activities associated with implementation of natural community enhancement and management in the protected cultivated lands could result in local, temporary, adverse natural community effects. However, cultivated lands are frequently disturbed and species that use this natural community are accustomed or habituated to such disturbances. Any adverse effects are expected to be minimal and will be avoided and minimized with implementation measures described in Appendix 3.C.

5.4.13.2 Beneficial Effects

With implementation of the BDCP, 48,625 acres of cultivated lands that provide suitable habitat for covered and other native wildlife species will be protected and managed to sustain covered species populations. Protection of cultivated lands will be targeted in areas where they provide connectivity between other conservation lands. Protection of cultivated lands will ensure maintenance of the crop types that provide higher overall value per acre, on average, than the habitat lost for covered species and other native wildlife that use cultivated lands. Irrigated pastures, alfalfa, and annually cultivated irrigated cropland provide foraging habitat for covered species, including the Swainson's hawk, white-tailed kite, western burrowing owl, greater sandhill crane, and tricolored blackbird.

Grain, corn, and rice fields provide foraging habitats for sandhill cranes, waterfowl, wading birds, and shorebirds. Additionally, 1,500 acres of rice lands or equivalent-value habitat for giant garter snakes will be maintained in Conservation Zones 4 and/or 5. Rice fields provide foraging habitat for many bird species as well as important aquatic habitat for giant garter snakes and western pond turtles.

Small patches of important wildlife habitats associated with cultivated lands, such as isolated oaks, trees and shrubs along field border and roadside, remnant groves, riparian corridors, water conveyance channels, grasslands, ponds, and wetlands will also be protected. Maintenance of these small but important wildlife habitats will benefit covered wildlife species as well as a diversity of noncovered native wildlife. Cultivated lands are used primarily for foraging by several species that nest in riparian areas, roadside trees, or isolated trees and groves. Wetlands, streams, ponds, hedgerows, groves, and other remnant natural or created habitats will be maintained to provide the full range of habitat elements necessary to support covered species in cultivated lands.

5.4.13.3 Net Effects

Implementation of the BDCP will result in an estimated decrease of 55,571 acres (12%) of cultivated lands in the Plan Area (Table 5.4-3) and an estimated increase of 41,709 acres (67%) cultivated lands in protected status. Cultivated lands will be protected in crop types and areas that are most beneficial to covered and other wildlife species, based on connectivity and proximity to associated natural community types such as riparian areas that provide suitable nesting habitat for Swainson's hawks and other raptors that forage in cultivated lands. Protected cultivated lands will also include wetlands that provide nesting habitat for tricolored blackbirds or roosting habitat for sandhill cranes. Protected cultivated lands will be managed and enhanced to optimize habitat value for covered and other wildlife species within the constraints of the farming operation. As described in Section 5.6, *Effects on Covered Wildlife and Plant Species,* cultivated lands will be protected, managed, and enhanced to replace lost foraging habitat values for Swainson's hawks, sandhill cranes, and tricolored blackbirds. Additionally, rice lands will be maintained for giant garter snakes. The BDCP will offset adverse effects on the wildlife habitat values of cultivated lands and provide for the conservation and management of covered species that rely on cultivated lands in the Plan Area.

Table 5.4-1. Maximum Allowable Loss of Natural Communities

Natural Community	Total Existing Modeled Natural Community in the Plan Area[b]	Maximum Allowable Loss by Covered Activity[a,b,c] (Acres): CM1 Water Facilities and Operation – Tunnel/Pipeline Facilities Construction: Permanent[d,e]	CM1 – Tunnel/Pipeline Facilities Construction: Permanent Reusable Tunnel Material[f]	CM1 – Tunnel/Pipeline Facilities Construction: Temporary (Borrow and Spoil)[d,g,e]	CM1 – Tunnel/Pipeline Facilities Construction: Temporary[d]	CM2 Yolo Bypass Fisheries Enhancement – Fremont Weir and Yolo Bypass Improvements: Permanent[h]	CM2 – Fremont Weir and Yolo Bypass Improvements: Temporary[h]	CM4 Tidal Natural Communities Restoration – Construction and Inundation[i]: Permanent[i,j,k]	CM5 Seasonally Inundated Floodplain Restoration – Levee Construction: Permanent[l]	CM5 – Levee Construction: Temporary[l]	CM7 Riparian Natural Community Restoration – Riparian Restoration as Part of Tidal Natural Communities Restoration: Permanent	CM7 – Riparian Restoration as Part of Seasonal Floodplain Restoration: Permanent[m]	CM8 Grassland Natural Community Restoration: Permanent[n]	CM10 Nontidal Marsh Restoration – Construction and Inundation: Permanent[n]	CM11 Natural Community Enhancement and Management – Construction of Recreational-Related Facilities: Permanent	CM18 Conservation Hatcheries – Construction: Permanent[n]	Maximum Allowable Loss: Permanent[o]	Maximum Allowable Loss: Temporary (Borrow and Spoil)	Maximum Allowable Loss: Temporary
Tidal perennial aquatic	86,263	178	0	0	2,101	8	11	18	2	5	0	0	0	0	0	0	206	0	2,117
Tidal mudflat[p]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A
Tidal brackish emergent wetland[q]	8,501	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0
Tidal freshwater emergent wetland[q]	8,856	5	1	0	10	6	0	1	1	1	0	0	0	0	0	0	14	0	11
Valley/foothill riparian	17,644	16	18	1	29	89	88	552	43	35	0	0	0	0	0	0	718	1	152
Nontidal freshwater perennial emergent wetland	1,385	1	1	0	5	25	1	99	0	0	0	0	0	0	0	0	126	0	6
Nontidal perennial aquatic	5,489	2	55	0	7	24	12	189	28	16	0	0	0	0	0	0	298	0	35
Alkali seasonal wetland complex	3,723	0	0	0	0[r]	45	0	27	0	0	0	0	0	0	0	0	72	0	0
Vernal pool complex	11,284[s]	15[s]	0	0	0[r,s,t]	0	0	52[s,t]	0	0	0	0	0	0	0	0	67	0	0
Managed wetland	70,698	7	0	0	28	24	44	13,746	0	0	0	0	0	0	0	0	13,777	0	72
Other natural seasonal wetland	276	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Grassland	76,315	211	249	0	158	388	239	1,122	51	34	11	399	0	0	50	35	2,516	0	431
Inland dune scrub	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cultivated lands	481,909	1,448	3,140	199	1,196	629	363	39,565	2,087	1,194	960	3,593	2,000	1,950	0	0	55,372	199	2,753
Total	**772,362**	**1,871**	**3,464**	**200**	**3,534**	**1,238**	**758**	**55,384**	**2,212**	**1,285**	**971**	**3,992**	**2,000**	**1,950**	**50**	**35**	**73,167**	**200**	**5,577**

Notes for Table 5.4-1.

N/A = Not available.

[a] The following covered activities and associated federal actions (listed here by the header/category as described in Chapter 4, *Covered Activities and Associated Federal Actions*) are assumed not to have footprint impacts on natural communities or species habitat: Operations and Maintenance of Existing SWP Facilities; Power Generation Water Use - Mirant Delta, LLC activities; Activities to Reduce Contaminants; Activities to Reduce Predators and Other Sources of Direct Mortality; Monitoring and Research Programs; Emergency Actions; CVP Operations and Maintenance; and Joint Federal and Nonfederal Actions.

[b] Existing acreage of natural communities and acreage of natural community loss are estimated using models created from detailed vegetation mapping, See Chapter 2, Section 2.3, *Existing Ecological Conditions*, for a complete description of mapping methods. Effects on natural communities will be tracked during implementation through on-the-ground surveys performed by qualified biologists.

[c] See Table 5.J-1, *Quantitative Effects Analysis Methods and Assumptions*, in Appendix 5.J, for a description methods and assumptions relevant to estimating natural community loss by covered activity type.

[d] Permanent and temporary effects assessed under *CM1 Water Facilities and Operation* are associated with construction of the following conveyance-related facilities: forebay, intake facilities, permanent access roads, shaft locations, and transmission lines. See Chapter 4, Section 4.2.1.1, *4.2.1.1. North Delta Diversions Construction and Operations*, for a complete description of all activities assessed under CM1.

[e] Current proposed transmission line alignment extends outside the Plan Area, although final alignment is unknown. Acreage loss associated with transmission line construction outside the Plan Area is included in this column. Plan Area will be adjusted if needed for final plan when transmission line alignment is further designed.

[f] This represents the maximum area potentially necessary for storing reusable tunnel material. This material will likely be moved to other sites for use in levee build-up and restoration, and the affected area will likely be restored. While this effect is categorized as permanent, because there is no assurance that the material will eventually be moved, the effect will likely be temporary. Furthermore, the amount of storage area needed for reusable tunnel material is flexible (based on height of storage piles and other factors) and the footprint used in the effects analysis is based on a worst case scenario: the actual area to be affected by reusable tunnel material storage will likely be less than the estimated acreage.

[g] A borrow area is a location from where construction material, such as sand or clay, will be taken. A spoil area is where construction by-products, such as removed earth, will be placed and stored. A borrow/spoil area is an area that will originally be used for borrow and then later be used for spoil. While these impacts are considered temporary, because affected lands will be restored when conveyance facility construction is complete, for the purposes of determining net effects, impacts are considered permanent.

[h] Permanent and temporary effects assessed under *CM2 Yolo Bypass Fisheries Enhancement* include activities associated with Fremont Weir improvements, Putah Creek realignment activities, Lisbon weir and fish crossing improvements, and Sacramento Weir improvements.

[i] Inundation: Tidal flooding of existing wetland habitat as a result of tidal restoration actions. Inundation can cause permanent loss of habitat from either the removal of habitat or the conversion of one habitat type to another. See Table 5.J-1, *Quantitative Effects Analysis Methods and Assumptions*, in Appendix 5.J, for a description of relevant assumptions. All construction is assumed to occur within the inundation footprint.

[j] Permanent loss calculations are based on hypothetical tidal restoration designs and include those areas modeled by ESAPWA (Appendix 3.B, *BDCP Tidal Habitat Evolution Assessment*) to be below extreme high water elevation. See Table 5.J-1 (Appendix 5.J) for methods and assumptions used to apply the hypothetical footprint to determine effects.

[k] Tidal restoration is expected to include riparian restoration where elevations are favorable. Permanent loss from riparian restoration was determined by non-GIS methods. See Table 5.J-1 (Appendix 5.J) for a complete list of methods and assumptions.

[l] Calculation of effects based on hypothetical floodplain restoration designs. See Table 5.J-1 (Appendix 5.J) for details.

[m] Based on restoration design assumptions described in Appendix 5.E, *Habitat Restoration*, and the effects analysis assumptions detailed in Table 5.J-1 (Appendix 5.J).

[n] Permanent loss was determined based on non-GIS methods described in Table 5.J-1 (Appendix 5.J).

[o] Totals may not sum due to rounding.

[p] Tidal mudflat features were not mapped in the BDCP vegetation layer.

[q] Effects on tidal wetland communities are based on hypothetical tidal restoration designs and include those areas modeled by ESAPWA (Appendix 3.B, *BDCP Tidal Habitat Evolution Assessment*) to be below MLLW in Suisun and MLLW + 1 ft. in the rest of the Delta. See Table 5.J-1 (Appendix 5.J) for methods and assumptions used to apply the hypothetical footprint to determine effects.

[r] Loss reduced to zero. Although the temporary powerline footprint overlaps 2 acres of alkali seasonal wetland complex and 16 acres of vernal pool complex in Conservation Zone 8, AMM30 requires that wetted acres of alkali seasonal wetlands and vernal pools be avoided during temporary powerline installation.

[s] Of the 11,284 acres of vernal pool complex natural community, 2,576 acres are considered “degraded”. Of the original (some impacts subsequently reduced, see table notes r and t) 15 acres of permanent loss (CM1), 16 acres of temporary loss (CM1), and 372 acres of permanent loss (CM4), 7 acres, 2 acres, and 370 acres of loss are to degraded vernal pool complex, respectively.

[t] Total permanent loss reduced from 372 acres (CM4) to 52 acres. This reduction is based on a 10-acre cap for total loss of wetted acres, assuming 15% density of vernal pools in the area affected. Acreage of vernal pool complex loss may be higher if actual vernal pool density is lower. The maximum acreage loss is based on loss of wetted acres and not total vernal pool complex acreage.

1 **Table 5.4-2. Periodic Effects on Natural Communities**

Natural Community	Total Existing in Plan Area	Comparison of Periodic Effect for Different Flow Regimes[a]							Seasonally Inundated Floodplain
		1,000 cfs[b]	2,000 cfs[c]	3,000 cfs[d]	4,000 cfs[e]	5,000 cfs[f]	6,000 cfs (A)[g]	6,000 cfs (B)[h]	
Tidal perennial aquatic	86,263	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Tidal brackish emergent wetland	8,501	0	0	0	0	0	0	0	0
Tidal freshwater emergent wetland	8,856	24	46	52	58	28	31	28	3
Valley/foothill riparian	17,644	72	89	81	92	74	78	51	266
Nontidal freshwater perennial emergent wetland	1,385	6	7	7	7	7	8	8	8
Nontidal perennial aquatic	5,489	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Alkali seasonal wetland complex	3,723	264	574	662	744	504	554	338	0
Vernal pool complex	11,284					0	0	4	0
Managed wetland	70,698	966	2,070	2,321	2,612	1,407	1,510	931	6
Other natural seasonal wetland	276								2
Grassland	76,315	385	783	1,072	1,277	1,076	1,193	779	514
Inland dune scrub	19								0
Cultivated lands	481,909	2,894	3,767	4,097	4,911	4,442	5,100	3,908	8,915
Developed	90,278								360
Total	**772,363**	**4,612**	**7,335**	**8,292**	**9,699**	**7,540**	**8,475**	**6,046**	**9,714**

[a] These columns provide effects comparisons for seven flow regimes. See Table 5.J-1, *Quantitative Effects Analysis Methods and Assumptions*, in Appendix 5.J, for a description methods and assumptions relevant to assessing periodic effects.

[b] Notch flow = 1,000 cfs; existing flow = 2,170 cfs; and proposed flow =3,170 cfs.

[c] Notch flow = 2,000 cfs; existing flow = 2,647 cfs; and proposed flow = 4,647 cfs.

[d] Notch flow = 3,000 cfs; existing flow = 3,073 cfs; and proposed flow = 6, 073 cfs.

[e] Notch flow = 4,000 cfs; existing flow = 2,976 cfs; and proposed flow = 6,976 cfs.

[f] Notch flow = 5,000 cfs; existing flow = 4,393 cfs; and proposed flow = 9,343 cfs.

[g] Notch flow = 6,000 cfs; existing flow = 4,037 cfs; and proposed flow = 10,037 cfs.

[h] Notch flow = 6,000 cfs; existing flow = 6,289 cfs; and proposed flow = 12,289 cfs.

Table 5.4-3. Net Effects of BDCP Implementation on Natural Communities

	Existing Condition		Long-Term Loss or Conversion			BDCP Conservation		Net Effect of BDCP Implementation					
								Extent Modeled			Extent Protected		
Natural Community	Total Extent in Plan Area (acres)[a]	Existing Conservation Lands (acres)[b]	Permanent (acres)[c]	Temporary (Borrow and Spoil) (acres)[c,d]	Permanent Protected (acres)[b,c]	Expected Restoration (acres)[e]	Expected Protection (acres)[e]	Total Extent in the Plan Area (acres)	Net Change in Total Extent in Plan Area (acres)[g]	Percent Change in Total Extent over Existing	Total Protected in the Plan Area (acres)	Net Change in Extent Protected (acres)	Percent Change in Extent of Protected over Existing
Tidal perennial aquatic	86,263	41,260	207	0	186	0	0	86,056	-207	0%	41,074	-186	0%
Tidal mudflat[f]	-	-	-	-	-	-	-	-	-		-	-	-
Tidal brackish emergent wetland[e]	8,501	8,380	1	0	0	6,000	0	14,500	5,999	71%	14,380	6,000	72%
Tidal freshwater emergent wetland[f]	8,856	4,927	13	0	9	24,000	0	32,843	23,987	271%	28,918	23,991	487%
Valley/foothill riparian	17,644	5,508	717	1	531	5,000	750	21,926	4,282	24%	10,727	5,219	95%
Nontidal freshwater perennial emergent wetland	1,385	654	127	0	71	800	25	2,058	673	49%	1,408	754	115%
Nontidal perennial aquatic	5,489	1,424	299	0	95	400	25	5,589	101	2%	1,754	330	23%
Alkali seasonal wetland complex	3,723	2,910	72	0	45	72	150	3,723	0	0%	3,087	177	6%
Vernal pool complex	11,284	6,292	67[h]	0	0	67	600	11,284	0	0%	6,959	667	11%
Managed wetland	70,698	64,984	13,778	0	13,556	500	8,100	57,420	-13,278	-19%	60,028	-4,956	-8%
Other natural seasonal wetland	276	227	0	0	0	0	0	276	0	0%	227	0	0%
Grassland	76,315	20,816	2,517	0	1,185	2,000	8,000	75,798	-517	-1%	29,631	8,815	42%
Inland dune scrub	19	14	0	0	0	0	0	19	0	0%	14	0	0%
Cultivated lands	481,909	61,942	55,372	199	6,891	0	48,625	426,338	-55,571	-12%	103,676	41,734	67%
Total	**772,363**	**219,338**	**73,170**	**200**	**22,569**	**38,839**	**66,275**	**737,832**	**-34,531**	**-4%**	**301,884**	**82,545**	**38%**

[a] Acreage of existing natural community and acreage of natural community loss are estimated using models created from detailed vegetation mapping, See Chapter 2, Section 2.3, *Existing Ecological Conditions*, for a complete description of mapping methods. Effects on natural communities will be tracked during implementation through on-the-ground surveys performed by qualified biologists.

[b] Existing conservation lands were categorized into open-space types, defined in Chapter 3, Section 3.2.4.2.2, *Existing Conservation Lands*.

[c] See Table 5.J-1, *Quantitative Effects Analysis Methods and Assumptions*, in Appendix 5.J, for a description methods and assumptions relevant to estimating natural community loss by covered activity type.

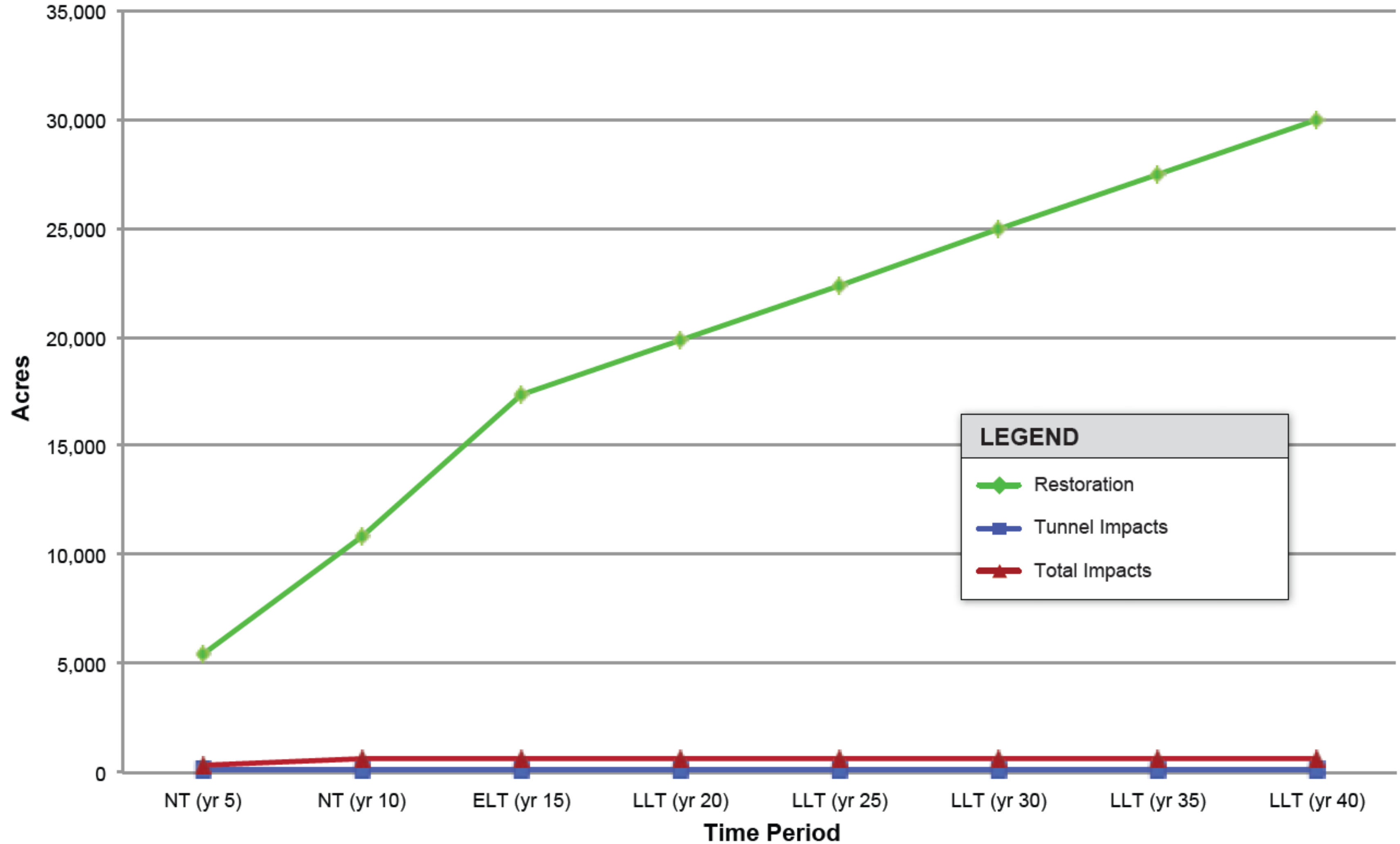
[d] A borrow area is a location from which construction material, such as sand or clay, will be taken. A spoil area is an area where construction by-products, such as removed earth, will be placed and stored. A borrow/spoil area is an area that will originally be used for borrow and later for spoil.

[e] See Appendix 5.J, Attachment 5J.B, *Natural Community Restoration and Protection Contributing to Covered Species Conservation*, for a description of methods used to determine total conservation.

[f] Tidal mudflat features were not mapped in the BDCP vegetation layer.

[g] Temporary borrow and spoil impacts are included, because they are considered permanent for the purposes of assessing net effects.

[h] Permanent loss reduced from 15 acres (CM1) and 370 acres (CM4) to 3 acres and 64 acres, respectively. This reduction is based on a 10-acre cap for loss of wetted acres, assuming 15% density of vernal pools in the area affected. Acreage loss was distributed proportionally between CM1 and CM4, because they have potential to overlap with vernal pool complexes. Acreage of vernal pool complex loss may be higher if actual vernal pool density is lower. The maximum acreage loss is based on loss of wetted acres and not total vernal pool complex acreage.



Notes:

Assume that impacts are evenly distributed within each time period.

Impacts are permanent impacts calculated for tidal perennial aquatic, tidal brackish emergent wetland, and tidal freshwater emergent wetland.

Restoration acreage includes minimum acreage for tidal brackish emergent wetlands and tidal freshwater emergent wetlands only. This and additional restoration and protection of tidal natural communities and transitional uplands will total 65,000 acres.

Graphics...BDCP HCP (created 11/3/10) (Rev. 9/6/13 TM)

Figure 5.4-1
Tidal Natural Communities Restoration versus Permanent Impacts

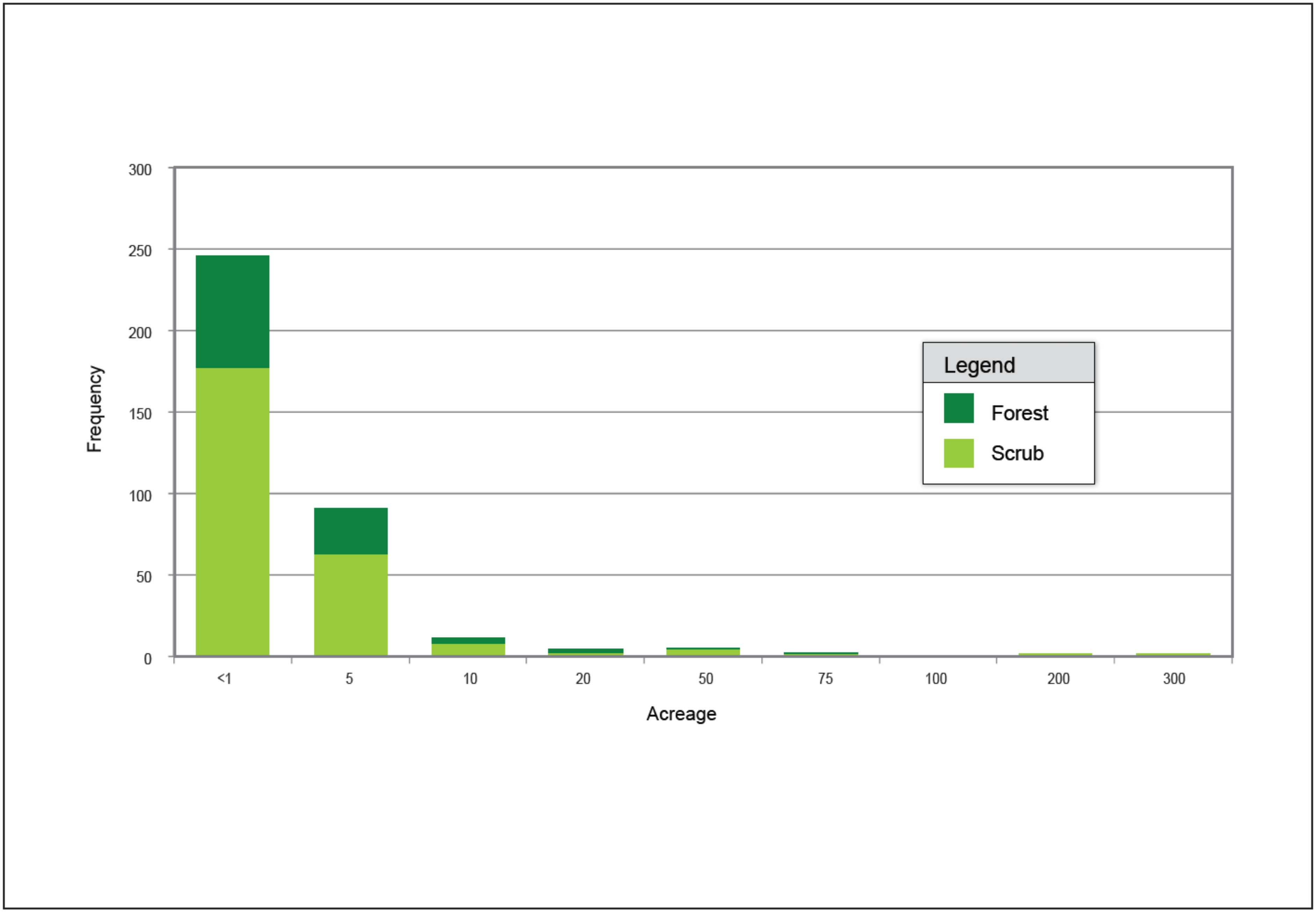
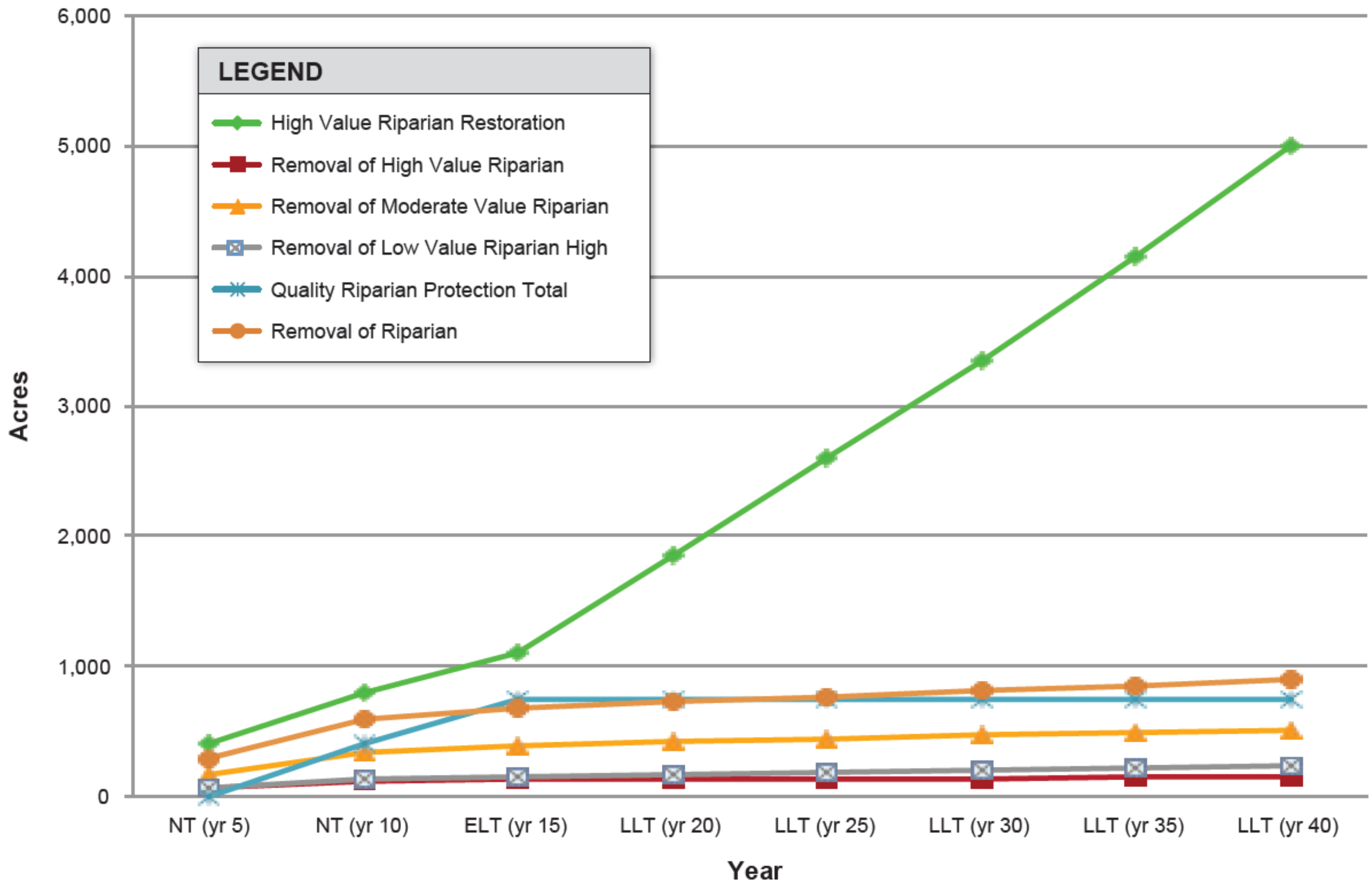


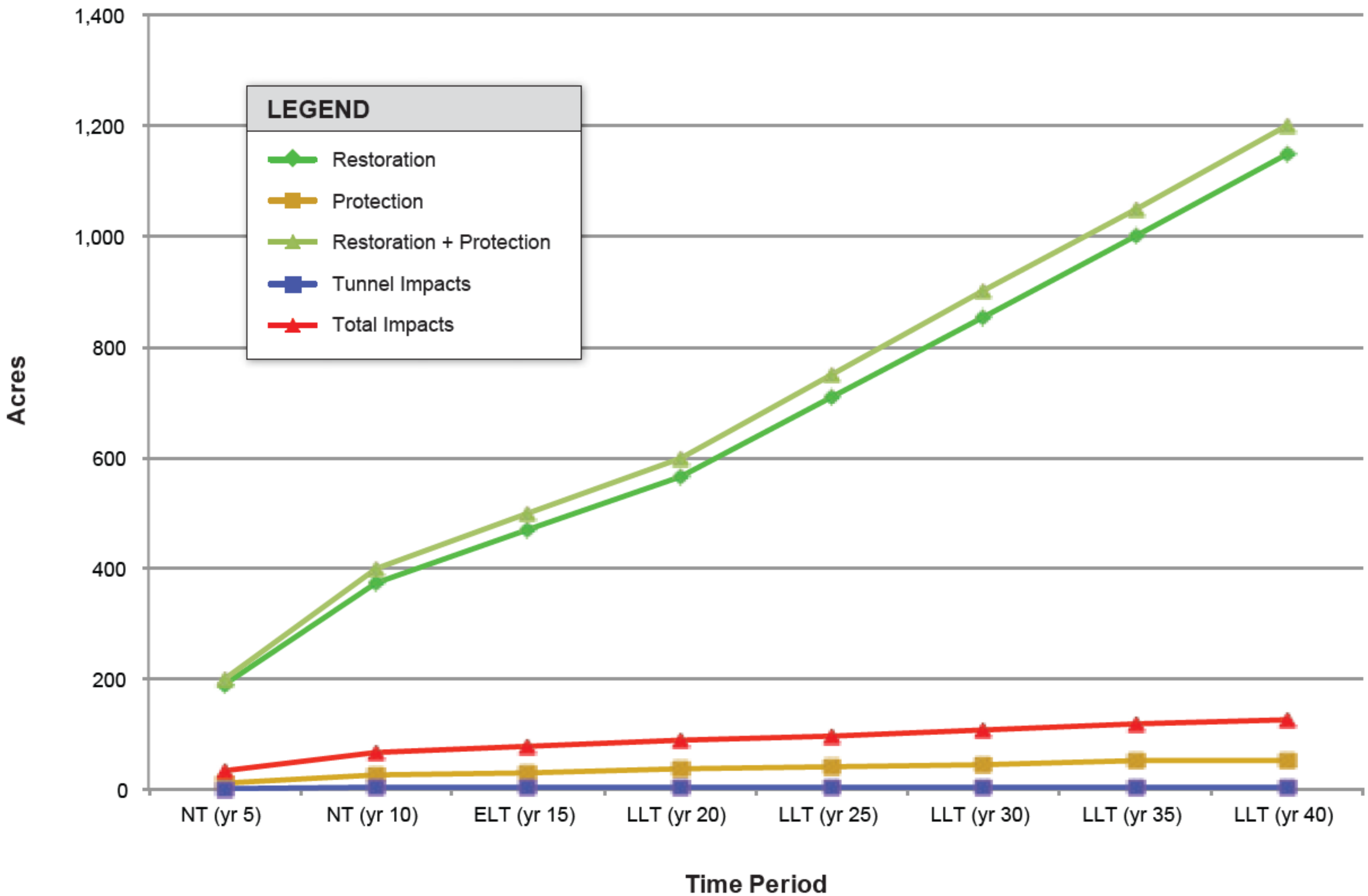
Figure 5.4-2
Size Distribution of Affected Riparian Forest and Scrub Polygons

Graphics.../BDCP Other Chapters (created 11/3/10 SAIC) (Rev. 11/13/12 TM)



Notes: Assume that impacts are evenly distributed within each time period.
Impacts are permanent impacts calculated for valley foothill riparian.

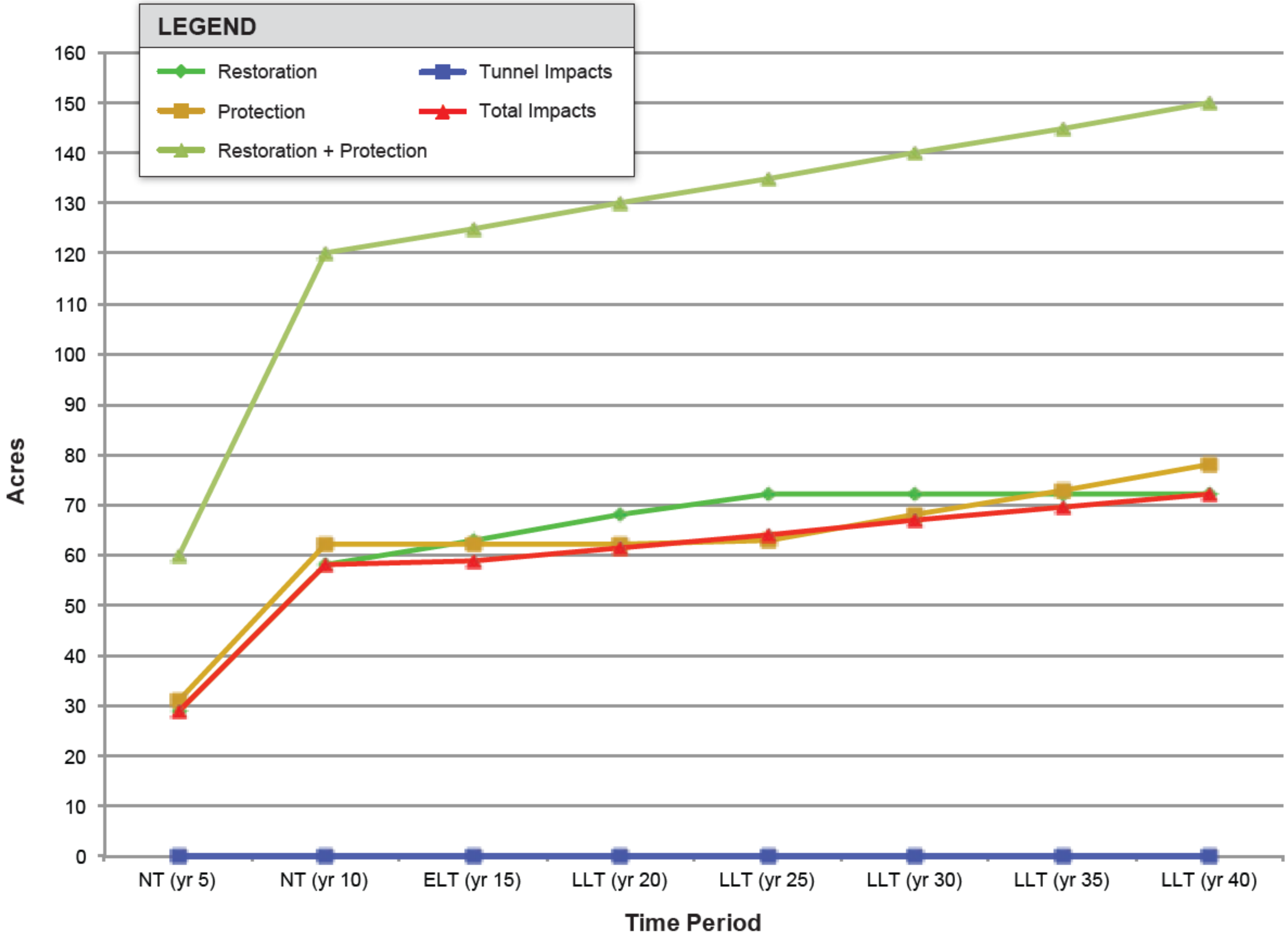
Figure 5.4-3
Cumulative Riparian Restoration and Protection versus Cumulative Permanent Removal



Notes: Assume that impacts are evenly distributed within each time period.
Impacts are permanent impacts calculated for nontidal permanent freshwater emergent wetland.

Graphics.../BDCP Other Chapters/SAIC Nov 2010 (created 11/3/10) (Rev. 8/30/13 TM)

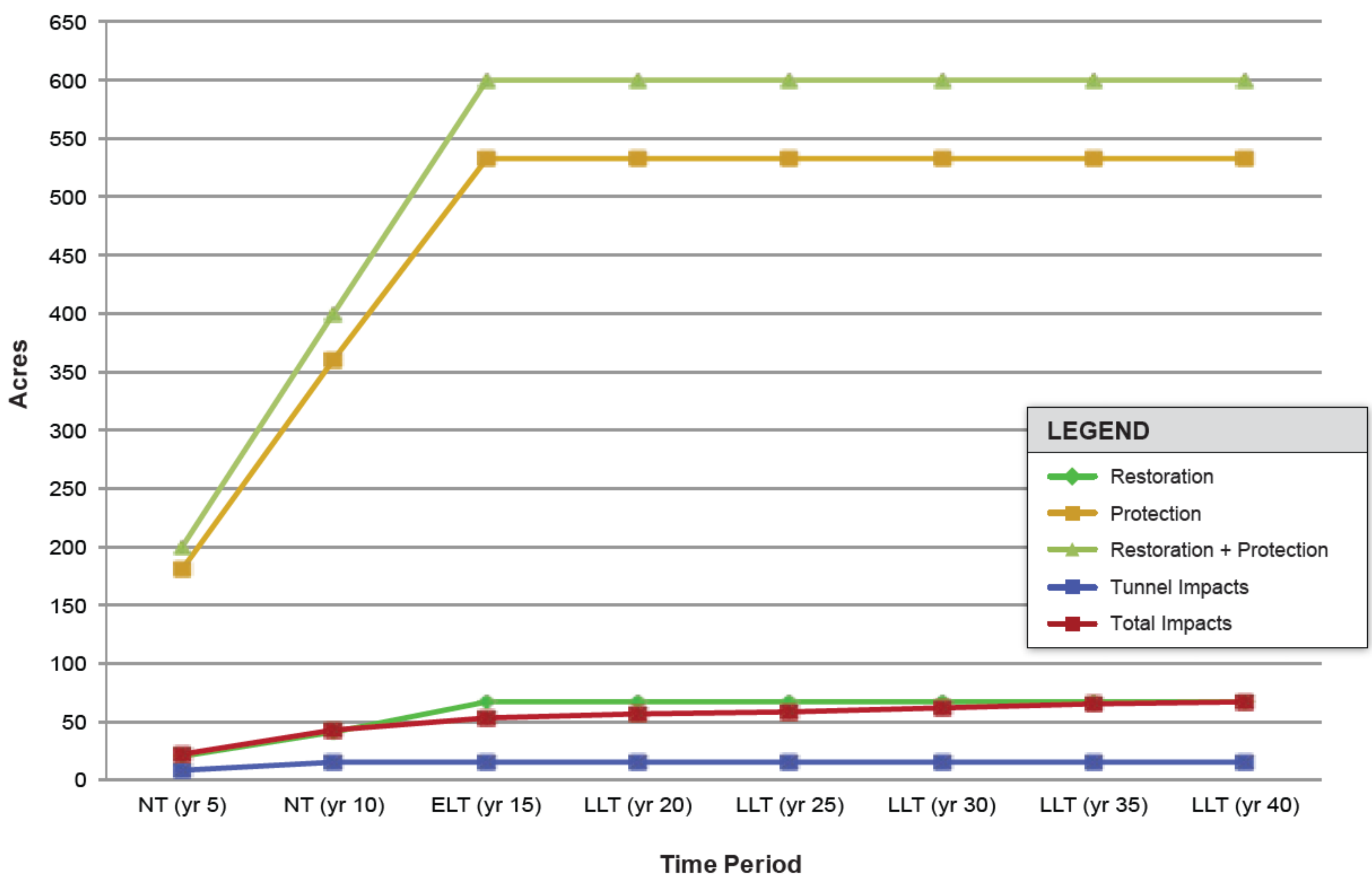
Figure 5.4-4
Nontidal Marsh Natural Community Restoration and Protection versus Permanent Impacts



Notes: Assume that impacts are evenly distributed within each time period.
Impacts are permanent impacts calculated for alkali seasonal wetland complex.

Graphics.../BDCP Other Chapters/SAIC Nov 2010 (created 11/3/10) (Rev. 8/30/13 TM)

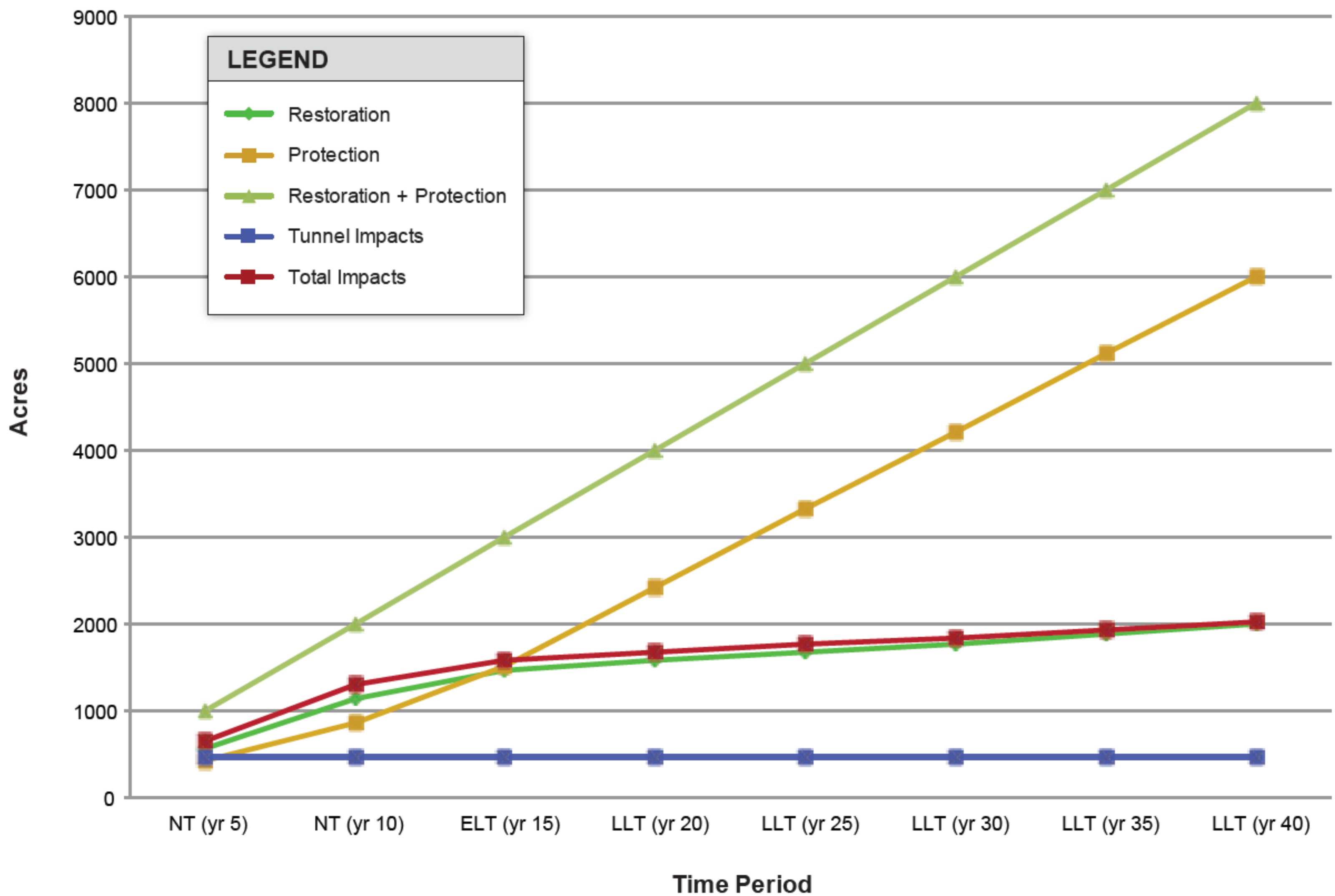
Figure 5.4-5
Alkali Seasonal Wetland Natural Community Restoration and Protection versus Permanent Impacts



Notes: Assume that impacts are evenly distributed within each time period.
Impacts are permanent impacts calculated for vernal pool complex.
An estimated 1 acre of vernal pool complex will be lost based on the hypothe ical tidal restoration footprint. An additional estimated 371 acres of degraded vernal pool complex will be lost based on the hypothetical footprint, but degraded vernal pool complex is categorized under the grassland natural community rather than the vernal pool complex natural community. During implementation, avoidance will be required so that no more than 10 wetted acres of vernal pools will be removed, and vernal pools will be restored to accomplish no net loss of wetted vernal pool acres.

Graphics... BDCP HCP (created 11/3/10) (Rev. 9/6/13 TM)

Figure 5.4-6
Vernal Pool Complex Natural Community Restoration and Protection versus Permanent Impacts



Notes: Assume that impacts are evenly distributed within each time period.
Impacts are permanent impacts calculated for grassland.

Figure 5.4-7
Grassland Natural Community Restoration and Protection versus Permanent Impacts

5.5 Effects on Covered Fish

This section describes the net effects of the BDCP on each covered fish species. The net effects analysis is based on consideration of the importance of different environmental attributes (stressors) and potential change to these attributes because of the BDCP. The first step in the attribute ranking approach was to apply a qualitative assessment of the relative importance of different attributes (stressors) to the different life stage of covered fish populations in the Plan Area (and, if relevant, in the broader Study Area for covered fish species occurring in upstream areas that may see changes because of the BDCP). The justification for such an approach is provided in Section 5.2.7.10, *Approach for Determining Net Effects on Fish Species*. Limitations to this approach include challenges in assigning relative importance to attributes independently given their interdependencies. The second step in the stressor ranking process was to form a qualitative conclusion regarding the magnitude of change to an attribute because of the BDCP (zero to very high, either beneficial [positive] or adverse [negative]). The last step in the process was to assess the effects of the BDCP by considering the magnitude of change concluded to occur to the attribute because of the BDCP in light of the importance of the attribute. This process is described further below. The level of certainty associated with assumptions of importance and the conclusions regarding change was also qualitatively scaled from low to very high.

For each environmental attribute discussed in the analysis of effects of the BDCP on covered fish species, the importance assumed for the attribute and the change in the attribute concluded to result from the BDCP were converted into numeric ranks (scores) based on the following scale: no importance or no change = 0; low importance or low change = 1 (or -1 for negative changes); medium (moderate) importance or medium (moderate) change = 2 (or -2 for negative changes); high importance or high change = 3 (or -3 for negative changes); critical importance or very high change = 4 (or -4 for negative changes). Attribute importance and change scores were then multiplied together to derive an effect score for each attribute within each life stage of each species. The numeric effect score values thus derived were then transformed back to a qualitative scale based on the following conversion scale: 0 = zero, 1 = very low, 2-3 = low, 4-8 = moderate (medium), 9-15 = high, and 16 = very high. The break-points for this scale are based on consideration of the combination of importance and change. For example, an attribute with high importance (score = 3) and high positive change (score = 3) was assumed to result in a high positive effect (3 × 3 = 9). Similarly, an attribute with medium (moderate) importance (score = 2) and medium (moderate) change (score = 2) was assumed to result in a moderate positive effect (2 × 2 = 4). A low negative change (score = -1) for an attribute of critical importance (score = 4) would result in a moderate negative effect (-1 × 4 = -4). Achievement of a very high positive effect would be the result of a very high positive change to a critically important attribute. Conclusions about the certainty of the effect of the BDCP's changes to environmental attributes were derived in the same manner as the conclusions about the effect of the BDCP, i.e., by converting certainty conclusions for attribute importance and change to numeric ranks, multiplying them together, and then converting back to a qualitative scale; the only difference was that there was no 'very low' certainty category, this instead being part of the low certainty category.

Conclusions regarding the current importance of different environmental attributes to the covered fish species and the changes to each attribute because of BDCP are based on the analyses presented below and in the various technical appendices referenced below. A series of agency workshops was conducted in August 2013 that allowed biologists from USFWS, NMFS, CDFW, DWR, and Reclamation to provide their opinion and rationale for attribute importance and attribute change because of BDCP. The comments received at the workshops were based on the assumptions of the high-outflow scenario (HOS). Where agency workshop comments differed appreciably from ICF's conclusions, these are described in the text below; otherwise, if not explicitly referred to below, it can be assumed that agency comments generally were consistent with ICF's conclusions. The analyses below account for potential differences in outcomes that may arise because of the agency biologist focus on the high-outflow scenario.

5.5.1 Delta Smelt

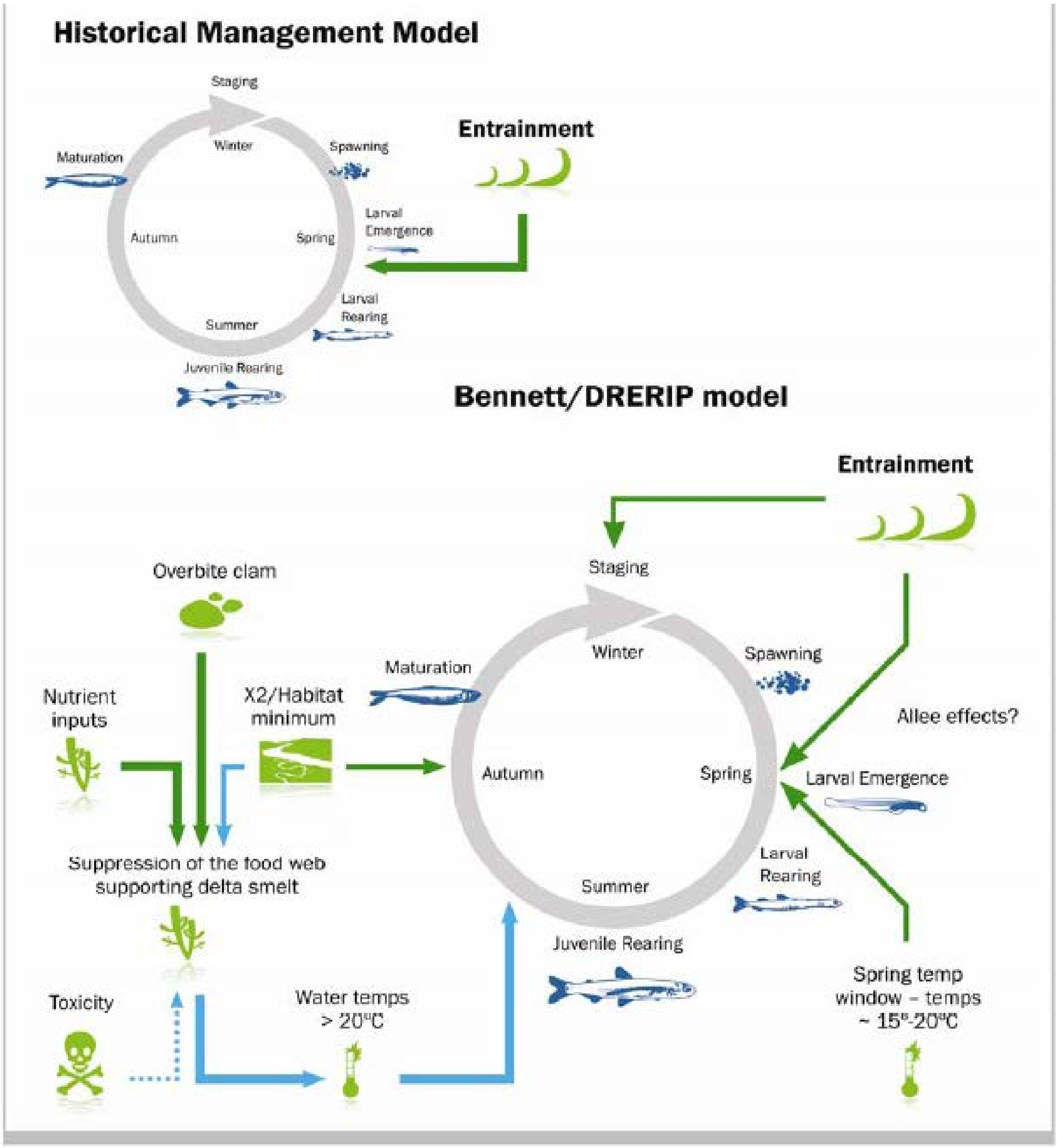
The delta smelt (*Hypomesus transpacificus*) is a small (typically 60 to 70 millimeters [mm] standard length), translucent fish endemic to the San Francisco estuary (Moyle 2002). The species is distributed throughout the Plan Area, although occurrence in the Yolo Bypass is limited to the lower reaches of the Toe Drain (Sommer et al. 2001a) and delta smelt do not occur on floodplains (Nobriga and Herbold 2009). Delta smelt also occurs outside the Plan Area in the Napa and Petaluma Rivers and occasionally upstream in the Sacramento River. Delta smelt relative abundance declined in the early 1980s, increased somewhat in the 1990s, and then dropped to record lows in the 2000s (Thomson et al. 2010). The species is listed under the ESA and the California Endangered Species Act (CESA). The life cycle of delta smelt generally spans a single year that ends with spawning in the early spring, although a small proportion of the population survives to spawn a second time (Bennett 2005). The delta smelt life history is described as diadromous by Sommer et al. (2011), reflecting the general pattern of spawning during spring in freshwater areas followed by juvenile migration to turbid, open-water, low-salinity areas of the Plan Area to feed and mature in the summer and fall. Evidence suggests that delta smelt are present in some subregions of the Plan Area year-round (e.g., Cache Slough) (Sommer et al. 2011). It is unclear if this represents the same individuals remaining in the same subregion throughout their lives. Genetic analyses demonstrate that the species is a single panmictic population without distinct subpopulations (Fisch et al. 2011). A detailed species account of delta smelt is presented in Appendix 2.A, *Covered Species Accounts*.

A decision tree is applied in the BDCP to use science developed prior to the implementation of *CM1 Water Facilities and Operation* to determine initial operations for fall outflow for delta smelt (See Chapter 3, Section 3.4.1.4.4, *Decision Trees*, for additional information). For delta smelt, the decision tree is focused on the need for management of fall outflows to achieve the Fall X2 requirement of the USFWS (2008a) BiOp. This effects analysis considered the effects of operations with and without implementation of the Fall X2 provisions, as described below and in Appendices 5.B through 5.F.

As described in Section 5.2.7.10, *Approach for Determining Net Effects on Fish Species*, the net effects methodology employed here for delta smelt uses two complementary approaches, attribute (stressor) rankings and conceptual models. Both approaches were used, because each has limitations that can be overcome to some degree by the other approach. In addition, if the results from each approach were similar or the same, they provide corroborating evidence for the net effects.

Conceptual models of delta smelt are also used to assess net effects. These conceptual models describe the primary environmental attributes thought to affect the species. The conceptual models are used in the net effects analysis to assess the extent to which the BDCP affects important elements in the conceptual models. The main elements of these conceptual models are presented below. The models have evolved over time, incorporating new science and information. The effects analysis attempts to capture this evolution and the best available information to date.

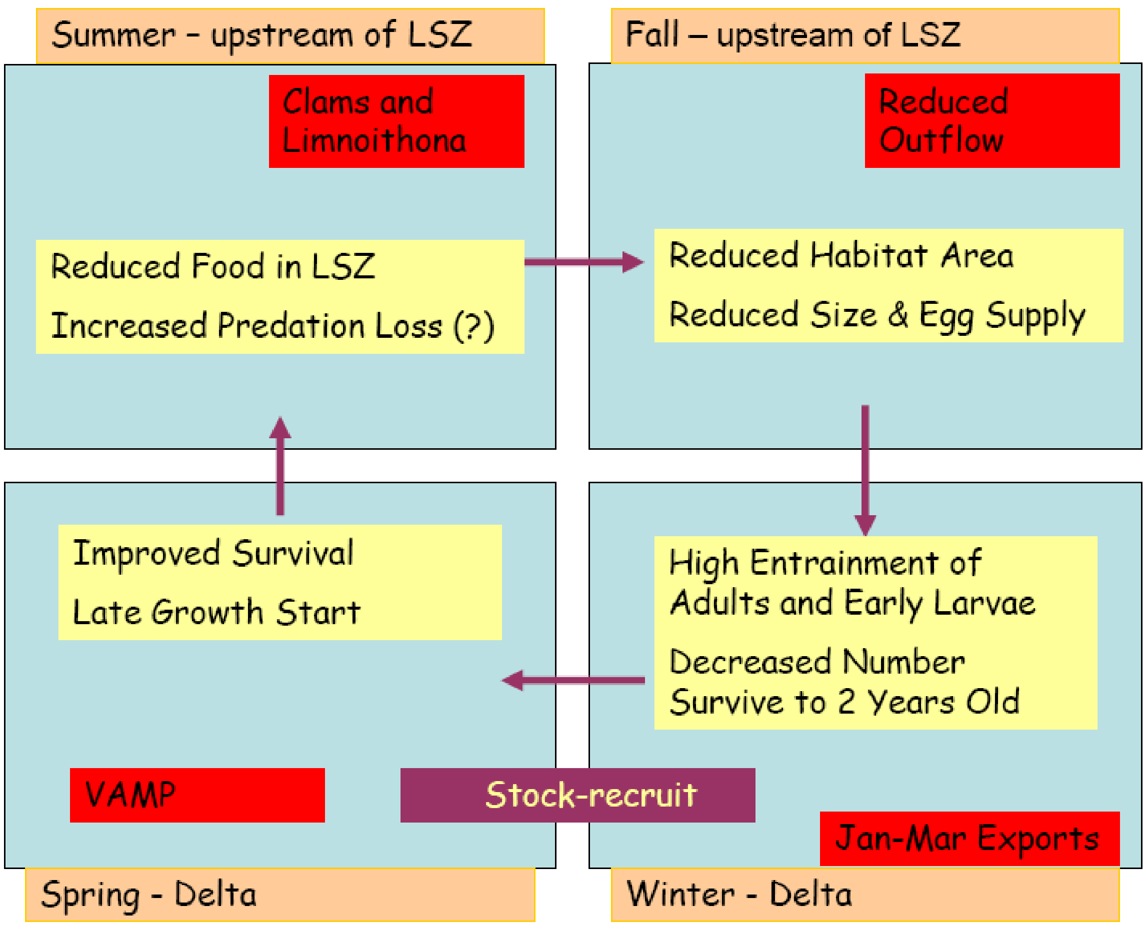
Nobriga and Herbold's (2009) DRERIP conceptual model for delta smelt was nearly identical to the model presented in the USFWS (2008a:146) BiOp. Nobriga and Herbold (2009) included a "simplest plausible model" that was contrasted with what they considered to be the historical management model (Figure 5.5.1-1). These diagrams depict the sequential nature of stressors on the delta smelt population and the greater awareness of multiple stressor hypotheses proposed by Bennett and Moyle (1996) and Bennett (2005). The historical management model considered entrainment as the main (only) factor, whereas Nobriga and Herbold (2009) followed Bennett (2005) in introducing greater awareness of potential multiple stressors and indirect effects of factors such as nutrient inputs and the overbite clam (*Potamocorbula amurensis*) suppressing the foodweb during the juvenile rearing period, with this rearing period being affected by the extent of low-salinity zone habitat. In their simplest plausible model, Nobriga and Herbold (2009) also introduced the concept of potential Allee effects at low population size, i.e., a reduction in per capita reproductive output driven by factors such as insufficient males to fertilize female eggs, which could in turn lead to inbreeding and genetic drift. Note that Nobriga and Herbold (2009) also discussed other themes not explicitly characterized in the simplest plausible model such as spawning timing, which were more explicitly included in the conceptual model by Baxter et al. (2010), discussed next.



Source: Nobriga and Herbold 2009.

Figure 5.5.1-1. Conceptual Diagrams Contrasting the Historical (Pre-2000) Model of Delta Smelt Management with the Simplest Plausible Model for the DRERIP

The Baxter et al. (2010) delta smelt conceptual model (Figure 5.5.1-2) was provided as part of the updated Pelagic Organism Decline (POD) study plan and synthesis report. As such, the model has a major focus on addressing potential mechanisms underlying the delta smelt decrease in abundance during the POD. Building on earlier models and subsequent studies, the Baxter et al. (2010) model contains various elements common to the Bennett (2005) and Nobriga and Herbold (2009) conceptual models. The model characterized winter/spring entrainment of adults and early larvae as an important factor in some years, with the probability of survival to age 2 being reduced. The potential importance of the Vernalis Adaptive Management Program's (VAMP) spring San Joaquin River flow pulses and reduced exports was expressed in the conceptual model as resulting in improved survival of later spawned larvae relative to early larvae; early larvae would be more susceptible to entrainment loss, whereas late larvae would have had less time to grow. Baxter et al. (2010) hypothesized that this late growth start, coupled with relatively low summer food quantity (*Potamocorbula* and nonnative jellyfish consumption) and food quality (less nutritious zooplankton such as *Limnoithona*) as well as reduced extent of low-salinity zone abiotic habitat, would result in poorer survival and smaller adult fish at the end of summer/fall. Smaller, less abundant delta smelt would then produce fewer offspring the following spring.



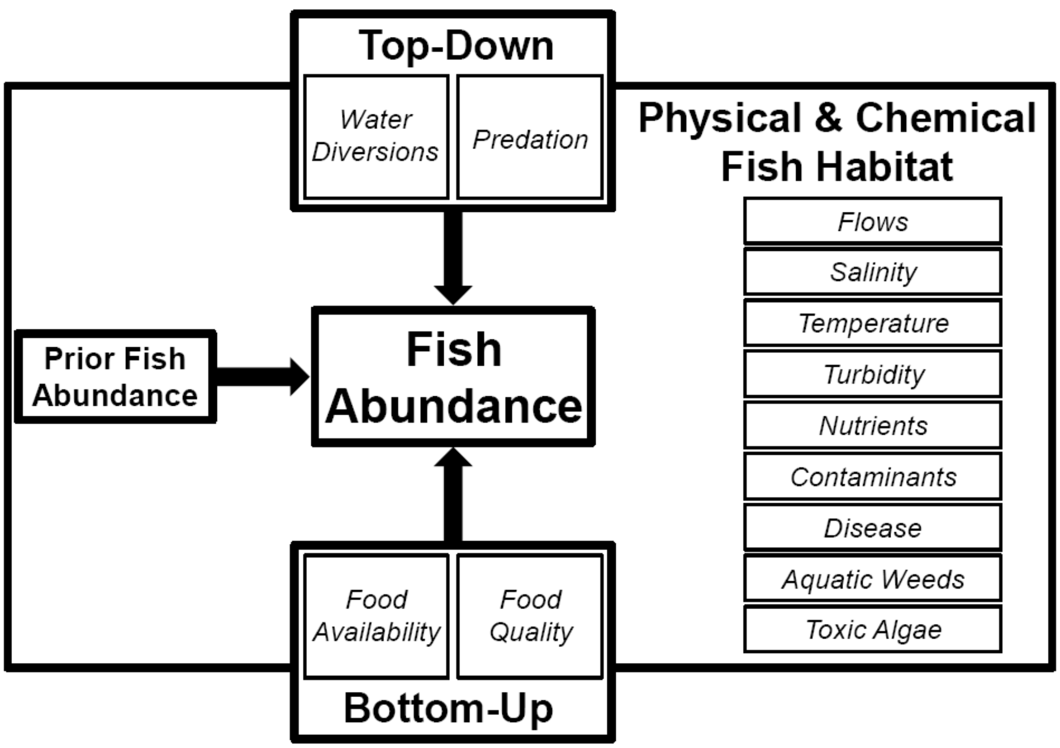
Source: Baxter et al. 2010.

Figure 5.5.1-2. Delta Smelt Species Model

Underlying the Baxter et al. (2010) delta smelt conceptual model is the basic conceptual model for the POD (Sommer et al. 2007 as updated by Baxter et al. 2010). This posits that fish abundance in a given generation is a function of top-down effects (predation and entrainment influencing mortality rate), bottom-up effects (food quantity and quality influencing growth and survival), and fish abundance in previous generations (stock-recruitment relationships), with habitat quantity and quality overlapping all other factors (Figure 5.5.1-3). A contrasting conceptual model was provided by Glibert et al. (2011), wherein ecological stoichiometry—primarily consideration of nutrient (nitrogen:phosphorus) ratios in this context—was offered as the explanation for changes leading up to the POD. Glibert et al. (2011) suggested that some of the same elements of the POD conceptual model of Sommer et al. (2007) were linked and sequential. The Glibert et al. (2011) conceptual model held that nutrient changes (primarily increased ammonium loading and decreased phosphate loading from wastewater effluent) triggered changes in the foodweb supporting pelagic fish such as delta smelt. Biogeochemical changes followed, leading to greater propensity for colonization by invasive macrophytes (Brazilian waterweed [*Egeria densa*]), zooplankton, and bivalves (*Potamocorbula*). Then came increases in piscivores and *Microcystis* because of their ability to sequester phosphorus, with planktivorous fish such as delta smelt being relatively poor at sequestering phosphorus and thereby declining in abundance. These changes culminated in greater susceptibility of planktivorous fishes to stressors such as food limitation and predation (Figure 5.5.1-4). Although the conceptual models of Baxter et al. (2010) and Glibert et al. (2011) differ, the importance of multiple stressors (attributes) is common to both. In a precursor to the broader work by Glibert et al. (2011), Glibert (2010:229) concluded the following.

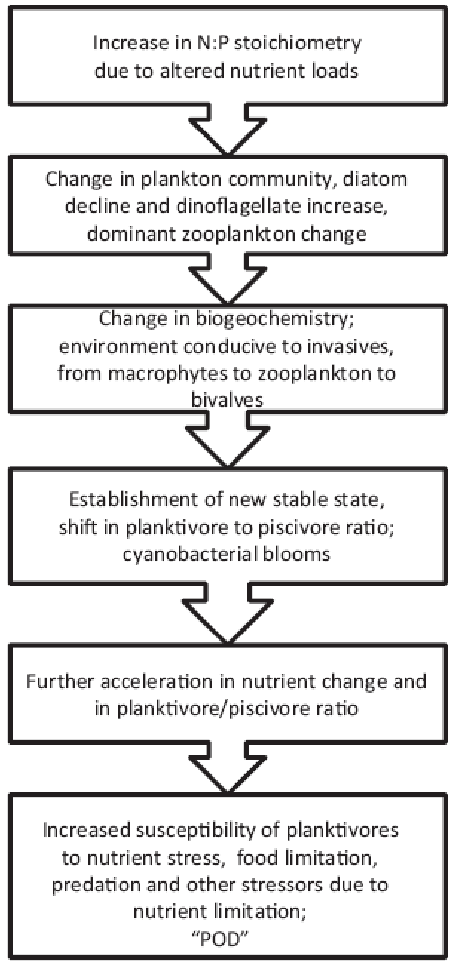
> [A] clear management strategy is the regulation of effluent N discharge through nitrification and denitrification. Until such reductions occur, other measures, including regulation of water pumping or manipulations of salinity, as has been the current strategy, will likely show little beneficial effect.

This suggests recognition that other attributes (stressors) such as entrainment may also be of importance, albeit secondary importance, according to Glibert (2010).



Source: Updated from Sommer et al. 2007; sourced from Baxter et al. 2010.

Figure 5.5.1-3. Basic Conceptual Model of Pelagic Organism Decline



Source: Glibert et al. 2011.

Figure 5.5.1-4. Conceptual Model of Pelagic Organism Decline Based on Ecological Stoichiometry

5.5.1.1 Beneficial Effects

5.5.1.1.1 Restored Tidal Habitat

Restoration of tidal natural communities (CM4) will substantially increase the amount of tidal natural communities in the Plan Area, mostly in the Cache Slough and Suisun Marsh subregions, substantially increasing suitable habitat for delta smelt early life stages and with the potential to increase food for local consumption and export to open-estuary areas.

Loss of tidal wetlands in the Delta is the most obvious and pervasive change that has occurred as a result of development (Kimmerer 2004; BDCP Science Advisors 2007). *CM4 Tidal Natural Communities Restoration* calls for restoration of 65,000 acres of tidal natural communities and uplands to accommodate sea level rise (Appendix 5.E, *Habitat Restoration*, Section 5.E.4, *Conservation Measure 4 Tidal Natural Communities Restoration*). These actions are anticipated to substantially increase intertidal and subtidal habitat in the Plan Area. The degree to which the current extent of intertidal and subtidal habitat limits delta smelt population performance in terms of provision of suitable habitat space for occupancy and ecosystem services such as food production is uncertain. Considerable loss of tidal marshes occurred prior to the major population decline in delta smelt, which has only been monitored over the last five or six decades. Delta smelt were comparatively rare when routine monitoring started (Nobriga and Herbold 2009). Therefore, the effect of large-scale landscape conversion on delta smelt was not observed and is unknown. However, it is reasonable to think that such a large degree of change to the San Francisco Estuary landscape could have deteriorated elements of habitat suitability including food production and transfer to open-water habitats (Bennett 2005; Feyrer et al. 2007, 2011; Bennett et al. 2008; Nobriga et al. 2008; Baxter et al. 2010; Mac Nally et al. 2010; Thomson et al. 2010; Maunder and Deriso 2011; Miller et al. 2012). Further discussion related to the importance of tidal habitat in terms of extent and location of the low-salinity zone and provision of food is provided in Section 5.5.1.1.2, *Fall X2 Decision-Tree Process*, as it pertains to juvenile delta smelt and the Fall X2 decision tree.

Delta smelt have been found across a wide range of habitats, including primarily open-water areas (e.g., Moyle 2002), with small numbers also found in other habitats such as intertidal marsh channels (Gewant and Bollens 2012). It is likely that habitat characteristics within tidal habitat (e.g., tidal excursion, velocity, temperature, food, and turbidity) influence their use by delta smelt and that channel width itself is not a constraint (Sommer and Mejia 2013), although it is recognized that channel width correlates with other habitat characteristics such as water depth that may be of more importance to delta smelt as a mostly open-water species. The analysis included in this section focuses on life stages of delta smelt other than juveniles, for which the analysis of tidal habitat and food benefits is included in Section 5.5.1.1.2, because it has relevance for the Fall X2 decision tree.

In the present analysis, tidal habitat extent is considered in terms of the importance of the extent of intertidal and subtidal habitat suitable for occupancy by delta smelt, considering both landscape features (e.g., water depth) and physicochemical characteristics (e.g., salinity). Adult delta smelt probably hold in spawning areas for at least a month after moving upstream before spawning (Sommer et al. 2011). It was assumed with low certainty that intertidal habitat is unimportant for this life stage, other than for the spawning function expressed in the importance to the egg life stage, because the life stage is primarily migratory. This was in accordance with sentiments expressed by agency biologists during the August 2013 workshops. Spawning habitat for delta smelt in the wild is unknown but, if similar to other smelts, may consist of sandy beaches (Bennett 2005:17). The extent to which the current extent of spawning habitat may limit the species is unknown, although Miller et al. (2012:18) suggested that density-dependent effects observed as part of historical trends in delta smelt abundance deserve more study and that factors such as quantity of spawning habitat have not been examined. For this effects analysis, it was assumed with low certainty that the extent of intertidal habitat as a current constraint on delta smelt eggs is of moderate importance, primarily reflecting the need to give greater importance for this life stage than for the other life stages while recognizing that the other life stages have some low potential to occur in intertidal areas. This need to attach greater importance of intertidal habitat to the egg life stage than to other life stages reflected agency biologist sentiment during the August 2013 workshops, although it was generally noted by these biologists that low importance of this attribute's physical extent may be warranted for delta smelt eggs, with low certainty. The assumed moderate importance of intertidal habitat for the present analysis also included recognition of concepts expressed by some agency biologists during the August 2013 workshops that the flow-related abiotic characteristics at spawning locations are also of importance, e.g., the extent and location of spawning habitat and its positive relationship with higher Delta outflows may warrant high importance of the extent of spawning (egg) habitat[1]. For this effects analysis, it was assumed with moderate certainty that the subtidal habitat attribute is of low importance as a current constraint on delta smelt eggs; agency biologists during the August 2013 workshops felt that zero or low importance (with low certainty) was warranted. For larval delta smelt, it was assumed with low certainty that intertidal habitat extent has low importance and that subtidal habitat has moderate importance. Low or moderate importance of intertidal habitat was suggested by agency biologists during the August 2013 workshops, with low certainty. The potential importance of subtidal habitat for larval delta smelt suggested diverse opinion between agency biologists, with some suggesting low importance (with high certainty reflecting no evidence of this type of habitat being limiting) and others suggesting critical importance (if the attribute is considered to be the extent of low-salinity zone channel edge habitat). Floodplains were assumed with very high certainty to be unimportant for any life stage, because delta smelt do not occur on floodplains (Nobriga and Herbold 2009:28). In addition, discussions during the agency biologist workshops in August 2013 suggested that channel margin habitat is not important as a current constraint for any delta smelt life stages, because the main areas of channel margin are outside the range of most delta smelt.

Analysis of egg and larval delta smelt habitat extent in the Plan Area, as examined with the habitat suitability analysis (Appendix 5.E, *Habitat Restoration,* Section 5.E.4.4, *Evaluation*), suggests that *CM4 Tidal Natural Communities Restoration* would result in considerably more suitable habitat for delta smelt than currently exists (Appendix 5.E, Section 5.E.4.4.2.4, *Suitability of Restored Habitat for Covered Fish Species*) (Table 5.5.1-1 and Table 5.5.1-2). For egg-larvae[2] and larval delta smelt, the habitat suitability analysis suggests that habitat units (HUs) over the entire Plan Area would increase by approximately 50% under the BDCP compared to existing conditions. Changes in habitat suitability between existing conditions (EBC2) and future conditions without the BDCP (EBC2_LLT) or conditions with the BDCP (ESO_LLT) generally reflected increasing temperature that was assumed to occur because of climate change and regardless of the BDCP. The exception was within Suisun Marsh, for which habitat suitability in the late long-term was slightly lower under the BDCP for egg-larvae because of relatively higher salinity in the Suisun Marsh subregion caused by the tidal prism increasing with proposed BDCP restoration and sea level rise.

[1] During the August 2013 workshops, some agency biologists suggested Plan Area flows to be of importance to the adult or egg life stages in terms of defining the extent and location of spawning habitat. For clarification, the present effects analysis considers Plan Area flows to be an attribute defined by its importance in facilitating broader (e.g., subregion to subregion) migrations and movements of covered fish species within the Plan Area in a manner conducive to relevant life stages' general ecology (e.g., for juvenile salmonids from the Sacramento River region, the magnitude of Sacramento River flow that facilitates downstream migration through the Plan Area). For delta smelt, previous agency biologist comments and comments during the August 2013 workshops on the importance of Plan Area flows for migration and movement suggested that the tidally-facilitated movement exhibited by delta smelt (e.g., at the adult stage, during the migration from downstream rearing areas to upstream spawning areas; Sommer et al. 2011) was not a current constraint on the species; accordingly, for this effects analysis Plan Area flows for migration and movement of the mobile life stages (larvae, juveniles, and adults) were assumed unimportant, with high certainty. For eggs, a sessile life stage, Plan Area flows for migration and movement are not applicable. Related to this, discussion during the agency biologist workshops in August 2013 also suggested importance of Plan Area flows (principally Old and Middle River flows) in terms of entrainment risk—this mechanism is assumed to be captured under the attribute of entrainment at the South Delta export facilities, as discussed further in Section 5.5.1.1.3.

[2] As noted in Appendix 5.E, *Habitat Restoration*, Section 5.E.4.4.1.2, the egg-larvae life stage is immediately post-hatch and represents habitat conditions relevant to spawning and the earliest larval life stage; eggs themselves are quite resistant to variability in environmental parameters, although substrate type may be of importance but was not known for existing conditions or for potential BDCP restoration areas.

The habitat suitability analysis did not attempt to forecast future trends in turbidity, as there is some uncertainty related to future changes, as described in Section 5.5.1.2.1, *Increased Water Clarity*. In the absence of modeling data to inform potential changes in turbidity, the analysis assumed that future turbidity would be similar to existing conditions; however, it is possible that turbidity under the BDCP will change in some areas, with the change possibly being positive in some areas and negative in others (Section 5.5.1.2.1). Coupled with this is the potential for the continuation of a long-term decline in regional suspended sediment that has been observed in the decades leading up to existing conditions (Cloern et al. 2011).

The Cache Slough, Suisun Marsh, Suisun Bay, and West Delta subregions appear to offer the best geographic locations for delta smelt occupancy with respect to the current distribution of the species. Restoration in these areas was estimated to result in approximately 40% more suitable habitat for delta smelt under the BDCP compared to existing conditions. With sea level rise and increasing salinity, occupation of upper-Delta subregions such as Cache Slough by delta smelt may increase, in which case habitat restoration in the Cache Slough and West Delta ROAs will gain importance. The current occupation of the Cache Slough subregion year-round by delta smelt (Sommer et al. 2011) also suggests potential importance of restoration in this area; the extent of suitable habitat in this subregion was estimated to be 2 to 2.5 times greater under the BDCP than under existing conditions for larval and juvenile delta smelt (Table 5.5.1-1 and Table 5.5.1-2). Protection of adjacent upland areas under the BDCP will allow expansion of aquatic habitat as sea level rises. Based on the current delta smelt distribution and environmental changes modeled for the future, it is unlikely that tidal habitat restoration in the South Delta or Cosumnes/Mokelumne ROAs will provide significant habitat benefits for direct occupancy by the delta smelt egg or larval life stages because of relatively high water temperature and water clarity (whereas there may be some food production in these ROAs that could be exported to other areas; see analysis of food benefits below).

Potential changes in delta smelt habitat extent within the Plan Area, as expressed by overall HUs from the habitat suitability analysis, reflect changes in intertidal and subtidal habitat acreage as well as associated habitat quality. Over the whole Plan Area, the total extent of intertidal habitat is estimated to be approximately 24,000 acres under existing conditions, increasing to 28,500 acres because of sea level rise in the future without BDCP (Appendix 5.E, *Habitat Restoration*, Section 5.E.4.4.2.1, *Physical Habitat Extent*). Following BDCP restoration in the late long-term, it is estimated that there would be approximately 56,000 acres of intertidal habitat, a doubling of the extent compared to future conditions without the BDCP. Considering the subregions best aligning with the current distribution of delta smelt (i.e., Suisun Bay, Suisun Marsh, West Delta, and Cache Slough), the existing or future extent of intertidal habitat without the BDCP is estimated to be 19,000 to 20,000 acres, compared to nearly double that in the late long-term with the BDCP (approximately 36,500 acres). Subtidal habitat in these same subregions is estimated to be 53,000 to 54,000 acres under existing conditions or late long-term conditions without the BDCP, compared to over 69,000 acres under the BDCP in the late long-term (Appendix 5.E, Section 5.E.4.4.2.1, *Physical Habitat Extent*).

It is concluded with moderate certainty that, even with some changes in overall tidal habitat suitability, as described above, there would be an overall very high positive change in the intertidal habitat attribute for occupancy by delta smelt eggs and larvae as a result of restoration actions under *CM4 Tidal Natural Communities Restoration*. The certainty level reflects some uncertainty regarding selection of habitat types by delta smelt. Agency biologist opinion from the August 2013 workshops also generally suggested that a conclusion of a very high change in intertidal habitat would be warranted (with moderate to very high certainty related to the ability to restore the physical extent of the habitat), but noted that the function of the restored intertidal habitat for delta smelt may have less to do with direct occupation as opposed to other functions such as production of food (discussed further below for the purposes of this analysis). It is further concluded with moderate certainty that there would be a moderate positive change in subtidal habitat for eggs and larval delta smelt. Limited agency biologist opinion during the August 2013 workshops suggested that low or moderate positive change was appropriate. Use of restored areas by delta smelt will depend on the habitat characteristics within these areas (e.g., the extent of tidal excursion and velocity, temperature, and turbidity) (Sommer and Mejia 2013). There is uncertainty related to how much subtidal restored habitats in particular may be limited in value because of colonization by invasive aquatic vegetation (IAV) (Appendix 5.F, *Biological Stressors on Covered Fish*, Section 5.F.4.2.4, *Predation Risk in Restored Habitats*) and associated nonnative fish species that may prey on delta smelt or compete for food. *CM13 Invasive Aquatic Vegetation Control* aims to control IAV in the ROAs, but there remains uncertainty related to the ability to do so effectively. Issues related to effectiveness of restoration and examples from the Plan Area are described in more detail in of Appendix 5.E, *Habitat Restoration*, Attachment 5.E.B, *Review of Restoration in the Delta*.

1 **Table 5.5.1-1. Habitat Units and Habitat Suitability Indices for Delta Smelt Egg-Larvae under Three**
2 **Scenarios[a]: Existing Conditions, Future Conditions without the BDCP, and Future Conditions with the**
3 **BDCP**

Subregion (Restoration Opportunity Area)	Scenario[a]	Habitat Units	Habitat Suitability Index
Cache Slough (Cache Slough ROA)	EBC2	5,348	0.87
	EBC2_LLT	6,006	0.79
	ESO_LLT	14,970	0.80
	Change due to BDCP (LLT)[b]	8,964 (+149%)	.01 (+1%)
North Delta (No ROA)	EBC2	602	0.85
	EBC2_LLT	892	0.76
	ESO_LLT	642	0.76
	Change due to BDCP (LLT)[b]	-250 (-28%)	0.00
Suisun Marsh (Suisun Marsh ROA)	EBC2	6,547	0.84
	EBC2_LLT	5,994	0.76
	ESO_LLT	12,947	0.73
	Change due to BDCP (LLT)[b]	6,953 (+116%)	-.03 (-4%)
Suisun Bay (No ROA)	EBC2	7,475	0.75
	EBC2_LLT	4,922	0.67
	ESO_LLT	3,909	0.67
	Change due to BDCP (LLT)[b]	-1,013 (-21%)	0.00
West Delta (West Delta ROA)	EBC2	7,231	0.87
	EBC2_LLT	6,161	0.81
	ESO_LLT	6,766	0.82
	Change due to BDCP (LLT)[b]	605 (+10%)	.01 (+1%)
East Delta (Cosumnes/Mokelumne ROA)	EBC2	1,687	0.86
	EBC2_LLT	2,198	0.75
	ESO_LLT	3,701	0.77
	Change due to BDCP (LLT)[b]	1,503 (+68%)	.02 (+3%)
South Delta (South Delta ROA)	EBC2	5,213	0.86
	EBC2_LLT	5,055	0.79
	ESO_LLT	18,484	0.79
	Change due to BDCP (LLT)[b]	13,429 (+266%)	0.00
All	EBC2	34,101	N/A
	EBC2_LLT	31,229	N/A
	ESO_LLT	61,420	N/A
	Change due to BDCP (LLT)[b]	30,191 (+97%)	N/A

[a] For descriptions of scenarios, see Table 5.2-3.
N/A = not applicable

Table 5.5.1-2. Habitat Units and Habitat Suitability Indices for Delta Smelt Larvae under Three Scenarios[a]: Existing Conditions, Future Conditions without the BDCP, and Future Conditions with the BDCP

Subregion (Restoration Opportunity Area)	Scenario[a]	Habitat Units	Habitat Suitability Index
Cache Slough (Cache Slough ROA)	EBC2	9,264	0.87
	EBC2_LLT	10,907	0.89
	ESO_LLT	25,612	0.89
	Change due to BDCP (LLT)[b]	14,705 (+135%)	0.00
North Delta (No ROA)	EBC2	2,251	0.59
	EBC2_LLT	2,657	0.60
	ESO_LLT	2,481	0.61
	Change due to BDCP (LLT)[b]	-176 (-7%)	.01 (+2%)
Suisun Marsh (Suisun Marsh ROA)	EBC2	10,660	0.86
	EBC2_LLT	11,024	0.87
	ESO_LLT	20,912	0.85
	Change due to BDCP (LLT)[b]	9,888 (+90%)	-.02 (-2%)
Suisun Bay (No ROA)	EBC2	16,031	0.75
	EBC2_LLT	15,967	0.74
	ESO_LLT	15,910	0.74
	Change due to BDCP (LLT)[b]	-57 (-.4%)	0.00
West Delta (West Delta ROA)	EBC2	22,378	0.80
	EBC2_LLT	23,645	0.81
	ESO_LLT	26,029	0.82
	Change due to BDCP (LLT)[b]	2,384 (+10%)	.01 (+1%)
East Delta (Cosumnes/Mokelumne ROA)	EBC2	1,961	0.34
	EBC2_LLT	2,452	0.35
	ESO_LLT	3,249	0.35
	Change due to BDCP (LLT)[b]	797 (+33%)	0.00
South Delta (South Delta ROA)	EBC2	9,933	0.52
	EBC2_LLT	10,444	0.51
	ESO_LLT	21,182	0.51
	Change due to BDCP (LLT)[b]	10,738 (+103%)	0.00
All	EBC2	72,478	N/A
	EBC2_LLT	77,096	N/A
	ESO_LLT	115,375	N/A
	Change due to BDCP (LLT)[b]	38,279 (+50%)	N/A

[a] For descriptions of scenarios, see Table 5.2-3.
[b] ESO_LLT vs. EBC2_LLT.
N/A = not applicable

From the perspective of delta smelt, a major reason for restoring tidal natural communities (CM4), in addition to providing the direct habitat benefits discussed above, is to contribute to food production in the Plan Area. There is much evidence for the importance of food as a current constraint on the delta smelt population at both larval and juvenile life stages. A decrease in food resources (principally calanoid copepods) has been linked to declines in delta smelt abundance in several studies. Kimmerer (2008) demonstrated a positive correlation between survival of juvenile delta smelt from summer to fall and density of calanoid copepods during that period. Miller et al. (2012) found that minimum density of the calanoid copepods *Eurytemora affinis* and *Pseudodiaptomus forbesi* during the spring delta smelt larval period (April through June) and average density of *E. affinis* and *P. forbesi* during the fall (September through December) were significantly related to interannual trends in fall delta smelt relative abundance. Maunder and Deriso (2011) found that minimum density of *E. affinis* and *P. forbesi* before the larval life stage (April through June) and average density of *E. affinis* and *P. forbesi* after the juvenile life stage (July through August) were important factors associated to changes in delta smelt abundance in their life-cycle model. Mac Nally et al. (2010) found some statistical evidence that summer calanoid copepod density was associated with annual trends in abundance of delta smelt in the fall. The decrease in food resources appears to have occurred because of change in phytoplankton and zooplankton communities related to grazing by nonnative organisms (e.g., *Potamocorbula*) (Winder and Jassby 2011) and anthropogenic nutrient imbalance (Dugdale et al. 2007; Glibert et al. 2011).

The main hypothesis behind CM4 is that restoration of shallow tidal marshes and associated shallow subtidal habitat will increase the growth of phytoplankton and thereby increase the amount of zooplankton that are the food base for delta smelt (Baxter et al. 2010). An analysis of food change potential for juvenile delta smelt is provided in Section 5.5.1.1.2, for it has considerable relevance to the Fall X2 decision tree that is the focus of that section; the analysis here focuses on the other feeding life stages, larvae and adults. For this effects analysis, it was assumed with high certainty that the abundance of zooplankton has critical importance as a current constraint for delta smelt larvae, and it was further assumed with high certainty that zooplankton community composition has high importance for larval delta smelt. It was assumed with very high certainty, based on existing studies (Lott 1998; Nobriga 2002), that benthic/epibenthic prey (e.g., amphipods) and insects are unimportant to delta smelt larvae because they are too large for them to feed on. For the analysis of the potential constraints of food availability to adult delta smelt, it was assumed that zooplankton community composition is unimportant (with low certainty), that zooplankton abundance and insect abundance is of low importance (with low certainty), and that benthic/epibenthic prey abundance is of moderate importance (with low certainty). These assumptions directly reflect agency biologist comments from the August 2013 workshops.

Restoration of tidal habitat and its potential to increase productivity were evaluated using the relationship between phytoplankton growth rate and average habitat depth developed by Lopez et al. (2006). The mean prediction from that relationship was used as an indicator of potential food productivity increases in each subregion as a result of restoration of shallow tidal areas (Appendix 5.E, *Habitat Restoration*, Section 5.E.4.4.2.5, *Food in the Delta and the Effect of the Conservation Measures on Food for Covered Fish Species*). The analysis suggests the potential for a considerable increase in primary productivity over existing conditions (Table 5.5.1-3), which may translate into increased food resources for larval and adult delta smelt. However, the direct relationship between local primary productivity and its dispersal so that it can become food for higher trophic levels beyond these areas is unclear because of the influence of invasive clams, transfer rates, and other factors (Lopez et al. 2006; Cloern 2007; Lucas and Thompson 2012). In particular, invasive bivalves such as *Corbicula* can consume large amounts of phytoplankton and in some cases can keep pace with primary production rate, resulting in little or no net production leaving shallow areas (Lucas and Thompson 2012). Further, the different primary producers respond differently to quantity, form, and ratios of nutrients (Glibert et al. 2011). Invasive bivalve grazing and nutrient conditions in the estuary thus is likely to limit the production of phytoplankton (particularly diatoms) and its long-distance transfer, but it is concluded that more productivity is possible with a higher ratio of shallow water to deep water than without this change.

Table 5.5.1-3. Depth-Averaged Phytoplankton Growth Rate and Prod-Acres under Three Scenarios[a]: Existing Conditions, Future Conditions without the BDCP, and Future Conditions with the BDCP

Subregion (Restoration Opportunity Area)	Scenario[a]	Phytoplankton Growth Rate (per day)	Prod-Acres
Cache Slough (Cache Slough ROA)	EBC2	0.89	10,111
	EBC2_LLT	0.94	11,918
	ESO_LLT	0.97	29,569
North Delta (No ROA)	EBC2	0.71	2,661
	EBC2_LLT	0.76	3,587
	ESO_LLT	0.76	3,172
Suisun Marsh (Suisun Marsh ROA)	EBC2	1.12	13,935
	EBC2_LLT	1.06	13,413
	ESO_LLT	0.99	24,422
Suisun Bay (No ROA)	EBC2	0.70	14,222
	EBC2_LLT	0.67	13,773
	ESO_LLT	0.67	13,701
West Delta (West Delta ROA)	EBC2	0.78	22,591
	EBC2_LLT	0.79	23,378
	ESO_LLT	0.82	26,673
East Delta (Cosumnes/Mokelumne ROA)	EBC2	0.81	4,818
	EBC2_LLT	0.91	6,797
	ESO_LLT	0.94	8,936
South Delta (South Delta ROA)	EBC2	0.76	15,061
	EBC2_LLT	0.80	16,372
	ESO_LLT	0.89	38,090
All	EBC2	N/A	83,400
	EBC2_LLT	N/A	89,599
	ESO_LLT	N/A	144,562

[a] For descriptions of scenarios, see Table 5.2-3.
N/A = not applicable.

Therefore, while the production of increased zooplankton (i.e., food) is expected from the increased phytoplankton production in restored tidal areas, the magnitude of the change from the perspective of delta smelt is complicated by these other factors. Increased food production under the BDCP has the potential to be of greater importance to delta smelt in and adjacent to the main areas currently occupied by delta smelt—the Cache Slough, West Delta, and Suisun Marsh subregions; combined, approximately 70% greater productivity potential (prod-acres) is estimated in these subregions in the under the BDCP LLT scenarios compared to EBC2_LLT (Table 5.5.1-4). A relative change of this magnitude would be appreciable but would still be considerably lower than the observed decline in phytoplankton density observed following the invasion by *Potamocorbula* (Cloern and Jassby 2012:13). The value of potentially high production in the South Delta and Cosumnes/Mokelumne ROAs will depend on export to areas where delta smelt life stages are more likely to occur, given the relatively limiting habitat suitability in these areas (see analysis above). Further discussion of potential changes in food production potential is provided in Section 5.5.1.1.2, particularly as it relates to delta smelt juveniles.

Under the BDCP (ESO_LLT), no appreciable difference in the extent of suitable *Potamocorbula* habitat is estimated in the Suisun Bay and West Delta subregions, based on the extent of habitat of 2-ppt salinity and greater during the summer-fall recruitment period (Appendix 5.F, *Biological Stressors on Covered Fish*, Section 5.F.6.3.1). This lack of difference reflects the inclusion of the Fall X2 provisions of the USFWS (2008a) BiOp. Not including the fall outflow requirements (LOS_LLT) was estimated to result in 10 to 20% more suitable habitat for *Potamocorbula*, which would have potential implications for food production for delta smelt. Management of fall outflow and the decision-tree process that will be applied to it are discussed further in Section 5.5.1.1.2.

It is concluded with low certainty that *CM4 Tidal Natural Communities Restoration* would have a moderate positive change on zooplankton abundance for larval delta smelt and a low positive change for adult delta smelt, with the relative difference between life stages reflecting the greater coincidence of the larval life stage with warmer spring temperatures at which time zooplankton productivity increases. The low level of certainty is attributable to the potential for consumption of enhanced primary production by invasive clams and the uncertainty related to export of foodweb materials from restored habitat areas, including effective conversion of phytoplankton to zooplankton. During the August 2013 workshops, agency biologists also felt that low certainty generally was warranted in terms of conclusions related to changes in zooplankton abundance for larval delta smelt, although there was a range of opinion in terms of the relative change (from low to high being suggested); it was felt that the potential for a low positive change for adults was perhaps slightly more certain because of the mostly winter occurrence of adults and occupancy of areas outside of the BDCP ROAs.

Changes in zooplankton community composition that have occurred within the Plan Area appear to have been a result of factors that would not change under the BDCP (e.g., invasive species introduction, changes in nutrient composition). Therefore, it is concluded with high certainty that the BDCP would not result in a change in zooplankton community composition, a viewpoint shared by agency biologists during the August 2013 workshops. Restoration of appreciable quantities of tidal marsh is expected to greatly increase detrital production and has the potential to result in a large increase in benthic/epibenthic production of crustaceans such as amphipods, as well as insects; as noted above, there is a substantial (doubling) estimated relative change in intertidal habitat extent proposed under the BDCP within the subregions closest to the current main distribution of delta smelt. Reflecting points raised during the August 2013 agency biologist workshops, it is concluded with high certainty that restoration under CM4 represents a low positive change to the benthic/epibenthic and insect prey abundance attributes for delta smelt adults; the low change is concluded because of the relatively low productivity that would be characteristic of the colder (winter) conditions during which this life stage occurs.

5.5.1.1.2 Fall X2 Decision-Tree Process

The decision-tree process will use best available science developed before initial operations of the north Delta facility to determine the fall Delta outflow that is necessary, in conjunction with the other conservation measures, provide for the conservation and management of delta smelt.

How fall outflow effects delta smelt abundance and habitat quality is an active area of research, and understanding of these effects is expected to improve in the coming years. That improved understanding is likely to materially affect the BDCP's mix of conservation measures to achieve two biological objectives through management of Fall X2: Objective DTSM2.1 (Chapter 3, Section 3.3.7.1.3, *Species-Specific Goals and Objectives*), which concerns availability of delta smelt habitat and is defined in terms of habitat area with a specific range of salinities, turbidities, flows, and other features; and Objective DTSM1.3, the delta smelt abundance objective. Under the USFWS (2008a) BiOp, it is hypothesized that the fall habitat objective will be achieved by providing fall (September–November) flows necessary to position X2 in or near Suisun Bay in wet or above-normal years. This hypothesis is currently being tested in the Fall Low Salinity Habitat Studies (FLaSH Studies) (Delta Stewardship Council 2010), and is being informed by annual reviews of USFWS (2008a) BiOp effectiveness (Anderson et al. 2012); it will continue to be evaluated in the decision-tree process. Alternatively, it is hypothesized that new shallow-water habitat areas created through restoration of tidal natural communities (CM4) could accomplish this objective with lower outflow during the fall. If restoration of habitat for delta smelt is successful, there may be no need to provide the "high outflow scenario" fall outflows in Table 3.4.1-1, *Water Operations Flow Criteria and Relationship to Assumptions in CALSIM Modeling*, in Chapter 3, to meet the biological objectives for this species. Collaborative scientific research to test each of these hypotheses will be conducted before initial operations of the north Delta facility.

A decision-tree process will be used to determine the initial operations for fall outflow under CM1 before the north Delta facilities become operational approximately 10 years after permit issuance. More information is provided in Chapter 3, Section 3.4.1.4.4, *Decision Trees*. USFWS, CDFW, and NMFS will make the final decision about criteria that will be applicable when the conveyance facilities become operational pursuant to the decision-tree process. The fish and wildlife agencies' (USFWS, NMFS, and CDFW) determination will be based on best available science at the time of CM1 implementation. The determination will include updated analysis of historical data, results of the Adaptive Management Plan outlined as part of the RPA[3], and other appropriate scientific information that exists at the time of the decision. The primary questions that the Fall X2 decision tree is intended to answer include the following.

- What are the important sources of mortality for delta smelt during the fall?
- Is the areal extent of the fall low salinity zone a driver of delta smelt abundance?
- How important are fall habitat conditions, including food supply and resultant growth, to egg production the following spring (see Rose et al. 2013a,b)?
- Are these important habitat attributes described above linked to outflow and can they be provided separate from outflow?

[3] The USFWS (2008a) Fall X2 RPA requires that adaptive management be used to assess the effectiveness of the action. In 2010, the Bureau of Reclamation produced the *Draft Plan for Adaptive Management of Fall Outflow for Delta Smelt Protection and Water Supply Reliability*.

- How do different outflow operations (i.e., pulse flows vs. more continuous flow) in the fall affect delta smelt abundance?

The following sections summarize and analyze the two conceptual models that underlie the Fall outflow decision tree (Chapter 3, Section 3.4.1.4.4, *Decision Trees*).

Potential outcome 1: Fall X2 is implemented as part of CM1 operations.

This potential determination may be made if ongoing monitoring and research of delta smelt and its habitat indicates that fall outflow, or habitat elements provided by fall outflow that cannot be separated from it, are necessary to provide for the conservation and management of delta smelt.

Conceptual model 1: Fall outflow provides key delta smelt habitat attributes—either directly or by providing delta smelt with maximum opportunity to access areas providing key habitat attributes.

Delta smelt have been extensively targeted by monitoring and incidentally collected in numerous additional sampling programs for many decades (Moyle et al. 1992; Bennett 2005; Merz et al. 2011). Not surprisingly therefore, they have been collected from numerous nominal habitat types including open waters, bay shoals, channel margins, tidal marsh channel networks, flooded islands, and Clifton Court Forebay (see as examples Moyle et al. 1992; Aasen 1999; Dege and Brown 2004; Nobriga et al. 2005; Brown and May 2006; Hobbs et al. 2006; Feyrer et al. 2007; Merz et al. 2011; Gewant and Bollens 2012; Sommer and Mejia 2013; Feyrer et al. 2013). However, delta smelt is known to be primarily a pelagic fish with a variable, population-level spatial distribution that remains associated with waters of low salinity and high turbidity (see as examples Moyle et al. 1992; Sweetnam 1999; Bennett et al. 2002; Dege and Brown 2004; Kimmerer 2004; Bennett 2005; Feyrer et al. 2007; Kimmerer et al. 2009; Feyrer et al. 2013) and seasonally avoids warm summer water temperatures (see as examples Kimmerer 2008; Nobriga et al. 2008). Thus, although delta smelt can use a large variety of nominal habitat types, there is high scientific certainty about their *primary* habitat needs.

The first peer-reviewed scientific evidence that fall outflow might affect habitat suitability for delta smelt and ultimately species viability was published by Feyrer et al. (2007). These authors analyzed 36 years of fall midwater trawl (FMWT) data for several fishes, including delta smelt. They showed that the detectable distribution of delta smelt (their presence or absence in individual trawl samples) was correlated with the specific conductance and clarity (transparency) of the water that was sampled. Specific conductance generally corresponds with salinity and water clarity generally corresponds with turbidity. Their analysis showed that delta smelt were most frequently collected when specific conductance and water clarity were simultaneously low. Their analysis also showed that this set of conditions (termed an "environmental quality index" [EQI]) by the authors), simultaneously reflecting [at least] two habitat attributes, was occurring at fewer and fewer sampling stations over time, because specific conductance was increasing at the western stations (i.e., primarily in the Suisun Bay/West Delta subregions) and water transparency was increasing at the southeastern stations (in the South Delta subregion). Lastly, they used linear regression analyses to generate simple stock-recruit relationships for delta smelt; these statistical models performed better when average fall specific conductance was included to help explain the variation in young fish produced per adult.

The Feyrer et al. (2007) paper resulted in a closer look into fall outflow trends and predicted consequences to delta smelt habitat suitability. This second paper showed that the conclusions drawn from pooling all years of data were not distinctly different from the individual annual patterns; in other words, delta smelt have consistently been collected most often when specific conductance and water transparency were simultaneously low. Feyrer et al. (2011) advanced the Feyrer et al. (2007) EQI by using GIS-based spatial weighting of the original two-metric habitat index. This alternative index was similar to their previously published unweighted EQI in exhibiting a substantial decline as of the mid-1980s. The alternative index also had a nonlinear inverse relationship with X2 that indicated delta smelt fall habitat suitability increased most rapidly as a function of X2 when X2 moved from about 80 km to about 70 km from the Golden Gate Bridge, and was loosely correlated with the FMWT abundance index for delta smelt.

Because Feyrer et al. (2011) conducted a statistical test for the correlation between the abundance and habitat indices (and found a statistically significant positive correlation), this could be taken as implying that the decline in the habitat index caused the decline in delta smelt. However, because the abundance and habitat indices are derived from the same data, the decline in the habitat index over time because of more frequently occurring conductivity and water clarity conditions at which delta smelt probability of occurrence is lower (i.e., greater conductivity and water clarity) inevitably results in a correlation between abundance and habitat indices. Nevertheless, given the general annual consistency in the relationship between delta smelt probability of occurrence and the two habitat variables included in the abiotic habitat index (Feyrer et al. 2011: Figure 1), the study generally illustrated that higher abundance indices occurred at higher values of the abiotic habitat index and lower abundance indices occurred at lower habitat index values. It is noteworthy that 2011 was the first year since 1998 that Fall X2 was located near Chipps Island (river km 75) and the FMWT index for delta smelt increased about 12-fold over its 2010 value when abundance indices from earlier in 2011 (20-mm, STNS) had only reached about twice their 2010 values.

Several statistical population or life cycle models for delta smelt have since been published that have tested for an influence of Fall X2 (or measures correlated with it) on delta smelt catch per unit effort or life stage to life stage survival in a manner conceptually similar to the analysis in Feyrer et al. (2007) (Mac Nally et al. 2010; Thomson et al. 2010; Miller et al. 2012). None of these researchers has found Fall X2 (or measures correlated with it) to be a significant predictor of delta smelt population performance with more complex statistical modeling. In at least one case (Miller et al. 2012), conclusions drawn from the analysis may suffer from the same limitation noted above for the study Feyrer et al. (2011), i.e., that an index of fall habitat derived from the same monitoring data as the response variable (fall abundance index) is not independent of the response variable. Recently, an individual-based life-cycle model for delta smelt was developed (Rose et al. 2013a) and vetted (Rose et al. 2013b). This model found delta smelt growth rates during the fall to be a major determinant of egg supply the following spring and that the mechanism was the juvenile fishes' bioenergetic environment (prey density interacting with water temperature). In this model, fall growth had a strong effect on predicted increases and decreases in the virtual delta smelt population through its ultimate effect on egg supply. t should be noted that Rose et al. (2013a, 2013b) did not incorporate any delta smelt responses to turbidity into their model (e.g., distribution, vital rates, etc.) so it is not yet clear whether it supports or refutes the population dynamic implications of the habitat suitability indices derived by Feyrer et al. (2007, 2011). In addition, Rose et al. (2013a) used salinity to simulate reasonable distributions of individuals within the system but not to directly affect growth or mortality[4].

[4] Salinity was used to distribute individuals realistically, similar to what has been observed from field data. Once individuals were spatially distributed in the model, they then experienced the local conditions in the channels such as temperature and prey densities (Rose et al. 2013a).

Thus, the current state of science based strictly on peer-reviewed literature on delta smelt population dynamics linked with fall habitat conditions suggests the following.

- The distribution and relative abundance of delta smelt have been consistently correlated with two abiotic attributes of their habitat during the fall: water salinity and turbidity.
- Habitat indices derived from these two habitat attributes have a nonlinear correlation with the position of X2 in the fall.
- Low salinity/low turbidity conditions occur in fewer parts of the San Francisco estuary (including much of the Plan Area) than they used to.
- There is limited statistical (correlation-based) evidence that management of X2 in the fall has a measurable effect on the abundance or survival of subsequent life stages.
- There is evidence from individual-based life cycle modeling that aspects of abiotic and biotic habitat conditions for delta smelt are important in the fall.

There is no question that salinity and turbidity are not the only important delta smelt habitat attributes. During summer, water temperatures can reach stressful if not lethal levels in parts of the estuary (Nobriga et al. 2008), a trend that is anticipated to worsen given projected climate warming (Brown et al. 2013). Further, the interaction of water temperature and prey density is a widely agreed-upon constraint on delta smelt (Kimmerer 2008; Mac Nally et al. 2010; Maunder and Deriso 2011; Miller et al. 2012; Rose et al. 2013a, 2013b). However, low water salinity and transparency contribute to delta smelt's occurrence at Liberty Island and the adjacent reach of the Sacramento Deep Water Shipping Channel in the Cache Slough subregion (e.g., Nobriga et al. 2005). In addition, the trawl survey sampling grids are large enough to have robustly documented that delta smelt cannot be expected to occur in large numbers where the key abiotic habitat attributes (low salinity/low turbidity, and low water temperature in the summer) are not met (Feyrer et al. 2007; Nobriga et al. 2008; Kimmerer et al. 2009; Feyrer et al. 2011; Sommer and Mejia 2013).

Most individual attributes of delta smelt habitat are expected to become more challenging to effectively manage in the future (Brown et al. 2013). Placement of X2 in the Suisun Bay subregion during the fall expands the areal extent of habitat possessing salinity and water clarity with a higher probability of delta smelt occurrence (Feyrer et al. 2011) and the delta smelt population centroid of abundance, as measured with the FMWT, is quite closely associated with X2 (Sommer et al. 2011). Occurrence of much of the delta smelt population in the Suisun Bay subregion may provide relatively good opportunities for individuals to find high suitability habitat patches that meet their simultaneous needs for particular combinations of salinity, turbidity, temperature, and prey density so that they can safely and effectively forage long enough each day to meet their metabolic needs (per Rose et al. 2013a, 2013b). New, unpublished data analyses conducted by the Interagency Ecological Program's Management, Analysis, and Synthesis Team indicate that placing X2 in Suisun Bay increases the turbidity of low-salinity waters by placing the low-salinity zone where wind can resuspend sediment from the shoals of Grizzly and Honker Bays (high seasonal winds similarly help keep Liberty Island turbid). For these reasons, if ongoing monitoring and research of delta smelt and its habitat indicates that fall outflow provides habitat attributes that cannot be separated from it, the Fall X2 requirement may be necessary to support the conservation and management of this species. If, through the decision-tree process, this determination is made, the BDCP fall outflow operations will include the high fall outflow initial operations.

For the analysis of the conservation strategy's potential effects on delta smelt, the subtidal habitat attribute represents the importance to the delta smelt population of static (e.g., subtidal acreage) and dynamic (e.g., salinity and water temperature) habitat features as a current constraint to population performance. For juvenile delta smelt occurring in summer/fall, it was assumed for this effects analysis that the subtidal habitat attribute has high importance with moderate certainty that reflects the points discussed above. During the August 2013 workshops, agency biologists suggested that the subtidal habitat attribute (including dynamic elements attributable to freshwater flow, as indexed by outflow and X2) could be considered of critical importance (with moderate certainty).

The BDCP effects analysis used the fall abiotic habitat index method of Feyrer et al. (2011) to assess potential for change in abiotic habitat, with the methods described in more detail in Appendix 5.C, *Flow, Passage, Salinity, and Turbidity*, Section 5.C.4.5.2, *Delta Smelt Fall Abiotic Habitat Index*. As noted in the methods (and above), the fall abiotic habitat index estimates the areal extent of habitat weighted by the probability of occurrence of delta smelt within that habitat as a function of conductivity and water clarity, with the overall index being estimated by Fall X2. The method reflects the original geographic areas used by Feyrer et al. (2011) and therefore focuses primarily on the Suisun Bay, Suisun Marsh, and West Delta subregions, as well as portions of the Cache Slough subregion (excluding Liberty Island and the Sacramento Deepwater Ship Channel), the South Delta subregion, and the North Delta subregion. For the BDCP scenarios (i.e., ESO, HOS, and LOS), the method was modified to account for restored subtidal habitat adjacent to the Suisun Marsh and West Delta ROAs. Under the assumption that BDCP restoration actions (under *CM4 Tidal Natural Communities Restoration*) in the Suisun Marsh and West Delta ROAs would provide relevant habitat characteristics (conductivity and water clarity) that are equivalent to those characteristics in existing adjacent areas, the analysis based on the Feyrer et al. (2011) method suggests that under the BDCP (ESO_LLT and HOS_LLT), the fall abiotic habitat index would be 25 to 30% greater than under existing conditions or EBC2_LLT, averaged across all water-year types, with a 20 to 40% difference depending on water-year type (Appendix 5.C., Section 5.C.4.5.2, *Delta Smelt Fall Abiotic Habitat Index*). The likely change in the X2–fall abiotic habitat index relationship under future configurations of the Delta and the potential influence of additional factors such as water temperature and food availability add uncertainty to the various model results (see also Cloern et al. 2012; Brown et al. 2013). Monitoring in restored areas is expected to provide information on physicochemical characteristics of the new habitat in order to refine future habitat definitions and their linkages to delta smelt distribution and recruitment.

On the basis of the above analysis based on the Feyrer et al. (2011) fall abiotic habitat index method and incorporating BDCP restoration, it is concluded with moderate certainty that there would be a moderate positive change to the subtidal habitat attribute for juvenile delta smelt. This change reflects inclusion of the high fall outflow operations as the outcome of the decision-tree process.

Table 5.5.1-4. Average Delta Smelt Fall Abiotic Habitat Index under Existing Conditions and Future Scenarios[a] and Differences[b] between Scenarios

Water-Year Type	Scenario[a] or Scenario Comparison[b]						
	EBC2	EBC2_LLT	ESO_LLT	HOS_LLT	ESO_LLT vs. EBC2	ESO_LLT vs. EBC2_LLT	HOS_LLT vs. EBC2_LLT
A	5,035	4,865	6,314	6,268	1,279 (25%)	1,449 (30%)	1,403 (29%)
W	7,253	6,900	8,776	8,613	1,523 (21%)	1,876 (27%)	1,712 (25%)
AN	5,644	5,491	7,050	7,073	1,406 (25%)	1,559 (28%)	1,583 (29%)
BN	4,090	3,990	5,360	5,443	1,270 (31%)	1,370 (34%)	1,453 (36%)
D	3,559	3,475	4,783	4,834	1,224 (34%)	1,308 (38%)	1,359 (39%)
C	2,987	2,987	3,716	3,562	729 (24%)	729 (24%)	575 (19%)

A = all; W = wet; AN = above normal; BN = below normal; D = dry; C = critical.

[a] For descriptions of scenarios, see Table 5.2-3.

[b] Positive values indicate greater habitat index under BDCP scenarios than under existing conditions/future conditions without the BDCP.

Potential outcome 2: Fall X2 is not implemented as part of CM1 operations.

This potential determination may be made if ongoing monitoring and research of delta smelt and its habitat indicates that fall outflow is not necessary to provide for the conservation and management of delta smelt, or that habitat elements provided by fall outflow can be managed separately from it.

Conceptual model 2: Population performance of delta smelt is enhanced by biotic or abiotic habitat features that are not dependent on fall outflow of the magnitude described by the USFWS (2008a) Fall X2 requirement.

The high fall outflow operational criteria may be determined unnecessary through the decision-tree process either because scientific investigations show that there is no relationship between Fall X2 and delta smelt viability or that other BDCP actions such as CM4 will provide the habitat attributes needed to provide for the conservation and management of delta smelt. The areal extent of fall habitat for juvenile delta smelt is anticipated to substantially increase as a result of CM4. BDCP restoration would expand suitable habitat throughout the range of delta smelt, especially in the Suisun Marsh, West Delta, and Cache Slough ROAs. This restoration of tidal natural communities is hypothesized to provide necessary biotic and abiotic habitat functions for rearing delta smelt, including greater food availability within the ROAs that would be available to delta smelt in situ or through export to other areas.

Conceptual model 2 is based on the following elements.

- Food is a critical constraint for delta smelt.
- Habitat restoration will produce food and it will be exported to areas where delta smelt can consume it, or they will consume it in situ.
- Restoration sites will provide suitable habitat that delta smelt will occupy.
- BDCP will substantially increase habitat extent in the Plan Area.

Evidence for the importance of food as a critical constraint to the delta smelt population at various life stages was introduced in Section 5.5.1.1.1, *Restored Tidal Habitat*; survival between different life stages increases as food (primarily calanoid copepods) increases (Kimmerer 2008; Maunder and Deriso 2011; Miller et al. 2012); therefore an increase in food is hypothesized to lead to an increase in population abundance. For this effects analysis, it was assumed with high certainty that the abundance of zooplankton and the zooplankton community composition have critical and high importance, respectively, for juvenile delta smelt. Recent studies as part of the FLaSH studies showed that epibenthic amphipods comprised a greater proportion of delta smelt juvenile gut contents than in an earlier study by Lott (1998). Accordingly, epibenthic production was assumed with low certainty to have moderate importance to delta smelt juveniles. Insect abundance as a current constraint was assumed with low certainty to have low importance to juvenile delta smelt.

Support exists for the hypothesis that restoration of tidal marsh habitat will increase local food production and that this food will be exported to downstream areas (Jassby and Cloern 2000; Kneib et al. 2008). Food production in the West Delta and Suisun Marsh ROAs also may be enhanced by increases in residence time caused by changes in hydrodynamics resulting from water operations changes under *CM1 Water Facilities and Operation* (Appendix 5.C, *Flow, Passage, Salinity, and Turbidity,* Section 5.C.5.4.4, *Residence Time (DSM2-PTM)*). In addition to the direct benefit of providing physical habitat for covered fish, restoration of tidal habitat (including intertidal and subtidal areas) is expected to enhance productivity in the Plan Area and contribute to the Plan Area foodweb. Studies in locations throughout the United States, including the Bay-Delta and elsewhere along the Pacific Coast, indicate the potential for ecological benefits from restoring tidal wetlands, including foodweb support for fish species (Boesch and Turner 1984; Baltz et al. 1993; Simenstad et al. 1982; West and Zedler 2000; Bottom et al. 2005; Maier and Simenstad 2009; Simenstad et al. 2000; Howe and Simenstad 2011) and the export of nutrients and prey organisms to adjacent channels (Shreffler et al. 1992; Lucas et al. 2002; Lopez et al. 2006).

The actual foodweb benefits provided to delta smelt by *CM4 Tidal Natural Communities Restoration* will depend on site-specific characteristics of the restored areas as well as other ecological characteristics such as the pervasiveness of nonnative clams and their effect on overall productivity. To date, restoration of tidal wetlands in the Plan Area has had mixed results, with limited benefits where conditions favor invasive clams, IAV, and nonnative fish, as discussed further in Appendix 5.E, *Habitat Restoration*, Attachment 5.E.B, *Review of Restoration in the Delta.* Where these conditions do not occur, restoration has the potential to support development of foodwebs and conditions favorable to listed fish species, including delta smelt (e.g., restoration of Liberty Island [Whitley and Bollens 2013]). The location of Liberty Island as a restoration site well upstream of what is generally regarded as the low-salinity zone (Suisun Bay and Marsh/West Delta subregions) is significant and supports the underlying premise of conceptual model 2: availability of suitable biotic and abiotic habitat need not be dependent on a particular level of fall outflow to provide important rearing habitat for juvenile delta smelt, if restored areas can provide both suitable habitat to occupy and, perhaps more importantly, enhanced prey abundance. As noted above, under potential outcome 1 of the Fall X2 decision tree, it was assumed with moderate certainty that the extent of subtidal habitat (including the low-salinity zone) is of high importance to delta smelt juveniles. Intertidal habitat was assumed with low certainty to be of low importance to delta smelt juveniles; this essentially reflected the zero or low importance (with low certainty) suggested by fish and wildlife agency biologists during the August 2013 workshops.

With respect to the extent of suitable habitat for occupancy, *CM4 Tidal Natural Communities Restoration* was evaluated using the habitat suitability analysis (Appendix 5.E, Section 5.E.4.4.1.1, *Habitat Suitability Analysis*; also previously discussed above for egg-larvae and larvae). This method computes an abiotic habitat suitability index (HSI) that consists of the estimated acreage within the Plan Area that is projected to be provided under CM4 in the late long-term, weighted for suitability to delta smelt by several abiotic habitat characteristics (i.e., temperature, conductivity, water clarity, and depth, with suitability criteria developed from empirical data and agency biologist opinion). The resulting HUs are conceptually similar to the abiotic habitat index developed by Feyrer et al. (2011) but more fully reflect the potential of CM4 in terms of creation of additional habitat space over the entire Plan Area (within all relevant subregions, i.e., excluding the Yolo Bypass). The habitat suitability method was developed to identify the relative change in suitable juvenile delta smelt rearing habitat under the BDCP compared to future conditions without BDCP, and includes both intertidal and subtidal areas. Note that the juvenile life stage used in the HSI includes both summer and fall periods (July–December). A limitation of the method was that it was computed only for the ESO scenario, which includes high fall outflow, therefore probably overestimating suitability because of lower conductivity.

In order to assess potential changes in foodweb productivity because of BDCP restoration actions under CM4, a simple phytoplankton productivity versus depth relationship (Lopez et al. 2006) was used to estimate the magnitude of potential food production within each subregion (Appendix 5.E, Section 5.E.4.4.2.5, *Food in the Delta and the Effect of the Conservation Measures on Food for Covered Fish Species*), as previously discussed in Section 5.5.1.1.1, *Restored Tidal Habitat*. It is acknowledged that there is high uncertainty with these results because of the unpredictable effect of invasive clams consuming this food production or other factors potentially limiting production (Lucas and Thompson 2012). Analysis of juvenile delta smelt habitat suitability in the Plan Area predicts that *CM4 Tidal Natural Communities Restoration* would result in considerably more (nearly 50% more) habitat suitable for delta smelt than currently exists (Appendix 5.E, Section 5.E.4.4.2.1, *Physical Habitat Extent*) (Table 5.5.1-5), including areas both within and beyond the low-salinity zone. As noted above for larval and adult delta smelt, the proportional change in intertidal habitat is considerably greater than the proportional change for subtidal habitat. For the subregions that include the main areas of delta smelt occurrence (i.e., Suisun Bay, Suisun Marsh, West Delta, and Cache Slough), the existing or future extent of intertidal habitat without the BDCP is estimated to be approximately 20,000 acres, compared to nearly double that under the BDCP LLT scenarios (approximately 36,500 acres). Subtidal habitat in these same subregions is estimated to be nearly 55,000 acres under existing conditions or EBC2_LLT, compared to almost 70,000 acres under the BDCP LLT scenarios, an over 25% increase (Appendix 5.E, Section 5.E.4.4.1.1, *Physical Habitat Extent*). Tidal natural communities restoration under the BDCP also includes accommodation for sea level rise, so that under anticipated climate change, an appreciably greater extent of tidal habitat would be suitable for occupation by delta smelt. This is expected to be of importance should shifts in distribution occur as a result of changing estuarine salinity regime, for example (as salt encroaches further landward, because of sea level rise).

For comparative purposes, the fall abiotic habitat index from the method of Feyrer et al. (2011) was also included in the analysis potential outcome 2 of Fall X2 decision tree to illustrate the potential change in abiotic habitat within a more limited portion of the Plan Area that does not include appreciable amounts of restoration proposed under the BDCP (i.e., principally within the Cache Slough ROA). Based on the Feyrer et al. (2011) fall abiotic habitat index method adapted to include some BDCP restoration areas, under LOS_LLT the fall abiotic habitat index would be similar to EBC2_LLT, averaged across all water years, with greater indices in drier years and 11 to 27% lower average indices in wet and above-normal years (Table 5.5.1-6). This reflects two factors: absence of the high fall outflow under LOS_LLT, and exclusion of restored areas in the Cache Slough ROA from the BDCP scenarios. Nevertheless, the Feyrer et al. (2011) fall abiotic habitat index method suggests a similar overall extent of abiotic habitat in the Plan Area under LOS_LLT without high fall outflow and future conditions without the BDCP (EBC2_LLT), when averaged across all years; lower habitat indices in wet and above-normal water years were the result of the inclusion of the Fall X2 under EBC2_LLT. Given the relatively large extent of habitat that would be restored in the Cache Slough ROA, inclusion of these areas in the Feyrer et al. (2011) fall abiotic habitat index method would likely result in a greater habitat index under LOS_LLT than under EBC2_LLT, suggesting that even without high fall outflow, the BDCP would provide increased suitable fall abiotic habitat.

As with larval delta smelt, it is concluded that the change in intertidal habitat for juvenile delta smelt will be very high, with moderate certainty, as a result of BDCP tidal habitat restoration measures under CM4. It is also concluded with moderate certainty that there would be a moderate positive change to the subtidal habitat attribute for juvenile delta smelt. As noted for larval delta smelt, there is some uncertainty regarding selection of habitat types by delta smelt, as the use of restored areas by delta smelt will depend on the habitat characteristics within these areas (Sommer and Mejia 2013). However, evidence from Liberty Island, a passive restoration site, suggests that suitable habitat for delta smelt can exist in restored tidal areas given good food availability and abiotic conditions such as high turbidity (as a result of wind fetch and shallow water; see Appendix 5.C, *Flow, Salinity, Turbidity, and Passage*, Attachment 5C.D, *Water Clarity—Suspended Sediment Concentration and Turbidity*). Uncertainty also stems from how much restored habitats may be limited in value because of colonization by IAV (Appendix 5.F, *Biological Stressors on Covered Fish*, Section 5.F.4.2.4, *Predation Risk in Restored Habitats*) and associated nonnative fish species that may prey on delta smelt or compete with them for food. *CM13 Invasive Aquatic Vegetation Control* aims to control IAV in the ROAs, but there remains some uncertainty related to the ability to do so effectively.

The degree to which additional food resources produced in ROAs will become available to delta smelt outside the ROAs is also uncertain. Lehman et al. (2010) demonstrated that export of material from Liberty Island in the Cache Slough subregion was driven by tidal flows, but varied considerably from season to season; the area was both a source and a sink of zooplankton during their study. Considering the factors described above, and the results of the prod-acres analysis (Table 5.5.1-3), it is concluded that there will be a moderate positive change from *CM4 Tidal Natural Communities Restoration* on zooplankton abundance for juvenile delta smelt, with low certainty attributable to the potential for consumption of enhanced primary production by invasive clams and other factors as previously noted. Agency biologists suggested that low certainty is warranted for conclusions regarding potential change in zooplankton abundance because of CM4, with opinion regarding the magnitude of potential change ranging from low to high. Changes in zooplankton community composition that have occurred within the Plan Area were caused by factors that are not changed by BDCP, and as noted for larval delta smelt, it is concluded with high certainty that the BDCP will not result in a change in zooplankton community composition.

As described above for adult delta smelt, restoration of appreciable quantities of tidal marsh is expected to greatly increase detrital production and has the potential to provide a large increase in benthic/epibenthic production of crustaceans such as amphipods, as well as insects; as also noted above, there is a substantial (doubling) estimated relative change in intertidal habitat extent proposed under the BDCP within the subregions closest to the current main distribution of delta smelt. It is concluded with high certainty that restoration under CM4 represents a high positive change to the benthic/epibenthic and insect prey abundance attributes for delta smelt juveniles.

Potential changes in habitat suitable for delta smelt and the potential for greater zooplankton, benthic/epibenthic, and insect prey abundance described above provide support for conceptual model 2, that the high fall outflow operational criteria is not required to enhance delta smelt population performance and meet the biological objective for the species.

Table 5.5.1-5. Habitat Units and Habitat Suitability Indices for Delta Smelt Juveniles under Three Scenarios[a]: Existing Conditions, Future Conditions without the BDCP, and Future Conditions with the BDCP

Subregion (Restoration Opportunity Area)	Scenario[a]	Habitat Units	Habitat Suitability Index
Cache Slough (Cache Slough ROA)	EBC2	6,628	0.68
	EBC2_LLT	6,872	0.67
	ESO_LLT	15,780	0.67
	Change due to BDCP (LLT)[b]	8,908 (+129%)	0.00
North Delta (No ROA)	EBC2	1,172	0.38
	EBC2_LLT	1,221	0.35
	ESO_LLT	1,160	0.35
	Change due to BDCP (LLT)[b]	-61 (-5%)	0.00
Suisun Marsh (Suisun Marsh ROA)	EBC2	7,323	0.65
	EBC2_LLT	7,463	0.66
	ESO_LLT	14,694	0.61
	Change due to BDCP (LLT)[b]	7,231 (+97%)	-0.05 (-8%)
Suisun Bay (No ROA)	EBC2	12,430	0.49
	EBC2_LLT	11,808	0.46
	ESO_LLT	11,730	0.47
	Change due to BDCP (LLT)[b]	-78 (-1%)	0.01 (+2%)
West Delta (West Delta ROA)	EBC2	15,914	0.60
	EBC2_LLT	15,636	0.59
	ESO_LLT	17,213	0.59
	Change due to BDCP (LLT)[b]	1,577 (+10%)	0.00
East Delta (Cosumnes/Mokelumne ROA)	EBC2	1,488	0.31
	EBC2_LLT	1,667	0.29
	ESO_LLT	2,243	0.29
	Change due to BDCP (LLT)[b]	576 (+35%)	0.00
South Delta (South Delta ROA)	EBC2	4,998	0.30
	EBC2_LLT	4,812	0.28
	ESO_LLT	9,519	0.28
	Change due to BDCP (LLT)[b]	4,707 (+98%)	0.00
All	EBC2	49,952	N/A
	EBC2_LLT	49,479	N/A
	ESO_LLT	72,340	N/A
	Change due to BDCP (LLT)[b]	22,861 (+46%)	N/A

[a] Existing conditions = EBC2, future conditions without the BDCP = EBC2_LLT, and future conditions with the BDCP = ESO_LLT. For descriptions of scenarios, see Table 5.2-3.
[b] ESO_LLT vs. EBC2_LLT.
N/A = not applicable

Table 5.5.1-6. Average Delta Smelt Fall Abiotic Habitat Index for Three Scenarios[a] (Existing Conditions, Future Conditions without the BDCP, and Future Conditions with the BDCP [without high fall outflow: Low-Outflow Scenario]) and Differences[b] between Scenarios

Water-Year Type	Scenario[a] or Scenario Comparison[b]			
	EBC2	**EBC2_LLT**	**LOS_LLT**	**LOS_LLT vs. EBC2_LLT**
A	5,035	4,865	4,800	-65 (-1%)
W	7,253	6,900	5,043	-1,857 (-27%)
AN	5,644	5,491	4,880	-610 (-11%)
BN	4,090	3,990	5,290	1,300 (33%)
D	3,559	3,475	4,809	1,334 (38%)
C	2,987	2,987	3,617	630 (21%)

A = all; W = wet; AN = above normal; BN = below normal; D = dry; C = critical.

[a] For descriptions of scenarios, see Table 5.2-3.

[b] Positive values indicate greater habitat index under BDCP scenarios than under existing conditions/future conditions without the BDCP.

5.5.1.1.3 Reduced Entrainment

Overall entrainment of delta smelt under the BDCP will remain at or be less than levels experienced in the recent past, because operation of the north Delta diversions will reduce reliance on south Delta export facilities. Additional minor benefits may result from decommissioning of agricultural diversions in ROAs and implementation of an alternative intake for the North Bay Aqueduct.

The BDCP will ensure that the current hydrodynamic strategies to minimize entrainment that is required under the USFWS (2008a) BiOp will be maintained throughout the permit term, with further improvements in wetter water years. Losses of delta smelt larvae and juveniles to entrainment at the south Delta export facilities in spring (March through June) were estimated to range from 0 to 26% of the population per year from 1995 to 2006 (Kimmerer 2008 in Miller 2011:5). Implementation of south Delta export restrictions under the USFWS (2008a) BiOp appears to have limited entrainment loss of larval and juvenile delta smelt (Smelt Working Group 2010). Analyses of factors that could have influenced changes in abundance of delta smelt over time have included larval/juvenile entrainment and spring water exports. Several of these analyses did not find evidence linking spring entrainment loss or exports to population trends of delta smelt (Thomson et al. 2010; Maunder and Deriso 2011; Miller et al. 2012), and Mac Nally et al. (2010) found weak evidence to suggest an inverse relationship between delta smelt fall abundance and spring exports. Correlative analyses may not detect effects of spring entrainment because of subsequent factors influencing survival (e.g., food abundance) (Kimmerer 2008), and at the existing low abundance of delta smelt it is possible that the population productivity is density-independent, which means that mortality in one life stage due to entrainment might not be compensated for by greater survival in later stages and so affect population performance (Kimmerer 2011). As noted by Baxter et al. (2010:61), combined substantial losses of adult and larval/juvenile delta smelt in the same generation may cumulatively affect the delta smelt population.

Similar to larval/juvenile delta smelt, considerable proportional entrainment loss of adult delta smelt at the south Delta export facilities has been estimated using historical data: Kimmerer (2008) found that up to 50% per year of the adult population had been lost between December and March 2003 and that appreciable losses occurred in other years. A reexamination of Kimmerer's (2008) estimates by Miller (2011) prompted Kimmerer (2011) to suggest a downward revision of his original estimates by around 25%, but nevertheless the estimates were high in some years. Miller (2011) concluded that the Kimmerer (2008) estimates should have been further revised because of several other significant assumptions that Miller (2011) was unable to correct for that would lead to even greater overestimates. Further discussion of this issue is provided in Appendix 5.B, *Entrainment*, Section 5.B.2.2, *Potential Importance of Entrainment*. Implementation of south Delta export pumping restrictions under the USFWS (2008a) BiOp has considerably limited the entrainment loss of adult delta smelt (Smelt Working Group 2010; U.S. Fish and Wildlife Service 2011). The restrictions aim to keep proportional adult entrainment loss below around 5% of the population (U.S. Fish and Wildlife Service 2008a:387). Some links between proportional entrainment loss of adult delta smelt or winter exports and trends in the delta smelt population have been found in several studies. Mac Nally et al. (2010) found some weak evidence of an inverse relationship between winter exports and delta smelt fall abundance, whereas Thomson et al. (2010) found that winter exports had a high probability of inclusion in models explaining variation in delta smelt abundance but could not explain the step change in abundance during the POD. Entrainment loss of adult delta smelt was included in some of the better-fitting iterations of the state-space life-cycle model of Maunder and Deriso (2011), who concluded this result was unreliable. In an unpublished update of that analysis that applied the same procedures with data through 2010 (the original model used data for 1972–2006), Deriso et al. (2011) did not find evidence to support adult entrainment's inclusion as an important variable, based on model-fitting procedures similar to those from the original analysis. Miller et al. (2012) found that survival of delta smelt from fall to summer was statistically negatively associated with total proportional entrainment of delta smelt (adults and larvae/juveniles from the next generation), although survival from fall to fall (the full life cycle) was not related to total entrainment. Most recently, Rose et al. (2013b) concluded, based on individual-based modeling of delta smelt, that there is support for the effects of entrainment on delta smelt population vitality (expressed a population growth rate). Overall, then, there is some evidence for the importance of adult delta smelt entrainment as constraint to the population, based mostly on data collected prior to the USFWS (2008a) BiOp.

In light of the reduction in entrainment in recent years resulting from implementation of the USFWS (2008a) BiOp requirements, for this effects analysis it was assumed with moderate certainty that entrainment of delta smelt larvae and adults at the south Delta export facilities under existing conditions is an attribute of moderate importance. This importance assignment is due, in part, to the recent substantial reductions in entrainment, which are part of the existing biological conditions. For juvenile delta smelt, which are only found near the export facilities during the early portion of the life stage, it is assumed with moderate certainty that the importance of south Delta entrainment as a current constraint is low. The assumptions of entrainment importance are consistent with those suggested by agency biologists during the August 2013 workshops.

Analyses suggest that proportional entrainment loss of delta smelt larvae/juveniles at the south Delta export facilities would differ little over all years under ESO_LLT compared to EBC2_LLT (Appendix 5.B., Section 5.B.6.1.5, *Delta Smelt*). Results varied by water-year type, with greater use of the north Delta intakes in wetter years leading to appreciably less proportional entrainment under the BDCP when compared to EBC2_LLT and similar proportional entrainment when compared to existing conditions (EBC2). Greater reliance on the south Delta export facilities in drier years than in wetter years resulted in overall entrainment being similar under the BDCP and EBC2_LLT (i.e., accounting for sea level rise), or up to approximately 20% greater (in relative terms; less than 1% different in absolute terms) under BDCP compared to existing conditions, a result of the effect of sea level rise on X2, one of the variables included in the modeling (Appendix 5.B., Section 5.B.5.5.1.1, *Larvae/Juveniles*). Higher outflows under HOS_LLT could result in lower proportional entrainment loss of larval-juvenile delta smelt than under EBC2_LLT: under HOS_LLT, larval-juvenile entrainment proportion was around 20% less (in relative terms; 2% less in absolute terms) across all water-year types (Appendix 5.B, Section 5.B.6.5.2, *Delta Smelt (SWP/CVP South Delta Export Facilities: Proportional Entrainment Loss Regressions)*). As discussed in Appendix 5.B, Section 5.B.7, *Summary and Conclusions for Effects on Entrainment*, modeling of entrainment of larval-juvenile delta smelt—and indeed other species—has uncertainty because of real-time management decisions that could occur and alter export rates from those modeled here. Implementation of the BDCP would include a real-time operations management group, similar to (or a continuation of) the current Delta Smelt Working Group, which would meet weekly to examine hydrodynamic data and species distribution in order to recommend appropriate levels of export pumping that would minimize entrainment loss. Such decisions cannot be modeled accurately; accordingly, the results of the entrainment analyses should be viewed with some caution. Nevertheless, given that the daily management of water exports to limit entrainment under existing conditions also will occur under the BDCP, it is concluded with high certainty that the BDCP would provide a low positive change to this attribute (i.e., less south Delta entrainment loss) for larval and juvenile delta smelt. This conclusion is based on HOS_LLT, and is consistent with agency biologists from the August 2013 workshops, who suggested that zero or low positive change would be warranted on the basis of the high-outflow scenario.

Analyses suggest that, averaged over all years in the late long-term, proportional entrainment loss of adult delta smelt under the BDCP would be around 20% lower (in relative terms; 1.5% in absolute terms) than under existing conditions or future conditions without the BDCP (Appendix 5.B, Section 5.B.6.1.5.2, *Adult (Proportional Entrainment Loss Regression)*). Greater use of the north Delta intakes in wet, above-normal, and below-normal water years would lead to considerably less overall entrainment under the BDCP; whereas relatively greater reliance on the south Delta export facilities in dry and critical years would result in similar overall entrainment under the BDCP and existing conditions. Of probable importance to the delta smelt population is the avoidance of appreciable losses in both the adult and subsequent larval/juvenile population (Appendix 5.B, Section 5.B.6.1.5.2; Baxter et al. 2010). Therefore, it is concluded with high certainty that the BDCP would result in a moderate positive change to this attribute for adult delta smelt, i.e., moderately less south Delta entrainment loss. During the August 2013 workshops, agency biologists suggested that a low or moderate positive change conclusion was appropriate, with high certainty. As noted above for larval-juvenile delta smelt, it is difficult to model real-time decision-making; thus, the extent of positive change under the BDCP in light of existing and future real-time management cannot be predicted with very high certainty. In addition, the modeling was based solely on changes to Old and Middle River flows per the USFWS (2008a) BiOp, whereas other factors such as turbidity are of importance in influencing entrainment (Grimaldo et al. 2009), but these are not readily modeled (see additional discussion in Appendix 5.B, Section 5.B.5.5.1.2, *Adults*).

There are more than 2,500 water diversions, including agricultural diversions, in the Plan Area (Herren and Kawasaki 2001) (Appendix 5.B., Section 5.B.3.5, *Agricultural Diversions*). Losses of delta smelt occur at agricultural water diversions in the Plan Area (Cook and Buffaloe 1998; Nobriga et al. 2004). The extent of the entrainment is not known, but Nobriga and Herbold (2009) considered it unlikely to be affecting the delta smelt population to a great extent for the following reasons.

- The zone of hydrodynamic influence is very small and close to the shore, whereas delta smelt tend to be away from the shore.
- Many irrigators do not divert water every day.
- Many diversions are found in the south Delta, where risk for entrainment at the SWP/CVP export facilities is relatively high and habitat conditions are poor.
- Agricultural water use patterns have not changed since the 1930s.
- Other, littoral species that are more prone to entrainment at agricultural diversions do not appear to be affected and have comparatively healthy populations.

For this effects analysis, it was assumed with moderate certainty that entrainment at agricultural diversions is an attribute of low importance for larval, juvenile, and adult delta smelt. During the August 2013 workshops, agency biologists concurred with low importance for larvae and juveniles, whereas some thought that low or zero importance may be warranted for adults on the basis of strictly agricultural diversions that tend to occur outside of the delta smelt adult occurrence period (however, other nonproject diversions may also be of importance, e.g., in Suisun Marsh, so a low importance was retained); there was also concurrence with a moderate certainty assumption. Particle-tracking modeling suggests that entrainment of delta smelt larvae at the agricultural diversions would not greatly differ under the BDCP compared to under existing conditions (Appendix 5.B, Section 5.B.6.4.1.1, *Particle Tracking Modeling*). Implementation of *CM21 Nonproject Diversions* aims to reduce entrainment through removal, consolidation, relocation, reconfiguration, and screening at nonproject diversions (primarily agricultural diversions). Further, *CM4 Tidal Natural Communities Restoration* could result in the decommissioning of more than 12% of Plan Area agricultural diversions in the late long-term, and the DRERIP (Nobriga and Herbold 2009) evaluation of the previously proposed conservation measure to decommission nonproject diversions (similar to the current CM21) suggest a low magnitude effect with low certainty (Appendix 5.B, Section 5.B.6.4.3.1, *Delta Regional Ecosystem Restoration Implementation Plan Analysis of Nonproject Diversions*). Therefore, given that agricultural diversions typically are greatest during the larval or juvenile phases of the delta smelt life cycle (Appendix 5.B, Section 5.B.4.7, *Agricultural Diversions*), it is concluded with low certainty that the BDCP will result in a low positive change in this attribute for larval and juvenile delta smelt. It is also concluded with low certainty that the BDCP would result in a low positive change for adult delta smelt, , based on the potential for less diversion in certain areas such as Suisun Marsh.

Annual entrainment loss at the Barker Slough Pumping Plant in the Cache Slough subregion was estimated to range from fewer than 400 to more than 32,000 delta smelt larvae between 1995 and 2004 (U.S. Fish and Wildlife Service 2008a:170). The estimates were based on multiplying density of fish in the nearby water column by pumping rate; USFWS (2008a:171) noted that entrainment may have been lower because of the fish screen at the facility, but direct entrainment estimates were not made. For this effects analysis, it was assumed with moderate certainty that entrainment of delta smelt larvae at Barker Slough Pumping Plant under existing conditions is an attribute of low importance to the delta smelt population; the existing screens would exclude juvenile and adult delta smelt and so are not considered to be important to these life stages, with high certainty. Implementation of dual conveyance and a new North Bay Aqueduct Alternative Intake that could be used instead of the Barker Slough intake, under the BDCP, should lower entrainment of delta smelt larvae at the North Bay Aqueduct compared to existing conditions. Particle-tracking modeling results that do not account for the change in alternative intake location but focus solely on pumping differences between scenarios (Appendix 5.B, Section 5.B.4.6, *SWP North Bay Aqueduct*) and changes in hydrodynamics because of habitat restoration in the Cache Slough subregion show that entrainment of particles at the North Bay Aqueduct would be relatively lower under the BDCP compared to under existing conditions (average reduction of around 1% fewer particles being entrained, depending on starting distribution) (Appendix 5.B, Section 5.B.6.3.1.1, *Particle Tracking Modeling*). Therefore, there is the potential for a low positive change to this attribute as a result of the BDCP on this attribute for delta smelt larvae, with low certainty that this is of much consequence to the population.

5.5.1.2 Adverse Effects

5.5.1.2.1 Increased Water Clarity

The BDCP north Delta intakes will reduce the quantity of sediment entering the Plan Area, possibly increasing water clarity in some areas and negatively affecting delta smelt, although the BDCP has the potential for mixed effects on water clarity overall in delta smelt habitat. Uncertainty would be reduced considerably with development of a suspended sediment simulation model.

Water clarity (turbidity) is a very important habitat characteristic for delta smelt and is a significant predictor of larval feeding success (Baskerville-Bridges et al. 2004) and juvenile distribution (Nobriga et al. 2008; Feyrer et al. 2011) that has been correlated to long-term changes in abundance or survival either by itself or in combination with other factors (Thomson et al. 2010; Miller et al. 2012). For this effects analysis, it was assumed with very high certainty that water clarity is an attribute of critical importance to delta smelt larvae, juveniles, and adults. Water clarity was assumed to be unimportant to eggs, although during the August 2013 workshops agency biologists suggested that it had importance in determining which spawning areas may be selected (which, for the purposes of this effects analysis, is assumed to influence the adult life stage instead); otherwise, agency biologists concurred with the assumed importance for the other life stages. Cloern et al. (2011) noted the uncertainty in future turbidity trends in the Plan Area: specifically, it is unclear whether a 40-year average decline in turbidity of 1.6% per year will continue at this rate. Should such a trend continue, it presumably will decrease further delta smelt habitat quality in the Plan Area. How the BDCP may affect water clarity in the late long-term is uncertain, and depends on a variety of interacting factors (Appendix 5.C, *Flow, Passage, Salinity, and Turbidity*, Attachment 5C.D, *Water Clarity—Suspended Sediment Concentration and Turbidity*).

Because of the north Delta intakes, *CM1 Water Facilities and Operation* was estimated to result in around 8 to 9% less sediment in the late long-term entering the Plan Area from the Sacramento River, the main source of sediment for the Delta and downstream subregions. In addition, sediment accretion in the ROAs would occur over time as part of the development of tidal marsh under *CM4 Tidal Natural Communities Restoration*. These two conservation measures could limit sediment supply to areas of importance to delta smelt, such as Suisun Bay, which would result in less seasonal deposition of sediment that could be resuspended by wind-wave action to make/keep the overlying water column turbid. This may be especially true during low-flow periods such as the fall. The potential exists for wind-wave resuspension of sediment within the ROAs based on an analysis of typical prevailing wind speed, fetch, and water depth, which may provide relatively low water clarity and therefore good habitat for delta smelt; the Cache Slough and West Delta ROAs, areas of current and expected high densities of delta smelt, have the best potential for such resuspension

(Appendix 5.C, Attachment 5C.D), and the Cache Slough subregion is known to include a localized turbidity maximum zone caused by repeated cycles of tidal and wind-wave resuspension (Morgan-King and Schoellhamer 2012). A full suspended sediment model of the Plan Area would be required to quantitatively describe and predict the many interacting factors that influence water clarity and to reduce uncertainty regarding the potential effects of BDCP. However, restoration design will play an important role in improving turbidity conditions in specific areas, and adaptive management of *CM4 Tidal Natural Communities Restoration* will be used to maximize delta smelt habitat quality, including conditions related to water clarity. It is concluded with low certainty that the north Delta intakes' sediment removal (CM1) and trapping of sediment in ROAs (CM4), coupled with potential for resuspension in shallower restored areas, would have a variable effect over the Plan Area, but that there is a potential for a low negative change to water clarity (i.e., greater water clarity) for delta smelt juveniles. This is because the majority of the juvenile population tends to occur in the downstream ROAs, particularly Suisun Bay and the West Delta, to which sediment supply could be limited as discussed above. The change is concluded to be limited to the juvenile life stage because of the spatial (downstream) and temporal (low-flow periods) occurrence of this life stage. It is concluded with low certainty that there would not be changes to water clarity for the other life stages that occur in various parts of the Plan Area during higher-flow periods in which water clarity may be generally lower. During the August 2013 workshops, agency biologists suggested that zero or low negative change in the water clarity attribute would be appropriate for larvae and adults, and a low negative change would be appropriate for juveniles (following the logic presented above), all with low certainty. Although agency biologists were basing the conclusions on the BDCP high-outflow scenario, there is estimated to be relatively little difference in sediment entering the Plan Area from the Sacramento River between the evaluated starting operations scenario (ESO_LLT: 9%; Appendix 5.C, Attachment 5C.D) and the high-outflow scenario (HOS_LLT: 8%).

5.5.1.2.2 North Delta Intakes Entrainment and Impingement

Some losses of delta smelt may occur because of entrainment and impingement at the north Delta diversions; however, these losses would be an exceedingly rare occurrence, because much of the population occurs downstream of the diversions.

The centerpiece of *CM1 Water Facilities and Operation* is the implementation of dual conveyance by the construction of three intakes with 9,000-cfs total water diversion capacity along the Sacramento River in the north Delta subregion. Delta smelt mostly occur well downstream of this area but have been found in the vicinity of the screens as adults and larvae in USFWS seine surveys and CDFW striped bass egg and larvae surveys (Appendix 5.B, *Entrainment*, Section 5.B.6.2.2.1, *Occurrence near the Proposed North Delta Intakes*). Delta smelt greater than standard length of around 22 mm would be excluded from entrainment by the proposed screen mesh of 1.75 mm (Appendix 5.B, Section 5.B.6.2.2.2, *Entrainment*; Turnpenny 1981; Margraf et al. 1985; Young et al. 1997). For individuals contacting the screens, the potential for impingement-related injury and mortality exists (Appendix 5.B, Section 5.B.6.2.2.3, *Impingement and Screen Contact*; Swanson et al. 2005; White et al. 2007). Approach and sweeping velocity criteria for the north Delta intake screens have not been finalized, but approach velocity will be 0.33 foot per second (fps) (the criterion for salmonid fry) or less, and may be limited to 0.2 fps at times when delta smelt are present in the area in appreciable numbers (which is expected to be an exceedingly rare occurrence). As noted by Nobriga et al. (2004), delta smelt tend to be less abundant near the shore, so a relatively low proportion of individuals occurring near the intakes would be affected, but this is also uncertain because there is evidence for adult delta smelt migration being conducted by tidal "surfing" (Sommer et al. 2011), which may involve shoreward movement in some locations. Therefore, given the relatively low proportion of the delta smelt population that is likely to occur near the north Delta diversions and the use of state-of-the-art screening technology, it is concluded with high certainty that the north Delta intakes will have a low negative effect on larval, juvenile, and adult delta smelt. Note that because the north Delta diversions do not currently exist, the attribute's current importance and the change under the BDCP are somewhat artificial, but were assumed with high certainty to be both be low. Monitoring of entrainment and impingement will further inform the effect of this attribute following implementation.

5.5.1.2.3 Blue-Green Alga *Microcystis* Direct and Indirect Effects

Greater water residence time under the BDCP from changes in water operations and restoration may promote the toxic blue-green alga *Microcystis* and result in direct toxic effects on delta smelt and indirect effects on delta smelt through reductions in food availability.

The toxic blue-green alga *Microcystis* has been shown to have negative effects on the aquatic foodweb of the Delta, principally in the south Delta subregion and the middle to upper portions of the West Delta subregion near locations such as Collinsville, Antioch, and Franks Tract (Lehman et al. 2010). The distribution of *Microcystis* has been negatively correlated with chloride, total suspended solids, and total organic carbon and positively correlated with nitrate-N, soluble phosphorus, and total nitrogen (nitrate-N plus ammonium-N) (Lehman et al. 2008; 2010). There was no correlation with total nitrogen to soluble phosphorus ratio or with ammonium-N (Lehman et al. 2010). Lehman et al. (2008) found evidence that *Microcystis* cell density was higher at lower river flows and during periods of less flow variation later in the summer, as well as higher temperature and water clarity, with some variability between locations (broadly defined as Old River, San Joaquin River, and Sacramento River, and mostly including parts of the West Delta and South Delta subregions) in terms of environmental correlates. The blooms of *Microcystis* occur in late summer and fall, coinciding with the delta smelt juvenile life stage. Although direct effects on delta smelt have not been examined, Baxter et al. (2010) considered that, based on the work of Lehman et al. (2010), who analyzed two commonly found species, striped bass and silversides, there was some likelihood of potential negative effects on juveniles. High concentrations of *Microcystis* may result in direct toxic effects on delta smelt or indirect effects through reduced prey availability (Ger et al. 2009). For this effects analysis, it was assumed with low certainty that *Microcystis* is an attribute of moderate importance to delta smelt juveniles; this view generally was endorsed by agency biologists during the August 2013 workshops, with some suggesting high importance (with low certainty). Other life stages do not coincide with the typical timing of *Microcystis*; therefore, it was assumed with high certainty that this attribute is unimportant to them. As discussed in Appendix 5.F, *Biological Stressors on Covered Fish*, Section 5.F.8.3, *Potential Effects: Benefits and Risks*, changes in water operations under *CM1 Water Facilities and Operation* and restoration under *CM4 Tidal Natural Communities Restoration* would lead to longer water residence time within some portions of the Plan Area where *Microcystis* tends to be most likely to occur. This would result in greater magnitude of blooms, particularly in the late long-term due to the predictions of warmer water temperatures, a key predictor of bloom occurrence (Appendix 5.F, Section 5.F.8.1.1, *Cyanobacteria Microcystis*).

The likelihood of direct or indirect negative *Microcystis* effects on delta smelt juveniles during the fall is greater under the low-outflow scenario (LOS) than under the evaluated starting operations

(ESO) scenario and high-outflow scenario (HOS), because more of the delta smelt population may be further upstream (i.e., in the West Delta subregion) in response to the lower outflow (recall that LOS does not have the higher fall outflow). Average fall water residence time in the West Delta subregion, based on DSM2 modeling, would also be greater under LOS_LLT (35 days) than EBC2_LLT (27 days) and ESO_LLT (30 days).Overall, it is concluded with low certainty that the BDCP would result in a low negative change to the *Microcystis* attribute for delta smelt juveniles. Limited agency biologist opinion during the August 2013 workshops suggested that a conclusion of zero or low negative change was warranted, with low certainty. It is anticipated that future research will elucidate the importance of this organism to delta smelt and allow better predictions about whether BDCP actions will affect the magnitude and duration of the bloom, and if so, how to manage those effects. In addition, Glibert et al. (2011) presented evidence from other locations supporting the importance of altered nutrient balance (nitrogen-to-phosphorus ratio) and other factors for *Microcystis*, and Lehman et al. (2010) suggest that low flow during their study favored *Microcystis* over other primary producers in the West Delta subregion (Appendix 5.F, Section 5.F.8.1.1, *Cyanobacteria Microcystis*). The important non-BDCP action of the upgrade to the Sacramento Regional Wastewater Treatment Plant to reduce ammonium loading (see further discussion below) may reduce habitat suitability for *Microcystis* in the future.

5.5.1.2.4 Exposure to Contaminants

Exposure of delta smelt life stages to contaminants may occur following restoration under the BDCP. Exposure to agriculture-related contaminants later in the BDCP term may decrease because of restoration of agricultural areas.

It is uncertain to what extent contaminants may have contributed to the current status of pelagic fish species (Brooks et al. 2011). Spawning and early life stages could be affected by elevated concentrations of contaminants during typical winter runoff, but this has not been demonstrated for delta smelt. The effects of contaminant exposure on delta smelt eggs have not been evaluated, and lethal and sublethal effect levels are unknown. There is some evidence that fish embryos are less sensitive than larvae to pyrethroids (Oros and Werner 2005); however, the embryos may be exposed to higher concentrations, because they are in direct contact with the substrate where pyrethroids are more concentrated. The population-level effect of exposure of delta smelt eggs to contaminants is expected to be low but may be larger if sublethal effects have substantial population-level implications. For this effects analysis, it was assumed with low certainty that contaminants have low importance on all delta smelt life stages as the issue has not been studied extensively.

The BDCP could adversely affect delta smelt eggs and other life stages through changes in contaminants (e.g., methylmercury) as a result of changes in water operations (*CM1 Water Facilities and Operation* and *CM2 Yolo Bypass Fisheries Enhancement*) and habitat restoration (principally, *CM4 Tidal Natural Communities Restoration*). Analyses presented in Appendix 5.D, *Contaminants,* suggest that there is low potential for increased contaminant exposure under the BDCP, and there may be a beneficial effect in the late long-term because of reduced contaminants from restoration of areas previously used for agriculture. It is concluded with low certainty that the BDCP will result in a low negative change to this attribute for all delta smelt life stages. Limited agency biologist comment during the August 2013 workshops suggested that a zero or low negative change, with low certainty, was warranted.

5.5.1.2.5 Exposure to In-Water Construction and Maintenance Activities

In-water construction and maintenance effects of the covered activities could affect delta smelt but will be minimized with careful management.

In-water construction activities at the proposed north Delta intakes (*CM1 Water Facilities and Operation*) will be limited to one construction season during the months of June to October (Appendix 5.H, *Aquatic Construction and Maintenance Effects*). Delta smelt generally occur well downstream of the construction area, although as noted above for impingement and entrainment, some individuals do occur near the proposed intakes. The expectation is that most delta smelt will have left the construction area by June, as spawning will have largely been completed and larvae will have moved downstream. Any delta smelt present may experience adverse effects from underwater sound (e.g., pile driving), entrapment in enclosed areas (e.g., cofferdams), exposure to temporary water quality deterioration (e.g., suspended sediment and suspension of toxic materials), and accidental spills. Local shorelines will be temporarily and permanently affected by intake construction, although the existing river channel at the intake sites is generally of low value (steep sloping, revetted banks). Maintenance dredging also may decrease water quality temporarily. Restoration activities under *CM4 Tidal Natural Communities Restoration*, *CM5 Seasonally Inundated Floodplain Restoration*, *CM6 Channel Margin Enhancement*, and *CM7 Riparian Natural Community Restoration* may temporarily reduce water quality and will be more likely to affect delta smelt, because many of the activities will be closer to the species' main distribution. Breaching of levees to create tidal habitat may reduce areas of channel margin, but the breaching will result in considerable habitat gains. In-water activities associated with *CM14 Stockton Deepwater Ship Channel Dissolved Oxygen Levels, CM15 Localized Reduction of Predatory Fishes, CM16 Nonphysical Fish Barriers*, and *CM21 Nonproject Diversions* would have little to no effect on delta smelt because of the small scale of the work. Implementation of *CM22 Avoidance and Minimization Measures* will reduce the likelihood of adverse effects from in-water activities related to construction and maintenance on delta smelt. It is concluded with high certainty that construction and maintenance associated with the BDCP represent a minor adverse effect on delta smelt life stages. Note that the assessment of exposure to in-water construction and maintenance activities is not included in the net effects methodology, because it is not considered a long-term effect of the BDCP.

5.5.1.3 Impact of Take on Species

The BDCP will result in incidental take of delta smelt from several mechanisms. Construction and maintenance at the new north Delta intakes, restoration sites, conservation hatcheries, and nonphysical barriers may result in a number of minor adverse effects on delta smelt, including disturbance from in-water activity and hydrodynamic changes, physical injury from riprap/rock placement and noise and vibration, exposure to fuel or oil, and elevated suspended sediment (Appendix 5.H, *Aquatic Construction and Maintenance Effects*). These effects, however, would be temporary and are unlikely to have a considerable effect on delta smelt population dynamics because the species is mostly distributed well downstream of the area where the main in-water activities (construction of north Delta diversion facilities) will occur, and a number of measures will be taken to minimize effects to any residual fish that might be in the area, most importantly for delta smelt, the seasonal timing of in-water work. Additionally, conservation measures besides *CM1 Water Facilities and Operation* that would affect aquatic habitat would be implemented over time and throughout the Plan Area, avoiding temporal or spatial overlap of many adverse short-term construction effects. As a result, it is anticipated that the impact of take from these activities would be minimal.

At the south Delta diversion facilities, cumulative annual salvage of delta smelt between water years 1996 and 2009 ranged from approximately 336 to 154,650 individuals per year, with the highest salvage recorded in 1999 and 2000. Salvage decreased fairly dramatically in 2005 and has remained relatively low since (336 to 3,752 fish salvaged annually in 2005 to 2009), due to the low abundance of delta smelt during this period, changes in operations to conserve the species (U.S. Fish and Wildlife Service 2008a), and high water clarity. Recent estimates have been even lower: 76 adults and 48 juveniles in 2010; 48 adults and 0 juveniles in 2011 (Smelt Working Group 2010, U.S. Fish and Wildlife Service 2011). Based on lower entrainment estimated for the delta smelt population under the BDCP compared to existing conditions, as described above, there may be a reduction in take of delta smelt at the south Delta facilities that has the potential to provide a minor benefit at the population level (Section 5.5.1.1, *Beneficial Effects*). Salvage of delta smelt at the south Delta facilities could increase in the future if the population size increases as a result of the BDCP or other actions; however, this will not represent an increase in loss as a proportion of the population. There also may be take of larval delta smelt at diversions to the North Bay Aqueduct, but this take will be reduced by implementation of the alternative intake on the Sacramento River. It is anticipated that decreases in entrainment at the south Delta export facilities, the North Bay Aqueduct Barker Slough Pumping Plant, and numerous agricultural diversions that will be decommissioned in tidal restoration areas or screened/reconfigured under *CM1 Water Facilities and Operation* will more than offset any entrainment and impingement at the new north Delta diversion facilities. In general, the BDCP has the potential to reduce take of delta smelt through entrainment which, given the low abundance of the species and probable lack of excess production during the adult and larval-juvenile life stages that are not subject to entrainment, has the potential to contribute to a greater population size.

5.5.1.4 Net Effects

5.5.1.4.1 Summary

The qualitative conclusions from the attribute ranking process with respect to the net effects of the BDCP on delta smelt are depicted in Figure 5.5.1-5. The positive effects of the BDCP are concluded to outweigh the negative effects, so that the net effect of the BDCP is expected to benefit delta smelt, providing for the conservation and management of the species. The certainty of the effects of the BDCP generally is concluded to be moderate or low. This includes the potential changes related to food production and areal extent of habitat as a result of *CM4 Tidal Natural Communities Restoration*.

Delta smelt abundance levels are currently very low. The BDCP has the potential to provide positive effects on each life stage of delta smelt. The BDCP is expected to result in very low levels of entrainment relative to conditions prior to implementation of the USFWS (2008a) BiOp, and is expected to maintain total proportional entrainment loss across all SWP/CVP Delta export facilities at levels below those achieved under the current USFWS BiOp. The BDCP provides the additional benefit of natural communities restoration, which is expected to increase the extent of tidally influenced habitat, including tidal marshes and shallow subtidal habitats, in the Plan Area. Proposed restoration areas are spatially diverse, are within and adjacent to currently important habitats (e.g., Suisun Marsh and the Cache Slough subregion), and are expected to provide a range of habitat conditions, some of which will be suitable for delta smelt spawning and rearing. Expansion of habitat in the Cache Slough subregion in particular may be of particular importance in the late long-term if the species faces the increasingly challenging environmental conditions predicted to occur as a result of a warming climate and rising sea level. In addition to the potential direct habitat benefits from the restoration for delta smelt residing in the restored areas, the restoration is also intended to provide benefits from increased primary and secondary production from the tidal marshes and newly available open waters. There is low certainty in the potential export of food resources from the restoration areas as shown in Figure 5.5.1-5.

The magnitude of the potential benefit from food export out of restored areas is uncertain and depends on a number of factors, including how much restoration has been completed, how the restoration interacts with the tidal and freshwater flow regimes, whether the phytoplankton produced in the restoration areas will be available to zooplankton, and whether the zooplankton will be available to delta smelt, all of which depends on whether adverse conditions occur in the ROAs such as colonization by IAV and invasive clams. Additionally, the extent of the benefit of food production for delta smelt from BDCP tidal restoration may depend on emergent, system-scale factors like ratios of tidal marsh to open water and factors specific to particular regions. For example, appreciable benefits may result from export of food from the Suisun Marsh, West Delta, and Cache Slough ROAs because of year-round occurrence of delta smelt in these areas, whereas less benefit may occur from the South Delta and Cosumnes/Mokelumne ROAs due to delta smelt's seasonal occurrence in these regions, which often have water quality conditions that cannot meet the species' needs (Feyrer et al. 2007; Nobriga et al. 2008; Miller 2011). The Cache Slough subregion is expected to also receive some seasonally increased food production from the Yolo Bypass CM2.

Although uncertainty exists related to the magnitude of beneficial effects of tidal natural communities restoration in relation to increased food production for delta smelt (Lopez et al. 2006; Lucas and Thompson 2012), current scientific evidence indicates that higher food production will not occur without an increase in the ratio of shallow to deep water (Lopez et al. 2006; Cloern 2007). Action 6 of the USFWS (2008a) BiOp requires a program to create or restore 8,000 acres of intertidal and associated subtidal habitat in the Delta and Suisun Marsh. As noted by USFWS (2008a:381), "New evidence indicates how tidal marsh may benefit delta smelt even if they do not occur extensively within the marsh itself." The evidence was from Liberty Island, where spawning and rearing of delta smelt is apparent. USFWS (2008a:381) concluded "…these data suggest that freshwater tidal wetlands can be an important habitat type to delta smelt with proper design and location." Implementation of the BDCP will include several times the amount of tidal wetlands called for in the USFWS (2008a) BiOp, and deliberate restoration design and management to promote food production and export to areas where delta smelt occur. Knowledge gained from previous active and passive restoration projects in the Plan Area will be used to guide such efforts (Appendix 5.E, *Habitat Restoration*, Attachment 5.E.B, *Review of Restoration in the Delta*).

Adaptive management over the period of implementation will aim to maximize the food and direct habitat benefits to delta smelt. The process of determining the extent of benefits of restoration for delta smelt will begin with research conducted in a combination of existing tidal wetlands and near-term restoration projects constructed during the first 5 to 10 years of implementation. Because of the uncertainties in scaling differing Plan and non-Plan effects of, it is not certain that covered activities will provide the food benefits needed to increase delta smelt populations. However, the covered activities have the potential to provide a net benefit to delta smelt that does not exist in absence of the project as a result of the large amount of tidal wetland restoration. Realization of this considerable potential would augment the BDCP's anticipated contribution to recovery and conservation of delta smelt in the Plan Area as part of the overall conservation strategy.

Category	Appendix	Attributes	Definition	Eggs	Larvae	Juvenile	Adults
Food	E	Zooplankton community	Species composition of the zooplankton community and presence of suitable prey species	NA	Zero	Zero	
		Zooplankton abundance	The abundance of zooplankton	NA	Moderate	Moderate	Very Low
		Benthic & Epibenthic prey abundance	The abundance of epibenthic prey species such as amphipods	NA		Moderate	Low
		Insect abundance	The abundance of insect prey	NA		Low	Very Low
Entrainment & Impingement	B	North Delta Intakes	Potential entrainment/impingement from the proposed North Delta intakes	NA	Very Low-	Very Low-	Very Low-
		South Delta Pumps	Pumping rate from the CVP/SWP south Delta export facilities and resulting entrainment	NA	Low	Very Low	Moderate
		North Bay Aqueduct	Entrainment from the SWP NBA facilities	NA	Very Low		
		Ag Diversions	Entrainment from Agriculture Diversions	NA	Very Low	Very Low	Very Low
Migration & Movement	C	Plan Area Flows	Magnitude, timing, direction, and duration of flows during migratory periods throughout the Plan Area	NA			
		Interior Delta Entry	Entry of fish into the interior Delta from the mainstem Sacramento or San Joaquin Rivers through channels such as Georgiana Slough or Old River	NA	NA	NA	NA
		Passage Barriers	Structures or conditions that potentially block upstream or downstream migration	NA			
Habitat	C, E	Inter-tidal habitat	Intertidal area from the mean low low water level to the extreme high water level that may support intertidal vegetation and form mudflats; dynamic elements of habitat such as appropriate salinity are considered on a species-specific basis	Moderate	Moderate	Moderate	
		Channel Margin	The extent of shallow water, low slope habitat that generally is characterized by structural complexity, native emergent vegetation and riparian shading cover				
		Floodplains	The interface between upland topography and river hydrology during high flow events				
		Riparian	Forest and scrub that occurs along the margins of river channels and within floodplains	NA	NA	NA	NA
		Sub-tidal habitat	Extent and location of sub-tidal area in the Plan Area, including the low salinity zone (LSZ); dynamic elements of habitat such as appropriate salinity are considered on a species-specific basis	Low	Moderate	Moderate	
Sediment	C	Water clarity	Water clarity in the Plan Area as influenced by amount of suspended material within the water column		Zero	Moderate-	Zero
Temperature	C	Temperature	Adverse effects of high temperatures within the Plan Area	Zero	Zero	Zero	
DO	C	Dissolved Oxygen	Adverse effects of low dissolved oxygen level within the Plan Area			Zero	
Toxins	D, F	Contaminants	Adverse effects of methylated mercury, selenium, pesticides and other pollutants	Very Low-	Very Low-	Very Low-	Very Low-
		Microcystis	The abundance of Microcystis aeruginosa blooms that are toxic to covered fish species and their food			Low-	
Predation	F	Predation	The species-specific consumption of covered fish species by predatory fish (e.g., striped bass, Sacramento pikeminnow, centrarchid bass species, catfish, and inland silversides); note that the attribute aims to isolate predation effects that may not be captured by other attributes, e.g., at manmade structures such as the north Delta diversions	Zero	Zero	Zero	Zero
		Illegal Harvest	Illegal harvest of covered fish species in the Plan Area	NA	NA	NA	NA
In-stream Habitat	C	Sacramento R. Habitat	Flows in the Sacramento River mainstem (below Keswick Dam to the Plan Area) that influence spawning, egg incubation, rearing, or holding habitat	NA	NA	NA	NA
		Feather R. Habitat	Flows in the Feather River (below Oroville Dam to the confluence with the Sacramento River) that influence spawning, egg incubation, rearing, or holding habitat	NA	NA	NA	NA
		American R. Habitat	Flows in the American River (below Nimbus Dam to the confluence with the Sacramento River) that influence spawning, egg incubation, rearing, or holding habitat	NA	NA	NA	NA
Migration & Movement	C	Sacramento R. Migration Flows	Flows in the Sacramento River mainstem (below Keswick Dam to the Plan Area) that influence migration and movement	NA	NA	NA	NA
		Feather R. Migration Flows	Flows in the Feather River (below Oroville Dam to the confluence with the Sacramento River) that influence migration and movement	NA	NA	NA	NA
		American R. Migration Flows	Flows in the American River (below Nimbus Dam to the confluence with the Sacramento River) that influence migration and movement	NA	NA	NA	NA
Temperature	C	Sacramento R. Temperature	Adverse effects of high water temperatures in the Sacramento River mainstem (below Keswick Dam to the Plan Area)	NA	NA	NA	NA
		Feather R. Temperature	Adverse effects of high water temperatures in the Feather River (below Oroville Dam to the confluence with the Sacramento River)	NA	NA	NA	NA
		American R. Temperature	Adverse effects of high water temperatures in the American River (below Nimbus Dam to the confluence with the Sacramento River)	NA	NA	NA	NA

Certainty

- (grey) No effect conclusion made because attribute assumed not to have importance as a current constraint
- NA Life stage not present or not applicable
- (green) Low certainty
- (light blue) Moderate certainty
- (blue) High certainty
- (purple) Very high certainty

Figure 5.5.1-5. Effect of the Covered Activities on Delta Smelt

The potential benefits of the BDCP for delta smelt are assessed further by comparing the actions and conclusions of the BDCP to the main elements and conclusions of the USFWS (2008a) BiOp. The first element of the BiOp is reduction of south Delta exports to limit adult and larval/juvenile entrainment losses of delta smelt. As discussed above, the BDCP would achieve at least the same amount of entrainment protection. Second, Fall X2 in wet and above-normal years as required in the USFWS (2008a) BiOp as one element of delta smelt habitat restoration, is included in BDCP, subject to scientific verification of the efficacy of this action. The fall outflow decision-tree process is conceptually similar to the Fall X2 requirement of the USFWS (2008a) BiOp, and should provide the same level of protection for delta smelt with respect to Fall X2. The BDCP would provide substantial additional habitat (up to 50% more than under existing conditions) from restoration in areas of low salinity. Finally, the BiOp requires 8,000 acres of restoration to replace lost foodweb productivity attributable to the south Delta export facilities. The BDCP will restore several times this quantity of tidal natural communities (65,000 acres including sea level rise accommodation), providing the potential for greater restoration of foodweb productivity than under the BiOp. For these reasons, the BDCP is consistent with USFWS conservation goals and is expected to exceed the benefits to delta smelt provided under the BiOp.

Potential adverse effects of the BDCP on delta smelt include greater water clarity in the Plan Area because of sediment removal by the north Delta intakes and sediment capture in the upstream ROAs. Other adverse effects include the potential for greater *Microcystis* blooms of greater intensity resulting in toxic effects to delta smelt and their prey. There is also the potential for exposure to contaminants liberated during restoration actions. Adverse effects of the north Delta intakes (entrainment/impingement) are expected to be extremely minor and could be limited further through operational criteria such as real-time management of diversions during periods of relatively high delta smelt abundance in the area.

The BDCP will result in no net change in several attributes for delta smelt compared to existing conditions.

- As described in Appendix 5.D, *Contaminants*, ammonium levels, an important stressor influencing plankton communities in the Plan Area, will not change as a result of the BDCP.
- *Interior Delta Entry* is an attribute that relates to different migration routes through the Plan Area (e.g., entry to the East Delta subregion through the Delta Cross Channel and Georgiana Slough) and applies to juvenile salmonids and other anadromous species migrating through the Plan Area that could be affected by *CM16 Nonphysical Fish Barriers*, and is not applicable to delta smelt. The principal passage barriers that delta smelt may encounter in the Plan Area are the Suisun Marsh Salinity Control Gates; because changes in operations of the gates under the BDCP are unknown and probably of short duration, they were assumed to have no effect on delta smelt.
- *CM6 Channel Margin Enhancement, CM5 Restoration of Seasonally Inundated Floodplain,* and increased flooding of Yolo Bypass under *CM2 Yolo Bypass Fisheries Enhancement* will have no appreciable effects on delta smelt in terms of habitat for occupancy by different life stages.
- Dissolved oxygen (DO) appears largely unimportant to delta smelt under existing conditions. Areas for which DO was modeled show little difference between existing conditions and the BDCP (Appendix 5.C, *Flow, Passage, Salinity, and Turbidity*, Section 5.C.5.4.3, *Dissolved Oxygen*).

As discussed in Appendix 5.F, *Biological Stressors on Covered Fish Species*, a number of interacting factors could produce a positive or negative change in predation for delta smelt. Lower south Delta exports under *CM1 Water Facilities and Operation* may result in less smelt predation by predatory fish at the south Delta export facilities (e.g., in Clifton Court Forebay). Slower water velocity caused by CM1 and *CM4 Tidal Natural Communities Restoration* is expected to increase the potential for IAV (specifically *Egeria*) in a very limited subset of existing channels within the South Delta and West Delta subregions (Appendix 5.F, Section 5.F.5.2.4.3, *Water Velocity*), which would increase habitat suitability for largemouth bass and thereby potentially increase predation on delta smelt. (It should be noted that there is little field-based evidence for largemouth bass preying upon delta smelt [Nobriga and Feyrer 2007], despite experimental evidence that it could occur [Ferrari et al. 2013], and other evidence that greater largemouth bass relative abundance was somewhat statistically associated with lower delta smelt abundance [Mac Nally et al. 2010]). However, *CM13 Invasive Aquatic Vegetation Control* has appreciable potential to limit changes in IAV—both in existing channels and flooded islands and in the ROAs, for which the habitat appears suitable—to possibly to reduce current and future infestation (Appendix 5.F, Section 5.F.5.2.3.3, *Control of Water Hyacinth*). Placement of new structures in the water under CM1 (i.e., the north Delta intakes) and *CM16 Nonphysical Fish Barriers* has some potential for attracting predators and increasing predation on delta smelt, although there is limited spatial overlap of the proposed locations of these measures with the delta smelt population. *CM21 Nonproject Diversions* involves screening, relocating, modifying, or removing existing smaller water intakes (e.g., for agriculture) in the Plan Area, which could result in positive changes to predation if structures are removed or negative changes if new, larger structures that could harbor predators are built. Decommissioning and removal of smaller water intakes as part of restoration under CM4 presumably would also achieve positive changes in relation to habitat suitability. *CM15 Localized Reduction of Predatory Fishes* is largely focused on addressing known areas of relatively high predation mortality for juvenile salmonids through reductions in predator habitat suitability or direct removal/relocation of predators, so a measurable effect on delta smelt is unlikely. It is concluded with low certainty that the BDCP will make no net change to predation rates on delta smelt relative to existing conditions. The low certainty will be informed by monitoring and adaptive management related to each of the conservation measures.

Temperature effects of the BDCP in relation to existing conditions were not evident in the analyses of median spawning day of the year, number of stressful days, and number of lethal days (Appendix 5.C, *Flow, Passage, Salinity, and Turbidity*, Attachment 5C.C, *Water Temperature*). This suggests that climate rather than water operations governed temperature changes in the Plan Area. It is evident that climate change could have appreciable effects on delta smelt by making the spawning season earlier in the year and possibly disrupting its coincidence with other important variables (e.g., day length, flows) (Wagner et al. 2011). With climate change, the number of stressful and lethal days will increase into the future. As temperature increases, bioenergetic demands greatly increase, particularly in the warmer months of the year. Potentially greater food production from restored tidal marsh areas under *CM4 Tidal Natural Communities Restoration* would increase the potential of meeting these increased bioenergetic demands.

5.5.1.4.2 Application of Existing Conceptual Models in Net Effects Analysis

There is no modeling tool available that can quantitatively integrate the effects of BDCP and the effects of drivers and stressors on delta smelt that are outside the BDCP purview to make predictions about outcomes for delta smelt conservation. The net effects analysis presented here therefore also considers potential effects in relation to existing published conceptual models. The models are used here to qualitatively assess the extent to which the BDCP actions are expected to change the main elements identified in the models. The simplest plausible model for delta smelt from the DRERIP process includes, among other factors, entrainment of adults and larvae/juveniles (Nobriga and Herbold 2009; Figure 5.5.1-1). Similar or lower entrainment under the BDCP compared to existing conditions because of lower south Delta exports, as described above and illustrated in the entrainment conceptual model, would result in similar or greater delta smelt survival and abundance. Tidal habitat restoration under the BDCP will create appreciably greater shallow-water habitat that has the potential to increase phytoplankton abundance and therefore drive increases in delta smelt zooplankton prey (Figure 5.3-7). This would lessen the suppression of the juvenile delta smelt foodweb noted in the conceptual model of Nobriga and Herbold (2009) and improve delta smelt growth and condition, which would translate into greater fecundity, survival, and abundance. In addition, application of the decision tree for management of fall outflow and extensive habitat restoration would address the issue of the low-salinity zone minimum identified in the conceptual model (i.e., limitation in rearing habitat quantity and quality), which would again result in greater abundance through greater growth, survival, and fecundity. The BDCP's potential changes to juvenile rearing conditions are important in terms of enhancing habitat conditions within the Plan Area for the species, as evidence from recent studies investigating population dynamics suggests density dependence during this life stage (Bennett 2005; Maunder and Deriso 2011; Miller et al. 2012). Regardless of any density dependence, improved foraging opportunities would be of importance in relation to the potential for better growth and resultant fecundity, the importance of which was demonstrated in individual-based modeling by Rose et al. (2013a, 2013b).

The conceptual models for delta smelt and for fish species from the POD investigations (Figure 5.5.1-2 and Figure 5.5.1-3; Baxter et al. 2010) share many of the same elements as the DRERIP delta smelt conceptual model (Figure 5.5.1-1; Nobriga and Herbold 2009). In contrast, the ecological stoichiometry conceptual model of Glibert et al. (2011) emphasizes nutrient ratios as the root cause of a series of foodweb changes that negatively affect delta smelt (Figure 5.5.1-4), and there is increasing evidence that changes in nutrient composition have altered the Delta foodweb primarily through ammonium inhibition of nitrate uptake and resulting adverse effects on phytoplankton communities (Parker et al. 2012; Dugdale et al. 2012). As described in Appendix 5.D *Contaminants*, Section 5.D.4.4, *Ammonia/um*, the BDCP would not greatly change the dilution of ammonia/ammonium from the main source, the Sacramento Regional Wastewater Treatment Plant, which is upstream of the north Delta intakes.

A foreseeable important future non-BDCP action is the change to the wastewater treatment plant's discharge permit that requires reductions in ammonium inputs to the Sacramento River through nitrification and denitrification (Dugdale et al. 2012). Parker et al. (2012) concluded that the delivery of ammonium to the northern San Francisco Estuary affects the pelagic foodweb and the success of pelagic fishes such as delta smelt. They further suggested that control of river nutrients, especially ammonium loading, is essential to management efforts to increase the system's pelagic productivity. Dugdale et al. (2012) developed a conceptual model indicating that reduction of ammonium discharge coupled with sufficient residence time within Suisun Bay would be likely to promote spring diatom blooms fueled by improved nitrate uptake; Dugdale et al. (2012) noted that the *Potamocorbula* invasion has been considered the major factor in the disappearance of phytoplankton blooms in Suisun Bay (Alpine and Cloern 1988, Kimmerer and Orsi 1996 in Dugdale et al. 2012). Dugdale et al. (2012) argued that low *Potamocorbula* biomass in the spring suggests that some other causal agent may be suppressing phytoplankton productivity during this season. They also noted that if changes in ecological stoichiometry occur as a result of nutrient ratios reverting to values more akin to those historically observed, this may lead to reductions in invasive clams based on the case studies presented for other areas by Glibert et al. (2011). Clearly, one of the key ecological questions to be answered is whether nutrients or overbite clam have primacy in control of the estuarine foodweb. However, there could be appreciable potential for this non-BDCP action to positively affect the foodweb in the Plan Area through changes in zooplankton community composition and abundance which would benefit delta smelt and other species. The link to the BDCP is that the considerable extent of newly restored tidal areas, primarily under *CM4 Tidal Natural Communities Restoration*, presumably would achieve even greater potential for food production and hence export into offshore areas as a result of less ammonium loading and improved nutrient ratios in the Plan Area.

5.5.1.4.3 Conclusion

In conclusion, in relation to existing conditions, the BDCP's main beneficial effect for delta smelt is potentially greater food production from restoration actions, with some minor benefit related to reduced entrainment. This outcome can be adaptively managed to maximize the benefit of the BDCP. Restoration design and management will be implemented to continuously increase the potential for measurable benefits received from restored areas (e.g., through careful siting and sizing of restoration areas and breaches). The efficacy of high fall outflows will be tested through the decision-tree process (Chapter 3, Section 3.4.1.4.4, *Decision Trees*) and implemented based on information developed prior to *CM1 Water Facilities and Operation* implementation. Therefore, if needed to provide for the conservation and management of delta smelt, high fall outflow will be implemented. The primary driver of the BDCP effects is the potential magnitude of the benefit provided by tidal wetland restoration (Figure 5.5.1-5). While there is potential for large benefits for delta smelt, particularly if the SRWTP upgrades help restore the viability of a diatom based foodweb, these benefits cannot be validated and this effects analysis has appreciable uncertainty in this particular regard. Therefore, it is concluded that the BDCP will have a beneficial effect on the species, with low certainty in relation to the magnitude of the benefits occurring from food production and the ability of the delta smelt population to access it. The monitoring and adaptive management program will provide the opportunity to address existing uncertainties and alter the BDCP to maximize its long-term benefits. The Adaptive Management Team will provide the ability to respond immediately to potential threats to the species that might occur as a result of project operations, unforeseen changes in species distributions, or other factors. Therefore, the BDCP will minimize and mitigate impacts to the maximum extent practicable and provide for the conservation and management of the delta smelt in the Plan Area.

5.5.2 Longfin Smelt

Longfin smelt (*Spirinchus thaleichthys*) is a pelagic species that inhabits the Plan Area for periods of its life cycle. Longfin smelt occur along the Pacific coast from Alaska to the San Francisco Estuary (Lee 1980). The Bay-Delta DPS is a candidate for listing under the ESA and is listed as threatened under CESA.

Prespawning adult longfin smelt use the Plan Area and other portions of the San Francisco Estuary for staging and holding during upstream migration, and then spawn in the lower reaches of tributary rivers. The planktonic larvae are transported downstream after hatching, and, for those spawned in the Delta or Suisun Marsh, the early juvenile life stages primarily rear in the low-salinity areas of the West Delta and Suisun Bay subregions. Juvenile and adult longfin smelt migrate westward into San Francisco Bay.

Longfin smelt spawn adhesive eggs that are thought to be deposited on sand and gravel and possibly other hard substrates. Spawning occurs primarily in the lower reaches of the Sacramento River in the vicinity of Cache Slough and Rio Vista, although some spawning occurs in the lower San Joaquin River based on presence of early larval longfin smelt in CDFW larval trawl samples (California Department of Fish and Game 2009b). Longfin smelt spawn in the late winter and early spring months when water temperatures in the lower rivers and Delta are seasonally cool.

After hatching from the incubating eggs, longfin smelt larvae are planktonic and drift passively with water flows. Larvae are typically present in the Plan Area during the late winter and early spring months. Juvenile longfin smelt rear for a relatively short period of time in the spring (approximately March to June) in the Suisun Bay and the West Delta subregions before migrating downstream of the Plan Area into San Pablo and San Francisco Bays and nearshore coastal marine waters, where they continue to rear for a year or more. Larval and early juvenile longfin smelt could be affected by covered activities when they are present in the Plan Area during the winter and spring months.

Adult longfin smelt inhabit primarily brackish water and marine areas in San Pablo and San Francisco Bays and nearshore coastal marine waters. Adult longfin smelt are present in the Delta portions of the Plan Area typically from approximately November through March. Based on historical patterns, a substantial proportion of the adult longfin smelt population is expected to be in the Delta during these months in drier years. In wetter years, adult longfin smelt are expected to be distributed near the confluence of the Sacramento and San Joaquin Rivers in the lower West Delta subregion, in the Suisun Bay subregion, or in areas to the west of the Plan Area (e.g., the Napa River). During the fall, prespawning adult longfin smelt migrate upstream into the Suisun Bay subregion, the lower Sacramento River portion of the West Delta subregion, and other parts of the Delta prior to spawning. Adult longfin smelt could be affected by covered activities when they are present in the Plan Area during the fall and winter months.

Historically, from the late 1960s through mid-1990s, indices of longfin smelt abundance based on results of the CDFW FMWT surveys were variable among years but showed that the longfin smelt population abundance was relatively high compared to other fish species (California Department of Fish and Game unpublished data). Longfin smelt FMWT abundance indices declined substantially in the late-1980s/early-1990s and has remained at relatively low levels to date. The abundance index, based on the CDFW FMWT survey conducted in 2007, was the lowest on record over the 1967 to 2011 survey period (California Department of Fish and Game unpublished data). FMWT abundance indices suggest that abundance of longfin smelt in the Bay-Delta estuary has declined by more than

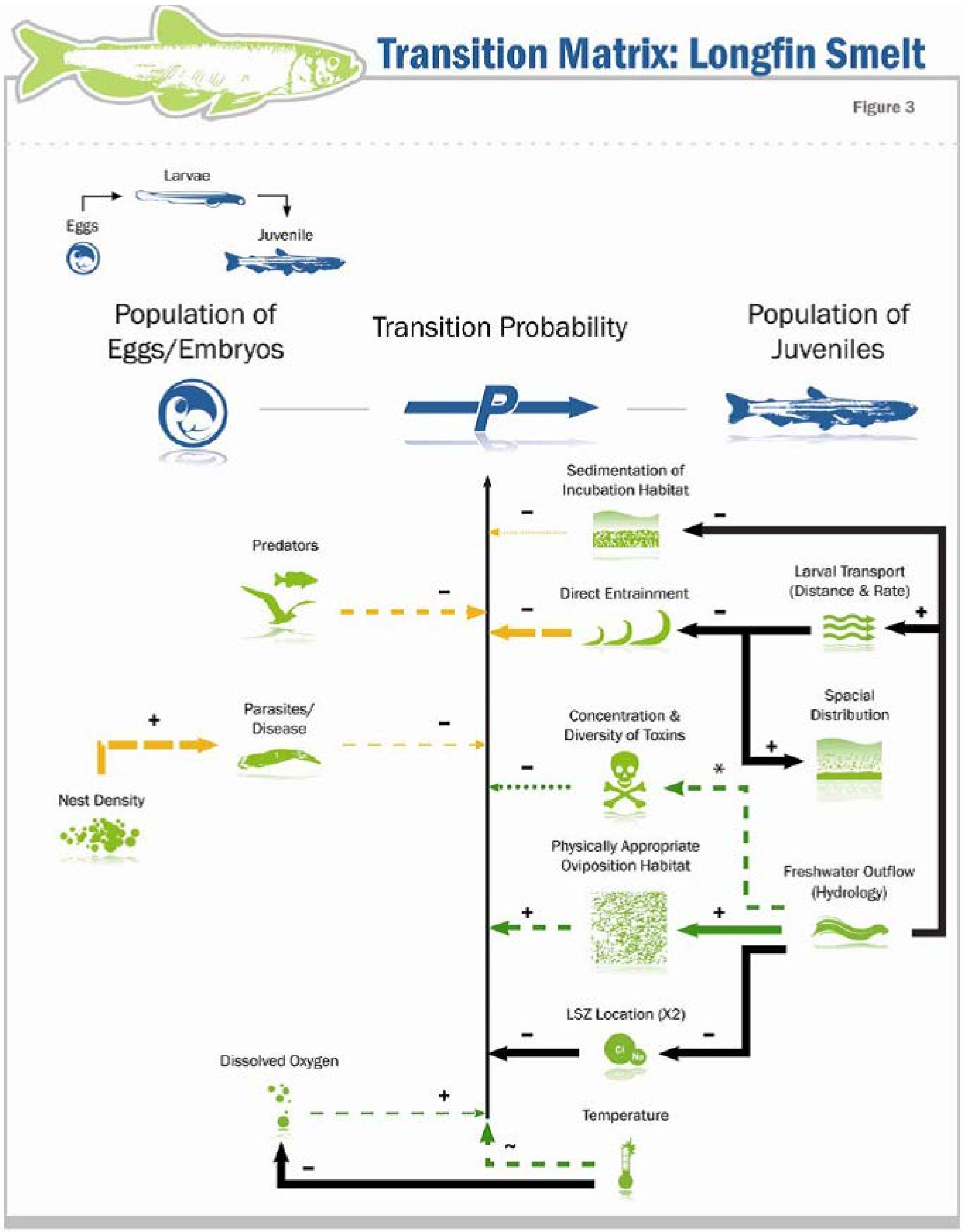
95% since the survey began (California Department of Fish and Game unpublished data). As noted below, this in part may be because of distributional shifts downstream in response to less favorable food conditions (Baxter et al. 2010). The major stressors thought to have contributed to the decline in longfin smelt abundance (not in order of importance) are reduced food availability, reduced Delta outflows during the winter and spring, reduced spawning habitat, reduced access to rearing habitat, prey consumption and predation by nonnative species, entrainment, exposure to toxins, exposure to seasonally elevated water temperatures, reduced turbidity, and low DO levels (Rosenfield 2010). A detailed species account of longfin smelt is presented in Appendix 2.A, *Covered Species Accounts*.

As a result of their life history, longfin smelt are expected to be affected both positively and negatively by conditions in the Plan Area for only a portion of their life cycle, although these effects have potential importance during the entire life cycle. The analysis of potential effects of the covered activities was developed based on the potential changes to conditions under Plan operations, such as changes in the risk of entrainment at the south Delta SWP/CVP export facilities or changes in habitat as a result of enhanced tidal marsh, considered individually for each action and life stage of the species.

A detailed species account of longfin smelt is presented in Appendix 2.A. As with delta smelt, a decision tree is applied to longfin smelt under the BDCP to use science developed prior to the implementation of *CM1 Water Facilities and Operation* to determine initial operations (Chapter 3, Section 3.4.1.4.4, *Decision Trees*). For longfin smelt, the decision tree is focused on the need for spring (March through May) Delta outflow. This effects analysis has evaluated the effects of operations with and without higher spring outflow, as described below and in Appendices 5.B through 5.F.

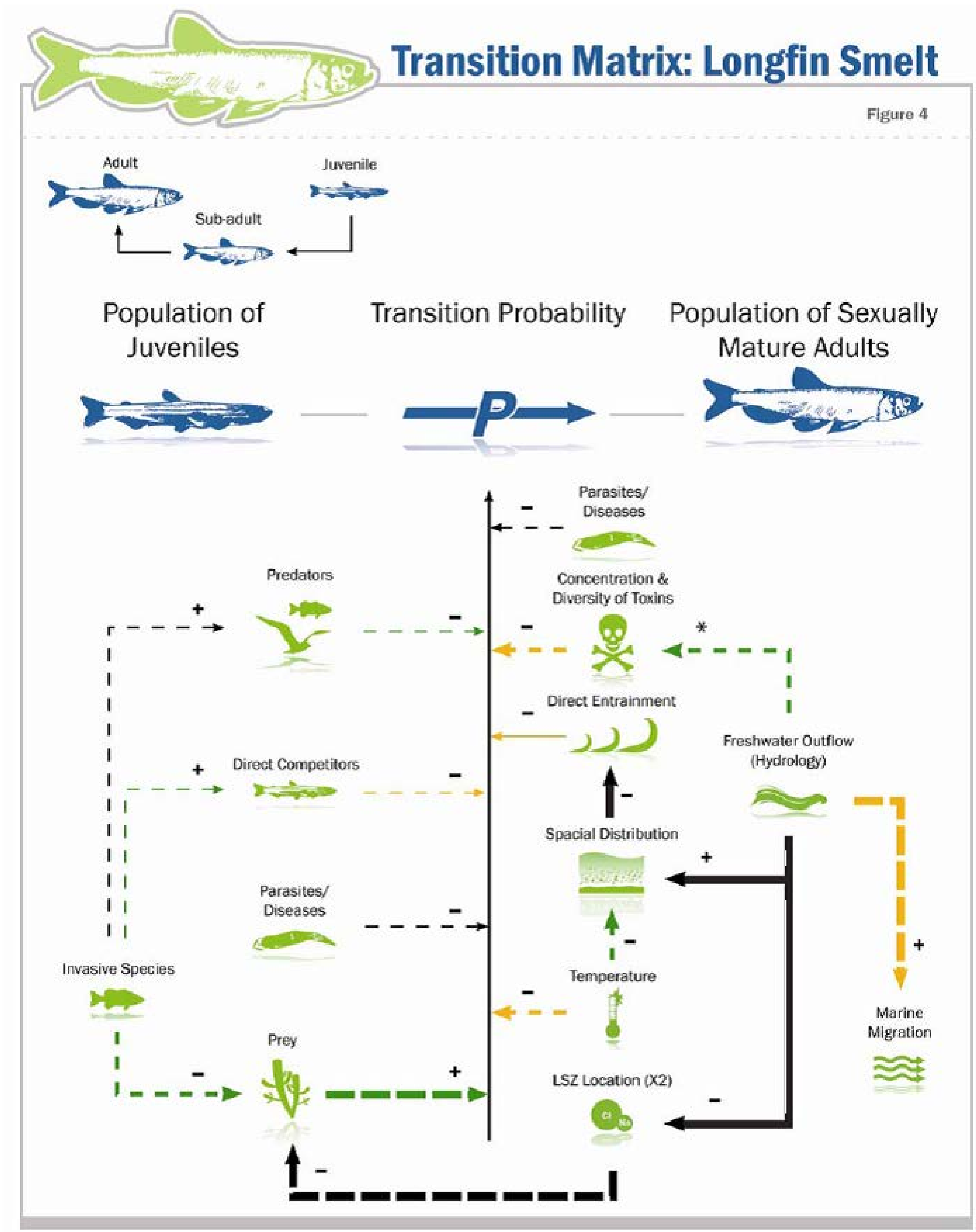
The attribute ranking procedure used to assess the effects of the BDCP on longfin smelt is outlined in the introduction to Section 5.5, *Effects on Covered Fish*. As noted above for delta smelt, this approach is limited by the difficulty in assigning relative importance to the different attributes independently, given the inherent dependencies between many of them. Therefore, as with delta smelt, conceptual models of longfin smelt are also used to assess the net effects of the BDCP. The main elements of these conceptual models are presented below.

Several conceptual models have been developed for the Bay-Delta longfin smelt population. The conceptual models provide a representation of current data and hypotheses on the effects of various biotic and abiotic factors that may be affecting the population dynamics of each life stage of longfin smelt. The conceptual models are used as a framework for assessing the potential net effects of the BDCP on the production, growth, survival, distribution, abundance, and overall population health of longfin smelt. Rosenfield (2010) developed three transition matrices for longfin smelt to address all of their life stages: egg to juvenile (Figure 5.5.2-1), juvenile to sexually mature adult (Figure 5.5.2-2), and sexually mature adult to egg (Figure 5.5.2-3). The model identifies factors that may be affecting each life stage, such as entrainment risk, freshwater outflow, food resources (zooplankton), contaminants, predation, and habitat linkages. The effect of the BDCP on these, or similar, factors was assessed qualitatively based on consideration of the magnitude and direction (positive or negative change) and level of certainty in the predicted response of longfin smelt to the BDCP. The conceptual model linkages were also used in developing the assessment of net effects of the BDCP on longfin smelt.



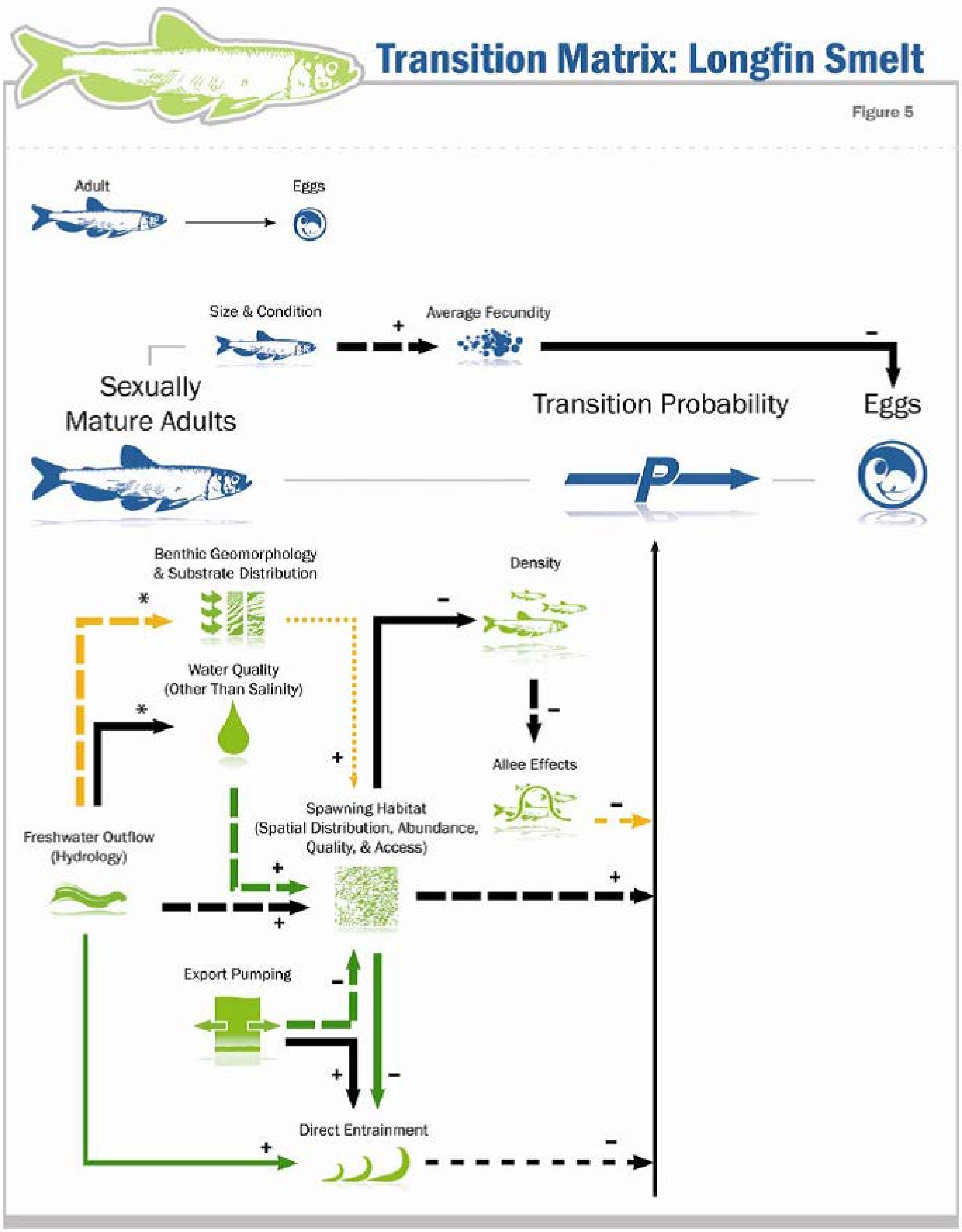
Source: Rosenfield 2010

Figure 5.5.2-1. Conceptual Model for Longfin Smelt Egg to Juvenile Life Stage

1 

2 Source: Rosenfield 2010

3 **Figure 5.5.2-2. Conceptual Model for Longfin Smelt Juveniles to Adult Life Stage**



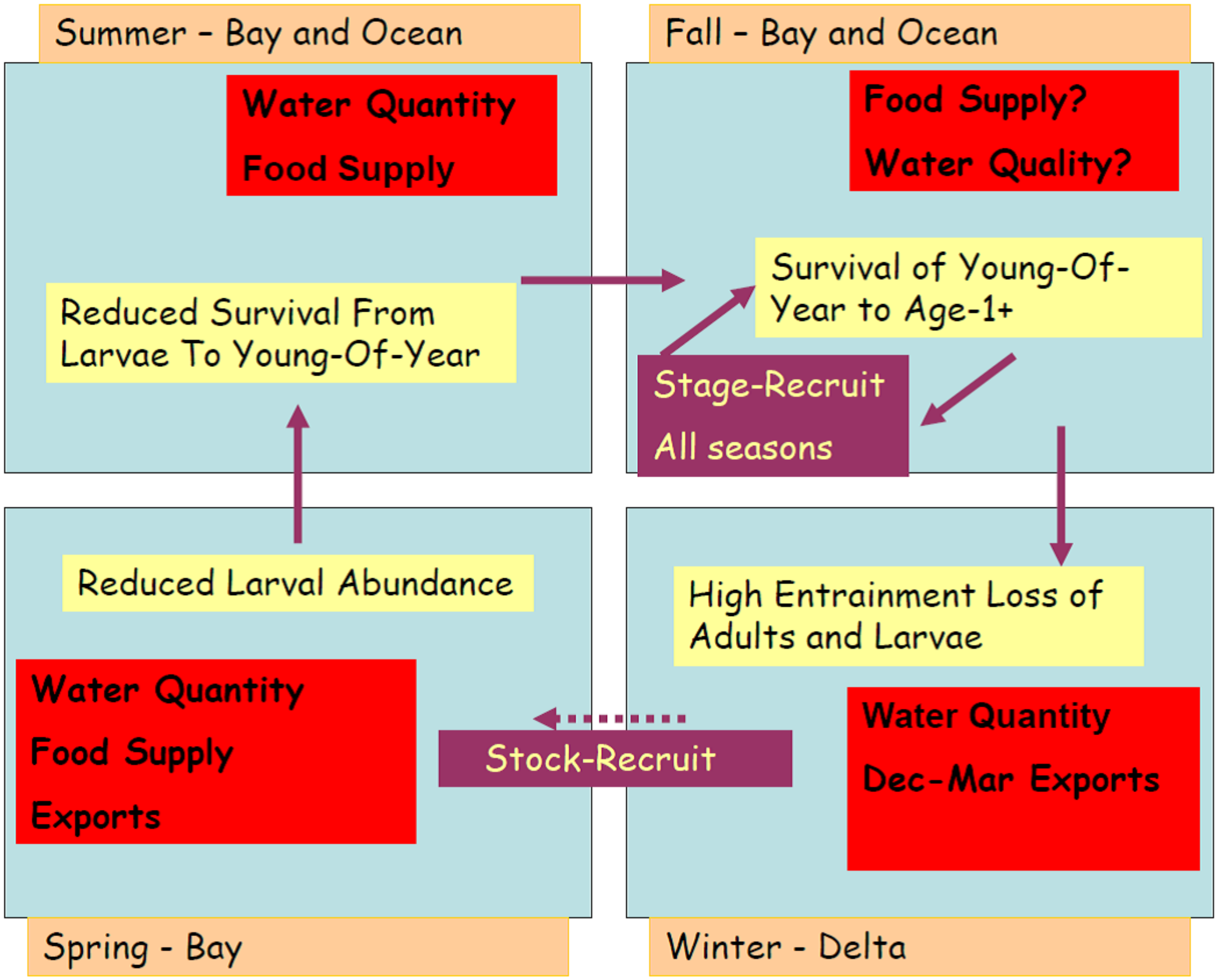
Source: Rosenfield 2010.

Figure 5.5.2-3. Conceptual Model for Longfin Smelt Adult to Egg Life Stage

The following three conceptual models also were considered and applied to the longfin smelt net effects analysis.

- Basic conceptual model for the POD (Figure 5.5.1-3 in Section 5.5.1, *Delta Smelt*; Baxter et al. 2010).
- Conceptual model for the POD based on ecological stoichiometry (Figure 5.5.1-4 in Section 5.5.1, *Delta Smelt*; Glibert et al. 2011).
- Species-specific conceptual model (Figure 5.5.2-4; Baxter et al. 2010), which relates to the following.
    - Survival from larvae to young-of-the-year during the summer as related to water quantity and food supplies in the bay and ocean.
    - Survival from young-of-the-year to age 1+ during the fall as related to food supplies and water quality in the bay and ocean.
    - Survival of adults and larvae as affected by entrainment losses and water quantity in the Delta (December through March).
    - Reduced larval abundance in the spring in response to water quantity (Delta outflow), food supplies, and water exports (entrainment).
    - A stock-recruitment relationship between adults and larvae in winter/spring, as well as stage-recruit relationships between successive life stages.

These conceptual models also provide insight into the importance of various linkages to factors thought to be important in the population dynamics of longfin smelt. These insights informed the determinations of relative importance of different attributes (stressors) on the longfin smelt population described below.



Source: Baxter et al. 2010

Note: The dotted line indicates that the importance of a stock recruitment relationship is unclear. The stage recruitment loop illustrates that both survival from age-0 to age-1 and from age-1 to age-2 are important.

Figure 5.5.2-4. Longfin Smelt Species Model

5.5.2.1 Beneficial Effects

5.5.2.1.1 Spring Outflow Decision-Tree Process

The decision-tree process will use best available science developed prior to dual conveyance operations to determine the initial operations for spring Delta outflow that are necessary, in conjunction with the other conservation measures, to provide for the conservation and management of longfin smelt.

Current science indicates that the decline in longfin smelt relative abundance observed from monitoring has been a result of foodweb changes, and that longfin smelt relative abundance is strongly correlated with winter-spring outflow from the Delta. Studies dating as far back as the 1980s suggest that spring (March–May) outflow is an important driver of longfin smelt abundance, and more recent investigations suggest that recruitment of longfin smelt per unit of outflow has declined over time. Investigations continue to study the relationship between food, flow, and longfin smelt abundance. The primary question related to longfin smelt conservation is the extent to which abundance can be increased through improved foodweb conditions for longfin smelt, and how these improvements may interact with the spring outflow-abundance relationship. As such, the BDCP includes two potential initial operations, each of which are analyzed in this effects analysis. Each of the two initial operations for spring outflow are based on a separate conceptual model. The first conceptual model posits that spring (March through May) Delta outflow provides key longfin smelt habitat attributes, either directly or by providing longfin smelt with maximum opportunity to access areas providing key habitat attributes. The second conceptual model posits that CM4 *Tidal Natural Communities Restoration* provides a functional lift in key habitat attributes that increases recruitment of longfin smelt per unit of spring outflow. Each of these conceptual models will be tested through the decision-tree process.

As noted above in the introduction to the longfin smelt effects analysis and in the species account of longfin smelt (Appendix 2.A, *Covered Species Accounts*), longfin smelt relative abundance has declined considerably over the period of FMWT monitoring. Although FMWT abundance indices can vary considerably from year to year, it is apparent that the longfin smelt decline has occurred in steps, the first of which coincided with the invasion of the estuary by the overbite clam, *Potamocorbula amurenis* (Kimmerer 2002). The second coincided with the POD in the early 2000s (Thomson et al. 2010). *Potamocorbula* caused major reductions in plankton productivity, which in turn facilitated species changes in the foodweb that historically supported longfin smelt (e.g., Alpine and Cloern 1992; Kimmerer et al. 1994; Kimmerer and Orsi 1996; Orsi and Mecum 1996; Jassby et al. 2002; Thompson et al. 2008; Greene et al. 2011; Winder and Jassby 2011). Thus, the late-1980s decline in longfin smelt abundance has been attributed to food limitation stemming from these foodweb changes (Kimmerer 2002; Mac Nally et al. 2010). Other hypotheses regarding the initial cause of the longfin smelt decline include a highly negative population response to the 1987–1994 drought (Rosenfield and Baxter 2007) and some combination of ammonium inhibition of phytoplankton growth rates and increasing nitrogen-to-phosphorus ratios stemming from wastewater inputs to the Sacramento River (Glibert et al. 2011). The overbite clam (*Potamocorbula*) hypothesis has the strongest scientific support, in part because of the abruptness of observed foodweb changes and the longfin smelt step decline; both were apparent 1 year after the clam was first reported from the estuary (Kimmerer 2002). Additionally, estimates of the overbite clam's grazing rate directly support the hypothesis that it can consume phytoplankton and certain zooplankton faster than they can replace themselves (e.g., Kimmerer et al. 1994).

In contrast, the reasons for the POD-era decline are not known, but may be related to further degradation of the supporting foodweb. The continuing decline of longfin smelt could be due to (1) ammonium inhibition of phytoplankton growth rates and increasing nitrogen-to-phosphorus ratios stemming from wastewater inputs to the Sacramento River (Wilkerson et al. 2006; Dugdale et al. 2007; Glibert et al. 2011; Parker et al. 2012), and/or (2) a longer-term response to ongoing foodweb impacts that stemmed from the *Potamocorbula* invasion (Winder and Jassby 2011). It is also possible that long-term changes in spatial distribution of longfin smelt because of factors such as a shift in spatial distribution (both downstream and toward the bottom, as a result of negative changes in the pelagic feeding environment within the Plan Area) may have contributed to lower FMWT indices (Baxter et al. 2010). An analogous mechanism was found for the FMWT's target species, age-0 striped bass, which are now relatively more common in shallower areas than previously observed (Sommer et al. 2011).

A decision-tree process will be used to determine the initial operations for spring outflow under CM1 once construction is completed. More information is provided in Chapter 3, Section 3.4.1.4.4, *Decision Trees*. The fish and wildlife agencies will make the final decision about which of the two criteria will be applicable when the conveyance facilities become operational pursuant to the decision-tree process. The fish and wildlife agencies' determination will be based on best available science at the time of CM1 operation. The determination will include updated analysis of historical data and other appropriate scientific information that exists at the time of the decision. The primary questions that the spring outflow decision tree is intended to answer include the following.

- What is the mechanism by which spring outflow is important for longfin smelt recruitment?
- What are the important sources of mortality for longfin smelt during the spring?
- Is there evidence that habitat restoration will increase longfin smelt recruitment per unit spring outflow?
- How do different outflow operations (e.g., pulse flows vs. more continuous flow) in the spring affect longfin smelt recruitment?
- The following sections summarize and analyze the two conceptual models that underlie the spring outflow branch of the decision tree.

Potential outcome 1: High spring outflow is implemented as part of CM1 operations.

This potential determination may be made if ongoing monitoring and research of longfin smelt and its habitat indicates that spring outflow, or habitat elements provided by spring outflow that cannot be separated from it, are necessary to provide for the conservation and management of this species and to meet the biological objectives for the species.

Conceptual model 1: Spring outflow provides key longfin smelt habitat attributes—either directly or by providing longfin smelt with maximum opportunity to access areas providing key habitat attributes.

Conceptual model 1 relies on the results of many studies pointing to the importance of winter-spring outflow in affecting longfin smelt population performance. Interannual variation in freshwater flow into and from the Plan Area affects longfin smelt recruitment; juvenile abundance is higher in high flow years and lower in low flow years. The association between estuary hydrodynamics and longfin smelt recruitment was first reported by Stevens and Miller (1983) who used FMWT data to explore linkages between Delta inflow and longfin smelt relative abundance. Their finding of a link between river flows into the estuary and the relative abundance of longfin smelt has been re-evaluated and re-confirmed numerous times using different hydrodynamic metrics such as X2 (Jassby et al. 1995; Kimmerer 2002; Kimmerer et al. 2009; Mac Nally et al. 2010; Thomson et al. 2010) and Delta outflow (Rosenfield and Baxter 2007; Sommer et al. 2007; Baxter et al. 2010). These analyses have been based on longer and longer time series and a variety of averaging periods for the flow variable(s). In considering the potential mechanisms behind the flow-abundance relationship, the California Department of Fish and Game (2009: 50) noted:

> The statistical relationship between X2 and longfin smelt abundance suggests winter-spring river flow generates some kind of habitat opportunity, but not all of the mechanisms are known (Jassby et al. 1995; Kimmerer 2002). The drop in longfin smelt abundance after the estuary was invaded by overbite clam suggests a big part of the mechanism was prey availability for young fish, but food production is not the only factor involved because the X2 response has persisted (Kimmerer 2002; Kimmerer et al. 2009).

Kimmerer et al. (2009: 385) noted that "although increases in quantity of habitat may contribute, the mechanism chiefly responsible for the X2 relationship for longfin smelt remains unknown. It may be related to the shift by young fish toward greater depth at higher salinity…possibly implying a retention mechanism."

Although the longfin smelt population has declined over time, as described above, this conceptual model is premised on the apparent strong positive influence of Delta outflow on population abundance as indexed with the FMWT, that has remained evident over time (Kimmerer et al. 2009). Statistically significant regressions between winter-spring Delta outflow and FMWT index have similar slopes for pre-*Potamocorbula* (1967–1987), post- *Potamocorbula* (1988–2000), and POD-era (2001–present) periods (Baxter et al. 2010: Figure 27; see also Kimmerer et al. [2009] for an examination of pre- and post-*Potamocorbula* period using data up to 2007). This indicates that the relative change in longfin smelt abundance index per unit Delta outflow has remained essentially the same over time, but for a given Delta outflow there is now a lower abundance index (i.e., the intercept of the flow-abundance regression has shifted down over time). Under conceptual model 1, the downward shift in longfin smelt recruitment per unit of spring outflow is largely because of the changes described above, principally the *Potamocorbula* invasion, as well as other factors such as changing nutrient composition because of wastewater (noted above) and negative hydrodynamic changes during the early life history (i.e., principally entrainment).

Thus, under this conceptual model, winter-spring outflow is posited to remain an important influence on longfin smelt recruitment, while recruitment per unit of outflow has declined over time. Conceptual model 1 emphasizes the need to provide winter-spring Delta outflows of sufficient magnitude in order to conserve the longfin smelt population. For BDCP, CDFW and FWS analyzed which winter-spring months were the most important determinants of longfin smelt population growth rate, as well as the magnitude of outflow required to achieve positive population growth. This analysis was based on relating the FMWT index in a given year to the index from 1 or 2 years prior (a type of stock-recruitment analysis). These analyses indicated that spring (March–May) Delta outflow in the range of 35,000 to 45,000 cfs would be required to achieve a positive population growth rate. This requirement formed the basis for the high-outflow scenario branch of the decision tree (Table 5.5.2-1). These outflow criteria are described further in Chapter 3, Section 3.4.1.4.3, *Flow Criteria*, and Section 3.4.1.4.4, *Decisions Trees*.

Table 5.5.2-1. March–May Average Outflow Criteria for the High-Outflow Outcome of the Spring Outflow Decision Tree

Exceedance	Outflow Criterion (cfs)
10%	>44,500
20%	>44,500
30%	>35,000
40%	>32,000
50%	>23,000
60%	17,200
70%	13,300
80%	11,400
90%	9,200

For this effects analysis, the importance of spring Delta outflow to longfin smelt was captured with the subtidal habitat attribute; this attribute indicates the importance of the low-salinity zone and its interaction with Delta outflow. For the analysis of potential outcome 1 of the spring outflow decision tree, it was assumed with high certainty that the subtidal habitat attribute was critically important to larvae and juveniles. Discussion with agency biologists during the August 2013 workshops around the importance of this attribute was similar to that of the discussion related to delta smelt, i.e., that Plan Area flows are of importance in allowing dynamic habitat formation. As noted above for delta smelt, the Plan Area flows attribute intends to capture the importance of flows that facilitate broad-scale movement from one area to another, e.g., for juvenile salmonid migrants travelling through the Plan Area. Previous agency biologist comments and comments during the August 2013 workshops on the importance of Plan Area flows for migration and movement suggest that the tidally facilitated movement exhibited by delta smelt is not a current constraint on the species' population performance—these same assumptions were used for longfin smelt. So, for this effects analysis, Plan Area flows for migration and movement of the mobile life stages (larvae, juveniles, and adults) were assumed with high certainty to be unimportant. In the context of capturing the importance of Delta outflow, agency biologists during the August 2013 workshops suggested that the importance may apply mostly to the larval and early juvenile life stages; for this effects analysis, it was assumed appropriate to consider both life stages, particularly given that the subsequent FMWT index that is correlated with outflow primarily consists of young-of-the-year juveniles. During the August 2013 workshops, agency biologists concurred that the importance of subtidal habitat in the context of the low-salinity zone and its interaction with Delta outflow should be assumed to be of critical importance (with high certainty in the context of Plan Area flows, and with moderate certainty in the context of subtidal, low-salinity zone habitat).

Potential changes to the subtidal habitat attribute and the effects on longfin smelt abundance from Delta outflow changes were investigated from the perspective of Delta outflow-related changes using the Kimmerer et al. (2009) winter-spring X2–abundance regressions (Appendix 5.C, *Flow, Passage, Salinity, and Turbidity*, Section 5.C.4.5.1, *X2 Relative-Abundance Regressions*). These regressions have been calculated at various periods in the past, with similar results (Jassby et al. 1995; Kimmerer 2002). This analysis considered changes in relative abundance of juvenile (age 0) longfin smelt as a reflection of Delta outflow early in the life cycle, using average X2 from January to June as the index of outflow. Note that this period includes the winter as well as the main spring (March–May) period recently suggested to be of greatest importance for flow.

The analysis based on the Kimmerer et al. (2009) winter-spring X2–abundance regressions estimates that longfin smelt average relative abundance under the high-outflow scenario (HOS_LLT) is 12% greater than under future conditions without BDCP (EBC2_LLT) when averaged across all water years (Table 5.5.2-2). Spring outflow under HOS_LLT, according to the criteria presented in Table 5.5.2-1, resulted in greater average relative abundance in wet, above-normal, and below-normal years (12 to 14%), but not in dry or critical years (no change or 6% less) (Table 5.5.2-2).

It is concluded with moderate certainty, on the basis of conceptual model 1, that the HOS_LLT would result in a low positive change to the subtidal habitat attribute for longfin smelt larvae and juveniles. During the August 2013 workshops, agency biologist opinion regarding the magnitude of the change was limited, but suggested a moderate positive change may be appropriate.

Table 5.5.2-2. Estimated Longfin Smelt Relative Abundance in the Fall Midwater Trawl[a] under Three Scenarios[b], Based on the X2–Abundance Regression[c], and Change in Abundance under the BDCP High-Outflow Scenario (Compared to Existing Conditions and to Future Conditions without the BDCP)

Water-Year Type	Relative Abundance[a]			Change[d] under HOS_LLT	
	EBC2	EBC2_LLT	HOS_LLT	Compared to EBC2	Compared to EBC2_LLT
All	8,754	5,861	6,589	-2,165 (-25%)	727 (12%)
Wet	18,621	11,880	13,558	-5,063 (-27%)	1,678 (14%)
Above normal	9,889	7,063	7,999	-1,890 (-19%)	936 (13%)
Below normal	4,344	3,141	3,532	-812 (-19%)	391 (12%)
Dry	2,290	1,799	1,794	-496 (-22%)	-6 (0%)
Critical	1,084	887	835	-249 (-23%)	-51 (-6%)

[a] Only results from fall midwater trawl regression shown because patterns were similar for the bay midwater trawl and bay otter trawl regressions.
[b] For descriptions of scenarios, see Table 5.2-3.
[c] Kimmerer et al. 2009.
[d] Negative values indicate lower abundance under the BDCP compared to existing conditions or future conditions without the BDCP.

Potential outcome 2: High spring outflow is not implemented as part of CM1 operations.

This potential determination may be made if ongoing monitoring and research of longfin smelt and its habitat indicates that spring outflow of the magnitude examined under potential outcome 1 is not necessary to support the conservation and management of this species because the functional lift provided by habitat restoration increases population benefits per unit of outflow.

Conceptual model 2: *CM4 Tidal Natural Communities Restoration* provides a functional lift in key habitat attributes that increases recruitment of longfin smelt per unit of spring outflow.

As noted above, the recruitment of longfin smelt per unit of Delta outflow has decreased over time, and this seems most likely to be related to reduced longfin smelt food supply caused by the invasion of overbite clam (*Potamocorbula*) and other factors such as changes in nutrients within the Plan Area; food limitation therefore appears to be of critical importance to longfin smelt. As discussed for delta smelt, evidence exists that restoration of tidal wetlands may increase productivity locally and through export of food to other areas. Conceptual model 2 relies on the hypothesis that *CM4 Tidal Natural Communities Restoration* provides a "functional lift" in the form of enhanced productivity and expanded habitat availability, and that this lift will increase the recruitment of longfin smelt per unit of Delta outflow. Under this hypothesis, substantial benefits of tidal natural community restoration provide for the conservation and management of longfin smelt and help meet the biological objectives for this species. Therefore, the high-outflow scenario for spring outflow (Table 5.5.2-1) would not be needed.

Diet studies indicate that longfin smelt larvae feed extensively on the zooplankton *Eurytemora* and *Pseudodiaptomus* (Hobbs et al. 2006), while juveniles (and adults) feed primarily on mysid shrimp, including *Neomysis* and *Acanthomysis* spp. (Feyrer et al. 2003). For this effects analysis, it was assumed with high certainty that the abundance of zooplankton has critical importance as a current constraint for longfin smelt larvae and juveniles, and it was further assumed with high certainty that zooplankton community composition has high importance for larval longfin smelt. During the

August 2013 workshops, agency biologists concurred with the critical importance/high certainty assumption for zooplankton abundance, but had low certainty in relation to the importance of zooplankton community composition. Based on available information (Hobbs et al. 2006; Rosenfield 2010; Baxter et al. 2010) and the opinions expressed by agency biologists during the August 2013 workshops, for adult longfin smelt zooplankton abundance and community composition are assumed with low certainty to be unimportant as attributes limiting the species in the Plan Area (Rosenfield 2010). Other food attributes (insects and benthic/epibenthic organisms) were assumed to be unimportant for larval longfin smelt in the Plan Area (with very high certainty, following the same rationale as provided for delta smelt, i.e., that these food items are too large to consume by larvae); whereas benthic/epibenthic prey abundance was assumed with moderate certainty to be of low importance for juvenile longfin smelt.

The relationship between phytoplankton growth rate and average habitat depth (Lopez et al. 2006) provides an indication of potential food productivity increases in the Plan Area as a result of tidal habitat restoration (Appendix 5.E, *Habitat Restoration,* Section 5.E.4.4.2.5, *Food in the Delta and the Effect of the Conservation Measures on Food for Covered Fish Species*). Results of those analyses suggest an increase of 60% in potential primary productivity across the entire Plan Area based on the production-acres metric (Table 5.5.1-3 in Section 5.5.1, *Delta Smelt*). This considerable increase in potential primary productivity may translate into increased food resources for larval and early juvenile longfin smelt within restoration sites. These additional food resources may also be exported to longfin smelt habitats beyond the restoration areas. The potential for enhanced primary productivity and its transfer to higher trophic levels is complicated by the uncertain influence of invasive clams and specific habitat characteristics such as water depth and residence time (Lucas and Thompson 2012).

Increased food production under the BDCP has the potential to be of particular importance in and adjacent to areas currently inhabited by longfin smelt, such as the West Delta, Suisun Marsh, and Cache Slough subregions. Total prod-acres in these subregions were estimated to be around 65% greater under the BDCP in the late long-term compared to existing conditions, although the increase in actual food for longfin smelt will depend on the degree to which this phytoplankton growth converts to zooplankton and is not consumed by clams. The benefits to longfin smelt of the high production potential in the south Delta with BDCP will depend on food export to areas where longfin smelt larvae and juveniles are more likely to occur. The potential for food export from the south Delta is unknown. Food produced in the Yolo Bypass may provide some seasonal benefit during periods of winter floodplain inundation and flow recession, depending on the distance that these resources are transported downstream to areas occupied by longfin smelt. Food production in the West Delta and Suisun Marsh subregions may also increase because of changes in hydrodynamics associated with BDCP water operations (e.g., longer hydraulic residence time within the Delta) (Appendix 5.C, *Flow, Salinity, Turbidity, and Passage,* Section 5.C.5.4.4, *Residence Time (DSM2-PTM)*) and subsequent increases in plankton productivity in these areas.

It is concluded that the BDCP will result in a moderate positive change to zooplankton abundance for larval longfin smelt, and low positive change to zooplankton abundance for juvenile longfin smelt, with low certainty for both. Less change is concluded for juveniles because they only spend the early portion of this life stage in areas that may benefit from restoration. These conclusions are made with low certainty because of factors such as invasive clam colonization of restoration sites and the uncertainty in export of food from restored areas. During the August 2013 workshops, agency biologists all concurred that conclusions about potential changes in zooplankton abundance should be made with low certainty, with the suggested magnitude of change ranging from low to high. It is concluded with high certainty that restoration of an appreciable extent of tidal habitat in the Plan Area will result in a low positive change to benthic/epibenthic prey abundance for juvenile longfin smelt[5].

In addition to potential benefits for enhanced foodweb productivity, tidal habitat restoration also offers the potential to provide greater habitat space for occupancy. Longfin smelt are unlike delta smelt in that only the earliest life stages would be likely to benefit from increased habitat space (i.e., eggs for spawning) and larvae. Consistent with the habitat suitability analysis presented in Appendix 5.E, *Habitat Restoration,* Section 5.E.4.4.1.1, *Habitat Suitability Analysis*, spawning is assumed to occur in shallow or deeper subtidal habitat; therefore, for this effects analysis, it was assumed with low certainty that intertidal habitat is not important for longfin smelt eggs (more specifically, egg-larvae), following the same convention for delta smelt. It was further assumed that intertidal habitat has low importance for longfin smelt larvae. Both of these assumptions were consistent with agency biologist opinion at the August 2013 workshops. As previously noted under the analysis of conceptual model 1, agency biologists expressed the opinion that subtidal habitat is of critical importance for larvae and early juveniles (recognizing the outflow-related aspect with respect to the low-salinity zone); the relevant aspect for this analysis was the critical importance for larvae, as juveniles would mostly be in areas further downstream than restored habitats. It was assumed with low certainty that subtidal habitat has low importance for longfin smelt eggs.

Although longfin smelt is commonly characterized as an open-water pelagic species and juveniles and subadults aggregate in deeper water (Rosenfield and Baxter 2007), adults may spawn in relatively shallow water (Rosenfield 2010), which would be expanded through BDCP tidal natural community restoration. Tidal natural community restoration will substantially increase the amount of habitat for potential occupancy by longfin smelt in the Plan Area, mostly in the Cache Slough and Suisun Marsh subregions. A habitat suitability analysis was conducted for two early life stages, egg-larvae (i.e., immediately pre- and posthatching) and larvae (feeding), that occur within tidal habitats of the Plan Area (Appendix 5.E Section 5.E.4.4.1.2, *Species Habitat Models, Longfin Smelt Habitat Model*). The results of the habitat suitability analysis for larval longfin smelt suggest considerably more tidal habitat would be available for these life stages of longfin smelt under the BDCP. Over the Plan Area, there would be an increase of at least 45% in HUs (144,000 HUs vs. 91,000 to 99,000 HUs) with the BDCP (ESO_LLT) compared with existing conditions (EBC2) and future conditions without the BDCP (EBC2_LLT) (Table 5.5.2-3; Appendix 5.E, Section 5.E.4.4.2.4, *Suitability of Restored Habitat for Covered Fish Species*)[6]. The Cache Slough, Suisun Marsh, and West Delta subregions appear to offer the best geographic locations for longfin smelt with respect to the current distribution of the species; approximately double the extent of tidal habitat for larval longfin smelt in the Cache Slough and Suisun Marsh subregions would occur under the BDCP compared with existing conditions. With sea level rise and increasing salinity, there may be even greater distribution of longfin smelt into upstream areas, in which case habitat restoration in the Cache

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[5] Although not directly linked to the analyses related to the spring-outflow decision-tree process, it should be noted that it was assumed with low certainty that zooplankton and benthic/epibenthic prey abundance have low importance for longfin smelt adults as a current constraint in the Plan Area; it is concluded that there is the potential for a low positive change to these attributes because of the BDCP (with low and high certainty, respectively).

[6] It should be noted that there is uncertainty related to future trends in turbidity, as described below. The analysis assumed future turbidity will be similar to existing conditions because modeling data were lacking to inform potential change. However, turbidity in some areas may change due to BDCP, with the change being positive in some areas and negative in others. There is a long-term downward trend in turbidity (suspended sediment) in the Plan Area (Cloern et al. 2011).

Slough and West Delta subregions will become more important to the species. Conservation of adjacent upland areas under the BDCP will allow expansion of aquatic habitat as sea level rises, maintaining or increasing the extent of tidal habitat for longfin smelt.

Based on the assumption that spawning habitat consists mostly of deeper subtidal habitat (i.e., elevations below 6 feet of mean lower low water) and shallow subtidal habitat to a lesser extent, results of the habitat suitability analysis suggest that habitat for the egg-larvae life stage would increase by about 10% under the BDCP in the late long-term. The increase would result mostly from restoration in the Cache Slough, West Delta, and South Delta ROAs (Table 5.5.2-4). Based on the current longfin smelt distribution and environmental changes modeled for the future, changes in the Cache Slough and West Delta subregions are probably of most utility for the species. The presence of IAV, the abundance of nonnative predators, and water quality issues may limit future expansion of the distribution of longfin smelt into the south Delta unless habitat restoration can restore suitable habitat characteristics in this area. The value of habitat available to longfin smelt in restored tidal habitat areas is expected to vary based on factors such as water depth, tidal action, substrate, and the potential for deposition of fine sediment that could adversely affect the health and hatching success of incubating eggs.

As noted above in the effects analysis for delta smelt, the proportional change in intertidal habitat that would result from *CM4 Tidal Natural Communities Restoration* is considerably greater than the proportional change for subtidal habitat. For the subregions that include the main areas of longfin smelt early life-stage occurrence (i.e., Suisun Bay, Suisun Marsh, West Delta, and Cache Slough), the existing or future extent of intertidal habitat without the BDCP is estimated to be approximately 20,000 acres, compared to nearly double that in the late long-term with the BDCP (approximately 36,500 acres). Subtidal habitat in these same subregions is estimated to be nearly 55,000 acres under existing or future conditions without the BDCP (late long-term), compared to almost 70,000 acres under the BDCP in the late long-term (Appendix 5.E *Habitat Restoration*, Section 5.E.4.4.2.1, *Physical Habitat Extent*).

It is concluded with moderate certainty that the change in intertidal habitat suitable for occupation by longfin smelt larvae as a result of the BDCP is very high. It is concluded with moderate certainty that there would be a low positive change to the subtidal habitat attribute for eggs and larvae. This uncertainty is related to the development of the restored habitat in terms of its potential for colonization by IAV and associated nonnative predatory fish species.

Table 5.5.2-3. Habitat Units and Habitat Suitability Indices for Longfin Smelt Larvae under Three Scenarios[a]: Existing Conditions, Future Conditions without the BDCP, and Future Conditions with the BDCP

Subregion (Restoration Opportunity Area)	Scenarioa	Habitat Units	Habitat Suitability Index
Cache Slough (Cache Slough ROA)	EBC2	9,709	0.92
	EBC2_LLT	11,231	0.92
	ESO_LLT	26,347	0.92
	Change due to BDCP (LLT)[b]	15,116 (+135%)	0.00
North Delta (No ROA)	EBC2	3,161	0.86
	EBC2_LLT	3,785	0.86
	ESO_LLT	3,531	0.86
	Change due to BDCP (LLT)[b]	-254 (-7%)	0.00
Suisun Marsh (Suisun Marsh ROA)	EBC2	11,833	0.97
	EBC2_LLT	12,137	0.98
	ESO_LLT	23,738	0.98
	Change due to BDCP (LLT)[b]	11,601 (+96%)	0.00
Suisun Bay (No ROA)	EBC2	20,570	0.96
	EBC2_LLT	20,810	0.96
	ESO_LLT	20,741	0.96
	Change due to BDCP (LLT)[b]	-69 (-0.3%)	0.00
West Delta (West Delta ROA)	EBC2	25,369	0.90
	EBC2_LLT	25,806	0.90
	ESO_LLT	28,309	0.90
	Change due to BDCP (LLT)[b]	2,503 (+10%)	0.00
East Delta (Cosumnes/Mokelumne ROA)	EBC2	4,612	0.81
	EBC2_LLT	5,871	0.81
	ESO_LLT	7,713	0.81
	Change due to BDCP (LLT)[b]	1,842 (+31%)	0.00
South Delta (South Delta ROA)	EBC2	15,366	0.81
	EBC2_LLT	16,493	0.81
	ESO_LLT	33,396	0.81
	Change due to BDCP (LLT)[b]	16,903 (+102%)	0.00
All	EBC2	90,620	N/A
	EBC2_LLT	96,133	N/A
	ESO_LLT	143,775	N/A
	Change due to BDCP (LLT)[b]	47,642 (+50%)	N/A

[a] For descriptions of scenarios, see Table 5.2-3.
[b] ESO_LLT vs. EBC2_LLT.
N/A = not applicable.

Table 5.5.2-4. Habitat Units and Habitat Suitability Indices for Longfin Smelt Egg-Larvae under Three Scenarios[a]: Existing Conditions, Future Conditions without the BDCP, and Future Conditions with the BDCP

Subregion (Restoration Opportunity Area)	Scenario[a]	Habitat Units	Habitat Suitability Index
Cache Slough (Cache Slough ROA)	EBC2	2,849	0.96
	EBC2_LLT	2,750	0.84
	ESO_LLT	5,573	0.87
	Change due to BDCP (LLT)[b]	2,823 (+103%)	.03 (+4%)
North Delta (No ROA)	EBC2	2,893	1.00
	EBC2_LLT	2,664	0.91
	ESO_LLT	2,773	0.91
	Change due to BDCP (LLT)[b]	109 (+4%)	0.00
Suisun Marsh (Suisun Marsh ROA)	EBC2	2,243	0.95
	EBC2_LLT	2,171	0.86
	ESO_LLT	2,210	0.84
	Change due to BDCP (LLT)[b]	39 (+2%)	-.02 (-2%)
Suisun Bay (No ROA)	EBC2	10,502	0.94
	EBC2_LLT	12,158	0.88
	ESO_LLT	13,489	0.87
	Change due to BDCP (LLT)[b]	1,331 (+11%)	-.01 (-1%)
West Delta (West Delta ROA)	EBC2	18,621	0.98
	EBC2_LLT	17,882	0.90
	ESO_LLT	19,247	0.89
	Change due to BDCP (LLT)[b]	1,365 (+8%)	-.01 (-1%)
East Delta (Cosumnes/Mokelumne ROA)	EBC2	3,179	0.99
	EBC2_LLT	2,930	0.87
	ESO_LLT	3,020	0.85
	Change due to BDCP (LLT)[b]	90 (+3%)	-.02 (-2%)
South Delta (South Delta ROA)	EBC2	11,012	0.93
	EBC2_LLT	11,685	0.90
	ESO_LLT	13,302	0.90
	Change due to BDCP (LLT)[b]	1,617 (+14%)	0.00
All	EBC2	51,299	N/A
	EBC2_LLT	52,240	N/A
	ESO_LLT	59,614	N/A
	Change due to BDCP (LLT)[b]	7,374 (+14%)	N/A

[a] For descriptions of scenarios, see Table 5.2-3.
[b] ESO_LLT vs. EBC2_LLT.
N/A = not applicable.

5.5.2.1.2 Reduced Entrainment

The BDCP would substantially change the amount and pattern of water exports from SWP/CVP facilities, which is anticipated to lower the number of longfin smelt entrained relative to existing biological conditions.

Entrainment has been a major issue of concern related to the aquatic species covered in the BDCP, as reflected in the longfin smelt conceptual models. Substantial numbers of juvenile and adult longfin smelt historically have been entrained at the south Delta export facilities (Rosenfield 2010). Larval longfin smelt are also entrained at the export facilities (Aasen 2010). Eggs adhere to the substrate and are not susceptible to entrainment. Recent operations mandated through the issuance of an incidental take permit by CDFW for operations of the south Delta export facilities, in association with both the USFWS (2008a) and the NMFS (2009) BiOp pumping restrictions to limit entrainment of delta smelt, have reduced entrainment of longfin smelt adults, larvae, and juveniles. Because of these regulations (77 FR 19755), USFWS no longer considers entrainment of longfin smelt at the south Delta export facilities to be a major threat to the population. Implementation of the BDCP will ensure that these low levels of entrainment continue into the future. In light of changes in pumping under the incidental take permit and BiOp, for this effects analysis, it was assumed with moderate certainty that south Delta entrainment of larval and juvenile longfin smelt is an attribute of low importance as a current constraint to the species, and that adult entrainment is unimportant to the species. During the August 2013 workshops, agency biologists generally agreed with these assumptions, with some thinking that entrainment for juveniles may be of zero importance.

Operational changes at the south Delta export facilities are expected to provide a moderate reduction in entrainment-related losses of longfin smelt in the south Delta. Results of particle-tracking model simulations for larval longfin smelt (Appendix 5.B, *Entrainment*, Section 5.B.6.1.6.1, *Larva*) are shown in Table 5.5.2-5, where the 60-day results are summarized as averages of scenarios with low, medium, and high outflow based on division of the 27 modeled hydroperiods into thirds of 9 hydroperiods each. The 60-day periods are shown in response to agency comments that shorter periods may result in the fate of particles not being sufficiently resolved. The results suggest that in the lowest flow periods (average outflow of around 14,000 cfs and lower) entrainment would be similar under the BDCP (ESO_LLT) and future conditions without the BDCP (EBC2_LLT) and lower under the BDCP than under existing conditions (EBC2). At higher outflows, entrainment under the BDCP would be lower than under existing conditions. Entrainment is more of an issue for longfin smelt in drier years when the population is further upstream, so it is concluded with high certainty that the BDCP would result in a slight reduction of the low levels of entrainment of longfin smelt larvae occurring at the south Delta export facilities under existing conditions (i.e., a low positive change to the south Delta entrainment attribute).

Table 5.5.2-5. Average Percentage of Particles Entrained at the South Delta Export Facilities after 60 Days Based on Wetter and Drier Starting Distributions Representing Longfin Smelt Larvae under Three Scenarios[a]: Existing Conditions, Future Conditions without the BDCP, and Future Conditions with the BDCP

Delta Outflow (cfs)	Wetter Starting Distribution			Drier Starting Distribution		
	EBC2	EBC2_LLT	ESO_LLT	EBC2	EBC2_LLT	ESO_LLT
4,500–13,725	2.9	1.7	1.8	3.3	3.0	3.0
20,349–30,035	1.1	1.2	0.3	1.3	1.3	0.4
34,327–64,008	1.5	1.3	0.8	1.8	1.5	1.3

[a] For descriptions of scenarios, see Table 5.2-3.

In years when flows on the Sacramento and San Joaquin Rivers are relatively high and Delta outflows are high, longfin smelt larvae are rapidly transported downstream out of the Delta and into Suisun Bay where their risk of adverse effects from south Delta exports is low. Results of the salvage density method entrainment analysis for juvenile longfin smelt suggest that the BDCP (ESO_LLT) would result in around 40% lower juvenile entrainment from March through June, averaged across all water years, compared to existing conditions (Table 5.5.2-6; Appendix 5.B, *Entrainment*, Section 5.B.6.1.6.2, *Juvenile*). Entrainment in drier years, when entrainment is a more important issue for longfin smelt because of less outflow and distribution further upstream, would be around 10 to 30% less under the BDCP than under existing conditions. Results of the salvage density method entrainment analysis for adult longfin smelt suggest that adult entrainment under the BDCP would be around 50% lower from December to March, averaged across all water years, compared to existing conditions, with 25 to 30% less under the BDCP in drier water years (Table 5.5.2-7; Appendix 5.B, Section 5.B.6.1.6.3, *Adult*). However, as noted above, entrainment of adult longfin smelt is no longer considered to be an attribute of importance as a constraint to the longfin smelt population. As noted for delta smelt, such a change reflects the ability to use the north Delta diversions in the winter and thereby reduce south Delta exports and entrainment risk. Entrainment of sexually mature adults in the south Delta is thought to be one to two orders of magnitude lower than that of juveniles (Grimaldo et al. 2009), although the importance of reproductively mature fish to the overall population is much greater than that of younger fish (Rosenfield 2010). Overall, it is concluded with high certainty that the BDCP will result in a moderate positive change to the south Delta entrainment attribute for juvenile (and adult) life stages of longfin smelt. Agency biologists at the August 2013 workshops felt that conclusions applied to delta smelt would also be appropriate (on the basis of the high-outflow scenario), i.e., up to a low positive change.

The above results are for the ESO scenario and would also apply to LOS, which has similar winter-spring flow. HOS would result in somewhat lower entrainment of longfin smelt during the months of March to May because of higher Delta outflow.

Table 5.5.2-6. Difference in Average Annual Entrainment Index[a] of Juvenile Longfin Smelt at the SWP/CVP South Delta Export Facilities under Future Conditions with the BDCP (Compared to Existing Conditions and to Future Conditions without the BDCP), Based on the Salvage Density Method

Water-Year Type	Change[b] under ESO_LLT[c]	
	Compared to EBC2[c]	Compared to EBC2_LLT[c]
Wet	-37,576 (-56%)	-39,655 (-57%)
Above normal	-1,011 (-23%)	-1,343 (-28%)
Below normal	-468 (-16%)	-779 (-24%)
Dry	-55,132 (-11%)	-123,418 (-21%)
Critical	-165,849 (-31%)	-125,616 (-25%)
All years	-106,464 (-39%)	-122,883 (-42%)

[a] Number of fish lost to entrainment
[b] Negative values indicate lower entrainment under the BDCP compared to existing conditions or future conditions without the BDCP.
[c] For descriptions of scenarios, see Table 5.2-3.

Table 5.5.2-7. Difference in Average Annual Entrainment Index[a] of Adult Longfin Smelt at the SWP/CVP South Delta Export Facilities under Future Conditions with the BDCP (Compared to Existing Conditions and to Future Conditions without the BDCP), Based on the Salvage Density Method

Water-Year Type	Change[b] under ESO_LLT[c]	
	Compared to EBC2[c]	Compared to EBC2_LLT[c]
Wet	-70 (-53%)[c]	-71 (-53%)
Above normal	-337 (-49%)	-342 (-50%)
Below normal	-777 (-39%)	-650 (-35%)
Dry	-375 (-31%)	-299 (-26%)
Critical	-7,614 (-32%)	-5,847 (-26%)
All years	-1,935 (-53%)	-1,849 (-52%)

[a] Number of fish lost to entrainment
[b] Negative values indicate lower entrainment under the BDCP compared to existing conditions or future conditions without the BDCP.
[c] For descriptions of scenarios, see Table 5.2-3.

Losses of longfin smelt have not been observed at agricultural water diversions in the Plan Area (Cook and Buffaloe 1998; Nobriga et al. 2004). For the purposes of this effects analysis, it was assumed with high certainty that entrainment at agricultural diversions is an attribute of low importance for larval longfin smelt[7]. Agricultural water diversions in the Plan Area were assumed with moderate certainty to have no importance for juvenile longfin smelt, because their seasonal and geographic distribution would not overlap with the operation of these diversions, and to have low importance for adult delta smelt (reflecting agency biologist opinion for potential entrainment

[7] The assumed importance of agricultural water diversions in the Plan Area for larval longfin smelt is consistent with the DRERIP (Essex Partnership 2009) evaluation of a previously proposed conservation measure to address nonproject diversions, which suggested a low magnitude effect with low certainty (Appendix 5.B, Section 5.B.6.4.3).

during the cooler months at diversions in Suisun Marsh). Particle-tracking modeling conducted as part of this effects analysis suggests that entrainment of longfin smelt larvae at the agricultural diversions will be lower under the BDCP than under existing conditions as a result of altered hydrodynamics from *CM1 Water Facilities and Operation* (Appendix 5.B, *Entrainment,* Section 5.B.6.4.2.1, *Particle-Tracking Modeling*). Changes in larval smelt entrainment are uncertain, because particle tracking is not necessarily an accurate representation of smelt larval behavior in relation to agricultural intakes, nor does it account for the changes in diversions from tidal restoration or *CM21 Nonproject Diversions*. Further, restoration under *CM4 Tidal Natural Communities Restoration* could result in the decommissioning of over 12% of Plan Area agricultural diversions by the late long-term. Greater benefits to smelt and other covered species associated with removing water diversion structures may occur from the reduction of predator holding habitat (see Appendix 5.F, *Biological Stressors on Covered Fish*) than from reductions in entrainment. It is concluded with low certainty that there will be a low positive change to this attribute from the BDCP for larval and adult longfin smelt.

Entrainment of longfin smelt larvae at the SWP North Bay Aqueduct Barker Slough pumping plant is assumed with moderate certainty to be an attribute with low importance. Particle tracking modeling results showed that few particles were entrained to this location and that differences between BDCP and existing conditions scenarios were variable (Appendix 5.B, Section 5.B.6.3.2.1, *Particle-Tracking Modeling*). Particle tracking modeling did not account for implementation of an alternative intake on the Sacramento River. It is concluded with moderate certainty that the BDCP will not change the North Bay Aqueduct entrainment attribute for longfin smelt larvae.

5.5.2.2 Adverse Effects

5.5.2.2.1 Increased Water Clarity

The BDCP north Delta intakes will reduce the quantity of sediment entering the Plan Area, possibly increasing water clarity in some areas and negatively affecting longfin smelt, although the BDCP has the potential for mixed effects on water clarity overall in longfin smelt habitat. Considerable uncertainty would be reduced with development of a suspended sediment simulation model.

As noted for delta smelt, water clarity (turbidity) appears to be a very important habitat characteristic for longfin smelt. Kimmerer et al. (2009) found that longfin smelt abundance and frequency of occurrence in the FMWT and 20-mm (spring) sampling surveys were associated with lower water clarity; there was little evidence for water clarity correlating with longfin smelt collection in bay trawling or during the summer townet survey. Long-term changes in longfin smelt fall abundance from the midwater trawl survey were associated with spring outflow and fall water clarity (Thomson et al. 2010). For this effects analysis, it is assumed with high certainty that water clarity is an attribute of high importance to longfin smelt larvae and juveniles. As noted for delta smelt, the future continuation of a long-term increase in water clarity in the Plan Area (Cloern et al. 2011) would decrease habitat availability for longfin smelt.

The effects of the BDCP on late long-term water clarity are uncertain and depend on a number of interacting factors. Construction and operation of the north Delta intakes under *CM1 Water Facilities and Operation* was estimated to result in around 8 to 9% less sediment entering the Plan Area in the late long-term (Appendix 5.C, *Flow, Salinity, Turbidity, and Passage*, Attachment 5C.D, *Water Clarity—Suspended Sediment Concentration and Turbidity*). As noted for delta smelt, capture of sediment in upstream ROAs could limit sediment supply to downstream portions of the Plan Area that are of particular importance to longfin smelt, such as Suisun Bay. As noted for delta smelt, various interacting factors could affect water clarity for longfin smelt within the Plan Area. It is concluded with low certainty that the north Delta intakes' sediment removal (CM1) and trapping of sediment in ROAs (*CM4 Tidal Natural Communities Restoration*) would result in a low negative change to water clarity (i.e., greater water clarity) for longfin smelt juveniles that occur in the downstream parts of the Plan Area at times when resuspension of sediment may be more important; no change in water clarity is assumed for longfin smelt larvae (again with low certainty), because of their occurrence at higher-flow times of the year when suspended sediment is relatively high.

5.5.2.2.2 Exposure to Contaminants

Exposure of longfin smelt life stages to contaminants may occur following restoration under the BDCP. Exposure to agriculture-related contaminants later in the BDCP term may decrease because of restoration of agricultural areas.

It is uncertain to what extent contaminants may have contributed to the current status of pelagic fish species (Brooks et al. 2011). Spawning and early life stages could be affected by elevated concentrations of contaminants during typical winter runoff, but this has not been demonstrated for longfin smelt. The effects of contaminant exposure on longfin smelt eggs have not been evaluated, and lethal and sublethal effect levels are unknown. No bioassay testing has been done with longfin smelt eggs to determine their response to various contaminant concentrations. For the effects analysis, it was assumed that the response of longfin smelt eggs to contaminant exposure will be similar to that of delta smelt eggs. There is some evidence that fish embryos are less sensitive to pyrethroids than are larvae (Oros and Werner 2005); however, they may be exposed to higher concentrations because they are in direct contact with the substrate where pyrethroids are more concentrated. For the effects analysis, it was assumed with low certainty that contaminants have low importance for all longfin smelt life stages.

The BDCP could adversely affect longfin smelt eggs and other life stages through changes in contaminants as a result of changes in water operations (*CM1 Water Facilities and Operation*, *CM2 Yolo Bypass Fisheries Enhancement*) and habitat restoration (principally, *CM4 Tidal Natural Communities Restoration*). Analyses presented in Appendix 5.D, *Contaminants*, suggest that there is low potential for increased contaminant exposure from the BDCP and there may be a beneficial effect in the late long-term because of reduced contaminants from restoration of areas previously used for agriculture. It is concluded that this represents a low negative change to this attribute, with low certainty, for all longfin smelt life stages.

5.5.2.2.3 Exposure to In-Water Construction and Maintenance Activities

In-water construction and maintenance effects of the covered activities could affect longfin smelt but will be minimized with careful management.

In-water construction activities at the proposed north Delta intakes (*CM1 Water Facilities and Operation*) will be limited to one construction season from June through October (Appendix 5.H, *Aquatic Construction and Maintenance Effects*). Longfin smelt generally occur well downstream of the construction area, although as noted for potential impingement/entrainment (see below), some individuals may occur in the vicinity of the proposed intakes. The seasonality of construction suggests that most longfin smelt will have left the area, as spawning will have been largely completed and larvae will have moved downstream. Any longfin smelt present may experience adverse effects from underwater sound (pile driving), entrapment in enclosed areas (e.g., cofferdams), exposure to temporary water quality deterioration (e.g., suspended sediment, suspension of toxic materials), and accidental spills. Habitat will be temporarily and permanently affected by intake construction, although habitat at the intake sites is generally of low value (steep-sloping, revetted banks). Maintenance dredging may decrease water quality temporarily.

Habitat restoration activities associated with *CM4 Tidal Natural Communities Restoration*, *CM5 Seasonally Inundated Floodplain Restoration*, *CM6 Channel Margin Enhancement*, and *CM7 Riparian Natural Community Restoration* may reduce water quality and may be more likely to affect longfin smelt because the activities are closer to the species' main distribution. Breaching levees to create tidal habitat may reduce areas of channel margin, but there will be considerable gains of habitat caused by the breaching and associated potential food production for longfin smelt. In-water activities associated with *CM14 Stockton Deep Water Ship Channel Dissolved Oxygen Levels*, *CM15 Localized Reduction of Predatory Fish, CM16 Nonphysical Fish Barriers*, and *CM21 Nonproject Diversions* will have little to no effect on longfin smelt because of the small scale of the work. Implementation of *CM22 Avoidance and Minimization Measures* will reduce the likelihood of adverse effects on longfin smelt from in-water activities related to construction and maintenance. Therefore, construction and maintenance associated with the BDCP represent a minor adverse effect, with high certainty, on longfin smelt life stages. Note that this assessment is not included in the net effects methodology because it is not considered a long-term effect of the BDCP.

5.5.2.2.4 North Delta Intakes Entrainment and Impingement

There is a small risk of entrainment of larval longfin smelt and impingement of adult longfin smelt at the north Delta intakes, although the intakes are well upstream of the species' typical Plan Area distribution.

The main change in water export infrastructure under the BDCP is the implementation of dual conveyance under *CM1 Water Facilities and Operation*, with construction of the north Delta intakes in the vicinity of Hood. These intakes are well upstream of the main distribution of longfin smelt within the Plan Area, although some longfin smelt have been observed in this area in the past in very low densities (Appendix 5.B, *Entrainment*, Section 5.B.6.2.3, *Longfin Smelt*). Only longfin smelt larvae less than about 25 mm could be entrained through the screens based on small size. Eggs adhere to the substrate and are not within the water column, so are not subject to entrainment. Adults could be impinged and injured if found in the vicinity of the intake screens. However, the screen design is intended to minimize impingement or injury of adults. In response to agency biologist comments during the August 2013 workshops, it was assumed that the north Delta intakes direct entrainment/impingement risk would be unimportant to longfin smelt, notwithstanding the anticipated exceedingly rare occurrence of longfin smelt encountering the intakes. Monitoring of entrainment and impingement will further inform the effect of entrainment and impingement on longfin smelt and other species at the north Delta intakes following implementation.

5.5.2.3 Impact of Take on Species

The BDCP may result in incidental take of longfin smelt from several mechanisms. Incidental take may occur during construction of the proposed on-bank intake facilities in the north Delta, aquatic habitat restoration construction, and as a result of entrainment at the SWP/CVP diversion facilities. Effects from north Delta intake and habitat restoration construction activities will include disturbance from in-water activity and hydrodynamic changes, physical injury from riprap/rock placement and noise and vibration, exposure to fuel or oil, and elevated turbidity/suspended sediment levels. These effects, however, will be temporary and are unlikely to have population-level effects on longfin smelt because longfin smelt are rarely documented in the area where the north Delta diversion facilities will be constructed (Moyle 2002) and are only seasonally present in areas where habitat restoration will occur. In addition, best management practices (BMPs) will be used to minimize effects on all protected fish species.

With regard to take at the south Delta diversion facilities, cumulative annual salvage of longfin smelt at SWP/CVP facilities between water years 1996 and 2009 ranged from approximately 0 to 97,734 individuals, with the highest salvage recorded in 2002. The second highest salvage was in 2001, when 6,642 longfin smelt were salvaged. Salvage was variable during this period but has been generally lower in recent years (0 to 1,491 fish salvaged annually from 2005 to 2009), potentially a result of the low abundance of longfin smelt during this period, actions implemented as part of the USFWS (2008a) BiOp, and court-ordered restrictions on water operations. Results of the entrainment analyses indicate that the level of take of longfin smelt under the BDCP would be lower than that estimated for the existing conditions as a result of reductions in south Delta export operations under most hydrologic conditions. Take of longfin smelt at the south Delta facilities could increase in the future if the population size increases as a result of the BDCP or other actions; however, this will not represent an increase in loss as a proportion of the population.

There also may be take of larval longfin smelt at diversions to the North Bay Aqueduct, but this take would be reduced by the alternative intake on the Sacramento River. Decreases in entrainment at the south Delta export facilities, North Bay Aqueduct Barker Slough pumping plant, and at numerous agricultural diversions that will be decommissioned in tidal habitat restoration areas will more than offset any entrainment and impingement at the proposed north Delta diversion facilities, which is expected to be extremely limited.

Construction activity associated with habitat restoration is expected to result in a temporary localized increase in the take of longfin smelt. The magnitude of potential take will vary depending on construction techniques, the location and size of restoration activities, and the seasonal timing of in-water construction activity relative to the life history and seasonal and geographic distribution of various life stages of longfin smelt. Implementation of BMPs, including those in *CM22 Avoidance and Minimization Measures*, will reduce and avoid potential adverse effects on habitat and incidental take of longfin smelt. A decrease in the application of pesticides and herbicides associated with changes in land use and eliminating currently unscreened water diversions in the areas where habitat restoration occurs is expected to reduce the take of longfin smelt. Preconstruction monitoring will be required to assess the potential for construction and flooding of restored habitat areas to resuspend toxic contaminants from soils that then will enter adjacent water bodies, and to assess the effects of habitat restoration on changes in the bioavailability of chemical contaminants such as methylmercury and the potential effects of contaminant exposure on various life stages of longfin smelt. Consideration in the design and development of aquatic habitat restoration projects will be required to minimize or avoid, to the maximum extent feasible, the risk that IAV and other nonnative species will colonize the habitat and that structures, hydrodynamics, and other conditions will increase the vulnerability of longfin smelt to predation mortality.

5.5.2.4 Net Effects

5.5.2.4.1 Summary

The qualitative conclusions from the attribute ranking process with respect to the net effects of the BDCP on longfin smelt are depicted in Figure 5.5.2-5. The positive effects of the BDCP are concluded to outweigh the negative effects, so that the net effect of the BDCP is expected to be beneficial to longfin smelt. The certainty of the effects of the BDCP generally is concluded to be moderate or low. This includes the potential changes related to food production and areal extent of habitat as a result of *CM4 Tidal Natural Communities Restoration*.

Longfin smelt are currently at very low levels of abundance. The BDCP has the potential to provide benefits to each life stage of longfin smelt. The main beneficial effect of the BDCP is expected to be increases in food (zooplankton) production as a result of tidal natural community restoration, combined with increased spring outflow if it is determined to be needed through the decision-tree process. As described for delta smelt, proposed habitat restoration areas are spatially diverse and will provide greater opportunity to occupy a broader portion of the Plan Area; are adjacent to very important existing areas occupied by longfin smelt (e.g., the Cache Slough and Suisun Marsh subregions); and will provide a range of habitat conditions that will be suitable for longfin smelt spawning and rearing. Expansion of habitat in the Cache Slough and Suisun Marsh subregions as a result of BDCP may be of particular importance in the late long-term as the species faces increasingly challenging environmental conditions caused by a warming climate and rising sea level. The potential export of food resources from the restoration areas into existing open-water pelagic areas inhabited by longfin smelt may be the most important function of habitat restoration for longfin smelt. The extent to which this may occur is uncertain, and it is likely to be region- and site-specific: There is the potential for benefit to result from export of food from the Suisun Marsh, West Delta, and Cache Slough subregions and less benefit from the South Delta and Cosumnes/Mokelumne subregions because they are further from the species' main geographic range. The Cache Slough subregion may receive increased food production from the Yolo Bypass.

As described above under Section 5.5.2.1.1, increasing tidal habitat has the potential to increase production of phytoplankton, organic debris, and zooplankton that serve as the food resource for larval, juvenile, and adult longfin smelt. There is a growing body of information suggesting that changes in zooplankton densities and species composition have been a major factor in the long-term decline of longfin smelt through reductions in growth and survival. There is also a substantial body of information suggesting a strong positive association between winter-spring Delta outflow and longfin smelt survival and abundance. Although there is yet to be established a clear understanding of the mechanism, or mechanisms, underlying the relationship between flow and abundance, there are many plausible mechanisms connected to substantial influence outflow has on physical and biological conditions in the estuary. To address questions about the benefits and appropriate roles of habitat and flow restoration, the BDCP includes a specific adaptive management approach using a decision tree to determine the amount of spring Delta outflow needed at initial operation to provide for conservation and management of the species. In addition, conservation actions can be refined in the future based on results of monitoring changes in habitat conditions in the low-salinity zone, larval and juvenile smelt transport and distribution, zooplankton densities and species composition, and longfin smelt diet, growth, survival, and abundance over a range of Delta outflow and other conditions. The BDCP has the potential to provide a substantial benefit to longfin smelt as a result of the large amount of tidal wetland restoration and the expected food production to support the species.

Other potential benefits from the covered activities will include maintaining larval, juvenile, and adult entrainment loss at the south Delta export facilities at or below the low levels that have resulted from pumping restrictions under the USFWS (2008a) BiOp and the CDFW incidental take permit for longfin smelt.

The effects analysis suggests that implementation of a number of conservation measures as part of the covered activities will not change several stressors for longfin smelt, in many cases in a neutral manner similar to delta smelt. As described in Appendix 5.D, *Contaminants*, implementation of the BDCP is not expected to change ammonium loading, which is an important stressor influencing plankton communities in the Plan Area.

The principal passage barriers that longfin smelt may encounter in the Plan Area are the Suisun Marsh salinity control gates, for which changes in operations under the BDCP are uncertain and probably of short duration. Therefore, the Suisun Marsh Salinity Control Gates were assumed to have no effect on longfin smelt.

Floodplain restoration and increased flooding of the Yolo Bypass under *CM2 Yolo Bypass Fisheries Enhancement* is concluded to have no effects on longfin smelt in terms of habitat benefits for different life stages, although, as noted above, there may be increased food production and export to Cache Slough and the West Delta. Floodplain restoration and enhancement in the south Delta will provide additional local food supply, but are not expected to offer appreciable benefits to longfin smelt. *CM13 Invasive Aquatic Vegetation Control* is focused on IAV treatment within the restored areas and, therefore, does not address existing IAV outside the subregions, resulting in little change for longfin smelt but maintaining suitable habitat within the restored area. For the same reasons given for delta smelt, it is concluded with low certainty that the various interacting factors that could positively or negatively change the predation attribute for longfin smelt will have no net change from existing conditions under the BDCP. The low certainty of this conclusion will be informed by monitoring and adaptive management during Plan implementation.

Temperature effects of the BDCP were not evident in the analyses of the number of days exceeding 20°C (Appendix 5.C, *Flow, Passage, Salinity, and Turbidity*, Attachment 5C.C, *Water Temperature*), a threshold for habitat that the species typically occupies (Moyle 2002). As noted for other species, it is climate rather than water operations that determines temperature changes in the Plan Area. Climate change may affect longfin smelt similar to the ways it affects delta smelt (e.g., an earlier spawning season resulting in mismatch with other important habitat variables; Wagner et al. 2011). The number of days over 20°C is expected to increase in the future, leading to an increase in bioenergetic demands on juvenile and adult life stages of longfin smelt, particularly in the warmer months. Increased bioenergetic demands will further increase the food requirements of longfin smelt.

Category	Appendix	Attributes	Definition	Eggs	Larvae	Juvenile	Adults
Food	E	Zooplankton community	Species composition of the zooplankton community and presence of suitable prey species	NA	Zero	Zero	
		Zooplankton abundance	The abundance of zooplankton	NA	Moderate	Moderate	Very Low
		Benthic & Epibenthic prey abundance	The abundance of epibenthic prey species such as amphipods	NA		Very Low	Very Low
		Insect abundance	The abundance of insect prey	NA			
Entrainment & Impingement	B	North Delta Intakes	Potential entrainment/impingement from the proposed North Delta intakes	NA			
		South Delta Pumps	Pumping rate from the CVP/SWP south Delta export facilities and resulting entrainment	NA	Very Low	Low	
		North Bay Aqueduct	Entrainment from the SWP NBA facilities	NA	Zero		
		Ag Diversions	Entrainment from Agriculture Diversions	NA	Very Low		Very Low
Migration & Movement	C	Plan Area Flows	Magnitude, timing, direction, and duration of flows during migratory periods throughout the Plan Area	NA			
		Interior Delta Entry	Entry of fish into the interior Delta from the mainstem Sacramento or San Joaquin Rivers through channels such as Georgiana Slough or Old River	NA	NA	NA	NA
		Passage Barriers	Structures or conditions that potentially block upstream or downstream migration	NA			
Habitat	C, E	Inter-tidal habitat	Intertidal area from the mean low low water level to the extreme high water level that may support intertidal vegetation and form mudflats; dynamic elements of habitat such as appropriate salinity are considered on a species-specific basis		Moderate		
		Channel Margin	The extent of shallow water, low slope habitat that generally is characterized by structural complexity, native emergent vegetation and riparian shading cover				
		Floodplains	The interface between upland topography and river hydrology during high flow events				
		Riparian	Forest and scrub that occurs along the margins of river channels and within floodplains	NA	NA	NA	NA
		Sub-tidal habitat	Extent and location of sub-tidal area in the Plan Area, including the low salinity zone (LSZ); dynamic elements of habitat such as appropriate salinity are considered on a species-specific basis	Low	Moderate	Moderate	
Sediment	C	Water clarity	Water clarity in the Plan Area as influenced by amount of suspended material within the water column		Zero	Low-	
Temperature	C	Temperature	Adverse effects of high temperatures within the Plan Area		Zero	Zero	
DO	C	Dissolved Oxygen	Adverse effects of low dissolved oxygen level within the Plan Area				
Toxins	D, F	Contaminants	Adverse effects of methylated mercury, selenium, pesticides and other pollutants	Very Low-	Very Low-	Very Low-	Very Low-
		Microcystis	The abundance of Microcystis aeruginosa blooms that are toxic to covered fish species and their food				
Predation	F	Predation	The species-specific consumption of covered fish species by predatory fish (e.g., striped bass, Sacramento pikeminnow, centrarchid bass species, catfish, and inland silversides); note that the attribute aims to isolate predation effects that may not be captured by other attributes, e.g., at manmade structures such as the north Delta diversions	Zero	Zero	Zero	Zero
		Illegal Harvest	Illegal harvest of covered fish species in the Plan Area	NA	NA	NA	NA

In-stream Habitat	C	Sacramento R. Habitat	Flows in the Sacramento River mainstem (below Keswick Dam to the Plan Area) that influence spawning, egg incubation, rearing, or holding habitat	NA	NA	NA	NA
		Feather R. Habitat	Flows in the Feather River (below Oroville Dam to the confluence with the Sacramento River) that influence spawning, egg incubation, rearing, or holding habitat	NA	NA	NA	NA
		American R. Habitat	Flows in the American River (below Nimbus Dam to the confluence with the Sacramento River) that influence spawning, egg incubation, rearing, or holding habitat	NA	NA	NA	NA
Migration & Movement	C	Sacramento R. Migration Flows	Flows in the Sacramento River mainstem (below Keswick Dam to the Plan Area) that influence migration and movement	NA	NA	NA	NA
		Feather R. Migration Flows	Flows in the Feather River (below Oroville Dam to the confluence with the Sacramento River) that influence migration and movement	NA	NA	NA	NA
		American R. Migration Flows	Flows in the American River (below Nimbus Dam to the confluence with the Sacramento River) that influence migration and movement	NA	NA	NA	NA
Temperature	C	Sacramento R. Temperature	Adverse effects of high water temperatures in the Sacramento River mainstem (below Keswick Dam to the Plan Area)	NA	NA	NA	NA
		Feather R. Temperature	Adverse effects of high water temperatures in the Feather River (below Oroville Dam to the confluence with the Sacramento River)	NA	NA	NA	NA
		American R. Temperature	Adverse effects of high water temperatures in the American River (below Nimbus Dam to the confluence with the Sacramento River)	NA	NA	NA	NA

Certainty

- (gray) No effect conclusion made because attribute assumed not to have importance as a current constraint
- NA Life stage not present or not applicable
- (green) Low certainty
- (light blue) Moderate certainty
- (blue) High certainty
- (purple) Very high certainty

Figure 5.5.2-5. Effect of the Covered Activities on Longfin Smelt

5.5.2.4.2 Application of Existing Conceptual Models in the Net Effects Analysis

The existing conceptual models for longfin smelt from the POD investigations and DRERIP that are shown in Figure 5.5.2-1 through Figure 5.5.2-4 (Baxter et al. 2010; Rosenfield 2010) share a number of common elements, among them entrainment, food, and water quantity (outflow). The discussion here focuses on the simpler model of Baxter et al. (2010). As discussed above in Section 5.5.2.1, *Beneficial Effects*, entrainment of longfin smelt has been appreciably reduced through the incidental take permit for the SWP south Delta export facility, thus reducing issues with entrainment from the assumed high importance for adult and larval longfin smelt shown by Baxter et al. (2010). The BDCP will maintain or lower these low levels of entrainment, thus contributing positively to a factor identified as important in the Baxter et al. (2010) conceptual model. Tidal habitat restoration has potential to augment food supply for longfin smelt during occupation of the Plan Area in spring. Examining the conceptual model of Baxter et al. (2010) suggests that this would alleviate reduced larval abundance of longfin smelt, and address the third major attribute of the longfin smelt conceptual models. The decision-tree process will use best available science to determine the initial spring outflow operations upon commencement of *CM1 Water Facilities and Operation.* In so doing, the BDCP will address the last remaining element of Baxter et al.'s (2010) conceptual model for longfin smelt that appears most relevant during the species' seasonal occupation of the Plan Area, namely water quantity (outflow). The results of the effects analysis suggest that the high-outflow scenario has the potential to increase abundance in relation to existing conditions. Tidal habitat restoration is anticipated to provide additional productivity and capacity to the longfin smelt foodweb, such that the effects of a given level of outflow could be enhanced.

As noted for delta smelt, the conceptual model of Glibert et al. (2011) emphasizes nutrient ratios and ecological stoichiometry as the main reason for the decline of pelagic species such as longfin smelt. As described in the delta smelt net effects analysis, the non-BDCP action of the Sacramento Regional Wastewater Treatment Plant upgrade has the potential to positively affect the foodweb within the Plan Area through changes in zooplankton community composition and abundance that would benefit longfin smelt. Such an effect presumably would allow even greater potential for food production and export from the BDCP's tidal restoration areas as a result of less ammonium loading and improved nutrient ratios within the Plan Area.

5.5.2.4.3 Conclusion

The BDCP's main beneficial effect for longfin smelt is expected to be greater food production from substantial tidal habitat restoration in the Plan Area. Food produced in tidal restoration areas is expected to be exported and available to larval and juvenile longfin smelt inhabiting adjacent pelagic open water habitats. Reduced entrainment in the south Delta would also benefit the species. Additional spring outflow, if determined through the decision-tree process to be needed, would also benefit longfin smelt. There is uncertainty, however, regarding the dynamic balance between the benefits of habitat restoration and enhanced food supplies for longfin smelt, and the role of winter-spring Delta outflow as a factor affecting larval transport and habitat conditions in the low-salinity zone. The benefits to longfin smelt of reduced entrainment, increased habitat availability, and increased food are concluded to positively affect survival and reproduction. Combined with the decision tree for spring outflow, which will be used to determine the spring outflow operations, the BDCP is expected to provide for the conservation and management of longfin smelt in the Plan Area. The monitoring and adaptive management program will provide the opportunity to maximize the long-term net benefits of the BDCP. Therefore, the BDCP will minimize and mitigate impacts to the maximum extent practicable and provide for the conservation and management of the longfin smelt in the Plan Area.

5.5.3 Chinook Salmon, Sacramento River Winter-Run ESU

Salmon and steelhead (*Oncorhynchus* spp.) are commercially, culturally, and legally important species whose habitat will be affected by the covered activities. Four runs of Chinook salmon (*O. tshawytscha*) along with steelhead (*O. mykiss*) are seasonally present in the Plan Area and in the Study Area and were considered in the effects analysis. The entire populations of these five salmonid groups migrate through the Plan Area as juvenile emigrants to the ocean and again as returning adult spawners.

Winter-run Chinook salmon, with their summer-spawning life history, are unique to the Sacramento River watershed and their distribution historically was limited to the upper Sacramento River and Battle Creek (Yoshiyama et al. 1998). Winter-run Chinook salmon typically enter freshwater as immature adults during the winter and early spring and then hold for several months before spawning in early summer (Moyle 2002). Winter-run took advantage of the headwaters that provided clean, loose gravel, cold, well-oxygenated water, and year-round flow in riffle habitats for spawning and incubation. Construction of Shasta Dam in 1943 and Keswick Dam in 1950 blocked access to all of these upstream waters (Moyle 2002). Primary spawning habitats for winter-run Chinook salmon are now confined to the cold water areas between Keswick Dam and Red Bluff Diversion Dam. The lower reaches of the Sacramento River and the Plan Area serve as migration corridors for the upstream migration of adult and downstream rearing and migration of juvenile winter-run Chinook salmon. The Sacramento River winter-run Chinook ESU is listed as endangered under ESA and CESA.

The life cycle and status of winter-run Chinook salmon are detailed in the species accounts (Appendix 2.A, *Covered Species Accounts*). Briefly, winter-run Chinook salmon adults enter the Sacramento River basin between December and July with peak returns in March. Spawning occurs from mid-April to mid-August, peaking in May and June, in the Sacramento River reach between Keswick Dam and Red Bluff Diversion Dam (Vogel and Marine 1991). Winter-run fry begin to emerge from the gravel in late June to early July and continue through October (Fisher 1994). Emigrating juvenile winter-run pass the Red Bluff Diversion Dam as early as mid-July, typically peaking in September, and can continue through March in dry years (Vogel and Marine 1991; National Marine Fisheries Service 1997). Many apparently rear in the Sacramento River below Red Bluff Diversion Dam for several months before they reach the Delta (Williams 2006). Juvenile winter-run occur in the Delta primarily from November through April (and may extend from September to May) and remain in the Delta until they reach a fork length of approximately 118 mm and are between 5 and 10 months of age. Reductions in floodplain and tidal habitat in the Plan Area have reduced juvenile salmon rearing opportunities when compared with periods when habitat for juvenile salmon rearing was more suitable. Shallow-water habitat of floodplains provides for higher abundances of food and warmer temperatures which promote rapid growth. This results in larger out-migrants (Sommer et al. 2001a, 2001b), which presumably have higher survival rates in the ocean compared to mainstem Sacramento River out-migrants. Emigration to the ocean begins as early as November and continues through May (Fisher 1994; Myers et al. 1998).

For this effects analysis, it was assumed that foraging juveniles make up 70% of the winter-run Chinook entering the Plan Area, while the migrant forms makes up 30% of the juveniles entering the Plan Area. These proportions were developed based on literature review and discussions with agency biologists at workshops in August 2013. These proportions were used to qualitatively weight the effects of the BDCP on each ESU. Scoring of BDCP net effects (Section 5.5.3.5) considered the beneficial and adverse effects of the BDCP on foragers and migrants separately.

5.5.3.1 Beneficial Effects

5.5.3.1.1 Restored Floodplain, Tidal, and Channel Margin Habitat

Floodplain Habitat

The BDCP will change the configuration and operation of Fremont Weir and the Yolo Bypass, which will increase floodplain availability and usage and improve conditions for juvenile and adult winter-run Chinook salmon.

Loss of access to floodplain habitat in the Plan Area because of levee construction and other factors is a major stressor to juvenile salmonids (Williams 2009). The benefits of the Yolo Bypass to improved growth of rearing juvenile salmonids are well documented (Sommer et al. 2001a). There is also some evidence for the Yolo Bypass being a relatively high survival migration pathway for migrating Chinook salmon smolts, relative to the mainstem Sacramento River, based on unpublished UC Davis/DWR survival studies undertaken in 2012 for acoustically tagged smolts released into the Tule Canal/Toe Drain.

For this effects analysis, floodplain habitat availability is considered an attribute of critical importance for foraging winter-run Chinook salmon with high certainty, and an attribute of moderate importance with moderate certainty for migrating juvenile winter-run Chinook salmon because there appears to be some benefit from floodplains as an alternative migration pathway to the mainstem Sacramento River. During the August 2013 workshops with agency biologists, there was consensus regarding the critical or high importance of floodplain habitat for foraging Sacramento River-origin Chinook salmon in the Plan Area, but some thought that the importance for migrants should be low.

All winter-run Chinook salmon spawn upstream of the Yolo Bypass and therefore have the potential to benefit from *CM2 Yolo Bypass Fisheries Enhancement* (Appendix 5.C, *Flow, Passage, Salinity, and Turbidity*, Section, 5.C.5.4.1.3, *Proportion of Chinook Salmon That Could Benefit from CM2 Yolo Bypass Fisheries Enhancement*). Modifications to Fremont Weir under CM2 will considerably increase the frequency and duration of inundation in the Yolo Bypass, which is expected to increase food production and shallow-water, low-velocity rearing area for juvenile winter-run Chinook salmon during winter and early spring (Table 5.5.3-1). The relative increase in inundation area is estimated to be greatest in below-normal and dry years, particularly in the months of January and March/April, when the extent of inundated area was modeled to be two to three times greater than under existing conditions. Rearing benefit for juvenile winter-run Chinook salmon would be a result of increases in inundation during the winter and early spring (primarily November through March). Results of the Yolo Bypass Fry Rearing Model (Appendix 5.C, Section 5.C.5.4.1.4.1, *Yolo Bypass Fry Rearing Model Results*) for winter-run Chinook salmon foragers suggests that there would be modest potential increases in adult winter-run Chinook salmon abundance (expressed as ocean fishery returns) because of CM2 as currently proposed and analyzed, with a range of 1 to 8% more adults under the BDCP depending on water-year type. Note that other factors that could affect variability in ocean fishery returns, e.g., ocean productivity, were assumed to be constant between scenarios in order to focus on changes because of the Plan. The results of the Yolo Bypass Fry Rearing Model reflected the downstream movement of substantial numbers of winter-run Chinook foragers assumed by the model in response to upstream flow pulses (del Rosario et al. 2013), which often occurred prior to the additional benefit provided by the Fremont Weir notch. There may be difficulty in representing the downstream movement patterns of winter-run Chinook foraging juveniles in relation to changes in flow based on the simplified assumptions in the Yolo Bypass Fry Rearing Model. This is illustrated by the recent empirical examination of juvenile Chinook salmon entrainment into Yolo Bypass by Roberts et al. (2013), which used a combination of gauged flow data and fish catch data from rotary screw trapping at Knights Landing. They estimate that during 1997–2011, an annual average of just over 3% of winter-run Chinook salmon juveniles were entrained into the Bypass; with the Fremont Weir notched to similar specifications as proposed under the BDCP, an estimated 12.5% of individuals would have entered the bypass (Table 5.5.3-2). For the same years (1997–2011), the Yolo Bypass Fry Rearing Model estimates that 2.3% of winter-run Chinook entered the bypass under EBC2_LLT and 9.5% entered the bypass under ESO_LLT. As noted by Roberts et al. (2013) and demonstrated in Table 5.5.3-1 the duration of Yolo Bypass floodplain inundation would also be appreciably longer, allowing greater time for juvenile Chinook salmon to accrue growth and survival benefits.

There is a small risk of juvenile winter-run Chinook salmon stranding as a result of increased Yolo Bypass inundation, although the DRERIP (Essex Partnership 2009) evaluation of Yolo Bypass operations under the BDCP assessed the benefits of increased inundation to considerably outweigh this potential effect (Appendix 5.C, Section 5.C.5.4.1.2, *Stranding (Steelhead, Chinook Salmon, Sacramento Splittail, White Sturgeon, and Green Sturgeon)*), and adaptive management of the floodplain would address potential design issues during the implementation period. In light of the recent analysis by Roberts et al. (2013), other studies confirming the importance of Yolo Bypass floodplain for Chinook salmon rearing in some years (Sommer et al. 2001a; Sommer et al. 2005), it is concluded that the BDCP will provide a high positive change with high certainty to the floodplain attribute for foraging winter-run Chinook salmon juveniles.

Table 5.5.3-1. Average Daily Inundated Acreage[a] (Water Depth of 6.5 Feet or Less) in the Yolo Bypass under Three Scenarios[b]—Existing Conditions, Future Conditions without the BDCP, and Future Conditions with the BDCP—by Water-Year Type

Month	Water-Year Type[c]									
	W	AN	BN	Dry	C	W	AN	BN	Dry	C
	EBC2					EBC2_LLT				
Oct	293	0	0	257	0	275	0	0	257	0
Nov	1,509	371	0	362	0	1,401	371	0	88	0
Dec	8,762	3,069	1,334	849	0	8,510	2,859	1,337	884	0
Jan	14,643	9,183	3,386	1,041	708	14,835	9,805	3,133	1,018	708
Feb	16,326	12,814	6,230	2,433	971	17,091	13,229	6,217	2,443	972
Mar	13,370	9,496	1,680	1,459	699	13,787	10,234	1,685	1,475	699
Apr	10,193	3,330	981	679	0	10,315	3,330	1,063	679	0
May	1,101	404	0	0	0	408	404	0	0	0
Jun	438	0	0	0	0	0	0	0	0	0
	ESO_LLT (percent difference from EBC2)					ESO_LLT (percent difference from EBC2_LLT)				
Oct	294 (0%)	0 (0%)	0 (0%)	290 (13%)	0 (0%)	294 (7%)	0 (0%)	0 (0%)	290 (13%)	0 (0%)
Nov	1,486 (-2%)	318 (-14%)	0 0%)	123 (-66%)	0 (0%)	1,486 (6%)	318 (-14%)	0 (0%)	123 (40%)	0 (0%)
Dec	12,594 (44%)	4,203 (37%)	1,933 (45%)	1,428 (68%)	148 (0%)	12,594 (48%)	4,203 (47%)	1,933 (45%)	1,428 (62%)	148 (0%)
Jan	18,538 (27%)	13,598 (48%)	7,006 (107%)	2,272 (118%)	1,479 (109%)	18,538 (25%)	13,598 (39%)	7,006 (124%)	2,272 (123%)	1,479 (109%)
Feb	21,493 (32%)	17,908 (40%)	10,170 (63%)	4,374 (80%)	1,643 (69%)	21,493 (26%)	17,908 (35%)	10,170 (64%)	4,374 (79%)	1,643 (69%)
Mar	18,672 (40%)	17,835 (88%)	4,798 (186%)	4,536 (211%)	1,366 (95%)	18,672 (35%)	17,835 (74%)	4,798 (185%)	4,536 (207%)	1,366 (95%)
Apr	14,021 (38%)	6,654 (100%)	2,348 (139%)	1,052 (55%)	24 (0%)	14,021 (36%)	6,654 (100%)	2,348 (121%)	1,052 (55%)	24 (0%)
May	422 (-62%)	429 (6%)	0 (0%)	0 (0%)	0 (0%)	422 (3%)	429 (6%)	0 (0%)	0 (0%)	0 (0%)
Jun	0 (-100%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)

[a] Calculations were made using the relationships between Yolo Bypass flow and inundated acreage described in Appendix 5.C, *Flow, Passage, Salinity, and Turbidity*, Section 5.C.4.4.2.1, *Sacramento Splittail Habitat Area*.

[b] For descriptions of scenarios, see Table 5.2-3.

[c] Abbreviations of water-year types: W = wet; AN = above normal; BN = below normal; D = dry; C = critical

Table 5.5.3-2. Annual Percentage of Winter-Run Chinook Salmon Juveniles Entrained Onto the Yolo Bypass Under Existing Conditions and with Notching of Fremont Weir[a]

Water Year	Water-Year Type	Existing Conditions	With Notch
1997	W	15.9	22.5
1998	W	4.9	11.1
1999	W	2.0	14.3
2000	AN	16.3	25.2
2001	D	0.0	7.5
2002	D	0.1	6.3
2003	AN	1.7	15.9
2004	BN	0.7	9.2
2005	AN	0.0	9.9
2006	W	6.2	13.9
2007	D	0.0	6.0
2008	C	0.0	11.6
2009	D	0.0	10.2
2010	BN	0.4	11.2
2011	W	2.5	13.2
Average (1997–2011)		3.4	12.5
Wet and Above Normal Water Year Average		6.2	15.7
Dry and Critical Water Year Average		0.0	8.3

Source: Roberts et al. 2013.
[a] Assumed a Fremont Weir notch similar to that proposed under BDCP.

Survival and migration pathways through the Delta for smolt-sized winter-run Chinook salmon migrants, including entry into the Yolo Bypass, were assessed with the DPM (Appendix 5.C, Section 5.C.5.3.4.1, *Winter-Run Chinook Salmon*). The Yolo Bypass potentially offers a relatively high-survival migration pathway through the Delta portion of the Plan Area, with average survival from the DPM of 47–48% from Fremont Weir to Chipps Island; this compares to average survival by other pathways of around 15–18% (Interior Delta), 39–42% (Sutter/Steamboat Sloughs), and 35–38% (mainstem Sacramento River). Use of the Yolo Bypass route through the Delta will reduce the risk of entering the relatively low-survival interior Delta through Georgiana Slough or the Delta Cross Channel and of passing by the new north Delta intakes, and increase the diversity of migration pathways, which provides a safeguard against unpredictable stochastic events occurring along any single migration pathway. Based on the DPM, the average percentage of winter-run Chinook salmon smolts entering the Yolo Bypass under the BDCP in the late long-term would be 12–13%, which is more than double the average percentage entering under existing conditions (Table 5.5.3-3), and consistent with the appreciably larger percentage of winter-run Chinook salmon estimated by Roberts et al. (2013) for a notched Fremont Weir compared to existing conditions (Table 5.5.3-2). In addition, the Yolo Bypass migration pathway was available in all modeled years under the BDCP compared to less than half of years under existing conditions; Roberts et al. (2013) estimated little or no winter-run Chinook salmon entering the Yolo Bypass under existing conditions in 7 years from 1997 to 2011, with the majority of those years (6 out of 7) being dry or critical water years. Based on these considerations, it is concluded with moderate certainty that the BDCP would provide a moderate positive change to the floodplain attribute for migrating juvenile winter-run Chinook salmon. Ongoing studies of survival through the Yolo Bypass for smolt-sized Chinook salmon coupled with further refinement to the actual design of the Yolo Bypass and Fremont Weir operations will provide additional information that may further enhance these benefits.

Table 5.5.3-3. Percentage of Winter-Run Chinook Salmon Smolts Migrating from Fremont Weir to Chipps Island Via the Yolo Bypass Pathway under Four Scenarios[a], Based on the Delta Passage Model

Water Year	Scenario[a]			
	EBC2	EBC2_LLT	ESO_LLT	HOS_LLT
1976	0.0	0.0	1.8	1.8
1977	0.0	0.0	2.4	1.9
1978	3.9	7.1	21.6	22.2
1979	0.0	0.0	7.2	7.2
1980	7.8	8.0	21.7	28.3
1981	0.0	0.0	5.2	5.2
1982	12.9	14.4	24.0	24.6
1983	22.5	24.9	31.8	32.6
1984	6.6	7.6	28.7	34.6
1985	0.0	0.0	1.6	1.6
1986	18.3	19.6	21.8	21.8
1987	0.0	0.0	4.8	4.9
1988	0.0	0.0	3.2	3.2
1989	0.2	0.2	9.3	8.1
1990	0.0	0.0	2.2	2.1
1991	0.0	0.0	5.6	5.7
Average	4.5	5.1	12.1	12.9
Median	0.0	0.0	6.4	6.5

[a] For descriptions of scenarios, see Table 5.3-2.

Adult salmonids entering the Yolo Bypass can become trapped throughout the Yolo Bypass and in the concrete apron of the Fremont Weir and face mortality or considerable delay (Williams 2006:116; Harrell and Sommer 2003:94). Adults entering the downstream end of the Yolo Bypass migrate upstream a considerable way before encountering the Fremont Weir. The weir presently has limited adult fish passage, and fish can be trapped or must migrate back downstream and reenter the Sacramento River to continue their upstream migration. The impediment to upstream migration affects those fish entering the Yolo Bypass and migrating all the way upstream to Fremont Weir. Presumably the percentage of adult salmonids migrating up the Yolo Bypass is greater in years with overtopping of Fremont Weir, as attraction flows down the bypass increase, so that the attribute of passage barriers would not be of equal importance in all years. Based on these considerations, as well as the relatively small size of the winter-run Chinook salmon population in relation to other Chinook salmon races, the attribute of passage barriers in the Plan Area was assumed to be of moderate importance to winter-run Chinook salmon adults, with a moderate degree of certainty reflecting the relative lack of information on the percentage of winter-run Chinook salmon currently taking this pathway and experiencing delay.

The suite of actions proposed to improve adult fish passage as part of *CM2 Yolo Bypass Fisheries Enhancement* will benefit Sacramento River adult salmonids by reducing stranding and delay in the Yolo Bypass (Appendix 5.C, Section 5.C.5.3.12, *Fremont Weir Adult Fish Passage (CM2 Yolo Bypass Fisheries Enhancement)*). The efficacy of the passage improvements at the Fremont Weir and other locations in the Yolo Bypass (e.g., Lisbon Weir) cannot be estimated, but will be monitored, and adjustments will be made through adaptive management. Resulting improvements in migration may vary by year type as a result of differing inundation frequencies and volumes. The DRERIP (Essex Partnership 2009) evaluation of improved passage at Fremont Weir suggests that the benefits of increased passage will greatly outweigh potential risks (e.g., increased stranding as a result of increased attraction into the bypass). Accordingly, it is concluded with moderate certainty that CM2 will provide a high positive change to passage barriers for adult winter-run Chinook salmon. Agency biologist opinion during the August 2013 workshops were consistent in suggesting a moderate or high positive change, with moderate or high certainty.

Tidal Habitat

The BDCP will greatly increase the extent of tidal habitat that is suitable for winter-run Chinook salmon juveniles, particularly in the Cache Slough and Suisun Marsh subregions

Tidal areas, including intertidal and subtidal habitats, form important rearing habitat for foraging juvenile salmonids. Foraging salmonids may spend 2 to 3 months or more in the Plan Area (e.g., fall-run Chinook salmon [Kjelson et al. 1982], winter-run Chinook salmon [del Rosario et al. 2013]). Loss of tidal habitat because of land reclamation facilitated by levee construction is a major stressor on juvenile salmonids in the DRERIP conceptual model (Williams 2009). For this effects analysis, it was assumed with high certainty that intertidal habitat is an attribute with high importance for foraging salmonid juveniles and low importance with moderate certainty for migrating salmonid juveniles, which was consistent with agency biologist thinking during the August 2013 workshops. It was assumed with low certainty that subtidal habitat has low importance as a current constraint for foraging and migrating salmonid juveniles, to maintain consistency with the inclusion of the habitat in the HSI approach, described further below (agency biologists thought zero importance would be appropriate for both life-history stages). Both intertidal and subtidal habitat were assumed with very high certainty to not be current constraints for adult salmonids, consistent with agency biologist opinion on the level of importance. As noted in the introduction to this section, different Chinook salmon runs were assumed to have different proportions of foraging and migrating juvenile life stages, from which the habitat suitability analysis in Appendix 5.E, *Habitat Restoration,* can be interpreted. For winter-run Chinook juveniles entering the Plan Area, it was assumed that 70% are foraging juveniles and 30% were migrant juveniles, based on input received from agency biologists during the August 2013 workshops.

Analysis of increases in tidal habitat (combined intertidal and subtidal) using the HSI approach (Appendix 5.E, Section 5.E.4.4.1.1, *Habitat Suitability Analysis*) suggests that under the BDCP in the late long-term there may be a near doubling of tidal HUs in the Plan Area for foraging juvenile Chinook salmon (Table 5.5.3-4). Juvenile winter-run Chinook salmon originate in the Sacramento River region, and therefore the most relevant tidal habitat to assess changes in is found in the Cache Slough, North Delta, West Delta, Suisun Bay, and Suisun Marsh subregions. Tidal habitat in these subregions is estimated to change from just over 30,000 HUs under existing conditions to over 50,000 HUs under the BDCP in the late long-term (a two-thirds increase), with much of the change being driven by restoration in the Cache Slough ROA and Suisun Marsh ROA and to a lesser extent in the West Delta ROA (Table 5.5.3-4). The Cache Slough, Suisun Marsh, and West Delta subregions have relatively high HSI values (around 0.8 to 0.9) for foraging Chinook salmon that primarily were a result of relatively high turbidity in comparison to other subregions (in particular the East and South Delta subregions), and the assumed low suitability of low-turbidity water for rearing salmonids based on catches of fry-sized Chinook salmon in Sacramento River trawls (Figure 5.E.4-16 and Figure 5.E.4-17, in Appendix 5.E).

Table 5.5.3-4. Habitat Units and Habitat Suitability Indices for Rearing (Foraging) Chinook Salmon Juveniles under Three Scenarios[a]: Existing Conditions, Future Conditions without the BDCP, and Future Conditions with the BDCP

Subregion (Restoration Opportunity Area)	Scenario[a]	Habitat Units	Habitat Suitability Index
Cache Slough (Cache Slough ROA)	EBC2	6,081	0.93
	EBC2_LLT	7,122	0.92
	ESO_LLT	18,250	0.92
	Change due to BDCP (LLT)[b]	11,128 (+156%)	0.00
North Delta (No ROA)	EBC2	808	0.73
	EBC2_LLT	1,323	0.73
	ESO_LLT	1,069	0.73
	Change due to BDCP (LLT)[b]	-254 (-19%)	
Suisun Marsh (Suisun Marsh ROA)	EBC2	7,678	0.80
	EBC2_LLT	7,755	0.80
	ESO_LLT	14,375	0.80
	Change due to BDCP (LLT)[b]	6,620 (+85%)	0.00
Suisun Bay (No ROA)	EBC2	7,889	0.96
	EBC2_LLT	7,029	0.96
	ESO_LLT	6,573	0.96
	Change due to BDCP (LLT)[b]	-456 (-6%)	0.00
West Delta (West Delta ROA)	EBC2	9,459	0.85
	EBC2_LLT	9,602	0.84
	ESO_LLT	11,422	0.84
	Change due to BDCP (LLT)[b]	1,820 (+20%)	0.00
East Delta (Cosumnes/Mokelumne ROA)	EBC2	1,346	0.52
	EBC2_LLT	2,106	0.51
	ESO_LLT	2,812	0.51
	Change due to BDCP (LLT)[b]	706 (+34%)	0.00
South Delta (South Delta ROA)	EBC2	4,363	0.57
	EBC2_LLT	5,036	0.57
	ESO_LLT	13,607	0.57
	Change due to BDCP (LLT)[b]	8,571 (+170%)	0.00
Subregions Most Relevant to Sacramento River Region–Origin Salmonids: Cache + North + West + Suisun Marsh/Bay	EBC2	31,915	N/A
	EBC2_LLT	32,831	N/A
	ESO_LLT	51,689	N/A
	Change due to BDCP (LLT)[b]	18,858 (+57%)	N/A
Subregions Most Relevant to San Joaquin River Region–Origin Salmonids: South + East + West + Suisun Marsh/Bay	EBC2	30,735	N/A
	EBC2_LLT	31,528	N/A
	ESO_LLT	48,789	N/A
	Change due to BDCP (LLT)[b]	17,261 (+55%)	N/A
All Subregions	EBC2	37,624	N/A
	EBC2_LLT	39,973	N/A
	ESO_LLT	68,108	N/A
	Change due to BDCP (LLT)[b]	28,135 (+70%)	N/A

[a] For descriptions of scenarios, see Table 5.2-3.
[b] ESO_LLT vs. EBC2_LLT.
N/A = not applicable.

The above analysis of habitat suitability considers intertidal and subtidal habitats together. As described in Appendix 5.E, Section 5.E.4.2.4.1, *Species Habitat Models*, intertidal and subtidal habitats have different suitabilities for foraging and migrating Chinook salmon juveniles. For foragers, intertidal habitat has high suitability (= 1), whereas deep subtidal habitat has low suitability (= 0.2) (Table 5.E.4-3, *Assumed Habitat Preferences of Juvenile Salmonid Stage*, in Appendix 5.E, *Habitat Restoration*). For migrants, intertidal habitat has low suitability (= 0.2) and deep subtidal habitat has high suitability (= 1). As shown in Appendix 5.E, Section 5.E.4.4.2.1, *Physical Habitat Extent*, the change in the relative proportions of intertidal and subtidal habitat between existing conditions and the restored conditions proposed under the BDCP are not the same. Overall, within the Plan Area, it is estimated that under existing conditions there is around 24,300 acres of intertidal habitat (which would increase to 28,500 acres with sea level rise in the late long-term), whereas under the BDCP it is proposed that there would be around 56,000 acres of intertidal habitat, i.e., an approximate doubling in intertidal habitat. For subtidal habitat, the Plan Area total acreage under existing conditions is around 76,000 acres (and would be similar in the late long-term); with the BDCP, the proposed restoration would increase the subtidal area within the Plan Area to almost 105,000 acres. For the Plan Area subregions most relevant to winter-run Chinook salmon (i.e., Cache Slough, North Delta, West Delta, Suisun Bay, and Suisun Marsh subregions; see description above), the intertidal area under existing conditions is estimated at around 19,000 acres (21,000 acres in the late long-term), and is estimated to be around 37,000 acres with proposed BDCP restoration in the late long-term; for subtidal habitat, there are estimated to be around 57,000 acres under existing conditions (58,000 acres in the late long-term) compared to nearly 73,000 acres with proposed BDCP restoration in the late long-term.

Restoration of habitat in Suisun Marsh may be of considerable importance during higher outflow years in particular, when Chinook salmon fry may be dispersed farther downstream (Kjelson et al. 1982), and may also be important in other water-year types. Restoration in the Cache Slough ROA will provide important shallow-water, low-velocity habitat, which may be of particular importance in years when the Yolo Bypass floodplain is not inundated for appreciable lengths of time (McLain and Castillo 2009). In addition, for years when the bypass is inundated and appreciable proportions of the rearing population of Chinook salmon is entering the Cache Slough subregion from the Yolo Bypass, restored habitat will also serve an important rearing function for these individuals. Restoration in the Cache Slough and West Delta ROAs will provide important transition areas from upstream habitats as salmon gradually move downstream prior to ocean migration. Conservation of adjacent upland areas under the BDCP will allow expansion of aquatic habitat as sea level rises, expanding the areas of suitable habitat and benefitting rearing juvenile Chinook salmon. It is concluded with moderate certainty `that the positive change in intertidal habitat for foraging winter-run Chinook salmon juveniles is very high; for subtidal habitat, it is concluded with moderate certainty that the positive change is moderate. There is some uncertainty related to how much restored habitats may be reduced in value because of colonization by IAV (Appendix 5.F, *Biological Stressors on Covered Fish*, Section 5.F.4.2.4, *Predation Risk in Restored Habitats*) and associated nonnative fish species that may prey on juvenile Chinook salmon or compete for food. *CM13 Invasive Aquatic Vegetation Control* aims to control IAV in the ROAs, which may limit predation, but there is uncertainty related to the ability to do so effectively. Other uncertainties related to tidal habitat restoration in the Plan Area are discussed in Appendix 5.E, *Habitat Restoration*, Attachment 5.E.B, *Review of Restoration in the Delta*.

As noted above, intertidal and subtidal habitat was assumed to be of lower importance to migrating juvenile Chinook salmon than to foragers that rear in the Plan Area. Overall tidal habitat (i.e., intertidal and subtidal combined) in the previously discussed subregions most relevant to juvenile winter-run Chinook salmon migrants are estimated at around 50,000 HUs under existing conditions and nearly 65,000 HUs under the BDCP in the late long-term, a relative increase of around 20% (Table 5.5.3-5). It is concluded that this represents a moderate positive change in intertidal and subtidal habitat for migrating juvenile winter-run Chinook salmon juveniles, with moderate certainty that reflects the same factors discussed above for foraging juveniles. Agency biologist opinion during the August 2013 workshops emphasized the view that intertidal habitat for migrant juvenile Chinook salmon should receive a low or zero change; note that the relative lack of importance of intertidal habitat to migrating juveniles is captured in its assumed low importance (described above).

Table 5.5.3-5. Habitat Units and Habitat Suitability Indices for Migrating Chinook Salmon Juveniles under Three Scenarios[a]: Existing Conditions, Future Conditions without the BDCP, and Future Conditions with the BDCP

Subregion (Restoration Opportunity Area)	Scenario[a]	Habitat Units	Habitat Suitability Index
Cache Slough (Cache Slough ROA)	EBC2	5,897	0.93
	EBC2_LLT	6,732	0.92
	ESO_LLT	14,267	0.92
	Change due to BDCP (LLT)[b]	8,908 (+132%)	0.00
North Delta (No ROA)	EBC2	2,145	0.65
	EBC2_LLT	2,250	0.64
	ESO_LLT	2,243	0.64
	Change due to BDCP (LLT)[b]	-7 (-0.3%)	0.00
Suisun Marsh (Suisun Marsh ROA)	EBC2	4,037	0.76
	EBC2_LLT	4,230	0.75
	ESO_LLT	9,085	0.75
	Change due to BDCP (LLT)[b]	4,855 (+115%)	0.00
Suisun Bay (No ROA)	EBC2	17,402	0.96
	EBC2_LLT	18,153	0.96
	ESO_LLT	18,535	0.96
	Change due to BDCP (LLT)[b]	382 (+2%)	0.00
West Delta (West Delta ROA)	EBC2	19,418	0.83
	EBC2_LLT	19,723	0.82
	ESO_LLT	20,670	0.82
	Change due to BDCP (LLT)[b]	947 (+5%)	0.00
East Delta (Cosumnes/Mokelumne ROA)	EBC2	1,661	0.40
	EBC2_LLT	1,800	0.40
	ESO_LLT	2,352	0.40
	Change due to BDCP (LLT)[b]	552 (+31%)	0.00
South Delta (South Delta ROA)	EBC2	8,740	0.57
	EBC2_LLT	9,002	0.57
	ESO_LLT	14,997	0.57
	Change due to BDCP (LLT)[b]	5,995 (+67%)	0.00
Subregions Most Relevant to Sacramento River Region–Origin Salmonids: Cache + North + West + Suisun Marsh/Bay	EBC2	48,899	N/A
	EBC2_LLT	51,088	N/A
	ESO_LLT	64,800	N/A
	Change due to BDCP (LLT)[b]	13,712 (+27%)	N/A
Subregions Most Relevant to San Joaquin River Region–Origin Salmonids: South + East + West + Suisun Marsh/Bay	EBC2	51,258	N/A
	EBC2_LLT	52,908	N/A
	ESO_LLT	65,639	N/A
	Change due to BDCP (LLT)[b]	12,731 (+24%)	N/A
All Subregions	EBC2	59,302	N/A
	EBC2_LLT	61,889	N/A
	ESO_LLT	82,150	N/A
	Change due to BDCP (LLT)[b]	20,261 (+33%)	N/A

[a] For descriptions of scenarios, see Table 5.2-3.
[b] ESO_LLT vs. EBC2_LLT.
N/A = Not applicable.

Channel Margin Habitat

Channel margin enhancement will improve the extent of higher value nearshore habitat in the Plan Area for winter-run Chinook salmon juveniles.

Channel margin habitat in the Plan Area has been considerably reduced because of the construction of levees and the armoring of their banks with riprap (Williams 2009). For this effects analysis, it was assumed with high certainty that channel margin habitat represents an attribute of high importance for foraging juvenile winter-run Chinook salmon, and an attribute of moderate importance with moderate certainty for migrating juvenile winter-run Chinook salmon. During the August 2013 workshops, some agency biologists concurred with these assumptions (albeit with lower certainty), whereas other agency biologists felt moderate importance for foragers and low importance for migrants to be more appropriate. *CM6 Channel Margin Enhancement* is generally expected to benefit covered salmonids by improving rearing habitat and reducing the distance between areas of higher value nearshore habitat along migration corridors (i.e., improving connectivity, sensu Pringle 2003; Appendix 5.E, *Habitat Restoration,* Section 5.E.6.5.2.2, *Chinook Salmon and Steelhead*). The primary benefit of *CM6* will be an increase in high-value rearing habitat for foraging winter-run Chinook salmon juveniles, because of enhancement and creation of additional shallow-water habitat that will provide refuge from unfavorable hydraulic conditions and predation, as well as foraging habitat (Appendix 5.E, Section 5.E.6, *Conservation Measure 6 Channel Margin Enhancement*). Most fish research in the Plan Area's channel margin habitat has focused on Chinook salmon fry, i.e., foraging juveniles (McLain and Castillo 2009; H.T. Harvey & Associates with PRBO Conservation Science 2010) (Appendix 5.E, Section 5.E.6.4.2, *Post-Restoration Conditions*). Benefits for winter-run Chinook salmon migrant juveniles may be somewhat less than for foraging winter-run Chinook salmon fry, although the habitat may function as holding areas during downstream migration (Burau et al. 2007; Zajanc et al. 2013), thereby improving connectivity between higher value habitats along the migration route. The efficacy of the conservation measure may depend on the lengths of enhanced channel margin habitat and the distance between enhanced areas—that is, there may be a tradeoff between enhancing multiple shorter reaches that have less distance between them, and enhancing relatively few longer channel margin habitats with greater distances between them. Enhanced channel margin habitat near the proposed north Delta intakes (upstream, between the intakes, and downstream) would provide resting spots and refuge for fish moving through this area.

Focusing most channel margin enhancement proposed in the Plan Area under CM6 in the North and West Delta subregion channels that are likely to be used most by juvenile winter-run Chinook salmon—the mainstem Sacramento River, Sutter/Steamboat Sloughs, and Miner Slough (e.g., Figure 5.E.6-1, *Revetment within Channels of the Plan Area*, in Appendix 5.E, *Habitat Restoration*)—would represent around 9% of the length of these channels if 75% of the proposed 20 miles of CM6 channel margin enhancement occurred in this area. The relatively small proportion of overall CM6 channel margin enhancement that may occur in the East Delta and South Delta subregions are of little relevance to winter-run Chinook salmon juveniles, which would not be likely to occur in those subregions. The extent to which channel margin enhancement will affect winter-run Chinook salmon juveniles on a broad scale depends on the change in overall habitat value relative to existing conditions. By targeting areas that have been shown to have poor habitat value and biological performance coupled with extensive occurrence, it is possible that channel margin enhancement, together with associated restoration activities (e.g., *CM7 Riparian Natural Community Restoration*), may result in a benefit that is more than the relative length of channel margin that is restored, e.g., in a given river reach with poor habitat quality, restoration of a relatively small proportion of the reach (e.g., 10%) to very high habitat quality could result in a disproportionately high increase in overall habitat quality for the reach as a whole (e.g., 20%). Poor value channel margin locations relevant to winter-run Chinook salmon include the greatly altered reach of the Sacramento River between Freeport and Georgiana Slough, among others. Additional research on existing biological performance (e.g., survival studies in particular reaches for Chinook salmon fry) will complement the existing knowledge regarding habitat value. Monitoring will inform the assessment of the change in habitat value resulting from CM6. There may be some risk to juvenile salmonids associated with use of enhanced channel margin habitat by predatory fish species such as largemouth bass (H.T. Harvey & Associates with PRBO Conservation Science 2010; Appendix 5.E, *Habitat Restoration, Section* 5.E.6.4.2, *Post-Restoration Conditions*); this risk will be assessed as part of a monitoring and adaptive management program in order to determine the specific site features that may need to be altered to reduce the risk and to ensure that there is no additional predation risk above what is typical for the restored reaches.

Channel margin enhancement under CM6 will more than offset any potential negative effects of reductions in channel margin habitat for juvenile salmonids that will result from construction of the north Delta intakes, and from any potential changes to water elevation that will result from water operations and habitat restoration under the BDCP. Construction of the north Delta diversions in the Sacramento River between Freeport and Walnut Grove will result in the permanent loss of approximately 2.6 miles of channel margin habitat; however, this habitat in its current condition generally has low value for salmonids (no emergent vegetation, relatively steeply sloping banks, little overhead cover, and riprapped banks) (Appendix 5.H, *Aquatic Construction and Maintenance Effects*, Section 5.H.6.1.4, *Habitat Modification*). Potential changes in inundation frequency for riparian and wetland benches because of changes in water elevation caused by operations of the north Delta diversions (*CM1 Water Facilities and Operation*) and changes in tidal amplitude because of tidal habitat restoration (*CM4 Tidal Natural Communities Restoration*) have the potential to alter availability of channel margin habitat (Appendix 5.C, Section 5.C.5.4.2, *Wetland Bench Inundation*). Channel margin enhancement under CM6 will allow consideration of potential changes in water elevation under the BDCP in order to maximize the beneficial effects on juvenile salmonids and other species and to offset any adverse changes from changes in inundation frequency at existing locations.

It is concluded with moderate certainty that there will be a moderate positive change to the channel margin attribute for foraging and migrating juvenile winter-run Chinook salmon.

Food Benefits from Restored Habitat

Tidal, floodplain, and channel margin habitat restoration under the BDCP has considerable potential to greatly increase the quantity of food available for juvenile winter-run Chinook salmon

The potential food benefits of proposed tidal marsh (*CM4 Tidal Natural Communities Restoration*), channel margin (*CM6 Channel Margin Enhancement*), floodplain (*CM5 Seasonally Inundated Floodplain Restoration*), and riparian restoration (*CM7 Riparian Natural Community Restoration*) for juvenile Chinook salmon and other covered fish species are analyzed in Appendix 5.E, *Habitat Restoration*. Food is produced in restored habitat as phytoplankton and zooplankton, benthic and terrestrial insects, and through detritus produced by breakdown of aquatic and terrestrial vegetation (Figure 5.3-7). Its value to salmonids is determined by the amount of time that each salmonid life stage spends in the particular restoration area and the bioenergetic value of the food item (e.g., insect prey common in floodplains have higher nutritional value than zooplankton prey more common in rivers; Sommer et al. 2001b). Restored tidal marsh habitats will add complex channel networks that provide benefits to juvenile salmon at both the primary and secondary food levels. Marsh plants add particulate organic matter to primary and secondary foodwebs, which is important to juvenile salmon (Maier and Simenstad 2009). Intertidal marshes also contribute food resources from terrestrial components and the benthos to juvenile salmon. Channel margin habitat increases the amount of shallow-water habitat along migration corridors, thus increasing the amount of foraging area in littoral habitats. There is some evidence that growth of juvenile Chinook salmon in parts of the Plan Area is relatively poor (MacFarlane 2010; note that his examination included the area from Chipps Island to the Golden Gate, i.e., the Suisun Bay subregion and further seaward) which could, in part, be the result of food limitation (Williams 2012), possibly as a result of factors such as nonnative clams (National Marine Fisheries Service 2009a). The diet of foraging juvenile Chinook salmon in the Plan Area is made up of crustaceans (including zooplankton such as cladocerans and epibenthic amphipods) and insects (Kjelson et al. 1982; Grimaldo et al. 2009). For this effects analysis, it was assumed with moderate certainty that benthic /epibenthic prey abundance and insect abundance have high importance for foraging winter-run Chinook salmon juveniles and low importance for migrating juveniles. During the August 2013 workshops, some agency biologists felt that the lack of information regarding food limitation warranted an assumption of moderate importance for benthic/epibenthic abundance and insect abundance; others agreed with an assumption of high importance. For this effects analysis, it was assumed with moderate certainty that zooplankton abundance has moderate importance for foraging winter-run Chinook salmon and low importance for migrating juveniles. The moderate degree of certainty is due to the relatively few number of studies of food limitation.

Increased inundation of floodplain habitat under *CM2 Yolo Bypass Fisheries Enhancements* will create rearing habitat that enhances the growth of juvenile salmon through the production of food resources (chironomids, zooplankton, and terrestrial insects) (Sommer et al. 2001b; Jeffres et al. 2008). As noted above, the analysis of growth benefits using the Yolo Bypass Fry Rearing Model suggests relatively low benefits for winter-run Chinook salmon fry from rearing on the floodplain (Appendix 5.C, *Flow, Passage, Salinity, and Turbidity*, Section 5.C.5.4.1.4.1, *Yolo Bypass Fry Rearing Model Results*), which may reflect the difficulty in representing the dynamic downstream migration tendencies of juvenile Chinook salmon with a model; the empirical analysis by Roberts et al. (2013) provides greater support for the benefits that may be derived from CM2. Riparian areas, although not directly providing habitat, does provide important services and food resources that make their way into channel margins and floodplains, primarily when riparian areas are inundated with flooding flows (Appendix 5.E, *Habitat Restoration*, Section 5.E.7.2). Riparian vegetation is a source for organic material (e.g., falling leaves), insect food, and woody debris. This debris is an important habitat and food source for fish and aquatic insects (Opperman 2005). Juvenile Chinook salmon predominantly consume zooplankton and chironomids, with some amphipods derived from channel margin habitat and other littoral sources (Grimaldo et al. 2009). Juvenile salmonids also benefit from contributions of the riparian community to the aquatic foodweb in the form of terrestrial insects and leaf litter that enter the water. The considerable extent of tidal habitat restoration under *CM4 Tidal Natural Communities Restoration* and associated emergent vegetation that will be created are expected to provide large benefits to both phytoplankton-based and detritus-based elements of the juvenile Chinook salmon foodweb (Appendix 5.E, Section 5.E.4.4.2.1, *Physical Habitat Extent*). For winter-run Chinook salmon juveniles, which originate in the Sacramento River region, phytoplankton production potential (prod-acres) is estimated to increase by 50% under the BDCP (nearly 100,000 prod-acres; based on ESO_LLT, although the results essentially would be the same for HOS_LLT with similar restoration extent assumed) compared to existing conditions (around 65,000 prod-acres), largely because of restoration in the Cache Slough and Suisun Marsh ROAs (Table 5.5.3-6).

Table 5.5.3-6. Depth-Averaged Phytoplankton Growth Rate and Prod-Acres under Three Scenarios[a]: Existing Conditions, Future Conditions without the BDCP, and Future Conditions with the BDCP

Subregion (Restoration Opportunity Area)	Scenario[a]	Phytoplankton Growth Rate (per day)	Prod-Acres[b]
Cache Slough (Cache Slough ROA)	EBC2	0.89	10,111
	EBC2_LLT	0.94	11,918
	ESO_LLT	0.97	29,569
North Delta (No ROA)	EBC2	0.71	2,661
	EBC2_LLT	0.76	3,587
	ESO_LLT	0.76	3,172
Suisun Marsh (Suisun Marsh ROA)	EBC2	1.12	13,935
	EBC2_LLT	1.06	13,413
	ESO_LLT	0.99	24,422
Suisun Bay (No ROA)	EBC2	0.70	14,222
	EBC2_LLT	0.67	13,773
	ESO_LLT	0.67	13,701
West Delta (West Delta ROA)	EBC2	0.78	22,591
	EBC2_LLT	0.79	23,378
	ESO_LLT	0.82	26,673
East Delta (Cosumnes/Mokelumne ROA)	EBC2	0.81	4,818
	EBC2_LLT	0.91	6,797
	ESO_LLT	0.94	8,936
South Delta (South Delta ROA)	EBC2	0.76	15,061
	EBC2_LLT	0.80	16,372
	ESO_LLT	0.89	38,090
Subregions Most Relevant to Sacramento River Region–Origin Salmonids: Cache + North + West + Suisun Marsh/Bay	EBC2	N/A	63,520
	EBC2_LLT	N/A	66,069
	ESO_LLT	N/A	97,537
Subregions Most Relevant to San Joaquin River Region–Origin Salmonids: South + East + West + Suisun Marsh/Bay	EBC2	N/A	70,627
	EBC2_LLT	N/A	73,733
	ESO_LLT	N/A	111,822
All Subregions	EBC2	N/A	83,400
	EBC2_LLT	N/A	89,599
	ESO_LLT	N/A	144,562

[a] For descriptions of scenarios, see Table 5.2-3.
[b] Prod-acres are the product of phytoplankton growth rate and acreage.
N/A = Not applicable.

It is concluded with high certainty that there will be a moderate positive change to benthic/epibenthic and insect abundance for foraging juvenile winter-run Chinook salmon; whereas the change for migrants is concluded to be high, reflecting occurrence overlapping with early spring, when food productivity may be greater. Some agency opinion during the August 2013 workshops suggested that a high positive change would be appropriate; the change assumed here reflects the occurrence of winter-run Chinook salmon juveniles somewhat earlier in the system than other Chinook salmon juveniles, a point raised during the agency workshops, which would result in a relatively lower positive change than for other races of Chinook salmon such as fall-run. Related to this, it is concluded that there would be a low positive change in zooplankton abundance (again related to seasonality) with low certainty that reflects the potential for nonnative clams such as *Potamocorbula* and *Corbicula* to consume enhanced primary production in restored tidal areas (Lucas and Thompson 2012) and therefore limit the benefit to the phytoplankton-based food sources.

5.5.3.1.2 Reduced Entrainment

Entrainment loss of juvenile winter-run Chinook salmon under the BDCP will be appreciably lower than under existing conditions because the north Delta diversion operations will reduce reliance on south Delta export facilities.

A major component of the covered activities will be a switch from export pumping solely in the south Delta to dual conveyance, including both north and south Delta diversions. It is anticipated that this will maintain entrainment levels of juvenile salmonids well below the levels seen in recent years with the implementation of the NMFS (2009a) BiOp. Appreciable losses of juvenile salmonids have occurred historically at the south Delta export facilities, although relatively few estimates of the proportion of the population entrained have been made. Based on examination of data from tagged hatchery-origin smolts, Kimmerer (2008) estimated that up to 10% of hatchery-origin winter-run Chinook salmon may have been entrained at high rates of winter–spring south Delta export pumping but noted considerable uncertainty in the estimates because prescreen losses due to predation and other factors are difficult to quantify; in addition, the assumption made by Kimmerer (2008) of 100% capture efficiency by the Chipps Island trawl may not be appropriate (and would overestimate the entrainment percentage). Estimates of wild-origin winter-run Chinook salmon take at the south Delta export facilities as a percentage of the juveniles entering the Delta have ranged from less than 0.1% in 2007 to over 5% in 2001 (Llaban pers. comm.). Williams (2012:10–11) noted that the ratio of salvaged hatchery-origin winter-run Chinook salmon juveniles at the south Delta export facilities compared to the catch in Chipps Island trawls was relatively high compared to other Sacramento River runs (using data up to 2008), and suggested that the differences between runs required more scrutiny. The NMFS (2009a) BiOp for listed salmonids and green sturgeon is similar to the USFWS (2008a) BiOp for delta smelt in that it includes export pumping restrictions to limit entrainment during important juvenile migration months. For this effects analysis, it was assumed with moderate certainty that the south Delta pumps entrainment attribute under existing conditions for foraging and migrating juvenile winter-run Chinook salmon is of moderate importance.

The salvage density method provided a relatively straightforward assessment of potential entrainment changes at the south Delta facilities as a result of changes in export pumping under the BDCP (Appendix 5.B, *Entrainment*, Section 5.B.5.4, *Salvage-Density Method (SWP/CVP South Delta Export Facilities)*), albeit one that does not provide an estimate of the proportion of the population that will be entrained and that assumes a linear relationship between changes in pumping and changes in entrainment, which likely does not capture the actual relationship between exports and winter-run Chinook entrainment. Based on modeled changes in pumping, entrainment of juvenile winter-run Chinook salmon at the SWP/CVP south Delta export facilities will be lower under the BDCP than under existing conditions. The salvage density method results suggest that in the late long-term, juvenile winter-run Chinook salmon entrainment will decrease substantially overall (approximately 50% decrease in average entrainment across all water years), with the decrease being least in critical water years (approximately 18 to 30%) and most in wet water years (approximately 70%), with other water years intermediate (Table 5.5.3-7) (Appendix 5.B, Section 5.B.6.1.2.1, *Salvage-Density Method*). This reflects the proposed BDCP operations of a greater proportion of export pumping at the north Delta diversions in wetter years and a relatively greater proportion of export pumping at the south Delta diversions in drier years (Appendix 5.B, Section 5.B.4.1, *Relative Contribution of North and South Delta Intakes under the BDCP*).

Table 5.5.3-7. Difference in Average Annual Entrainment Index[a] of Juvenile Winter-Run Chinook Salmon at the SWP/CVP South Delta Export Facilities under Future Conditions with the BDCP (Compared to Existing Conditions and to Future Conditions without the BDCP), Based on the Salvage Density Method

Water-Year Type	Change[b] under ESO_LLT[c]	
	Compared to EBC2[c]	Compared to EBC2_LLT[c]
Wet	-8,253 (-70%)[b]	-8,237 (-70%)
Above normal	-3,931 (-59%)	-4,043 (-60%)
Below normal	-2,727 (-38%)	-2,241 (-33%)
Dry	-1,122 (-30%)	-809 (-23%)
Critical	-357 (-28%)	-205 (-18%)
All years	-3,696 (-53%)	-3,524 (-52%)

[a] Number of fish lost to entrainment
[b] For descriptions of scenarios, see Table 5.2-3.
[c] Negative values indicate lower entrainment under the BDCP compared to existing conditions or future conditions without the BDCP. Values are based on normalized salvage density (Appendix 5.B, *Entrainment*, Section 5.B.6.1.2.1, *Salvage-Density Method*).

The DPM was used to estimate the percentage of winter-run Chinook salmon smolts (greater than 70-mm fork length) salvaged at the south Delta export facilities (Appendix 5.B, Section 5.B.5.7, *Delta Passage Model Salvage Estimates: Juvenile Chinook Salmon (SWP/CVP South Delta Export Facilities)*). The DPM analysis was consistent with the salvage density method analysis in estimating average salvage (as an index of entrainment) under the BDCP around 60% lower than under existing conditions (Table 5.5.3-8; Appendix 5.B, Section 5.B.6.1.2.2, *Delta Passage Model Salvage Estimates*).

Table 5.5.3-8. Estimated Percentage Salvage at the SWP/CVP South Delta Export Facilities of Winter-Run Chinook Salmon Smolts Entering the Plan Area, Based on the Delta Passage Model

Water Year (Type[a])	By Scenario[b]			Change[c] under ESO_LLT	
	EBC2	EBC2_LLT	ESO_LLT	Compared to EBC2	Compared to EBC2_LLT
1976 (C)	0.061	0.056	0.033	-0.028 (-46%)	-0.024 (-42%)
1977 (C)	0.015	0.013	0.011	-0.004 (-29%)	-0.002 (-18%)
1978 (AN)	0.064	0.062	0.014	-0.050 (-78%)	-0.047 (-77%)
1979 (BN)	0.088	0.082	0.029	-0.059 (-67%)	-0.054 (-65%)
1980 (AN)	0.060	0.046	0.019	-0.041 (-68%)	-0.027 (-58%)
1981 (D)	0.055	0.055	0.023	-0.033 (-59%)	-0.033 (-59%)
1982 (W)	0.095	0.085	0.016	-0.079 (-83%)	-0.069 (-81%)
1983 (W)	0.060	0.070	0.008	-0.052 (-87%)	-0.063 (-89%)
1984 (W)	0.066	0.066	0.005	-0.061 (-92%)	-0.061 (-92%)
1985 (D)	0.058	0.056	0.022	-0.036 (-62%)	-0.034 (-61%)
1986 (W)	0.059	0.080	0.017	-0.041 (-70%)	-0.062 (-78%)
1987 (D)	0.050	0.046	0.028	-0.022 (-43%)	-0.018 (-38%)
1988 (C)	0.020	0.020	0.014	-0.007 (-34%)	-0.007 (-33%)
1989 (D)	0.023	0.017	0.011	-0.012 (-52%)	-0.006 (-33%)
1990 (C)	0.028	0.018	0.029	0.002 (5%)	0.012 (65%)
1991 (C)	0.015	0.011	0.009	-0.006 (-42%)	-0.003 (-24%)
Average	0.051	0.049	0.018	-0.033 (-65%)	-0.031 (-63%)

[a] W = wet; C = critical; AN = above normal; BN = below normal; D = dry

[b] For descriptions of scenarios, see Table 5.2-3.

[c] Negative values indicate lower abundance under the BDCP compared to existing conditions or future conditions without the BDCP.

The above assessment was based on the ESO scenarios, but is also applicable to LOS because of the similarity in spring flows between ESO and LOS scenarios (Appendix 5.B, Section 5.B.4.5, *Differences Between Evaluated Starting Operations, High-Outflow Scenario, and Low-Outflow Scenario*). South Delta entrainment of winter-run Chinook salmon juveniles under the HOS may be slightly lower than ESO because of lower south Delta exports to provide greater spring (March through May) Delta outflow for longfin smelt. Winter-run Chinook salmon salvage overlaps with the early portion of the March–May higher outflow period (Figure 5.B.6-2, *Mean Monthly Entrainment Loss of Juvenile Winter-Run Chinook Salmon Calculated from Observed Salvage Monitoring at the (a) SWP and (b) CVP South Delta Export Facilities, Water Years 1996–2008*, in Appendix 5.B). Based on the DPM analysis, the annual average percentage salvage would be 0.017% under HOS_LLT compared to 0.018% under ESO_LLT. Therefore, considering the results of the salvage density method, which includes all sizes of juvenile winter-run Chinook salmon (i.e., foragers and migrants), and the DPM, which includes only smolts (i.e., migrants), it is concluded that the BDCP will result in a high positive change to the south Delta entrainment attribute for rearing and migrating winter-run Chinook salmon juveniles. This conclusion is made with moderate certainty that reflects the limited ability to model real-time water operations management decisions under existing conditions and the BDCP, which could result in differences from the results observed here. Nevertheless, it is anticipated that the BDCP will have an appreciable positive change to this attribute for winter-run Chinook salmon juveniles. Limited agency opinion during the August 2013 workshops suggested a low positive change to be appropriate.

As noted by Vogel (2011:93–94), there does not appear to be much evidence of agricultural diversions having an appreciable adverse effect on covered salmonid juveniles in the Plan Area. Only two Chinook salmon were collected during agricultural diversion sampling over several days in 1993 through 1995 by Cook and Buffaloe (1998). Although agricultural diversions are numerous, their main period of use (summer) (Appendix 5.B, Section 5.B.4.7, *Agricultural Diversions*) generally has low overlap with the occurrence of covered salmonids, including juvenile winter-run Chinook salmon. For this effects analysis, it was assumed with low certainty that entrainment at agricultural diversions is an attribute with low importance for foraging and migrating juvenile salmonids. Agency biologist opinion at the August 2013 workshops generally concurred with this, while noting that recent laboratory studies have found that entrainment of juvenile Chinook salmon passing close to simulated agricultural intakes does occur (e.g., up to 8.5% of fish tested by Mussen et al. [2013]) and may warrant low or moderate importance. However, within the Plan Area, the seasonality of diversions is such that it does not coincide appreciably with Chinook salmon occurrence (Vogel 2011) and so a low importance was felt to be warranted. Decommissioning of agricultural diversions in lands restored as tidal habitat under *CM4 Tidal Natural Communities Restoration* and screen removal/modification/screening under *CM21 Nonproject Diversions* will reduce the number of unscreened diversions in the Plan Area (Appendix 5.B, Section 5.B.6.4.3.1, *Delta Regional Ecosystem Restoration Implementation Plan Analysis of Nonproject Diversions*). Consistent with the DRERIP analysis of CM21, it is concluded that the BDCP will provide a low positive change to this attribute, with low certainty, reflecting the relative lack of study of the issue; agency biologists suggested high certainty was warranted given available evidence suggesting little effect of agricultural diversions on salmonids. Changes to the North Bay Aqueduct's Barker Slough Pumping Plant and its proposed alternative intake on the Sacramento River will represent no change to this attribute for salmonids because the intake is currently screened and will remain so in the future, at both locations.

5.5.3.1.3 Reduced Entry into Interior Delta

Nonphysical barriers, north Delta intake bypass flows, and changed Delta hydrodynamics under the BDCP have the potential to reduce entry into the interior Delta for juvenile winter-run Chinook salmon.

Juvenile winter-run Chinook salmon may enter the interior Delta from the mainstem Sacramento River through Georgiana Slough and, when open, the Delta Cross Channel (although the latter generally is closed as a result of the NMFS [2009a] BiOp during the winter-run migration period). Survival through the interior Delta has been shown to be consistently appreciably lower than in the river mainstem (Perry et al. 2010, 2013; Brandes and McLain 2001). Perry et al. (2013) found that, based on observed patterns for hatchery-origin late fall–run Chinook salmon, eliminating entry into the interior Delta through Georgiana Slough and the Delta Cross Channel would increase overall through-Delta survival by up to approximately one-third. The need to reduce entry into the interior Delta by juvenile salmonids was recognized in the NMFS (2009a) BiOp, which requires that engineering solutions be investigated to lessen the issue. These solutions may include physical or nonphysical barriers.

For this effects analysis, it was assumed with high certainty that the attribute of interior Delta entry has high importance for migrating and foraging juvenile winter-run Chinook salmon.

CM16 Nonphysical Fish Barriers aims to inhibit juvenile salmonids from entering the interior Delta, potentially increasing through-Delta survival. Under CM16, juvenile winter-run Chinook salmon may benefit from a nonphysical barrier at the Sacramento River–Georgiana Slough divergence. Because they have good swimming abilities and moderately good hearing abilities, they are likely to respond to the main barrier stimulus, the acoustic signal, which is enclosed within a bubble curtain; strobe lights increase the probability of deterrence away from the barrier, because visual orientation away from the source of the barrier's noxious sound stimulus is improved (Appendix 5.C, *Flow, Passage, Salinity, and Turbidity,* Section 5.C.5.3.9, *Nonphysical Barriers*). Perry et al. (2012) found good effectiveness of a pilot nonphysical barrier at the Sacramento River–Georgiana Slough divergence: over 22% of acoustically tagged Chinook salmon smolts entered Georgiana Slough when the barrier was not operating, versus just under 7% when the barrier was operational, a relative decrease of 67% because of the barrier. Perry et al. (2012) found that several factors influenced the probability of fish entering Georgiana Slough, the most important of which were relative fish position in the channel cross section and operation of the barrier. It is important to note that the Sacramento River flow during the study (spring 2011) was high (approximately 20,000 to 50,000 cfs); the analysis is underway of data from a second season of study (spring 2012) with much lower flow. It is also important to note that the test fish were relatively large (110- to 140-mm fork length) hatchery-origin late fall–run Chinook salmon, for which the representativeness of wild-origin Chinook salmon juvenile migration and behavior is unknown (Williams 2012). Under an assumption of 67% deterrence from entering Georgiana Slough, based on Perry et al. (2012), sensitivity analyses of the DPM results suggest that winter-run Chinook salmon smolt through-Delta survival under the BDCP could be increased by around 6 to 7% in relative terms compared to no barrier (and existing conditions) (Appendix 5.C, Section 5.C.5.3.4.1.2). Assuming the same 67% deterrence in the IOS life-cycle model for winter-run Chinook salmon, mean and median escapement would be considerably greater (approximately 20–50%) than the equivalent BDCP scenario without the barrier assumption (Appendix 5.G, *Fish Life Cycle Models*, Section 5.G.3.2.1.5). The effectiveness of nonphysical barriers will depend on factors including the water velocity characteristics in the vicinity of the barrier and on the extent to which predatory fish may congregate along the barrier and prey on juvenile salmonids. The former factor is of importance when considering the potential effectiveness of CM16 for foraging winter-run Chinook salmon juveniles, which are smaller than migrants. Regarding predation, Perry et al. (2012) found that around 6% of acoustically tagged smolts released downstream of Steamboat Slough to test the effectiveness of the nonphysical barrier either did not reach the Sacramento River-Georgiana Slough divergence or were preyed upon near the divergence. However, it is not known what the baseline rate of predation was for this area.

CM1 Water Facilities and Operation includes bypass flow criteria for the Sacramento River below the north Delta intakes to limit the potential for increased frequency of reverse flows in the Sacramento River below Georgiana Slough, which would increase the probability of entry into the interior Delta. As demonstrated in Appendix 5.C, *Flow, Passage, Salinity, and Turbidity,* Section 5.C.5.3.8, *Sacramento River Reverse Flows Entering Georgiana Slough*, several lines of evidence point to the effectiveness of the bypass flow criteria. Detailed analysis of 15-minute DSM2-HYDRO modeling data suggest that in comparison to existing conditions (with and without sea level rise), the BDCP resulted in similar or slightly lower (a) incidence of reversed flows in the Sacramento River below Georgiana Slough, (b) percentage of Sacramento River flow entering Georgiana Slough, and (c) percentage of Sacramento River reversed flow entering Georgiana Slough. The percentage of downstream-migrating Chinook salmon smolts entering the interior Delta through Georgiana Slough/Delta Cross Channel, as assessed with the DPM, also is estimated to be similar or slightly lower under the BDCP than existing conditions, reflecting the use of the same DSM2 modeling data with which the above analysis was conducted. These results are attributable to inclusion of bypass flow requirements under CM1 and the effect of downstream restoration under the BDCP in the ELT and LLT, reducing tidal hydrodynamics at the Georgiana Slough divergence in comparison to existing conditions (particularly when sea level rise is factored into existing conditions). As described further in Section 5.5.3.2.1, *Near-Field and Far-Field Effects of the North Delta Diversions on Juvenile Winter-Run Chinook Salmon*, the magnitude of bypass flows that may be required to limit adverse effects on juvenile salmonids is still being examined by the BDCP proponents and fishery agencies.

Given the potential for effective deterrence with nonphysical barriers under *CM16 Nonphysical Fish Barriers* and the apparent effectiveness of north Delta intake bypass flows in limiting Sacramento River reverse flows in the vicinity of Georgiana Slough, coupled with changed hydrodynamics because of downstream restoration, it is concluded that there will be a low positive change to the interior Delta entry attribute for migrating juvenile winter-run Chinook salmon, with moderate certainty because there is some evidence for effectiveness based on larger smolts at higher flows (Perry et al. 2012). The same positive change is concluded for foraging winter-run Chinook salmon but with low certainty because the effectiveness for small fish has not been assessed. At the August 2013 workshops, agency opinion was divided on conclusions regarding the potential change in the interior Delta entry attribute for winter-run Chinook, ranging from a low or moderate positive change (with low certainty) to zero or a low negative change (again with low certainty), primarily reflecting the uncertainty concerning the influence of tidal habitat restoration in muting tidal influence and its potential to offset lower Sacramento River flows below the proposed north Delta intakes.

Winter-run Chinook salmon adults migrate upstream during the likely period of nonphysical barrier operation. Should they migrate up Georgiana Slough during a nonphysical barrier deployment period, there may be potential for impedance or migration delay from the nonphysical barrier's deterrence (Appendix 5.C, Section 5.C.5.3.9). The ability to swim under the nonphysical barrier would be good at Georgiana Slough if the pilot configuration of the barrier tested in 2011 were used, wherein the sound stimulus and bubble-generating apparatus were in the middle of the water column. This would result in greater potential for adult salmonids to swim beneath the bubble curtain than in shallower areas, where the bubble curtain may be near the substrate (e.g., at the Head of Old River; Bowen et al. 2012). The monitoring and adaptive management program will assess the risk to adult salmonids from delay at nonphysical barriers.

5.5.3.1.4 Reduced Predation

The BDCP could reduce losses of juvenile winter-run Chinook salmon at existing localized areas where predation is intense.

NMFS (2009b) ranked predation as a stressor of high importance to the decline of Central Valley Chinook salmon and steelhead. Vogel (2011) reported results from radio-tagging studies that indicated high levels of predation on salmonids at numerous hotspots such as sharp channel bends, deep scour holes, narrow levee breaches, diversion pump structures, and other artificial structures such as bridges, docks, pipelines, and more natural structural elements including downed trees. For this effects analysis, it was assumed with moderate certainty that predation of foraging and migrating juvenile winter-run Chinook salmon has high importance. This attribute generated perhaps the widest range of agency biologist opinion during the August 2013 workshops: some felt that it was of low importance with low certainty, whereas other felt it was of high importance with moderate or high certainty.

Several conservation measures have the potential to influence predation of juvenile salmonids under the BDCP (Appendix 5.F, *Biological Stressors and Covered Fish*, Section 5.F.6, *Fish Predation*). *CM1 Water Facilities and Operation* will have potential beneficial effects (reduction of predation associated with entrainment at the south Delta export facilities; see entrainment discussion above) and adverse effects (reduced flows below the north Delta diversions, leading to increased predation risk during migration, and potentially concentrations of predators at the north Delta diversions)—the latter are discussed further below in Section 5.5.3.2, *Adverse Effects*. *CM2 Yolo Bypass Fisheries Enhancement* provides greater access to the Yolo Bypass migration route and therefore may result in reduced predation relative to the Sacramento River route, where predation is relatively high (see discussion above in Section 5.5.3.1.1, *Restored Floodplain, Tidal, and Channel Margin Habitat*). Implementation of habitat restoration measures (*CM4 Tidal Natural Communities Restoration*, *CM5 Seasonally Inundated Floodplain Restoration*, and *CM6 Channel Margin Enhancement*) in association with IAV removal (*CM13 Invasive Aquatic Vegetation Control*) has considerable potential to increase the amount of shallow-water habitat available for salmonid rearing while minimizing the amount of habitat for predatory fish. Care must be taken when designing levee breaches at restoration sites to avoid creation of locations where predators may congregate and exploit tidal fluxes of prey, including juvenile salmonids (Vogel 2011:120). Decommissioning of water diversion structures in ROAs also will decrease predatory fish habitat (Vogel 2011:116). *CM15 Localized Reduction of Predatory Fishes* will identify and target predation hotspots for predatory fish capture or alteration of habitat to enhance juvenile salmonid survival (e.g., by removing derelict vessels). There are few Plan Area studies from which predator reduction effectiveness can be predicted, and there is considerable uncertainty around this measure (Appendix 5.F, Section 5.F.6, *Fish Predation*). Results from a recent predator study on the lower Mokelumne River suggested that positive changes to juvenile salmonid survival could be achieved but that success depends on sustained effort (Cavallo et al. 2012), as is proposed under the BDCP. The effectiveness of predation reduction efforts will be assessed with targeted research and monitoring, and adaptive management will be applied as necessary to modify the conservation measure. In particular, the potential for incidental take of covered fish species will need to be carefully assessed with regard to methods employed (Appendix 5.F, Section 5.F.6.3.1.4, *CM15 Localized Reduction of Predatory Fishes*). Nonphysical fish barriers (*CM16 Nonphysical Fish Barriers*) are intended to benefit juvenile salmonids by altering migration routes to avoid the relatively low-survival interior Delta (see above). Although uncertain, there may be adverse effects from predatory fish aggregating along the barrier structure and preying on juvenile salmonids, a phenomenon that will be addressed with targeted research and adaptive management. Under *CM21 Nonproject Diversions* and *CM4 Tidal Natural Communities Restoration*, numerous water intake structures that may harbor predators under existing conditions will be modified or removed, which also has the potential to benefit winter-run Chinook salmon juveniles.

It is concluded that there will be a low positive change to predation for foraging and migrating winter-run Chinook salmon juveniles under the BDCP, but with low certainty for the numerous reasons outlined above. This was consistent with some agency biologist opinion during the August 2013 workshops, whereas there was also the opinion expressed during the workshops that suggested zero or a low negative change would be appropriate, because of factors such as enhanced predation in the vicinity of the proposed north Delta intakes that may be greater than any potential positive effects from CM15.

5.5.3.1.5 Reduced Illegal Harvest

The BDCP will help reduce illegal harvest of adult winter-run Chinook salmon.

CM17 Illegal Harvest Reduction will decrease poaching of covered salmonids and other covered fishes. The Implementation Office will provide funding to increase the enforcement of fishing regulations in the Plan Area and upstream tributaries in order to reduce illegal harvest of covered salmonids. Funds will be provided to hire and equip 17 additional game wardens and six supervisory and administrative staff in support of the existing field wardens assigned to the Delta-Bay Enhanced Enforcement Program (DBEEP) over the term of the BDCP; this represents nearly a tripling of the existing 10-warden squad. It is hypothesized that enhanced enforcement on poaching will reduce mortality and potentially increase populations of Chinook salmon (all races) (Bay-Delta Oversight Council 1995; Williams 2006) and steelhead (California Department of Fish and Game 2007, 2008; Moyle et al. 2008). Poaching during the night is more prevalent than during the day, and increased enforcement could reduce its effect on overall fish mortality. For this effects analysis, it was assumed with moderate certainty that illegal harvest for adult winter-run Chinook salmon is an attribute of moderate importance, primarily occurring in holding pools in upstream portions of the Sacramento River (Roberts and Laughlin 2013); illegal harvest of foraging and juvenile winter-run Chinook salmon (e.g., to use as bait for fishing) was assumed with low certainty to be an attribute of low importance. The attribute importance conclusions generally reflected agency biologist opinion from the August 2013 workshops, with some opinion suggesting that adult illegal harvest could be of moderate or high importance.

The magnitude of benefits from this measure is expected to vary inversely with the population size of each covered species (Bay-Delta Oversight Council 1995; Begon et al. 1996; Futuyma 1998; Moyle et al. 2008). Winter-run Chinook salmon adult escapement has been very low in the last few years (e.g., approximately 1,500 fish in 2010). Roberts and Laughlin (2013) outline the main factors that should contribute to the effectiveness of CM17. Their main focus was on effectiveness related to sturgeon illegal harvest, but they also note that the proposed threefold increase in patrols proposed under CM17 would allow DBEEP officers to focus on reducing the illegal take of winter-run and spring-run Chinook salmon from their holding pools in upstream waterways. Between 2005 and 2012, DBEEP officers made approximately 160,000 contacts and issued nearly 16,000 warnings or citations, suggesting an approximate 90% compliance rate with existing fishing regulations. This compares with approximately 60% compliance 20 years earlier, at the start of the DBEEP. Increasing the patrol rate threefold is anticipated to result in a proportional increase in contacts, warnings, and citations, which would then lead to a greater compliance rate as the angling public becomes aware of increased patrols, as well as providing a greater number of contacts with the public that could lead to more evidence being provided of illegal activities such as commercialization of sport fishing (Roberts and Laughlin 2013). Wardens participating in the enhanced patrols would be able to educate anglers as to fishing regulations, thus improving compliance and encouraging participation of the public in schemes such as CALTIP that allow citizens to provide information on illegal activities. Expansion of the DBEEP would allow 7-day-a-week, 12-hour-per-day patrol coverage, and would allow additional areas to be patrolled than is currently possible. CM17 would allow a permanent 8-warden undercover team to operate year-round in order to conduct activities primarily related to sturgeon poaching, but also including investigation of party boats and illegal fishing guide services that target sturgeon and salmon. Currently, participation in undercover activities means that a uniformed presence in the field is appreciably reduced. In addition to direct benefits to Chinook salmon and other species from reduced illegal take, implementation of CM17 is expected to benefit covered fish species by providing reduction in pollution in the Delta through reduction in the number of sites at which marijuana is illegally grown, a practice that when close to waterways is detrimental to aquatic habitat because of the applied fertilizers, chemicals, and other substances (Roberts and Laughlin 2013).

It is concluded with high certainty that there will be a high positive change to the illegal harvest attribute for adult winter-run Chinook salmon, as well as for foraging and migrating juveniles. This conclusion reflects agency biologist comment during the August 2013 workshops, which was provided in person by the first author of the above-cited memorandum on the benefits of CM17 (Roberts and Laughlin 2013).

5.5.3.2 Adverse Effects

5.5.3.2.1 Near-Field and Far-Field Effects of the North Delta Diversions on Juvenile Winter-Run Chinook Salmon

Operation of the proposed north Delta diversions under the BDCP has the potential to adversely affect juvenile winter-run Chinook salmon through near-field (physical contact with the screens and aggregation of predators) and far-field (reduced downstream flows leading to greater probability of predation) effects.

As noted elsewhere in this effects analysis, under *CM1 Water Facilities and Operation*, three 3,000-cfs intakes would be constructed and operated in the Sacramento River in the vicinity of Hood. Juvenile winter-run Chinook salmon entering the Plan Area as foragers or migrants would pass in the vicinity of these three intakes, if they remained in the Sacramento River as opposed to entering the Yolo Bypass. Although the percentage of the population entering the Yolo Bypass would be greater under the BDCP than under existing conditions (see Table 5.5.3-3 for estimates of migrating juvenile entry into Yolo Bypass), the majority of winter-run Chinook would pass in the vicinity of the intakes. The north Delta intakes may have near-field (screen contact/impingement and predation) and far-field (reduced flow-related survival) effects on juvenile winter-run Chinook salmon. The model results of the average percentage of river flow diverted at the three intakes during the typical winter-run downstream migration period (December–April) vary from around 4 to 25% depending on water-year type (Appendix 5.B, *Entrainment,* Section 5.B.6.2.1.1, *Occurrence near the Proposed North Delta Intakes*), although it is uncertain the extent to which downstream migrating juveniles winter-run Chinook would be aggregated towards the intakes in response to these diversion percentages. Juvenile winter-run Chinook salmon would be greater than 30-mm standard length and therefore exceed the approximately 20-mm minimum size that is estimated to be necessary for exclusion from entrainment by the proposed vertical wedgewire mesh of 1.75 mm spacing (Appendix 5.B, Section 5.B.6.2.1.2, *Entrainment (Screening Effectiveness Analysis)*).

For individuals physically contacting the screens, there may be some potential for impingement-related injury and mortality, although these effects were not related to any measured criterion such as screen contact rate in laboratory studies by Swanson et al. (2004). It is uncertain the extent to which the relatively benign environment of the laboratory studies can inform a field-based situation. As noted for other species, approach and sweeping velocity criteria for the north Delta intake screens have not been finalized, but approach velocity will be less than or equal to 0.33 fps (the criterion for salmonid fry) and may at times be limited to 0.2 fps (the existing criterion for juvenile delta smelt). For this effects analysis, it was assumed with moderate certainty that the intakes have low importance for migrating and foraging winter-run Chinook salmon juveniles. During the August 2013 workshops, some agency biologist opinion suggested zero importance for migrant juveniles would be appropriate, whereas subsequent agency comment received following the workshops concurred with a low importance in order to capture the potential for a small negative effect. It is concluded with moderate certainty that there will be a low negative change to the north Delta intakes attribute to foraging and migrating juvenile salmonids as a result of contact and impingement at the north Delta diversions. Agency biologist opinion during the August 2013 workshops was in accordance with this conclusion, with some suggestion that high certainty may be warranted. The conclusion of low negative change does not include consideration of potential predation near the intakes, discussed further below. Monitoring of impingement and targeted studies of juvenile salmonid behavior in relation to the intake screens will further inform the effect of this attribute following implementation. It is not anticipated that there will be any adverse effects of the north Delta diversions on adult salmonids with respect to impingement.

Plan Area flows have considerable importance for downstream migrating juvenile salmonids, as shown by studies in which through-Delta survival of Chinook salmon smolts positively correlated with flow (Newman 2003; Perry 2010); although one recent study by Zeug and Cavallo (2013) did not find evidence for effects of inflow on the probability of recovery of coded-wire-tagged Chinook salmon in ocean fisheries. Flow-related survival, in terms of the influence of downstream river (net) flow, may be more important in areas with largely unidirectional downstream flow and lesser tidal influence, as opposed to strong tidal influence, because tidal influence progressively becomes much greater with movement downstream (see Appendix 5.C, *Flow, Passage, Salinity, and Turbidity,* Section 5.C.5.3.13.1.11, *Context for Monthly Average Flow Changes in Tidally Influenced Areas of the Plan Area (Delta Region)*, for discussion of context of flow changes). The DPM, for example, does not include a net flow-survival relationship in the Sacramento River below Rio Vista, because such a relationship is not supported by existing data (Appendix 5.C, Section 5.C.4.3.2.2, *Juvenile Chinook Salmon Smolt through-Delta Survival (Delta Passage Model)*). For this effects analysis, it was assumed with high certainty that Plan Area flows have critical importance for migrating juvenile winter-run Chinook salmon. Agency biologist opinion during the August 2013 workshops generally thought high importance to be warranted and others suggested moderate importance. It was noted during the workshops that different portions of the Plan Area have different levels of importance, e.g., mainstem Sacramento River flows below the proposed north Delta intakes may have more importance than, for example, Old and Middle River flows for Sacramento River-origin races such as winter-run Chinook salmon. The assumed attribute importance noted above intends to capture the overall importance of the various Plan Area flows relevant to migration and movement through the entire Plan Area. Dispersal of smaller, fry-sized Chinook salmon that may forage and rear in the Plan Area for longer periods of time is also related to flows upstream and within the Plan Area (Kjelson et al. 1982; Brandes and McLain 2001). Because foraging winter-run Chinook salmon are spending longer periods of time within the Plan Area and may not be as reliant on Plan Area channel flows for migration, it was assumed with moderate certainty that this attribute has high importance; the moderate level of uncertainty reflects the relative lack of study of the influence of flow on these sizes of fish. Some agency biologist opinion during the August 2013 workshops suggested that Plan Area flows are critically important for dispersal of foraging Chinook salmon throughout the Plan Area. Salmonids migrating down the Sacramento River generally will experience lower migration flows because of the north Delta diversions compared to existing conditions, which is a far-field effect of the north Delta diversions. It is important to emphasize that *CM1 Water Facilities and Operation* includes bypass flow criteria that will be managed in real time to minimize adverse effects of diversions at the north Delta intakes on downstream-migrating salmonids. Juvenile salmonids migrating down the Sacramento River often do so in pulses that are triggered by increases in flows. For example, it has been observed that pulses of winter-run Chinook salmon juveniles are caught in large numbers at Knights Landing (just upstream of the Plan Area) rotary screw traps when flows on the Sacramento River at Wilkins Slough increase to more than 400 cubic meters per second (around 14,000 cfs) (del Rosario et al. 2013). CM1 will account for such changes in flows and the associated pulses of fish by monitoring fish presence at locations such as Knights Landing and adjusting to low-level pumping as necessary. The proposed criteria for low-level pumping consist of total north Delta diversions of up to 6% of river flow for flows greater than 5,000 cfs and not more than 300 cfs at any intake. Following the initial pulse flows, schedules of post-pulse flows would be applied depending on flows in the river at the time. Additional detail is provided in Chapter 3, Section 3.3, *Biological Goals and Objectives*. The magnitude of bypass flows that may be required to limit adverse effects on juvenile salmonids remains under examination by the BDCP proponents and fish and wildlife agencies. As described above in Section 5.5.3.1.3, *Reduced Entry into Interior Delta*, modeling results indicate that currently proposed bypass flow criteria—in combination with changes in hydrodynamics induced by tidal restoration—would not result in an increase in the proportion of flow entering the interior Delta through Georgiana Slough compared to what occurs under existing conditions. Further investigation of estimated survival downstream of the north Delta intakes under the different post-pulse flow levels (I, II, III) is being undertaken to evaluate whether the proposed criteria are sufficiently protective; results from the initial part of this investigation are provided in Appendix 5.C, Section 5.C.5.3.6, *North Delta Diversion Bypass Flow Effects on Chinook Salmon Smolt Survival* (see methods in Appendix 5.C, Section 5.C.4.3.2.4)..

Mean monthly river flows simulated from CALSIM-II varied considerably between different water-year types and months during the main winter-run Chinook salmon downstream migration period (December through April). Flows in the Sacramento River below the north Delta intakes generally would be approximately 10 to 20% lower under the ESO compared to existing conditions when averaged across all water years, with averages by individual water years ranging from not greatly different (December of critical years) to nearly 30% lower under the BDCP in April of above-normal years (Table 5.5.3-9). Flows under HOS would generally be similar (<5%) to those under ESO during December through March and greater than flows under ESO during April by up to 35% in the late long-term. Flows under LOS would generally be similar to those under ESO throughout the December through April period. The results of the DPM, which do not account for habitat restoration, suggest that overall through-Delta survival of winter-run Chinook salmon smolts would be similar or slightly lower under the BDCP compared to existing biological conditions (Table 5.5.3-10) (Appendix 5.C, Section 5.C.5.3.4.1.1, *Overall Survival through the Delta*); this is also true for the HOS (average survival = 33.2% under HOS_LLT; Table 5.C.5.3-59, *Percentage of Winter-Run Chinook Salmon Smolts Surviving through the Delta under EBC2, HOS, and LOS Scenarios, Based on Delta Passage Model*) and LOS (average survival = 33.3% under LOS_LLT; Table 5.C.5.3-59) scenarios, because there is little overlap of the DPM entry migration timing for winter-run Chinook salmon smolts. The observed patterns represented tradeoffs between positive and negative changes from the BDCP relative to the existing conditions: under the BDCP, there would be the positive effect of greater Yolo Bypass entry (with relatively high survival) and reduced interior Delta mortality because of lower entrainment loss from the south Delta export facilities, versus less survival through the Sacramento River and Steamboat/Sutter Slough pathways because of lower flows on the Sacramento River (See Table 5.C.5.3-35, *Percentage Use and Survival of Winter-Run Chinook Salmon Smolts Migrating Down Different Through-Delta Pathways under EBC and ESO Scenarios, from Delta Passage Model*, in Appendix 5.C, for pathway-specific survival estimates). Estimated survival in the Sacramento River mainstem from the divergence with the Delta Cross Channel and Georgiana

Slough to Chipps Island under ESO_LLT and HOS_LLT would average around 93 to 94% of survival under EBC2_LLT, based on applying the flow-survival relationship of Perry (2010) (Appendix 5.C, Section 5.C.5.3.6.1.1, *Winter-Run Chinook Salmon*). It is concluded that the BDCP would result in a low negative change to Plan Area flows for foraging and migrating winter-run Chinook salmon, with high certainty for migrating juveniles and moderate certainty for foraging juveniles, reflecting the relative difference in knowledge about what the change may mean to these different juvenile behavior types. Limited agency biologist opinion during the August 2013 workshops suggested a moderate negative change would be justified on the basis of large negative changes in flow during February and March.

Table 5.5.3-9. Estimated Average Monthly Flows by Water-Year Type for Sacramento River Below North Delta Diversion Facilities, Based on CALSIM II

Month	Water-Year Type[a]	Scenario[a]			Change[b] under ESO_LLT	
		EBC2 (cfs)	EBC2_LLT (cfs)	ESO_LLT (cfs)	Compared to EBC2	Compared to EBC2_LLT
Jan	W	50,599	52,878	43,883	-6,716 (-13.3%)[b]	-8,994 (-17%)
	AN	38,350	40,484	33,047	-5,304 (-13.8%)	-7,438 (-18.4%)
	BN	22,883	22,653	18,431	-4,452 (-19.5%)	-4,221 (-18.6%)
	D	17,222	17,451	14,939	-2,283 (-13.3%)	-2,512 (-14.4%)
	C	14,527	15,073	13,966	-561 (-3.9%)	-1,107 (-7.3%)
	AVG	31,469	32,595	27,220	-4,249 (-13.5%)	-5,374 (-16.5%)
Feb	W	56,778	59,847	49,932	-6,846 (-12.1%)	-9,915 (-16.6%)
	AN	44,745	47,786	39,397	-5,349 (-12%)	-8,390 (-17.6%)
	BN	30,829	31,592	25,437	-5,392 (-17.5%)	-6,155 (-19.5%)
	D	21,218	21,107	17,751	-3,467 (-16.3%)	-3,356 (-15.9%)
	C	14,829	14,291	12,979	-1,850 (-12.5%)	-1,311 (-9.2%)
	AVG	36,642	38,087	31,736	-4,906 (-13.4%)	-6,351 (-16.7%)
Mar	W	49,379	50,993	40,299	-9,080 (-18.4%)	-10,694 (-21%)
	AN	43,809	45,088	35,162	-8,646 (-19.7%)	-9,926 (-22%)
	BN	23,300	22,915	16,710	-6,591 (-28.3%)	-6,205 (-27.1%)
	D	20,409	20,650	16,213	-4,196 (-20.6%)	-4,437 (-21.5%)
	C	13,113	13,137	11,961	-1,153 (-8.8%)	-1,176 (-9%)
	AVG	32,445	33,134	26,086	-6,359 (-19.6%)	-7,049 (-21.3%)
Apr	W	37,941	37,543	28,339	-9,602 (-25.3%)	-9,205 (-24.5%)
	AN	26,006	24,931	17,897	-8,110 (-31.2%)	-7,035 (-28.2%)
	BN	17,445	17,128	14,235	-3,210 (-18.4%)	-2,893 (-16.9%)
	D	13,040	12,904	11,826	-1,214 (-9.3%)	-1,078 (-8.4%)
	C	10,198	10,365	9,808	-390 (-3.8%)	-557 (-5.4%)
	AVG	23,169	22,826	18,066	-5,103 (-22%)	-4,760 (-20.9%)
May	W	31,699	24,500	18,652	-13,047 (-41.2%)	-5,848 (-23.9%)
	AN	20,708	18,657	15,722	-4,986 (-24.1%)	-2,935 (-15.7%)
	BN	13,851	12,394	12,134	-1,717 (-12.4%)	-261 (-2.1%)
	D	10,714	11,427	11,633	918 (8.6%)	206 (1.8%)
	C	7,631	8,011	7,608	-22 (-0.3%)	-403 (-5%)
	AVG	18,915	16,295	13,953	-4,961 (-26.2%)	-2,342 (-14.4%)
Jun	W	23,671	18,603	15,070	-8,601 (-36.3%)	-3,533 (-19%)
	AN	16,451	16,051	14,041	-2,410 (-14.7%)	-2,010 (-12.5%)

Month	Water-Year Type[a]	Scenario[a]			Change[b] under ESO_LLT	
		EBC2 (cfs)	EBC2_LLT (cfs)	ESO_LLT (cfs)	Compared to EBC2	Compared to EBC2_LLT
	BN	13,420	13,898	13,247	-173 (-1.3%)	-651 (-4.7%)
	D	12,367	12,656	12,087	-280 (-2.3%)	-568 (-4.5%)
	C	9,880	10,123	9,403	-476 (-4.8%)	-719 (-7.1%)
	AVG	16,365	14,880	13,124	-3,241 (-19.8%)	-1,756 (-11.8%)
Jul	W	19,889	21,425	18,173	-1,716 (-8.6%)	-3,252 (-15.2%)
	AN	21,881	22,727	20,291	-1,590 (-7.3%)	-2,436 (-10.7%)
	BN	21,258	20,513	17,266	-3,993 (-18.8%)	-3,247 (-15.8%)
	D	19,076	18,957	13,429	-5,647 (-29.6%)	-5,528 (-29.2%)
	C	14,178	13,767	10,410	-3,768 (-26.6%)	-3,357 (-24.4%)
	AVG	19,400	19,797	16,151	-3,249 (-16.7%)	-3,647 (-18.4%)
Aug	W	15,911	16,064	10,427	-5,484 (-34.5%)	-5,636 (-35.1%)
	AN	16,389	17,491	12,175	-4,214 (-25.7%)	-5,316 (-30.4%)
	BN	15,763	16,232	12,274	-3,489 (-22.1%)	-3,958 (-24.4%)
	D	15,862	14,351	10,582	-5,280 (-33.3%)	-3,769 (-26.3%)
	C	9,901	8,996	8,382	-1,519 (-15.3%)	-614 (-6.8%)
	AVG	15,066	14,891	10,733	-4,333 (-28.8%)	-4,158 (-27.9%)
Sep	W	27,571	27,212	19,827	-7,743 (-28.1%)	-7,385 (-27.1%)
	AN	20,549	21,006	13,210	-7,339 (-35.7%)	-7,796 (-37.1%)
	BN	12,340	12,306	8,515	-3,825 (-31%)	-3,791 (-30.8%)
	D	11,149	8,620	8,861	-2,288 (-20.5%)	241 (2.8%)
	C	8,059	7,292	8,580	520 (6.5%)	1,287 (17.7%)
	AVG	17,483	16,763	12,874	-4,608 (-26.4%)	-3,888 (-23.2%)
Oct	W	12,903	13,277	10,166	-2,737 (-21.2%)	-3,112 (-23.4%)
	AN	10,436	11,864	10,291	-144 (-1.4%)	-1,572 (-13.3%)
	BN	11,052	12,124	10,197	-855 (-7.7%)	-1,927 (-15.9%)
	D	9,898	10,487	9,011	-887 (-9%)	-1,476 (-14.1%)
	C	9,537	9,964	9,452	-85 (-0.9%)	-512 (-5.1%)
	AVG	11,074	11,776	9,831	-1,242 (-11.2%)	-1,945 (-16.5%)
Nov	W	20,772	19,285	14,622	-6,150 (-29.6%)	-4,663 (-24.2%)
	AN	16,856	15,925	11,531	-5,324 (-31.6%)	-4,394 (-27.6%)
	BN	13,721	13,037	9,467	-4,255 (-31%)	-3,570 (-27.4%)
	D	12,685	11,914	9,467	-3,219 (-25.4%)	-2,448 (-20.5%)
	C	9,824	9,295	8,209	-1,614 (-16.4%)	-1,086 (-11.7%)
	AVG	15,618	14,647	11,219	-4,398 (-28.2%)	-3,427 (-23.4%)
Dec	W	37,465	37,022	31,257	-6,208 (-16.6%)	-5,766 (-15.6%)
	AN	22,241	22,629	20,348	-1,893 (-8.5%)	-2,280 (-10.1%)
	BN	16,935	16,692	15,155	-1,780 (-10.5%)	-1,537 (-9.2%)
	D	15,511	15,159	13,977	-1,534 (-9.9%)	-1,182 (-7.8%)
	C	11,289	10,632	11,005	-284 (-2.5%)	372 (3.5%)
	AVG	23,082	22,784	20,154	-2,928 (-12.7%)	-2,629 (-11.5%)

[a] W = wet; C = critical; AN = above normal; BN = below normal; D = dry

[b] For descriptions of scenarios, see Table 5.2-3.

[c] Negative differences indicate lower values under the BDCP.

Table 5.5.3-10. Percentage Through-Delta Survival Estimates for Winter-Run Chinook Salmon Smolts, Based on the Delta Passage Model

Water Year (Type[a])	By Scenario[b]			Change[c] under ESO_LLT	
	EBC2[a]	EBC2_LLT	ESO_LLT	Compared to EBC2	Compared to EBC2_LLT
1976 (C)	23.0	22.5	22.1	-0.9 (-4%)	-0.3 (-2%)
1977 (C)	18.7	19.6	20.9	2.3 (12%)	1.4 (7%)
1978 (AN)	46.2	46.6	43.9	-2.3 (-5%)	-2.6 (-6%)
1979 (BN)	33.2	33.2	29.1	-4.1 (-12%)	-4.1 (-12%)
1980 (AN)	43.6	43.5	42.3	-1.3 (-3%)	-1.2 (-3%)
1981 (D)	31.7	29.9	26.7	-5.0 (-16%)	-3.2 (-11%)
1982 (W)	51.2	51.0	52.1	0.9 (2%)	1.1 (2%)
1983 (W)	52.1	51.6	52.3	0.3 (1%)	0.8 (1%)
1984 (W)	44.5	44.0	40.4	-4.1 (-9%)	-3.6 (-8%)
1985 (D)	27.8	26.5	26.0	-1.8 (-6%)	-0.5 (-2%)
1986 (W)	40.4	39.9	40.6	0.1 (0%)	0.7 (2%)
1987 (D)	30.6	30.4	28.3	-2.3 (-7%)	-2.1 (-7%)
1988 (C)	25.2	24.4	24.3	-0.8 (-3%)	-0.1 (0%)
1989 (D)	33.3	33.2	31.4	-1.9 (-6%)	-1.8 (-5%)
1990 (C)	24.3	23.6	24.3	0.0 (0%)	0.6 (3%)
1991 (C)	29.0	28.3	27.0	-2.0 (-7%)	-1.3 (-5%)
Average	34.7	34.2	33.2	-1.4 (-4%)	-1.0 (-3%)
Median	32.4	31.8	28.7	-1.5 (-5%)	-0.8 (-3%)

[a] W = wet; C = critical; AN = above normal; BN = below normal; D = dry
[b] For descriptions of scenarios, see Table 5.2-3.
[c] Negative differences indicate lower values under the BDCP.

As noted above, potential predation effects at the north Delta intakes could occur, if predatory fish aggregated along the screens as has been observed at other long screens in the Central Valley (Vogel 2008). A bioenergetics model (Appendix 5.F, *Biological Stressors on Covered Fish,* Section 5.F.6.3.1.4, *CM15 Localized Reduction of Predatory Fishes*) was used to provide an estimate of the percentage of migrating winter-run Chinook salmon juveniles entering the Plan Area that might be consumed by striped bass near the north Delta diversions, under various assumptions. This analysis suggests that considerably less than 1% of winter-run Chinook salmon juveniles could be preyed upon, although there is appreciable uncertainty in the parameters used in the model. In addition, the baseline mortality in the reach is not known. An important stressor reduction target as part of the winter-run Chinook salmon biological goals and objectives is the maintenance of survival rates through the reach containing the north Delta intakes to 95% or more of the existing survival rate in this reach (Chapter 3, Section 3.3.7.3.3, *Species-Specific Goals and Objectives*). Sensitivity analyses were conducted with the results of the DPM to estimate the effect of a reduction on overall through-Delta survival to 95% of the survival that otherwise would have occurred. This suggests that overall through-Delta survival would be around 4% less than survival without the assumed additional mortality in the north Delta intakes reach (Appendix 5.C, *Flow, Passage, Salinity, and Turbidity,* Section 5.C.5.3.4.1.1, *Overall Survival through the Delta*). Another scenario of predation loss (explored further in Appendix 5.F, Section 5.F.4.2.2, *Fixed Predation Loss at North Delta Diversion*

Intakes) is a 5% loss of winter-run Chinook salmon at each of the three north Delta intakes based on losses in association with the Glenn Colusa Irrigation District diversion and screen in the upper Sacramento River, which would result in a cumulative loss of around 12% across three BDCP intakes. A number of factors make such a comparison uncertain, including location of the GCID intake in the upper Sacramento River on a relatively narrow oxbow. As noted above, it is possible that the BDCP will reduce localized predation at areas with relatively intense predation, and this includes the north Delta intakes should they be found to harbor predators. The uncertainty associated with predation at the north Delta intakes will be addressed with targeted research and adaptive management during implementation of the BDCP, and will also be informed by early implementation studies currently in the planning stage.

5.5.3.2.2 Reduced Attraction Flows in the Sacramento River

Sacramento River attraction flows for migrating adult winter-run Chinook salmon will be lower from operations of the north Delta diversions under the BDCP.

Attraction flows and the importance of olfactory cues to adult Chinook salmon was well described by Marston et al. (2012):

> Chinook salmon rely primarily on olfactory cues to successfully migrate through the Delta's maze of waterways to home back to their natal river (Groves et al. 1968; Mesick 2001). Juvenile salmon imprint by acquiring a series of chemical waypoints at every major confluence that enables them to relocate their river of origin (Quinn 1997; Williams 2006).

Marston et al. (2012) used recoveries of coded-wire tags from hatchery-origin Chinook salmon to estimate stray rates of adults. Fish released further upstream in-river had considerably lower straying rates than fish released downstream (including in San Francisco Bay) presumably because the fish released downstream had imprinted on fewer waypoints. For the Sacramento River, the stray rate for fish released upstream of the confluence of the Sacramento and San Joaquin Rivers was very low (average 0.1%, range 0 to 6.7%; Marston et al. 2012 [Methods Appendix:10])—if this rate is representative of wild populations spawned upstream, then it suggests a very low rate of straying for fish emigrating from natal tributaries in the Sacramento River basin with the existing flows through the Plan Area. As noted by Marston et al. (2012:18), Quinn (1997) suggested that background levels of straying for hatchery-origin salmon are 2 to 5%, although few studies have been conducted on wild-origin Chinook salmon; one such study for wild-origin Mokelumne River Chinook salmon—albeit a population with appreciable hatchery influence—reported a stray rate of over 7% (Williams 2006 as cited by Marston et al. 2012). Therefore, for this effects analysis, it was assumed with high certainty that Plan Area migration flows for adult winter-run Chinook salmon (incorporating factors such as olfactory cues) are of low importance as an attribute that has been changed from its historical condition, as judged by the low stray rate of Sacramento-origin hatchery fish. The high certainty level reflects the low levels of straying reported for adult Chinook salmon from the Sacramento River region under existing flow conditions. During the August 2013 workshops, agency biologists thought low or moderate importance with low certainty may be warranted for Sacramento River region Chinook salmon adults, including winter-run.

Sacramento River flows downstream of the proposed north Delta intakes generally will be lower under BDCP operations relative to existing conditions, with differences between water-year types because of differences in the relative proportion of water being exported from the north Delta and south Delta facilities. In addition, more flow will be entering the Yolo Bypass as a result of CM2 Yolo Bypass Fisheries Enhancement. As assessed by DSM2 fingerprinting analysis, the average percentage of Sacramento River–origin water at Collinsville, where the Sacramento and San Joaquin Rivers converge in the West Delta subregion, was always slightly lower under the BDCP than under existing conditions (Appendix 5.C, *Flow, Passage, Salinity, and Turbidity,* Section 5.C.5.3.13.1.3, *Winter-Run Chinook Salmon*). In the late long-term, the average percentage of Sacramento River water at the confluence during the assumed adult winter-run Chinook salmon December through June migration period was 2 to 8% lower under the BDCP (66 to 73%) compared to existing conditions (66 to 77%). (Table 5.C.5.3-193, *Monthly Average (With Range in Parentheses) Percentage of Water at Collinsville Originating in the Sacramento River during December-June under EBC and ESO Scenarios*, in Appendix 5.C). The effects of flow reduction in the lower reach of the Sacramento River on the attraction and upstream migration of adult salmonids are uncertain. Sacramento River flow at Rio Vista generally was lower during the December through June adult migration period under the ESO scenarios relative to EBC2 scenarios, except in December of critical years (Table 5.C.5.3-187, *Mean Monthly Flows (cfs) in Sacramento River at Rio Vista for EBC and ESO Scenarios*, and Table 5.C.5.3-188, *Differences between EBC and ESO Scenarios in Mean Monthly Flows (cfs) in Sacramento River at Rio Vista*, in Appendix 5.C). The differences in mean monthly flows were greatest in wet, above-normal, and below-normal years during the months of March–June, when differences were around 10 to 30% less under ESO scenarios compared to EBC scenarios when comparing within the same time periods. In contrast, flows in March–May were similar or greater under HOS_LLT (which includes higher March–May Delta outflow as part of the decision tree for longfin smelt) compared to EBC2_LLT (Table 5.C.5.3-235, *Mean Monthly Flows (cfs) in Sacramento River at Rio Vista for EBC2, HOS, and LOS Scenarios*, and Table 5.C.5.3-236, *Differences between EBC2 Scenarios and HOS and LOS Scenarios in Mean Monthly Flows (cfs) in Sacramento River at Rio Vista*, in Appendix 5.C). Flows in the lower Sacramento River are influenced by tidal hydrodynamics (Appendix 5.C, *Flow, Passage, Salinity, and Turbidity,* Section 5.C.5.3.13.1.11, *Context for Monthly Average Flow Changes in Tidally Influenced Areas of the Plan Area (Delta Region)*). The influence of the tide may also affect adult attraction and migration. For example, initial results from studies of acoustically tagged adult fall-run Chinook salmon within the Plan Area found that the majority (58%) of upstream movements detected at the Cache Slough/Sacramento River/Steamboat Slough convergence were movements into Cache Slough, compared to 29% into the Sacramento River and 13% into Steamboat Slough (Stein and Cuetara 2004); the authors suggested that the larger flows (primarily tidal) of Cache Slough may have influenced this pattern, and the movements into Cache Slough occurred both with and against the prevailing flow. The study also found that many fish entering Cache Slough returned downstream to Rio Vista. Olfactory cues have been shown to be important in guiding adult salmonids to upstream spawning habitat (Hasler and Scholz 1983; Quinn 2005). For example, adult sockeye salmon detected and behaviorally responded to a change in olfactory cues (e.g., dilution of olfactory cues from their natal stream) of greater than approximately 20% (Fretwell 1989). This may indicate that flow differences estimated during the adult winter-run Chinook salmon migration period under the BDCP will not be of considerable importance, although this is uncertain. In considering the results of the DSM2 fingerprinting results and the CALSIM flow analyses, as well as the above literature, it is concluded with low certainty that there will be a low negative change to adult migration Plan Area flows under the BDCP for upstream migrating adult winter-run Chinook salmon. The low certainty in these conclusions would be informed by monitoring and targeted research under the BDCP (e.g., examining migration success of tagged adult Chinook salmon under different flow regimes), with any adverse effects being addressed by adaptive management.

5.5.3.2.3 Exposure to In-Water Construction and Maintenance Activities

In-water construction and maintenance effects of the BDCP could affect winter-run Chinook salmon.

As described for other species, the main in-water construction activities at the proposed north Delta intakes (*CM1 Water Facilities and Operation*) will be limited to one construction season during the months of June through October (Appendix 5.H, *Aquatic Construction and Maintenance Effects*). The construction area is directly on the main migration route for winter-run Chinook salmon juveniles and adults. The seasonality of construction is intended to minimize adverse effects, although there remains potential for some winter-run Chinook salmon juveniles and adults to enter the area during construction (Appendix 5.H, Section 5.H.6.1, *CM1 Water Facilities and Operation*). Any winter-run Chinook salmon present may experience adverse effects from underwater sound (pile driving), entrapment within enclosed areas (e.g., cofferdams), exposure to temporary water quality deterioration (e.g., suspended sediment, suspension of toxic materials), and accidental spills. Habitat will be temporarily and permanently affected by intake construction, although habitat at the intake sites is generally of somewhat low value (steep-sloping, revetted banks with no emergent vegetation and little overhead cover). Maintenance dredging also may decrease water quality temporarily. Habitat restoration activities associated with *CM4 Tidal Natural Communities Restoration, CM5 Seasonally Inundated Floodplain Restoration*, *CM6 Channel Margin Enhancement*, and *CM7 Riparian Natural Community Restoration* may contribute to reduced water quality. Breaching of levees to create tidal habitat may reduce areas of channel margin, but there will be considerable gains of habitat caused by the breaching. In-water activities associated with other *CM14 Stockton Deep Water Ship Channel Dissolved Oxygen Levels, CM15 Localized Reduction of Predatory Fishes, CM16 Nonphysical Fish Barriers,* and *CM21 Nonproject Diversions* will have little to no effect on salmonids because of the small scale of the work. Implementation of *CM22 Avoidance and Minimization Measures* will reduce the likelihood of adverse effects from in-water activities related to construction and maintenance on juvenile and adult salmonids. Therefore, it is concluded with high certainty that construction and maintenance associated with the BDCP represent a minor adverse effect on winter-run Chinook salmon adults and juveniles.

5.5.3.2.4 Exposure to Contaminants

The BDCP will contribute to a reduction in winter-run Chinook salmon exposure to contaminants in the late long-term, although localized increases in contaminant exposure may occur as a result of tidal habitat and floodplain restoration.

The BDCP could adversely affect winter-run Chinook salmon life stages occurring in the Plan Area through changes in contaminants as a result of changes in water operations (*CM1 Water Facilities and Operation, CM2 Yolo Bypass Fisheries Enhancement*) and habitat restoration (principally, *CM4 Tidal Natural Communities Restoration*). Analyses presented in Appendix 5.D, *Contaminants*, suggest that there is low potential for increased contaminant exposure from the BDCP, and there may be a beneficial effect in the late long-term because of reduced contaminants from restoration of areas previously used for agriculture. It is concluded with low certainty that this represents a low negative change to this attribute for juvenile (foragers and migrant) winter-run Chinook salmon in the Plan Area. The importance of contaminants to these life stages of winter-run Chinook salmon was assumed to be low, with low certainty, which captured the limited agency biologist opinion during the August 2013 workshops (although one viewpoint suggested potential importance in relation to imprinting during the juvenile life stages and therefore homing as adults).

5.5.3.3 Impact of Take on Species

The BDCP may result in incidental take of winter-run salmonids from several mechanisms. Construction and maintenance at the proposed north Delta intakes, restoration sites, conservation hatcheries, and nonphysical barriers may result in a number of adverse effects on salmonids, including disturbance from in-water activity and hydrodynamic changes, physical injury from riprap/rock placement and noise and vibration, exposure to fuel or oil, and elevated turbidity levels (Appendix 5.H, *Aquatic Construction and Maintenance Effects*). These effects, however, will be temporary and are unlikely to be considerable on salmonids because a number of measures will be taken, including timing of in-water work to minimize potential adverse effects on salmonids. As a result, there will be minimal impact of take from these activities.

In relation to existing conditions, the BDCP will reduce overall entrainment at water diversions of winter-run Chinook salmon as a result of dual conveyance. Use of the south Delta pumps will be reduced in favor of the north Delta intakes, which will be designed to limit impingement and mortality of juvenile salmonids. The north Delta intakes will be used to export more water in wetter years, as dictated by Sacramento River at Hood bypass flow criteria.

Lower river flow downstream of the north Delta intakes under the BDCP may reduce survival of juvenile winter-run Chinook salmon during downstream migration along the Sacramento River and also could negatively affect upstream migration of adult winter-run Chinook salmon by changing attraction flows/olfactory cues. These effects are not readily quantifiable in terms of take, however, and will need to be evaluated through research and adaptive management.

5.5.3.4 Abundance, Productivity, Life-History Diversity, and Spatial Diversity

The VSP concept is used by NMFS to define criteria for assessment of actions on salmonid populations listed under the ESA (McElhany et al. 2000). VSP provides four parameters: abundance, life history productivity, biological diversity and spatial structure, that are useful concepts for characterizing the health or viability of salmonid populations. For this analysis, which includes winter-run Chinook salmon as well as the other salmonids considered in the BDCP effects analysis, abundance was evaluated in terms of habitat capacity based on the quantity of habitat and food. The four VSP parameters can be related to characteristics of habitat and changes in habitat conditions. As a result, although it is not possible to quantitatively relate BDCP actions to changes in the VSP parameters, the environmental changes resulting from BDCP conservation measures can be qualitatively related to the VSP parameters to provide insights into the effect of BDCP on salmonids within the Plan Area. To do this, the environmental attributes assessed in the effects analysis were associated with VSP parameters (Table 5.5.3-11), based on input received during the August 2013 workshops with agency biologists. For each attribute, importance of the attribute and the change in the attribute concluded to result from the BDCP were converted into numeric ranks (scores) based on the following scale: no importance or no change = 0; low importance or low change = 1 (or -1 for negative changes); medium (moderate) importance or medium (moderate) change = 2 (or -2 for negative changes); high importance or high change = 3 (or -3 for negative changes); critical importance or very high change = 4 (or -4 for negative changes). Attribute importance and change scores were then multiplied together to derive an effect score for each attribute within each life stage of each species. The qualitative conclusions from this process with respect to the net effects of the BDCP are discussed further in Section 5.5.3.5, *Net Effects*.

The multiplied effect scores (i.e., importance × change) for the attributes associated with VSP parameters were averaged across life stages to provide an indication of the effect of BDCP on the VSP parameters. The numeric values thus derived were then transformed back to a qualitative scale based on the following conversion scale: 0 = zero, 1 = very low, 2-3 = low, 4-8 = moderate (medium), 9-15 = high, and 16 = very high. The break-points for this scale are based on consideration of the combination of importance and change. For example, an attribute with high importance (score = 3) and high positive change (score = 3) was assumed to result in a high positive effect (3 × 3 = 9). Similarly, an attribute with medium (moderate) importance (score = 2) and medium (moderate) change (score = 2) was assumed to result in a moderate positive effect (2 × 2 = 4). A low negative change (score = -1) for an attribute of critical importance (score = 4) would result in a moderate negative effect (-1 × 4 = -4). Achievement of a very high positive effect would be the result of a very high positive change to a critically important attribute. The result of this procedure is a qualitative change in each VSP attribute that is concluded to result from implementation of the BDCP (Figure 5.5.3-1). The analysis focused only on attributes related to the Plan Area (but included consideration of conservation measures that may extend beyond the Plan Area, e.g., CM17 *Illegal Harvest Reduction*); this was because analysis of environmental changes in the upstream Study Area (i.e., including the mainstem rivers and their tributaries upstream of the Plan Area) generally suggested limited change except in the Feather River, for which change is discussed in relation to net effects for salmonid species as necessary based on occurrence and estimated effects. This exercise is intended to provide insights into the possible effect of the BDCP on the VSP parameters for Central Valley salmonids but the results should not be interpreted as projected quantitative change in any VSP parameter because of BDCP.

Table 5.5.3-11. Assumed Association between BDCP Environmental Attributes and Viable Salmonid Population Parameters

Category	Attributes	Life-Cycle Productivity	Capacity	Diversity	Spatial Structure
Food	Zooplankton community		x		
	Zooplankton abundance	x	x		
	Benthic & Epibenthic prey abundance	x	x		
	Insect abundance	x	x		
Entrainment & Impingement	North Delta Intakes	x			
	South Delta Pumps	x			
	North Bay Aqueduct	x			
	Ag Diversions	x			
Migration & Movement	Plan Area Flows	x		x	
	Interior Delta Entry	x			
	Passage Barriers	x			
Plan Area Habitat	Inter-tidal habitat		x	x	
	Channel Margin		x	x	
	Floodplains		x	x	
	Riparian		x	x	
	Sub-tidal habitat		x	x	
Sediment	Water clarity	x			
Temperature	Temperature	x			
DO	Dissolved Oxygen	x			
Toxins	Contaminants	x			
	Microcystis	x			
Predation	Predation	x			
	Illegal Harvest	x			

5.5.3.4.1 Abundance (Capacity)

A viable salmonid population must be sufficiently abundant to provide genetic diversity and to withstand fluctuations in environmental conditions. McElhany et al. (2000) provide general guidelines for abundance within populations while Lindley at al. (2007) use abundance as an evaluation metric for Central Valley spring-run Chinook populations. Although clearly an important parameter, the abundance of salmonids is the result of the integration of all conditions experienced over the course of their life history and so is a poor discriminator of habitat conditions. For purposes of evaluating the BDCP, abundance is evaluated in terms of habitat capacity, which is a function of the quantity of suitable habitat available to life stages as well as the availability of food. Habitat capacity can result in density dependent survival. Survival generally declines as abundance approaches carrying capacity due to limitations on food, space and other consumable habitat commodities (Hayes et al. 1996). This relationship can apply to the population as a whole or to individual life stages (Moussalli and Hilborn 1986). The abundance of salmonids in the Central Valley is controlled to a great degree by conditions outside the Plan Area, primarily by conditions in the Pacific Ocean (Lindley et al. 2009) where salmonids spend the majority of their life cycle but also by conditions upstream of the Plan Area where spawning and early rearing occurs. Nonetheless, improving Delta conditions is key to the recovery of Central Valley salmonids (National Marine Fisheries Service 2009b). Attributes associated with habitat capacity are marked in Table 5.5.3-11 and in particular are associated with the extent of intertidal, floodplain, channel margin, riparian, and subtidal habitat that is subject to restoration or augmentation under *CM2 Yolo Bypass Fisheries Enhancements*, *CM4 Tidal Natural Communities Restoration*, *CM5 Seasonally Inundated Floodplain Restoration*, *CM6 Channel Margin Enhancement*, and *CM7 Riparian Natural Community Restoration*, as well as food-related attributes such as insect abundance. Note that riparian habitat changes under CM7 are likely to be associated with CM4 and CM6, and so is not considered separately here. Figure 5.5.3-1 illustrates the results of the qualitative evaluation of changes in attributes related to capacity. The capacity of the Plan Area to support salmonid life stages is expected to be increased by the expansion of intertidal, floodplain and channel margin habitat, with the associated benefits accruing to foraging and migrating juvenile salmonids. Habitat restoration under the BDCP is expected to substantially increase the amount of shallow intertidal and subtidal habitat that is used for foraging by juvenile salmonids. Expansion of these habitats is also expected to increase food supply. CM4 in particular should increase the area of flooded freshwater marsh which provides substrate for aquatic insects that are key prey items for foraging salmonids (McLain and Castillo 2009). As discussed above, CM4–CM7 will greatly increase the Plan Area HUs for juvenile salmonids as a result of the combination of relatively high habitat suitability and substantial restoration acreage under the BDCP. The benefits for migrating juvenile salmonids will be less. However, all juvenile salmonids engage in both foraging and migrating behavior to varying degrees. As a result, populations that enter the estuary in a more advanced state of smoltification still will receive some benefit from habitat restoration. The positive change in capacity is estimated to be relatively greater for Sacramento River-origin salmonids because of a greater extent of channel margin enhancement under CM6 and more frequent floodplain inundation under CM2, relative to the extent of floodplain restoration under CM5 for San Joaquin River-origin salmonids (Figure 5.5.3-1).

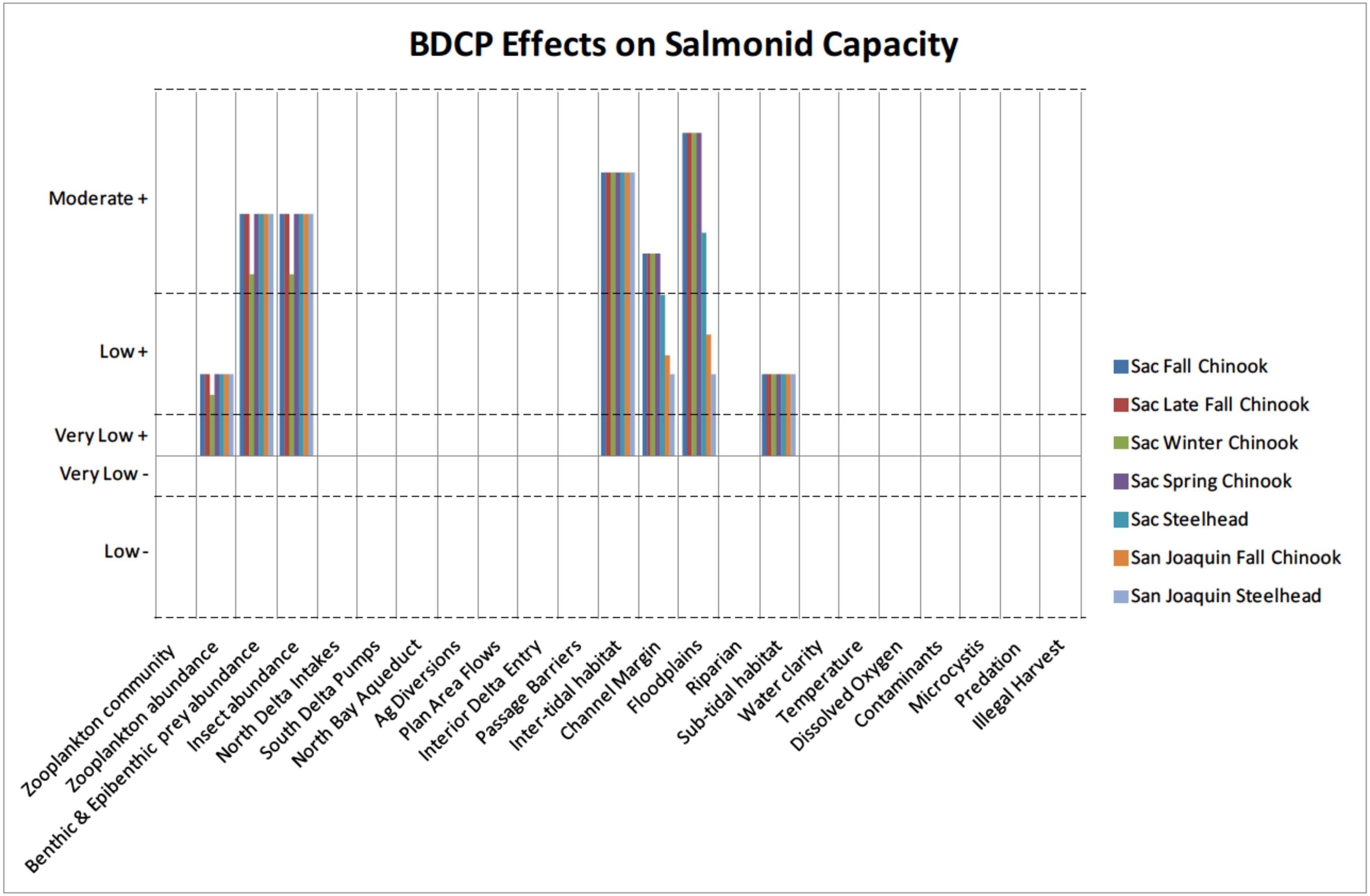

Figure 5.5.3-1. Qualitative Evaluation of the Effects of the BDCP on the Viable Salmonid Population Parameter of Abundance (Capacity)

5.5.3.4.2 Productivity

Life-history productivity relates to the quality of habitat experienced by salmonids over their life history including conditions in the Plan Area affected by BDCP. Productivity refers to density-independent survival or the maximum survival that could occur without the effects of competition or limitations on consumable habitat commodities (Hayes et al. 1996). Productivity can also be thought of as the "momentum" that is driving population abundance toward capacity resulting in a positive population growth path. The BDCP potentially affects a number of attributes associated with habitat quality issues including entrainment, factors related to migration and movement (e.g., Plan Area flows and passage barriers), food (a factor that affects both capacity and productivity), water quality, and predation (Table 5.5.3-11). These factors affect the survival of salmonid life stages in the Plan Area and can be affected by BDCP actions. The BDCP offers the potential to increase survival and productivity of the salmonids based on changes to conditions discussed in previous sections. Restoration of tidal habitats, channel margin, and floodplain habitats should increase food supply that is expected to increase overall productivity of salmonids passing through the Plan Area (Figure 5.5.3-2). Lower overall entrainment across all water-year types as a result of dual conveyance, along with use of nonphysical barriers (for Sacramento River-origin salmonids) or the operable gate at the Head of Old River (for San Joaquin River-origin salmonids) to reduce entry into the interior Delta, as well as passage improvements for adults at the Fremont Weir (for Sacramento River-origin salmonids) and the Stockton Deepwater Ship Channel (for San Joaquin River-origin salmonids), is expected to contribute positively to productivity. However, for Sacramento River-origin salmonids, less Sacramento River flow below the north Delta intakes may influence productivity negatively by affecting juvenile downstream migration and possibly adult upstream migration through less attraction flows, although the potential for the latter has not been studied in detail and may require targeted research and adaptive management. Bypass flow criteria and real-time monitoring of downstream migration pulses will aim to adjust north Delta intake operations when juvenile salmonids are most abundant. It is concluded that lowered predation under the BDCP through *CM15 Localized Reduction of Predatory Fishes*, in addition to other factors discussed above, has the potential to increase productivity and offset the potential for greater predation at some locations such as the north Delta intakes. As noted above, there is appreciable uncertainty related to changes in predation related to CM15. More certain appears to be the potential positive change to productivity that would result from *CM17 Illegal Harvest Reduction*; the relatively low positive contribution to a productivity change apparent in Figure 5.5.3-2 reflects the averaging over several life stages, with only adult harvest assumed to be of high importance. Because of the susceptibility to illegal harvest of adults in upstream areas, winter-run and spring-run Chinook salmon are expected to obtain a higher positive change to productivity from CM17 than other races.

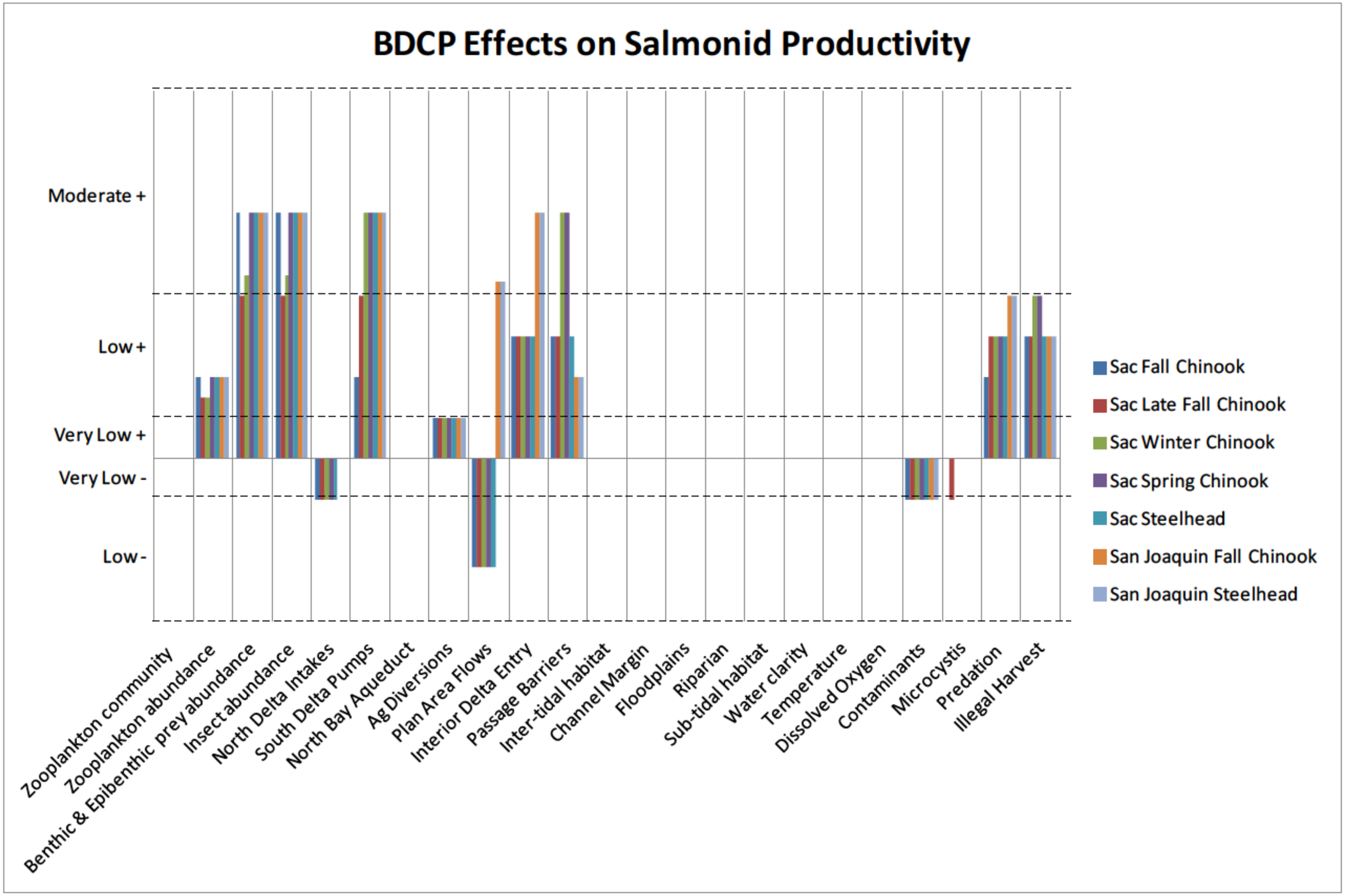

Figure 5.5.3-2. Qualitative Evaluation of the Effects of the BDCP on the Viable Salmonid Population Parameter of Productivity

5.5.3.4.3 Life-History Diversity

Life-history diversity is a reflection of the underlying spatial and temporal diversity in survival conditions encountered by salmonid populations across their life histories. A diversity of habitat conditions in the Plan Area should add to the tendency of salmonids to express a diversity of life histories. Channelization of the Delta along with flow regulation have reduced overall environmental diversity encountered by salmonids in the Plan Area. Under the BDCP, restoration of tidal and other habitat, including substantial amounts of floodplain, have the potential to contribute to an increase in life-history diversity for salmon by expanding the diversity of depths and nearshore conditions, which will enhance the foraging and migrating behavior of juveniles (Figure 5.5.3-3). This should increase population resiliency in the face of normal environmental variation and may enhance survival in the face of future climate change and other stochastic events, i.e., an increase in the portfolio effect (Carlson and Satterthwaite 2011). The expected positive effect of the BDCP on populations from the Sacramento and San Joaquin River regions should enhance the portfolio effect at the broader, ESU level, as well as within individual ESUs. Flow affects diversity because it is a major control on environmental variability for numerous variables over short and long time frames. To the extent that BDCP may decrease that variability in some portions of the Plan Area (primarily related to Sacramento River-origin salmonids in relation to the lower flow below the north Delta intakes), there could be a small negative impact on diversity from the change in the Plan Area flows attribute. As illustrated in Figure 5.5.3-3, the potential negative change from lower Plan Area flows for Sacramento River-origin salmonids is appreciably less than the potential positive change from restoration and enhancement of habitat.

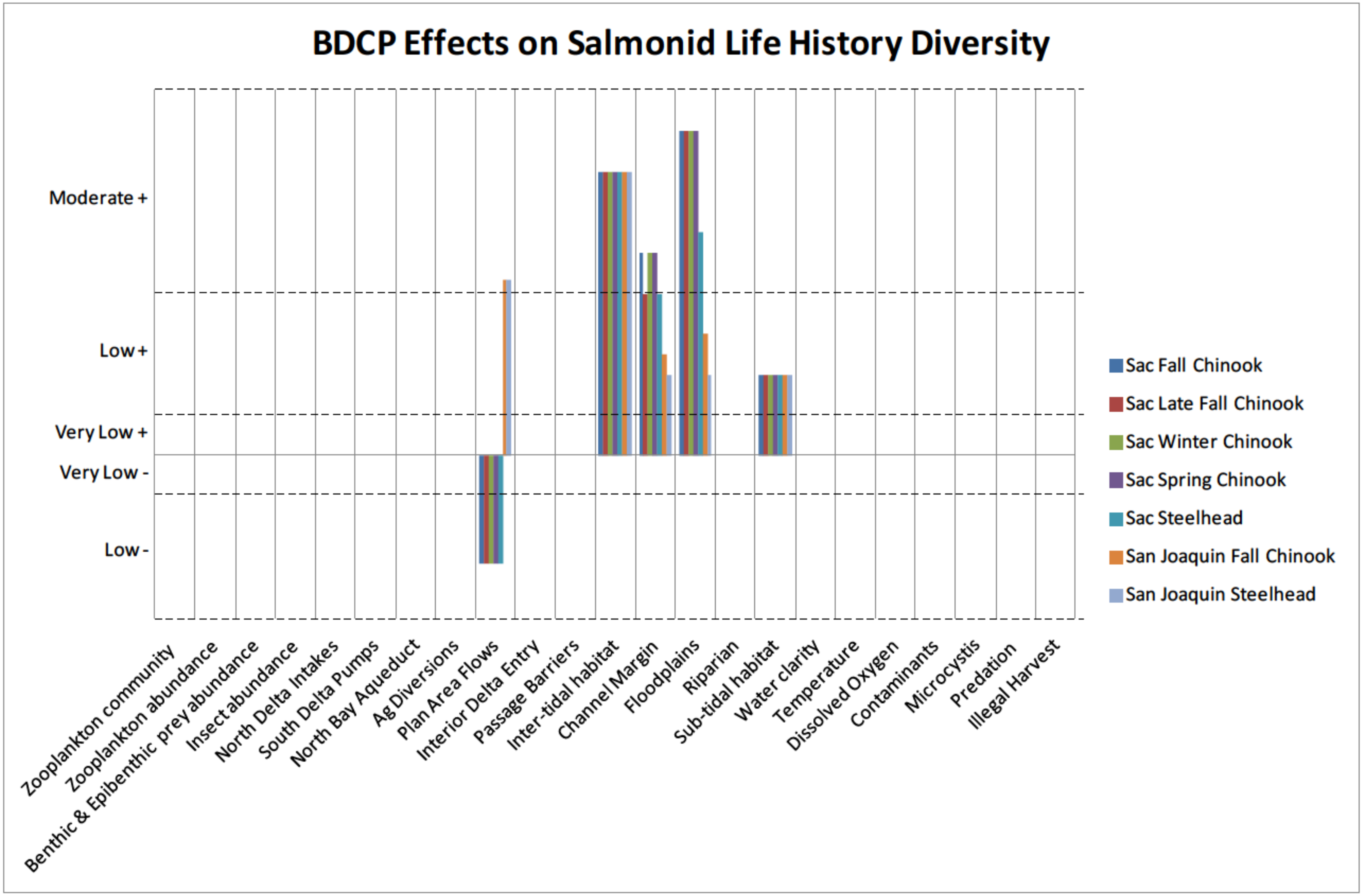

Figure 5.5.3-3. Qualitative Evaluation of the Effects of the BDCP on the Viable Salmonid Population Parameter of Life-History Diversity

5.5.3.4.4 Spatial Diversity

Spatial diversity of salmonids relates to the need for multiple populations and population segments to increase genetic diversity and to reduce the risk of catastrophic events on the persistence of the ESU. Spatial diversity develops from the availability of alternative habitats, the value of which may wax and wane over time because of natural and anthropogenic conditions but always ensuring that suitable habitat pathways exist to maintain the populations over time (Lindley et al. 2007). All salmonid spawning occurs in riverine environments and outside the Plan Area. As discussed previously, BDCP has little impact on upriver conditions and is unlikely to affect spatial diversity through this means. As discussed during the August 2013 agency biologist workshops, the BDCP's positive effects on factors that may be limiting San Joaquin River salmonids such as south Delta entrainment and straying could to some extent contribute to spatial diversity at the whole ESU level for Central Valley fall-run/late fall–run Chinook salmon and Central Valley steelhead. However, it is unlikely that actions within the Plan Area would change spatial diversity in terms of facilitating recolonization of upstream tributaries that currently have zero or low populations.

5.5.3.5 Net Effects

Figure 5.5.3-4 shows the relative population-level outcomes that are concluded to result from implementation of the BDCP, by attribute, for Sacramento River-origin salmonids covered under the BDCP, including winter-run Chinook salmon,. The graph illustrates the effect of the BDCP, by considering the change to an attribute for each life stage in light of the importance of the attribute to that life stage, as described above in Section 5.5.3.4, *Abundance, Productivity, Life History Diversity, and Spatial Diversity*. The positive effects of the BDCP are concluded to outweigh the negative effects, so that the net effect of the BDCP is expected to benefit winter-run Chinook salmon. Most of the concluded effects are made with moderate certainty, whereas the benefit of enhanced floodplain availability for foraging juveniles is assessed to be of high certainty. Many effect conclusions are made with low certainty that reflect low certainty about the current importance of the attribute (e.g., the importance of zooplankton prey abundance as a current constraint), low certainty about the magnitude of the change that BDCP may provide (e.g., positive changes to the predation attribute under CM15 *Localized Reduction of Predatory Fishes*), or low certainty regarding both the importance and change to the attribute (e.g., for the effect of the BDCP on contaminants and the resulting effect on biological performance). The negative change in Plan Area flows for migrating juvenile winter-run Chinook salmon is also made with high certainty; it is re-emphasized here, as discussed above, that in addition to BDCP bypass flow requirements, real-time operations would aim to minimize any potential adverse effects of the north Delta intakes on Plan Area flows in relation to migrating juvenile salmonids.

The BDCP is expected to increase considerably the amount of shallow-water tidal habitat that benefits foraging winter-run Chinook salmon. Restoration of tidal habitat under *CM4 Tidal Natural Communities Restoration* should appreciably increase the amount of tidal habitat (in particular, intertidal habitat) in the Plan Area. Restoration is planned to provide a large quantity of habitat with conditions suitable for foraging winter-run Chinook salmon in the Suisun Marsh, Cache Slough, and West Delta ROAs. Restored habitat in the South Delta and Cosumnes/Mokelumne ROAs is of little relevance to winter-run Chinook salmon because their geographic distribution and origin in the Sacramento River basin means occupation of these ROAs would be less frequent than the other ROAs. Juvenile salmonids forage in shallow-water habitat where they eat a variety of planktonic and benthic prey (McLain and Castillo 2009). This type of habitat is planned to be restored under the

BDCP, and is expected to provide an appreciable direct habitat benefit for foraging salmonids, including winter-run Chinook salmon.

The BDCP also plans to restore channel margin and floodplain habitats that provide direct habitat benefits for foraging and migrating winter-run Chinook salmon. In particular, *CM2 Yolo Bypass Fisheries Enhancement* will enhance conditions in the Yolo Bypass, which has been shown to be a highly beneficial habitat for juvenile salmonids (Sommer et al. 2001a), and for which the existing quantitative analysis suggests a positive effect that is supported by the recent empirical analysis by Roberts et al. (2013). The BDCP will provide improved adult and juvenile salmonid passage at Fremont Weir, increase the inundation period of the bypass, and enhance habitat conditions across the bypass itself. The current analysis also suggests a positive effect for migrating winter-run Chinook salmon as an alternative, relatively high-survival migration pathway through the Plan Area compared to the mainstem Sacramento River and other pathways.

In addition to the direct habitat benefits, restoration of tidal areas should augment the Plan Area foodweb and potentially enhance food supply for covered fish species. This has the potential to benefit both foraging and, to some extent, migrating juvenile winter-run Chinook salmon. Production of phytoplankton is greatest in shallow-water areas, and restored shallow-water habitats have been shown to enhance phytoplankton production in many cases (Jassby and Cloern 2000), although as noted elsewhere in this effects analysis, some uncertainty exists because of potential consumption of primary productivity by invasive clams (Lucas and Thompson 2012). Restoration of tidal habitats and the increase in inundation of the Yolo Bypass, with probable export of food from the floodplain, should enhance feeding conditions for juvenile salmonids, including winter-run Chinook salmon, as well.

The BDCP will decrease entrainment of winter-run Chinook salmon at the south Delta export facilities. The new north Delta intakes are designed with screens and velocity criteria that, in combination with pulse flow protection, should limit adverse effects to winter-run Chinook salmon juveniles, although the potential for negative interactions remains and will be informed by targeted research and adaptive management. The north Delta intakes bypass flows, under the BDCP, coupled with altered hydrodynamics from downstream restoration, will limit incidences of reverse flows at the Georgiana Slough entrance to the interior Delta which, in combination with nonphysical barriers, has the potential to reduce interior Delta entry and therefore lessen the use of this relatively low-survival Plan Area migration pathway by winter-run Chinook salmon. *CM15 Localized Reduction of Predatory Fishes* has the potential to improve juvenile winter-run Chinook salmon at localized predation hotspots and/or mitigate the effects of potentially increased predation in locations such as the new north Delta intakes, with much targeted research and adaptive management required to inform the relatively low certainty in this measure.

Category	Appendix	Attributes	Definition	Eggs	Foragers	Migrants	Adults
Food	E	Zooplankton community	Species composition of the zooplankton community and presence of suitable prey species	NA	Zero	Zero	
		Zooplankton abundance	The abundance of zooplankton	NA	Low	Very Low	
		Benthic & Epibenthic prey abundance	The abundance of epibenthic prey species such as amphipods	NA	Moderate	Low	
		Insect abundance	The abundance of insect prey	NA	Moderate	Low	
Entrainment & Impingement	B	North Delta Intakes	Potential entrainment/impingement from the proposed North Delta intakes	NA	Very Low -	Very Low -	
		South Delta Pumps	Pumping rate from the CVP/SWP south Delta export facilities and resulting entrainment	NA	Moderate	Moderate	
		North Bay Aqueduct	Entrainment from the SWP NBA facilities	NA			
		Ag Diversions	Entrainment from Agriculture Diversions	NA	Very Low	Very Low	
Migration & Movement	C	Plan Area Flows	Magnitude, timing, direction, and duration of flows during migratory periods throughout the Plan Area	NA	Low-	Moderate-	Very Low -
		Interior Delta Entry	Entry of fish into the interior Delta from the mainstem Sacramento or San Joaquin Rivers through channels such as Georgiana Slough or Old River	NA	Low	Low	NA
		Passage Barriers	Structures or conditions that potentially block upstream or downstream migration	NA			Moderate
Habitat	C, E	Inter-tidal habitat	Intertidal area from the mean low low water level to the extreme high water level that may support intertidal vegetation and form mudflats; dynamic elements of habitat such as appropriate salinity are considered on a species-specific basis	NA	High	Low	
		Channel Margin	The extent of shallow water, low slope habitat that generally is characterized by structural complexity, native emergent vegetation and riparian shading cover	NA	Moderate	Moderate	
		Floodplains	The interface between upland topography and river hydrology during high flow events	NA	High	Moderate	
		Riparian	Forest and scrub that occurs along the margins of river channels and within floodplains	NA	NA	NA	
		Sub-tidal habitat	Extent and location of sub-tidal area in the Plan Area, including the low salinity zone (LSZ); dynamic elements of habitat such as appropriate salinity are considered on a species-specific basis	NA	Low	Low	
Sediment	C	Water clarity	Water clarity in the Plan Area as influenced by amount of suspended material within the water column	NA	Zero	Zero	
Temperature	C	Temperature	Adverse effects of high temperatures within the Plan Area	NA			
DO	C	Dissolved Oxygen	Adverse effects of low dissolved oxygen level within the Plan Area	NA			
Toxins	D, F	Contaminants	Adverse effects of methylated mercury, selenium, pesticides and other pollutants	NA	Very Low -	Very Low -	
		Microcystis	The abundance of Microcystis aeruginosa blooms that are toxic to covered fish species and their food	NA			
Predation	F	Predation	The species-specific consumption of covered fish species by predatory fish (e.g., striped bass, Sacramento pikeminnow, centrarchid bass species, catfish, and inland silversides); note that the attribute aims to isolate predation effects that may not be captured by other attributes, e.g., at manmade structures such as the north Delta diversions	NA	Low	Low	
		Illegal Harvest	Illegal harvest of covered fish species in the Plan Area	NA	Low	Low	Moderate
In-stream Habitat	C	Sacramento R. Habitat	Flows in the Sacramento River mainstem (below Keswick Dam to the Plan Area) that influence spawning, egg incubation, rearing, or holding habitat	Zero	Zero	Zero	Zero
		Feather R. Habitat	Flows in the Feather River (below Oroville Dam to the confluence with the Sacramento River) that influence spawning, egg incubation, rearing, or holding habitat	NA	NA	NA	NA
		American R. Habitat	Flows in the American River (below Nimbus Dam to the confluence with the Sacramento River) that influence spawning, egg incubation, rearing, or holding habitat	NA	NA	NA	NA
Migration & Movement	C	Sacramento R. Migration Flows	Flows in the Sacramento River mainstem (below Keswick Dam to the Plan Area) that influence migration and movement	NA	Zero	Zero	Zero
		Feather R. Migration Flows	Flows in the Feather River (below Oroville Dam to the confluence with the Sacramento River) that influence migration and movement	NA	NA	NA	NA
		American R. Migration Flows	Flows in the American River (below Nimbus Dam to the confluence with the Sacramento River) that influence migration and movement	NA	NA	NA	NA
Temperature	C	Sacramento R. Temperature	Adverse effects of high water temperatures in the Sacramento River mainstem (below Keswick Dam to the Plan Area)	Zero	Zero		Zero
		Feather R. Temperature	Adverse effects of high water temperatures in the Feather River (below Oroville Dam to the confluence with the Sacramento River)	NA	NA	NA	NA
		American R. Temperature	Adverse effects of high water temperatures in the American River (below Nimbus Dam to the confluence with the Sacramento River)	NA	NA	NA	NA

Certainty

- No effect conclusion made because attribute assumed not to have importance as a current constraint
- NA — Life stage not present or not applicable
- Low certainty
- Moderate certainty
- High certainty
- Very high certainty

Figure 5.5.3-4. Effect of the Covered Activities on Winter-Run Chinook Salmon

A potential adverse effect of the BDCP on adult winter-run Chinook salmon will be the reduction in flow downstream of the north Delta diversions on the Sacramento River. Use of dual conveyance means that some water will be exported directly from the Sacramento River, reducing river flow below the north Delta intakes. This is concluded to somewhat reduce survival of winter-run Chinook salmon juveniles migrating past the intakes, with the effects more likely to occur in the less tidally influenced reaches where river flow dominates migration flows. The reduced outflow from the Sacramento River during the winter-run adult migration period along with the possible change in olfactory signals due to the change in flow mixture could affect upstream migration. The certainty of this adverse effect is very low, however, but should be monitored and evaluated during implementation. Contaminants and other negative effects from restoration and construction activities may occur but are anticipated to be low.

BDCP does not propose any changes in Shasta operating criteria, and BDCP does not affect upstream temperatures or flows in ways that would require a change in Shasta operations. Several models show no change in upstream conditions as a result of BDCP. However, one model (SacEFT) shows adverse effects under some conditions. After extensive investigation of these results, they appear to be a function of high model sensitivity to relatively small changes in estimated upstream conditions. Therefore, BDCP does not change the ability of Shasta Reservoir to meet its operating criteria for cold water pool and downstream temperature, including end of September and end of May storage. These criteria are required by the NMFS (2009a) BiOp to ensure that there are no unacceptable flow- or temperature-related effects on Sacramento River covered fish species, including winter-run Chinook. Appendix 5.C, *Flow, Passage, Salinity, and Turbidity* includes analysis of winter-run Chinook salmon habitat for upstream holding, spawning, egg incubation, and rearing, or for downstream migration flows in the upper Sacramento River, based on a variety of analyses conducted. Besides SacEFT, these models predict that there would be no change on upstream habitat. Additionally, an important biological objective for winter-run Chinook salmon is to avoid degradation of upstream habitat, which the modeling results suggest has been achieved through maintenance of the operational criteria from the NMFS (2009a) BiOp for Shasta Reservoir and upper Sacramento River flows.

Application of the winter-run Chinook salmon life-cycle models (IOS and OBAN) provides an assessment of the combined effects of some of the covered activities (Appendix 5.G, *Fish Life Cycle Models*) across winter-run Chinook life stages. Both models were developed to focus on operations-based representations of the current configuration of the Plan Area that reflect changes in river flow, upstream temperature, and migration routing, in addition to factors that the BDCP does not affect (primarily ocean harvest). IOS and OBAN are limited in terms of the ability to represent any potential changes from conservation measures related to habitat restoration under *CM4 Tidal Natural Communities Restoration* and *CM6 Channel Margin Enhancement*. Additionally, potential increased growth of winter-run Chinook salmon juveniles from *CM2 Yolo Bypass Fisheries Enhancement* is not included. The results of both models suggest future climate change effects would dominate changes in adult winter-run Chinook salmon escapement in the future, which is of appreciable concern for the species. Factoring in climate change, relatively small differences in upstream conditions between the BDCP LLT scenarios and EBC2_LLT resulted in greater adult escapement under HOS_LLT or lower adult escapement under ESO_LLT and LOS_LLT. These results reflect what appears to be appreciable model sensitivity to relatively small changes in estimated upstream conditions because, as noted above, the BDCP does not change Shasta Reservoir and upper Sacramento River operating criteria, so that changes in upstream areas derived from modeling, be they positive or negative, may not be fully reflective of the nature of actual changes that could occur.

Within the Plan Area, OBAN suggests positive effects of the BDCP, although this was a function of the model only representing factors that the BDCP positively influences (Yolo Bypass inundation and south Delta exports). A sensitivity analysis of the effects of 5% mortality in association with the north Delta intakes for HOS_LLT suggests that mean escapement would be slightly lower than without such mortality, but still higher than the mean escapement under EBC2_LLT. IOS suggests through-Delta survival would be slightly lower than existing conditions under ESO_LLT, HOS_LLT, and LOS_LLT—little difference in these results between ESO, HOS, and LOS reflects the low overlap of winter-run Chinook salmon juvenile migration with the spring outflow period that differentiates these scenarios, as previously described above for the results of the DPM. Sensitivity analyses of the effects of a nonphysical barrier reducing interior Delta entry at Georgiana Slough, and predation at the north Delta intakes, illustrated the potential effects of these other factors. In general, life-cycle modeling suggests that changes in winter-run Chinook salmon adult abundance in the late long-term would be dominated by climate change, and that any improvements to the Plan Area that are not captured by the life-cycle modeling have the potential to result in an overall benefit to winter-run Chinook.

Although the BDCP generally is not expected to change water temperatures in the Plan Area, climate change is predicted to result in increasingly difficult conditions for salmonids in the future. Climate change-induced temperature increase coupled with stressful habitats near the southern edge of salmonids' range make California's salmonids particularly vulnerable (Katz et al. 2012). It is predicted that climate changes will influence how, when, and where precipitation falls, which will significantly alter salmonid habitat. Lower baseline flows will increase temperatures, especially in the summer and fall, as the result of lower snowpack accumulation. Winter-run Chinook salmon are particularly vulnerable because the early life stages occur during the warm summer months (in contrast to all other Chinook salmon populations), whereas spring-run Chinook salmon are vulnerable because they must oversummer before spawning. A qualitative assessment of Central Valley salmonids covered by the BDCP suggested that winter-run, spring-run, and late fall–run Chinook salmon will be vulnerable to climate change in all watersheds they inhabit, steelhead will be vulnerable in most watersheds inhabited (with possible refuges present), and fall-run Chinook salmon will be vulnerable in portions of the watershed inhabited (with their ocean-type life history resulting in a lower risk from warming tributaries because they tend to leave during cooler months) (Moyle et al. 2008). Using modeling techniques, Thompson et al. (2011) found that spring-run Chinook salmon in Butte Creek were unlikely to survive climate change even when changes in water operations were made that will provide more water for fish.

Covered salmonid species, including winter-run Chinook salmon, may benefit from reduced operations of the Suisun Marsh salinity control gates (*CM1 Water Facilities and Operation*), although there is some uncertainty related to the frequency of the changes and to what extent the gates delay adult salmonids under existing conditions (Appendix 5.C, *Flow, Passage, Salinity, and Turbidity,* Section 5.C.5.3.10, *Suisun Marsh Salinity Control Structure*). The potential positive effect of changes to the Suisun Marsh Salinity Control Gates for adult winter-run Chinook salmon are assumed for this effects analysis to be captured under the high change associated with passage improvements at Fremont Weir (Section 5.5.3.1.1, *Restored Floodplain, Tidal, and Channel Margin Habitat*).

Water temperature was examined at the subregional scale in the Plan Area, and there was little difference between existing conditions and the BDCP for the number of days within the suboptimal, optimal, supraoptimal, and lethal ranges for winter-run Chinook salmon (Appendix 5.C, Attachment 5C.C, *Water Temperature*). As noted above, climate change is a driver that will have increasing importance for the species into the future. DO also was found to be similar between existing conditions and the BDCP (Appendix 5.C, Section 5.C.5.4.3, *Dissolved Oxygen*).

As described for delta smelt, there is uncertainty about the nature of changes in turbidity that may result from implementation of the BDCP (Appendix 5.C, Attachment 5C.D, *Water Clarity—Suspended Sediment Concentration and Turbidity*), although the issue is of greater importance for delta smelt. Turbidity in newly restored areas may be relatively high as a result of factors such as water depth and wind fetch resuspending sediments, whereas turbidity outside the restored areas could be affected by the north Delta intakes and restoration areas capturing sediment that otherwise would have moved downstream. In contrast to delta smelt, for which much of the juvenile population would be in downstream areas such as Suisun Bay that are reliant on resuspension of sediment during low-flow periods (e.g., summer/fall), winter-run Chinook salmon may occur in the mid-upper portions of the Delta (e.g., North Delta, Cache Slough, and West Delta subregions) during relatively high-flow times of the year, so it is concluded with low certainty that there would be no change to the water clarity attribute for any life stage. Agency biologist opinion during the August 2013 workshops suggested a potential zero or low negative change, with low certainty, reflecting the potential for less sediment in the system as well as lower river velocity downstream of the north Delta intakes to affect water clarity.

In conclusion, the magnitude of benefits of the BDCP for winter-run Chinook salmon at the population level cannot be quantified with certainty. Nonetheless, the overall net effect of the BDCP is expected to be a positive change that has the potential to increase the resiliency and abundance of winter-run Chinook salmon relative to existing conditions. This overall conclusion is made with moderate certainty. The BDCP should conserve the species in the Plan Area and may help it cope with expected climate change and the ongoing threats to recovery. Katz et al. (2012) point to the likelihood of extinction of many California salmon populations. Increasing air and water temperatures as well as a general shift in hydrologic regime (rain-dominated rather than snow-dominated) will increase stresses to Central Valley salmonids regardless of the BDCP. The BDCP will not directly address the main effects of climate change (i.e., increased temperature) but, by expanding habitat, increasing habitat diversity, and increasing the number of productive habitat patches in the Delta, the BDCP may lead to a more robust winter-run Chinook salmon population with the resiliency and diversity necessary to cope with a changing environment.

Therefore, the BDCP will minimize and mitigate impacts to the maximum extent practicable and provide for the conservation and management of the winter-run Chinook salmon in the Plan Area.

5.5.4 Chinook Salmon, Central Valley Spring-Run ESU

Central Valley spring-run Chinook salmon (*Oncorhynchus tshawytscha*) was once the most abundant run of salmon in the Central Valley (Campbell and Moyle 1992). Spring-run Chinook salmon were historically predominant throughout the Central Valley occupying the upper and middle reaches (1,000 to 6,000 feet) of the San Joaquin, American, Yuba, Feather, Sacramento, McCloud and Pit Rivers, with smaller populations in most tributaries with sufficient habitat for adult salmon holding over the summer months (Stone 1874; Rutter 1904; Clark 1929). However, the population has sharply declined in large part due to loss of habitat above the rim dams on the Sacramento system that have blocked most of the upper watershed habitat used by spring-run Chinook (Lindley et al. 2006). Spring-run Chinook were once abundant in the San Joaquin River system but have been extirpated by construction of Friant Dam and other habitat changes in the San Joaquin system.

Today, naturally spawning populations of Sacramento River region spring-run Chinook salmon with consistent spawning returns are restricted to Butte Creek, Deer Creek, and Mill Creek (Good et al. 2005), although returns to Battle Creek have increased in recent years. There is a small spawning population that has been documented in Clear Creek (Newton and Brown 2004). In addition, the Feather River, Yuba River (Feather River system) and Battle Creek support small populations (National Marine Fisheries Service 2009a, 2009b). The Feather River Hatchery produces large numbers of spring-run Chinook salmon. The lower reaches of the Sacramento River and the Plan Area serve as migration corridors for the upstream migration of adult and downstream rearing and migration of juvenile spring-run Chinook salmon. For purposes of understanding the BDCP effects, it is important to note that spring-run Chinook from Clear, Battle, Mill and Deer Creeks can use Yolo Bypass if the Fremont Weir is overtopping, but otherwise proceed towards the Plan Area via the main stem Sacramento River. Spring-run Chinook from Butte Creek emigrate through the Sutter Bypass and enter the Sacramento River below Fremont Weir and may only move into the Yolo Bypass during higher flow periods when Sutter Bypass flow becomes hydrologically connected to the Yolo Bypass across the Sacramento River. Fish from the Feather River system also enter the Sacramento River below the Fremont Weir at lower flows, but at higher flows Feather River water enters the Sutter Bypass and so spring-run Chinook salmon from the Feather and Yuba Rivers may enter the Yolo Bypass.

Spring-run Chinook salmon life history and status are discussed more thoroughly in Appendix 2.A, *Covered Species Accounts*. Briefly, the Central Valley spring-run Chinook salmon ESU is listed as a threatened species under the ESA. The original ESU designation included all naturally spawned populations of spring-run Chinook salmon in the Sacramento River and its tributaries in California, including the Feather River; more recently, the hatchery population at Feather River hatchery was added to the ESU. The San Joaquin populations are considered extirpated and are not included in the ESU.

Spring-run Chinook salmon enter freshwater as immature fish, migrate far upriver, hold in cool water pools for a period of months during the spring and summer, and delay spawning until the early fall. Adult Central Valley spring-run Chinook salmon begin their upstream migration in late January and early February (California Department of Fish and Game 1998) and enter the Sacramento River between March and September, primarily in May and June (Yoshiyama et al. 1998; Moyle 2002). Spring-run Chinook salmon fry emerge from the gravel from September to April (Moyle 2002; Harvey 1995; Bilski and Kindopp 2009) and the emigration timing is highly variable, as they may migrate downstream as young-of-the-year or as juveniles or yearlings (Williams 2012).

Fry may emigrate from their natal stream and then continue downstream to the estuary and rear, they may leave their natal stream and rear for a period in the Sacramento River and then move to the Delta, or may take up residence in the stream for a period from weeks to a year (Healey 1991) and emigrate as fully smolted juveniles. The majority of juvenile Chinook from Clear, Battle, Deer and Mill Creeks emigrate as sub-yearling fish though smaller portions of the population emigrate in later waves (Lindley et al. 2006). Emigrants may rear in the Sacramento River for a period and then enter the Plan Area as sub-yearling pre-smolts that feed in the Delta for some period prior to moving toward the ocean (Williams 2012); these are termed foragers. In the Delta, these fish forage in shallow areas with protective cover, such as tidally influenced sandy beaches and shallow water areas with emergent aquatic vegetation (Meyer 1979; Healey 1980). Another segment of the spring-run Chinook emigration, especially hatchery fish, reaches freshwater maturity in the tributaries (or the Feather River Hatchery) and enters the Delta as smolts bound for the ocean; these are termed migrants. Migrant juveniles may feed as they move through the Delta but they spend a relatively short period in the Plan Area before moving into the ocean. For this effects analysis, it was assumed that foraging juveniles make up 20% of the spring-run Chinook entering the Plan Area while the migrant forms makes up 80% of the juveniles entering the Plan Area. These proportions were developed based on literature review and discussions with agency biologists at workshops in August 2013. These proportions were used to qualitatively weight the effects of the BDCP on each ESU. Scoring of BDCP net effects (Section 5.5.4.5) considered the beneficial and adverse effects of the BDCP on foragers and migrants separately.

5.5.4.1 Beneficial Effects

5.5.4.1.1 Restored Floodplain, Tidal, and Channel Margin Habitat

Floodplain Habitat

The BDCP will change the configuration and operation of Fremont Weir and the Yolo Bypass, which will increase floodplain availability and usage and improve conditions for migrating juvenile and adult spring-run Chinook salmon.

Floodplains provide food and habitat benefits for juvenile salmon and other fish species (Crain et al. 2004). Sommer et al. (2001a) found higher growth of juvenile salmonids using the Yolo Bypass reflecting increased access to insects and other prey. Floodplains also provide alternative migration routes and could lead to increased life-history diversity and spatial structure within populations. Floodplain functioning reflects both the physical connection between the river and the adjacent floodplain but also the extent and schedule of high flow events (Williams et al. 2009; Opperman 2012). Floodplain areas in the Plan Area have been greatly reduced due to construction of dikes and levees and channel dredging that have separated rivers from their floodplain (Whipple et al. 2012). Loss of access to floodplain habitat in the Plan Area because of levee construction is a major stressor to juvenile salmonids (Williams 2009).

For this effects analysis, floodplain habitat is considered to be critical for foraging salmonids including spring-run Chinook salmon with high certainty based on the observations of Sommer et al. (2001b), and other investigators. For juvenile spring-run Chinook exhibiting the migrant behavior (the majority of juvenile spring-run Chinook reaching the Plan Area), floodplain habitat has a low importance with moderate certainty reflecting the value of floodplains as alternative passage routes. As noted for winter-run Chinook salmon (above), during the August 2013 workshops with agency biologists, there was consensus regarding the critical or high importance of floodplain habitat for foraging Sacramento River region Chinook salmon in the Plan Area but some thought that the importance for migrants should be low.

The extent to which spring-run Chinook are affected by changes in the Yolo Bypass and lower Sacramento River varies between populations based on their geographic relationship to the Fremont Weir. NMFS has identified existing populations of spring-run Chinook in Mill, Deer and Butte creeks slough they also are found in Battle Creek, Clear Creek and the Feather/Yuba system (Lindley et al. 2004). Feather River Hatchery also releases spring-run Chinook. The downstream migrating spring-run Chinook population consists of juveniles from all these systems. Spring-run Chinook from Battle, Clear, Mill and Deer creeks emigrate predominantly as sub-yearling fish (generally foragers in the Plan Area) and can move into the Yolo Bypass when flow goes across the Fremont Weir. However, the Feather River enters the Sacramento below the Fremont Weir. Similarly, fish from Butte Creek emigrate through the Sutter Bypass and do not enter the Yolo Bypass until flow is high enough to hydrologically connect the two Bypasses. As described in Appendix 5.C, *Flow, Passage, Salinity, and Turbidity* (Section 5.C.5.4.1.3, *Proportion of Chinook Salmon That Could Benefit from CM2 Yolo Bypass Fisheries Enhancement*), around 35% of spring-run Chinook salmon escapement is to tributaries upstream of Fremont Weir and so this proportion of the population has the potential to benefit from CM2 in terms of enhanced entry to the Yolo Bypass under lower flow conditions (note that this estimate excludes Feather River and Yuba River fish); individuals from all populations would have the opportunity to benefit from the greater duration of inundation that would occur under CM2, described further below, as well as less probability of stranding with sustained flows into the Bypass.

CM2 Yolo Bypass Fisheries Enhancement describes actions to improve habitat conditions in the Yolo Bypass and to increase its use by foraging and migrating juvenile and migrating adult salmonids. Spring-run Chinook salmon are expected to benefit from improvements to the Yolo Bypass discussed for winter-run Chinook (Section 5.5.3.1.1, *Restored Floodplain, Tidal, and Channel Margin Habitat*). In contrast to the winter-run, the majority of spring-run Chinook appear in the Delta as smolts (termed migrants) although this is heavily influenced by hatchery releases (Lindley et al. 2004). For this effects analysis, it was assumed that 80% of the juvenile spring-run Chinook entering the Plan Area exhibit predominantly migrant behavior and 20% exhibit predominantly foraging behavior. Natural runs in Butte, Mill and Deer creeks appear to have a greater proportion of sub-yearling foragers (Lindley et al. 2006; Williams 2012). It is expected that juvenile spring-run Chinook, especially those exhibiting the foraging behavior would benefit from the greater feeding opportunities in the Yolo Bypass. CM2 is expected to substantially increase the inundated acreage of floodplain in the Yolo Bypass in most months and water years (Table 5.5.3-1 in Section 5.5.3, *Chinook Salmon, Sacramento River Winter-Run ESU*). Inundated acreage increased especially during February, March and April when sub-yearling foraging fish are present.

Increased spill over the Fremont Weir under BDCP should increase the proportion of spring-run Chinook using this route of downstream passage. As discussed above, the benefit of this measure for enhanced access to the Yolo Bypass under lower flow conditions will generally accrue to natural-origin spring-run Chinook in Battle, Clear, Mill and Deer creeks. As noted above, Butte Creek spring-run Chinook mainly reach the Plan Area via the Sutter Bypass and mainstem Sacramento River during lower flow years, and the Feather River/Yuba River populations also would use the mainstem pathway in lower flow years. Results from the DPM suggest a three- to four-fold increase in the percentage of spring-run Chinook juveniles (exclusive of populations from Butte Creek and further downstream) using the Yolo Bypass and reaching Chipps Island under BDCP in the late long-term (Table 5.5.4-1). The Yolo Bypass provides a relatively high survival migration route through the lower Sacramento River. Use of the Yolo Bypass route by juvenile salmonids reduces the risk of entering the relatively low-survival interior Delta through Georgiana Slough or the Delta Cross Channel and of passing by the new north Delta intakes. The Yolo Bypass route also increases the diversity of migration pathways, which provides a safeguard against unpredictable stochastic events occurring along any single migration pathway. The Yolo Bypass migration pathway results from the DPM generally are consistent with the recent empirical analysis of Roberts et al. (2013), who estimated that under existing conditions an annual average of nearly 3.5% of spring-run Chinook salmon juveniles migrating from tributaries upstream of the Fremont Weir (as represented by catch in Knights Landing rotary screw traps) entered the Yolo Bypass during the 1997–2011 period (Table 5.5.4-2). Notching of the Fremont Weir to the specifications proposed under the BDCP was estimated to result in an annual average of nearly 13% of spring-run Chinook juveniles entering the Yolo Bypass (Roberts et al. 2013). Note that the estimates by Roberts et al. (2013) may be conservative in that spring-run-sized individuals captured after releases of fall-run smolts were made from Coleman National Fish Hatchery were assumed to be fall-run hatchery smolts.

Table 5.5.4-1. Percentage of Spring-Run Chinook Salmon Smolts[a] Migrating from Fremont Weir to Chipps Island via the Yolo Bypass Pathway under Four Scenarios[b], Based on the Delta Passage Model

Water Year	Scenario[b]			
	EBC2	EBC2_LLT	ESO_LLT	HOS_LLT
1976	0.0	0.0	1.9	1.9
1977	0.0	0.0	1.9	1.9
1978	1.4	2.2	18.6	18.6
1979	0.0	0.0	2.7	2.7
1980	0.3	0.3	9.3	55.6
1981	0.0	0.0	6.0	6.1
1982	17.8	18.9	24.0	24.0
1983	11.6	15.4	24.0	24.0
1984	0.0	0.0	10.9	47.9
1985	0.0	0.0	2.0	2.0
1986	6.7	7.4	10.3	10.5
1987	0.0	0.0	3.1	3.4
1988	0.0	0.0	2.3	2.4
1989	0.3	0.4	17.6	11.4
1990	0.0	0.0	2.6	2.6
1991	0.0	0.0	6.5	6.6
Average	2.4	2.8	9.0	13.8
Median	0.0	0.0	6.2	6.3

[a] Percentages only apply to spring-run Chinook salmon that originate from natal tributaries upstream of Fremont Weir.

[b] For descriptions of scenarios, see Table 5.2-3.

Table 5.5.4-2. Annual Percentage of Spring-Run Chinook Salmon Juveniles Entrained Onto the Yolo Bypass Under Existing Conditions and with Notching of Fremont Weir[a]

Water Year	Water-Year Type	Existing Conditions	With Notch
1997	W	13.2	21.1
1998	W	6.1	11.2
1999	W	1.1	13.7
2000	AN	8.0	18.4
2001	D	0.0	4.1
2002	D	0.1	7.6
2003	AN	0.7	14.0
2004	BN	0.5	10.6
2005	AN	0.0	11.5
2006	W	7.2	16.2
2007	D	0.0	8.7
2008	C	0.0	11.3
2009	D	0.0	6.5
2010	BN	0.5	12.3
2011	W	13.0	22.7
Average (1997–2011)		3.4	12.7
Wet and Above Normal Water Year Average		6.2	16.1
Dry and Critical Water Year Average		0.0	7.7

Source: Roberts et al. 2013.
[a] Assumed a Fremont Weir notch similar to that proposed under the BDCP.

Based on the above information, the benefits of the BDCP for floodplain habitats under CM2 is expected to result in a high positive change (with high certainty) for foraging juvenile spring-run Chinook salmon and a moderate positive change (with moderate certainty) for migrant juveniles.

Adult salmonids entering the Yolo Bypass can become trapped throughout the Yolo Bypass and in the concrete apron of the Fremont Weir and face mortality or considerable delay (Williams 2006:116; Harrell and Sommer 2003:94). Adults entering the downstream end of the Yolo Bypass migrate upstream a considerable way before encountering the Fremont Weir. The weir presently has limited adult fish passage, and fish can be trapped or must migrate back downstream and reenter the Sacramento River to continue their upstream migration. Based on these considerations, and the relatively low abundance of spring-run Chinook salmon in relation to most other races, the attribute of passage barriers was rated of moderate importance to spring-run Chinook salmon adults, with a moderate degree of certainty reflecting the lack of information on the percentage of spring-run Chinook salmon currently taking this pathway and experiencing delay.

CM2 Yolo Bypass Fisheries Enhancement provides a suite of measure that are expected to improve adult passage for fish including spring-run Chinook salmon. In particular, this measure provides for improved adult passage facility at the Fremont Weir and other locations. Accordingly, it is concluded with moderate certainty that CM2 will provide a high positive change to passage barriers for adult spring-run Chinook salmon. Agency biologist opinion during the August 2013 workshops were consistent in suggesting a moderate or high positive change, with moderate or high certainty.

The BDCP will expand floodplain habitat in the Plan Area to benefit juvenile salmonids outside the Yolo Bypass.

CM5 Seasonally Inundated Floodplain Restoration describes actions related to the expansion of floodplain habitat in the Plan Area outside the Yolo Bypass and mainly in the South Delta and San Joaquin River (Appendix 5.E, *Habitat Restoration*). Much of the floodplain areas in the lower San Joaquin system have been lost because of dikes and levees that separate the river from adjacent floodplains. Spring-run Chinook have been extirpated from the San Joaquin system and so there would be no benefit of this measure to spring-run Chinook in the short-term. However, the San Joaquin River Restoration Program has the goal of restoring spring-run Chinook to the San Joaquin River below Friant Dam. Planning and analysis of restoration under that program assumes that a restored spring-run Chinook population would consist primarily of subyearling foraging emigrants. These fish would receive a benefit from CM5, which would augment the efforts of the restoration program. However, as noted below for San Joaquin River fall-run Chinook salmon, the potential increase in floodplain inundation is somewhat limited by the flow regime in the lower San Joaquin River.

Tidal Habitat

The BDCP will increase the extent of tidal habitat suitable for spring-run Chinook salmon juveniles in the Plan Area, particularly in the Cache Slough and Suisun Marsh subregions.

As described above for winter-run Chinook salmon, tidal areas, including intertidal and subtidal habitats, form important rearing habitat for foraging juvenile salmonids where they feed on zooplankton, epibenthic and insect prey and may rear for several months (Kjelson et al. 1982).Loss of tidal habitat because of land reclamation facilitated by levee construction is a major stressor on juvenile salmonids in the salmonid DRERIP conceptual model (Williams 2009). Consistent with winter-run Chinook salmon above, for this effects analysis, it was assumed with high certainty that intertidal habitat is an attribute with high importance for foraging spring-run Chinook salmon juveniles and low importance with moderate certainty for migrating Chinook salmon juveniles, which was consistent with agency biologist opinions during the August 2013 workshops. It was assumed with low certainty that subtidal habitat has low importance as a current constraint for foraging and migrating salmonid juveniles, to maintain consistency with the inclusion of the habitat in the HSI approach, described further below (agency biologists thought zero importance would be appropriate for both life-history stages). Both intertidal and subtidal habitat was assumed to have zero importance as a current constraint for adult salmonids, with very high certainty, consistent with agency biologist opinion on the level of importance. While migrant juvenile salmonids may feed and utilize tidal habitat to some degree, they spend relatively little time in the Plan Area and are largely intent on moving through the area to the ocean. As noted in the introduction to this section, different Chinook salmon runs were assumed to have different proportions of foraging and migrating juvenile life stages, from which the habitat suitability analysis from Appendix 5.E, *Habitat Restoration,* can be interpreted. For spring-run Chinook juveniles entering the Plan Area, it was assumed that 20% are foraging juveniles and 80% were migrant juveniles. Hence, the expectation is that, in general, spring-run Chinook use tidal marsh and related habitats to a lesser degree than runs with a greater proportion of foraging juveniles such as fall-run and winter-run Chinook salmon.

CM4 Tidal Natural Communities Restoration will increase the amount of tidal natural communities (including transitional uplands to accommodate sea level rise) in the Plan Area by 65,000 acres. Analysis of increases in tidal habitat due to CM4 using the HSI approach (Appendix 5.E, *Habitat*

Restoration, Section 5.E.4.4.2.4, *Suitability of Restored Habitat for Covered Fish Species*) suggests that in the late long-term there may be a near doubling of tidal HUs in the Plan Area for foraging juvenile Chinook salmon (Table 5.5.4-4 in Section 5.5.3, *Chinook Salmon, Sacramento River Winter-Run ESU*). Given the relatively small proportion of foraging juveniles in the spring-run Chinook juvenile population, the benefit of CM4 is expected to be less than it would be for other runs with a higher proportion of foraging migrants. However, it is important to note that while foragers are a small proportion of the juvenile spring-run population entering the Plan Area, sub-yearling emigration during the first spring is typical of the remaining natural spring-run Chinook populations in the Sacramento River (Lindley et al. 2004). Many of these sub-yearling fish would enter the Plan Area as foragers and so this measure may provide greater benefit for these natural populations relative to spring-run Chinook juveniles generally that include a large hatchery contribution. As noted for winter-run Chinook salmon, the relative increase in intertidal habitat area proposed under the BDCP with CM4 is considerably greater than the relative change in subtidal area that would result from restoration under CM4, particularly in the subregions most relevant to spring-run Chinook salmon juveniles (especially Cache Slough, West Delta, and Suisun Marsh).

It is concluded that the change to intertidal habitat for spring-run Chinook salmon juveniles represents a very high positive change for foraging juveniles and a moderate positive change for migrant juveniles recognizing that migrants make up the majority of spring-run Chinook juveniles entering the Plan Area. These conclusions both have moderate certainty. As noted for winter-run Chinook salmon, agency biologist opinion during the August 2013 workshops suggested that intertidal habitat for migrant juvenile Chinook salmon should receive a low or zero change; note that the relative lack of importance of intertidal habitat is captured in its assumed low importance (described above). The change in subtidal habitat is concluded to be moderate for both foragers and migrants, again with moderate certainty. There is some uncertainty related to how much restored habitats may be reduced in value because of colonization by IAV and associated nonnative fish species that may prey on juvenile Chinook salmon or compete for food. *CM13 Invasive Aquatic Vegetation Control* aims to control IAV in the ROAs, which may limit predation, but there is uncertainty related to the ability to do so effectively. Other uncertainties related to tidal habitat restoration in the Plan Area are discussed in Appendix 5.E, *Habitat Restoration*, Attachment 5.E.B, *Review of Restoration in the Delta.*

Channel Margin Habitat

Channel margin enhancement will improve the extent of higher value nearshore habitat in the Plan Area for spring-run Chinook salmon juveniles.

Channel margin habitat in the Plan Area provides important feeding and resting habitat for juvenile salmonids and may provide resting habitat for upstream adult salmon (Williams 2009), although the latter was not considered of any importance during the agency biologist workshops in August 2013 and so was not considered further. Channel margin habitat in the Plan Area has been considerably reduced because of the construction of levees and the armoring of their banks with riprap (Williams 2009) and loss of riparian vegetation. For this effects analysis, it was assumed with moderate certainty that channel margin habitat represents an attribute of high importance for foraging juvenile spring-run Chinook salmon and moderate importance for migrating juvenile spring-run Chinook salmon. The moderate certainty level reflects the lack of focused study on these environments. As noted for winter-run Chinook salmon, during the August 2013 workshops, some agency opinion concurred with these assumptions (albeit with lower certainty), whereas other agency biologist felt moderate importance for foragers and low importance for migrants to be more appropriate. The role of channel margin habitat for salmonids and the effect of the covered activities is discussed more fully in the winter-run Chinook salmon account (Section 5.5.3.1.1, *Restored Floodplain, Tidal, and Channel Margin Habitat*).

CM6 Channel Margin Enhancement and *CM7 Riparian Natural Community Restoration* work together to improve habitat for spring-run Chinook along river corridors. These measures should reduce the distance between areas of higher value nearshore habitat along migration corridors (i.e., improving connectivity, sensu Pringle 2003; Appendix 5.E, *Habitat Restoration,* Section 5.E.6.5.2.2, *Chinook Salmon and Steelhead*) and provide cover and resting areas for juvenile and adult spring-run Chinook. The primary benefit of these measures will be an increase in high-value rearing habitat for foraging spring-run Chinook salmon juveniles, because of enhancement and creation of additional shallow-water habitat (Appendix 5.E, Section 5.E.6, *Conservation Measure 6 Channel Margin Enhancement*). Benefits for larger spring-run Chinook salmon migrant juveniles may be less than for foraging Chinook salmon fry, although the habitat may function as holding areas during downstream migration (Burau et al. 2007; Zajanc et al. 2013).

It is concluded with moderate certainty that there will be a moderate positive change in channel margin habitat for foraging and migrating juvenile spring-run Chinook salmon.

Food Benefits from Restored Habitat

Tidal, floodplain, and channel margin habitat restoration under the BDCP has considerable potential to increase the quantity of food available for juvenile spring-run Chinook salmon.

In addition to the direct habitat benefits discussed above, BDCP restoration of tidal marsh (*CM4 Tidal Natural Communities Restoration*), channel margin (*CM6 Channel Margin Enhancement*), floodplain (*CM5 Seasonally Inundated Floodplain Restoration*), and riparian areas (*CM7 Riparian Natural Community Restoration*) should enhance the production of zooplankton, epibenthic prey and insects that provide food for foraging and, to a lesser extent, migrating salmonids. Juvenile Chinook salmon predominantly consume zooplankton and chironomids (Dipteran insects), with some amphipods derived from channel margin habitat and other littoral sources (Grimaldo et al. 2009). These effects are analyzed in Appendix 5.E, *Habitat Restoration*, and are discussed more fully in Section 5.5.3.1, *Beneficial Effects*, with respect to winter-run Chinook. Benefits of these measures will especially accrue to juveniles exhibiting the foraging behavior, however, those juveniles migrating quickly through the Plan Area would still be feeding, albeit for shorter periods, and would receive some benefit of an enhanced food supply. Because of the relatively small proportion of juvenile spring-run Chinook that are actively foraging in the Plan Area compared to most other runs, these food benefits may be less for spring-run Chinook as a whole compared to other runs. However, juvenile spring-run Chinook should derive some benefit from increased food and, as noted previously, increased habitat and food for foraging juveniles may especially benefit juveniles from natural spring-run Chinook populations. As with winter-run Chinook salmon, it was assumed with moderate certainty that benthic/epibenthic prey abundance and insect abundance have high importance for foraging spring-run Chinook salmon juveniles and low importance for migrating juveniles. During the August 2013 workshops, some agency biologists felt that the lack of information regarding food limitation warranted an assumption of moderate importance for benthic/epibenthic abundance and insect abundance; others agreed with an assumption of high importance. For this effects analysis, it was assumed that zooplankton abundance has moderate importance for foraging spring-run Chinook salmon and low importance for migrating juveniles.

The potential of restored tidal habitat (CM4) to enhance the production of food for salmonids and other species was analyzed in Appendix 5.E. In addition to more qualitative analyses of the potential positive changes to benthic/epibenthic and insect prey (also discussed further in the winter-run Chinook salmon analysis presented above), the quantitative analysis was based on the assumption that shallow tidal habitat was conducive to the production of phytoplankton that in turn enhanced zooplankton production (Lopez et al. 2006). With this assumption, the projected increase in shallow tidal habitat could substantially enhance the pelagic foodweb in the Plan Area. These benefits, however, may be compromised by the enhanced production of clams (*Corbicula*) in shallow tidal habitats that can consume phytoplankton and reduce or eliminate the production of phytoplankton in shallow habitats (Lucas and Thompson 2012).

It is concluded with moderate certainty that there will be a high positive change to benthic/epienthic and insect food resources for foraging juvenile spring-run Chinook salmon and a high positive change for migrant juveniles. The change is concluded to be slightly higher than for winter-run Chinook salmon because of the later timing of spring-run Chinook salmon in the Plan Area, which would coincide with greater productivity associated with spring time and warmer temperatures; this reflects comments received during the August 2013 agency workshops. Low certainty is concluded for the potential low positive change to zooplankton abundance for foragers and moderate positive change for zooplankton for migrants because of the potential for nonnative clams to consume enhanced primary production in restored tidal areas and therefore limit the benefit to the phytoplankton-based food sources.

5.5.4.1.2 Reduced Entrainment

Entrainment loss of juvenile spring-run Chinook salmon under the BDCP will be appreciably lower than under existing conditions because the north Delta diversion operations will reduce reliance on south Delta export facilities.

In the past, large numbers of juvenile Chinook salmon have been entrained by the CVP/SWP south Delta export facilities (Kimmerer 2008). Operations of these facilities has been restricted in recent years due to actions imposed by the NMFS (2009a) BiOp. A major component of the covered activities will be a switch from export pumping solely in the south Delta to dual conveyance, including both north and south Delta diversions. It is anticipated that this will maintain entrainment levels of juvenile salmonids at or well below the levels seen in recent years with the implementation of the NMFS (2009a) BiOp. Appreciable losses of juvenile salmonids have occurred historically at the south Delta export facilities, although relatively few estimates of the proportion of the population entrained have been made. Williams (2012) noted that the ratio of tagged wild Butte Creek spring-run Chinook salmon salvaged at the south Delta export facilities in relation to the number of tags collected in trawling at Chipps Island was relatively low compared to other runs such as winter-run Chinook. Agency opinion during the August 2013 workshops suggested that low or moderate importance of the South Delta pumps entrainment attribute for spring-run Chinook foragers and juveniles would be appropriate, with moderate certainty.

For this effects analysis, it was assumed with moderate certainty that the south Delta entrainment attribute under existing conditions for foraging and migrating juvenile spring-run Chinook salmon is of moderate importance. This assumption is partly based on the rationale provided by some agency biologists during the August 2013 workshops that entrainment may be more important to spring-run Chinook salmon than to, say, fall-run Chinook salmon, because of the relatively low abundance of spring-run Chinook salmon.

The salvage density method provided a relatively straightforward assessment of the effect of changes to potential entrainment at the south Delta facilities because of changes in export pumping under the BDCP (Appendix 5.B, *Entrainment*,). Using this method, entrainment of juvenile spring-run Chinook salmon at the SWP/CVP south Delta export facilities is estimated to decrease substantially overall (approximately 40% decrease in average entrainment across all water years), with the decrease being least in critical water years (11%) and most in wet water years (63%, Table 5.5.4-3) (Appendix 5.B, *Entrainment*). As noted for winter-run Chinook salmon, this reflects the proposed BDCP operations of a greater proportion of CVP/SWP export pumping at the north Delta diversions in wetter years and a relatively greater proportion of export pumping at the south Delta diversions in drier years (Appendix 5.B, Section 5.B.4.1, *Relative Contribution of North and South Delta Intakes under the BDCP*). As described in Appendix 5.B, the salvage density method is based on size-based race-assignment criteria, which for spring-run Chinook salmon probably results in many genetically fall-run Chinook being classified as spring-run; nevertheless, the relative change in entrainment potential because of changes in south Delta export pumping during the relevant times of the year is the most important information from the analysis, rather than estimates of absolute numbers of fish (a general point which applies to most analyses).

Table 5.5.4-3. Difference in Average Annual Entrainment Index[a] of Juvenile Spring-Run Chinook Salmon at the SWP/CVP South Delta Export Facilities under Future Conditions with the BDCP (Compared to Existing Conditions and to Future Conditions without the BDCP), Based on the Salvage Density Method

Water-Year Type	Change[b] under ESO_LLT[c]	
	EBC2 vs. ESO_LLT	**EBC2_LLT vs. ESO_LLT**
Wet	-57,539 (-63%)	-58,340 (-63%)
Above normal	-7,375 (-28%)	-10,644 (-36%)
Below normal	-764 (-12%)	-1,579 (-22%)
Dry	-1,048 (-6%)	-1,960 (-11%)
Critical	-2,712 (-23%)	-1,316 (-13%)
All years	-14,787 (-38%)	-15,755 (-40%)

[a] Number of fish lost to entrainment

[b] For descriptions of scenarios, see Table 5.2-3.

[c] Negative values indicate lower entrainment under the BDCP compared to existing conditions or future conditions without the BDCP. Values are based on normalized salvage density (Appendix 5.B, *Entrainment*, Section 5.B.6.1.3.1, *Salvage-Density Method*).

The DPM was used to estimate the percentage of spring-run Chinook salmon smolts (greater than 70-mm fork length) salvaged at the south Delta export facilities (Appendix 5.B, *Entrainment*, Section 5.B.5.7, *Delta Passage Model Salvage Estimates: Juvenile Chinook Salmon (SWP/CVP South Delta Export Facilities)*). This analysis suggests average salvage (as an index of entrainment) under the BDCP would be 58% lower than under existing conditions (Table 5.5.4-4; Appendix 5.B, Section 5.B.6.1.6.2, *Delta Passage Model Salvage Estimates*), a somewhat greater difference than suggested by the salvage density method.

Table 5.5.4-4. Estimated Percentage Salvage at the SWP/CVP South Delta Export Facilities of Spring-Run Chinook Salmon Smolts[a] Entering the Plan Area under Three Scenarios[b]—Existing Conditions, Future Conditions without the BDCP, and Future Conditions with the BDCP—under the Delta Passage Model

Water Year (Type[a])	By Scenario[b]			Change[c] under ESO_LLT	
	EBC2	EBC2_LLT	ESO_LLT	Compared to EBC2	Compared to EBC2_LLT
1976 (C)	0.016	0.015	0.011	-0.006 (-34%)	-0.004 (-25%)
1977 (C)	0.011	0.010	0.007	-0.003 (-31%)	-0.003 (-26%)
1978 (AN)	0.030	0.031	0.006	-0.024 (-79%)	-0.024 (-79%)
1979 (BN)	0.025	0.023	0.013	-0.013 (-50%)	-0.010 (-45%)
1980 (AN)	0.017	0.017	0.008	-0.009 (-52%)	-0.009 (-53%)
1981 (D)	0.016	0.015	0.010	-0.005 (-34%)	-0.005 (-30%)
1982 (W)	0.061	0.054	0.011	-0.050 (-83%)	-0.043 (-80%)
1983 (W)	0.040	0.039	0.005	-0.035 (-88%)	-0.034 (-87%)
1984 (W)	0.028	0.027	0.007	-0.020 (-73%)	-0.019 (-73%)
1985 (D)	0.016	0.015	0.012	-0.004 (-24%)	-0.003 (-20%)
1986 (W)	0.021	0.039	0.008	-0.012 (-59%)	-0.031 (-78%)
1987 (D)	0.014	0.012	0.011	-0.002 (-16%)	-0.001 (-4%)
1988 (C)	0.012	0.011	0.009	-0.003 (-28%)	-0.003 (-23%)
1989 (D)	0.013	0.012	0.007	-0.005 (-42%)	-0.004 (-38%)
1990 (C)	0.010	0.010	0.007	-0.003 (-31%)	-0.003 (-31%)
1991 (C)	0.012	0.012	0.010	-0.002 (-15%)	-0.002 (-13%)
Average	0.021	0.021	0.009	-0.012 (-58%)	-0.012 (-58%)

[a] Water-year types: W = wet; AN = above normal; BN = below normal; D = dry; C = critical
[b] Percentages only apply to spring-run Chinook salmon that originate from natal tributaries upstream of Fremont Weir.
[c] For descriptions of scenarios, see Table 5.2-3.

The above assessment was based on the ESO scenarios, but is also applicable to the LOS because of the similarity in spring flows between ESO and LOS (Appendix 5.B, *Entrainment*, Section 5.B.4.5, *Differences Between Evaluated Starting Operations, High-Outflow Scenario, and Low-Outflow Scenario*). South Delta entrainment of spring-run Chinook salmon juveniles under the HOS may be somewhat lower than the ESO because of lower south Delta exports to provide greater spring (March–May) Delta outflow for longfin smelt, although the available results from the DPM suggest only a small difference (annual average of 0.008% instead of 0.009%). In light of the 40 to 60% lower entrainment under the BDCP compared to future conditions without the BDCP that was estimated by the salvage density method and DPM for spring-run Chinook salmon juveniles, it is concluded that the BDCP will result in a high positive change (reduction) to the south Delta entrainment attribute for rearing and migrating spring-run Chinook salmon juveniles. This conclusion is made with moderate certainty that reflects the limited ability to model real-time water operations management decisions under existing conditions and the BDCP, which could result in differences from the results observed here. Nonetheless, it is anticipated that the BDCP will result in a reduction in entrainment for spring-run Chinook salmon juveniles. Limited agency opinion during the August 2013 workshops suggested a low positive change to be appropriate.

As discussed above for winter-run Chinook salmon, there does not appear to be much evidence that agricultural diversions have an appreciable adverse effect on covered salmonid juveniles in the Plan Area. For this effects analysis, it was assumed with low certainty that entrainment at agricultural diversions is an attribute with low importance for foraging and migrating juvenile spring-run Chinook salmon. It is concluded that there would be a low positive change (i.e., reduced entrainment) in agricultural diversions under BDCP due to *CM4 Tidal Natural Communities Restoration* and the conversion of irrigated agricultural land to tidal wetlands, as well as screening of intakes under *CM21 Nonproject Diversions*. This conclusion has a low certainty due to the lack of focused studies on this issue (consistent with the previous DRERIP analysis of CM21; see Appendix 5.B, Section 5.B.6.4.3.1, *Delta Regional Ecosystem Restoration Implementation Plan Analysis of Nonproject Diversions*) although as noted for winter-run Chinook salmon, agency biologist opinion during the August 2013 workshops suggested high certainty may be warranted.

5.5.4.1.3 Reduced Entry into Interior Delta

Nonphysical barriers, north Delta intake bypass flows, and changed Delta hydrodynamics under the BDCP have the potential to reduce entry into the interior Delta for juvenile spring-run Chinook salmon

Juvenile spring-run Chinook salmon may enter the interior Delta from the mainstem Sacramento River through Georgiana Slough and, when open, the Delta Cross Channel (although the latter generally is closed as a result of the NMFS [2009a] BiOp during the spring-run migration period). Survival through the interior Delta has been shown to be consistently appreciably lower than the river mainstem (Perry et al. 2010; Perry et al. 2013). The need to reduce entry into the interior Delta by juvenile salmonids was recognized in the NMFS (2009a) BiOp, which requires that engineering solutions be investigated to lessen the issue. These solutions may include physical or nonphysical barriers. For this effects analysis, it was assumed with high certainty that the attribute of interior Delta entry has high importance for both migrating and foraging juvenile spring-run Chinook salmon. The moderate certainty level reflects the application to salmonids in general and the lack of specific studies of the effects of these passage routes on spring-run Chinook.

CM16 Nonphysical Fish Barriers aims to inhibit juvenile salmonids from entering the interior Delta, potentially increasing through-Delta survival. The benefits of this conservation measure are discussed more thoroughly in Section 5.5.3.1.3, *Reduced Entry into Interior Delta*, with respect to winter-run Chinook. The effectiveness of nonphysical barriers will depend on the water velocity characteristics in the vicinity of the barrier and on the extent to which predatory fish may congregate along the barrier and prey on juvenile salmonids. The former factor is of importance when considering the potential effectiveness of CM16 for foraging spring-run Chinook salmon juveniles, which are smaller than migrants. *CM1 Water Facilities and Operation* includes bypass flow criteria for the Sacramento River below the north Delta intakes in order to limit the potential for increased frequency of reversed flow in the Sacramento River below Georgiana Slough, which would increase the probability of entry of juvenile salmonids into the interior Delta. As demonstrated in Appendix 5.C, *Flow, Passage, Salinity, and Turbidity,* Section 5.C.5.3.8, *Sacramento River Reverse Flows Entering Georgiana Slough*, and discussed above in the analysis of winter-run Chinook salmon, several lines of evidence point to the effectiveness of the bypass flow criteria in avoiding this effect.

It is concluded that there will be a low positive change to the interior Delta entry attribute for migrating juvenile spring-run Chinook salmon because of 1) the potential for effective deterrence with nonphysical barriers under CM16, 2) the apparent effectiveness of north Delta intake bypass flows to limit Sacramento River reverse flows in the vicinity of Georgiana Slough and 3) the changed hydrodynamics because of downstream restoration. This conclusion has a moderate certainty, because there is some evidence for effectiveness based on larger smolts at higher flows (Perry et al. 2012). The same positive change is concluded for foraging spring-run Chinook salmon but with low certainty because the effectiveness for small fish has not been assessed. As noted for winter-run Chinook salmon, at the August 2013 workshops, agency biologist opinion was divided on conclusions regarding the potential change for interior Delta entry for Sacramento River region juvenile salmonids, ranging from a low or medium positive change (with low certainty) to zero or a low negative change (again with low certainty), primarily reflecting the uncertainty concerning the influence of tidal habitat restoration in muting tidal influence and its potential to offset lower Sacramento River flows below the proposed north Delta intakes.

5.5.4.1.4 Reduced Predation

The BDCP could reduce losses of juvenile spring-run Chinook salmon at existing localized areas where predation is intense.

NMFS (2009b) ranked predation as a stressor of high importance to the decline of Central Valley Chinook salmon and steelhead. Vogel (2011) reported results from radio-tagging studies that indicated high levels of predation on salmonids at numerous “hotspots” such as sharp channel bends, deep scour holes, narrow levee breaches, diversion pump structures, and other artificial structures such as bridges, docks, pipelines, and more natural structural elements including downed trees. For this effects analysis, it was assumed with moderate certainty that predation of foraging and migrating juvenile spring-run Chinook salmon is of high importance. As noted for winter-run Chinook salmon, this attribute generated a wide range of agency biologist opinion during the August 2013 workshops, with some believing that it is of low importance with low certainty, and others suggesting that it is of high importance with medium or high certainty.

As discussed for winter-run Chinook salmon (Section 5.5.3.1.4, *Reduced Predation*), several conservation measures have the potential to beneficially influence predation of juvenile salmonids. *CM15 Localized Reduction of Predatory Fishes* is intended to directly or indirectly (via habitat manipulation) reduce the number of predators at areas of high predation (see also, Appendix 5.F, *Biological Stressors on Covered Fish*, Section 5.F.6, *Fish Predation*). It is concluded that there will be a low positive change to predation for foraging and migrating spring-run Chinook salmon juveniles under the BDCP, but with low certainty for the numerous reasons discussed for winter-run Chinook salmon (Section 5.5.3.1.4, *Reduced Predation*). As noted for winter-run, this conclusion was consistent with some agency biologist opinion during the August 2013 workshops, whereas there was also the opinion expressed during the workshops that suggested zero or a low negative change would be appropriate, because of factors such as enhanced predation in the vicinity of the proposed north Delta intakes that may be greater than any potential positive effects from CM15.

5.5.4.1.5 Reduced Illegal Harvest

The BDCP will help reduce illegal harvest of adult spring-run Chinook salmon.

While poaching of salmon has been identified as a possible concern for recovery of salmonid populations, the extent of its impact on spring-run Chinook is not known. It is likely to be locally important as poachers target specific sites where fish are vulnerable, and for spring-run Chinook salmon may be important because population size is relatively low. For this effects analysis, illegal harvest is assumed with moderate certainty to be an attribute of moderate importance for spring-run Chinook salmon adults. Illegal harvest of foraging and migrant juvenile spring-run Chinook salmon was assumed with low certainty to be an attribute of low importance. As noted for winter-run Chinook salmon, the attribute importance conclusions above generally reflected agency biologist opinion from the August 2013 workshops. *CM17 Illegal Harvest Reduction* aims to decrease poaching of covered salmonids and other covered fishes. These effects are discussed more thoroughly in the winter-run Chinook salmon account (Section 5.5.3.1.5, *Reduced Illegal Harvest*), which outlines the main points made by Roberts and Laughlin (2013) in explaining the expected effectiveness of CM17. Spring-run Chinook salmon may especially benefit from CM17 because they hold in deep pools over the summer and can be targeted by poachers. It is concluded that there will be a high positive change (i.e., decrease) in the illegal harvest attribute for spring-run Chinook salmon juvenile foragers, juvenile migrants, and adults due to CM17 with high certainty for the reasons discussed in the winter-run Chinook salmon analysis.

5.5.4.1.6 Upstream Habitat Effects

The BDCP would not affect spring-run Chinook in the Sacramento River or Clear Creek habitat. In the Feather River, rearing conditions in the low-flow channel would generally be similar under the BDCP. High-flow channel rearing conditions may improve, but there could be marginally increased temperatures in the fall of critical water-year types under the HOS.

Upstream flows and water temperatures define the quantity and quality of adult spawning, egg incubation, fry and juvenile rearing, juvenile and adult migration, and adult holding habitat for spring-run Chinook salmon in upstream rivers. Flows (along with valley form and artificial restrictions) determine channel width and the quantity of stream habitat available to salmonid life stages. Reduced quantity of spawning habitat could increase competition for remaining habitat, result in redd superimposition, and reduce spawning success. This attribute was assumed with moderate certainty to be of high importance. Quality of the available habitat is set by temperature and other attributes affecting life stage survival. Reduced quality of juvenile rearing habitat could cause reduced juvenile growth and survival or delay or reduce successful smoltification and downstream migration. Collectively, the quantity and quality of habitat in upstream areas is accounted for as upstream habitat. Reduced quantity and quality of juvenile migration habitat could delay or reduce successful entry into the Delta and ocean, which could reduce survival in these locations. This attribute was assumed with moderate certainty to be of moderate importance. Reduced quantity and quality of adult migration and holding habitat could delay or reduce successful adult migration and spawning or staging. This attribute was assumed with moderate certainty to be of moderate importance. Upstream habitat conditions in the Sacramento system have been identified as a major limiting factor for recovery of the Sacramento spring-run Chinook ESU (National Marine Fisheries Service 2009b). This attribute was assumed with moderate certainty to be of high importance to spring-run Chinook life stages.

BDCP does not propose any changes in Shasta operating criteria, and BDCP does not affect upstream temperatures or flows in ways that would require a change in Shasta operations. Several models show no change in upstream conditions as a result of BDCP. Modeling results indicate that in the Sacramento River, there would be no flow- or water temperature–related effects of BDCP on spring-run Chinook salmon fry and juvenile rearing, juvenile migration, and adult holding habitat (Appendix 5.C, *Flow, Passage, Salinity, and Turbidity*, Attachment 5C.C, *Water Temperature*). There would be small increases in flows in the Sacramento River upstream of the Delta during the adult migration period. All NMFS flow and water temperature threshold criteria for the Sacramento River would generally be met under BDCP at similar or greater frequencies to those under conditions without the BDCP. Spawning and egg incubation conditions, including spawning area, redd scour and redd dewatering risk, under BDCP are predicted by SacEFT to be similar to those under existing biological conditions, except for a 12% reduction in egg incubation condition, which is a measure of water temperature-related egg survival. However, the Reclamation Egg Mortality Model predicts that egg survival would be unaffected by BDCP, except in below-normal water years (12% reduction in survival). The discrepancy between models appears to be a result of the methods used by each model in in egg incubation period and location of spawning. The SALMOD model, which integrates upstream flow- and water temperature-related effects on all early life stages (eggs, fry, and smolt) of spring-run Chinook salmon, predicts that there would be negligible differences between BDCP and existing conditions in juvenile production in the Sacramento River. After extensive investigation of these results, they appear to be a function of high model sensitivity to relatively small changes in estimated upstream conditions. Therefore, BDCP does not change the ability of Shasta Reservoir to meet its operating criteria for cold water pool and downstream temperature, including end of September and end of May storage. These criteria are required by the NMFS (2009a) BiOp to ensure that there are no unacceptable flow- or temperature-related effects on Sacramento River covered fish species, including spring-run Chinook. Appendix 5.C, *Flow, Passage, Salinity, and Turbidity* includes analysis of spring-run Chinook salmon habitat for upstream holding, spawning, egg incubation, and rearing, or for downstream migration flows in the upper Sacramento River, based on a variety of analyses conducted. Besides SacEFT, these models predict that there would be no change on upstream habitat. Additionally, an important biological objective for spring-run Chinook salmon is to avoid degradation of upstream habitat, which the modeling results suggest has been achieved through maintenance of the operational criteria from the NMFS (2009a) BiOp for Shasta Reservoir and upper Sacramento River flows. As such, taken together and considering that Shasta operating criteria and storage does not change under BDCP, it is concluded that there would be no effect of BDCP on Sacramento River spawning and egg incubation conditions for spring-run Chinook salmon.

Feather River flows would change under all of the BDCP outflow scenarios, with higher flows in the spring and lower flows in the summer, compared to conditions without BDCP. In the Feather River, the primary spring-run Chinook salmon spawning habitat is in the low-flow channel upstream of Thermalito Afterbay, although about one quarter of all Chinook salmon spawn downstream in the high-flow channel (Bureau of Reclamation 2008). There would generally be no flow-related effects of BDCP in the low-flow channel during the September through October spawning and egg incubation period. Although there would be no differences in water temperatures between ESO and LOS scenarios and the EBC2 scenarios during the spawning and egg incubation period in the low-flow channel, there would be small (5% to 6%) reductions under HOS relative to EBC2 in mean monthly water temperatures in critical water years during September and October. These results suggest that water temperatures during the driest years under HOS would be slightly warmer than water temperatures under EBC2 in September and October, which is a result of increased spring outflow under the HOS scenario. Increased temperatures can lead to reduced egg survival. Results of NMFS threshold analyses indicate that there are both small beneficial and adverse effects of ESO, HOS, and LOS on water temperatures in the Feather River low-flow channel. Adverse effects would generally be limited to ESO_ELT during September and HOS_ELT during October, whereas there would be beneficial effects under the remaining BDCP scenarios. Real-time operations could be used to minimize these effects, regardless of which Delta outflow criteria are implemented.

Spring-run Chinook salmon fry and juveniles are present in the Feather River both above (low-flow channel) and below Thermalito Afterbay (high-flow channel) from November through June. During this period, flows in the high-flow channel would be much greater under BDCP than under EBC2, particularly during April through June, in which flows would be up to 106% greater under ESO and up to 548% greater under HOS, depending on month and water-year type. Constant flows in the low-flow channel would remain similar among model scenarios throughout the period. There would be no flow-related effects of BDCP on spawning and egg incubation, juvenile migration, and adult holding in either the high-flow or low-flow channel. There would be small positive increases in flows in the Feather River during the adult migration period. The BDCP would not affect mean monthly water temperatures during the fry and juvenile rearing period in either the high-flow or low-flow channel. Results of NMFS threshold analyses indicate that there are both small beneficial and adverse effects of ESO, LOS, and HOS scenarios on temperature conditions during the spring-run Chinook salmon rearing period on the Feather River, although the large majority of results indicate either a benefit or no effect on temperature conditions. Real-time operations could be used to minimize these effects, regardless of which Delta outflow criteria is implemented.

5.5.4.2 Adverse Effects

5.5.4.2.1 Near-Field and Far-Field Effects of the North Delta Diversions on Juvenile Spring-Run Chinook Salmon

Operation of the proposed north Delta diversions under the BDCP has the potential to adversely affect juvenile spring-run Chinook salmon through near-field (physical contact with the screens and aggregation of predators) and far-field (reduced downstream flows leading to greater probability of predation) effects.

As noted elsewhere in this effects analysis, under *CM1 Water Facilities and Operation* there are three 3,000-cfs intakes proposed for construction and operation in the Sacramento River in the vicinity of Hood. Juvenile spring-run Chinook salmon entering the Plan Area would pass these three intakes if they remained in the Sacramento River as opposed to entering the Yolo Bypass. Although the percentage of the population entering the Yolo Bypass would be greater under the BDCP than existing conditions (see Table 5.5.4-1 for estimates of spring-run Chinook juvenile entry into Yolo Bypass), the emigrating population that does not use the Yolo Bypass would pass the proposed intakes. Although the north Delta intakes do not currently exist, they could be of some importance as a source of potential screen contact or impingement. This potential is assumed to be of low importance with moderate certainty for foraging and migrating juvenile spring-run Chinook salmon; as noted above for winter-run, some agency biologist opinion suggested zero importance for migrant juveniles would be appropriate, whereas subsequent agency comment received following the workshops concurred with a low importance in order to capture the potential for a small negative effect. The majority of spring-run Chinook would pass through the river reach containing the intakes where they may be subject to near-field (screen contact/impingement and predation) and far-field (reduced flow-related survival) effects that could reduce their survival. These potential effects are discussed more thoroughly for winter-run Chinook salmon above (Section 5.5.3.2.1).

CM1 calls for the North Delta intake structure to be constructed to meet and exceed current NMFS criteria for approach and sweep velocities, as discussed in more detail for winter-run Chinook salmon. However, effects may remain. Therefore, it is concluded with moderate certainty that there will be a low negative change in survival of spring-run Chinook because of the north Delta intakes to foraging and migrating juvenile salmonids. Agency biologist opinion during the August 2013 workshops was in accordance with this conclusion, with some suggestion that high certainty may be warranted. This conclusion does not include consideration of potential predation near the intakes, discussed further below. Monitoring of impingement and targeted studies of juvenile salmonid behavior in relation to the intake screens will further inform the effect of this attribute following implementation. It is not anticipated that there will be any adverse effects of the north Delta diversions on adult salmonids with respect to screen contact or impingement.

Plan Area flows have considerable importance for downstream migrating juvenile salmonids and will be affected by the proposed north Delta diversions. Evidence for flow-related impacts on survival are discussed for winter-run Chinook salmon above (Section 5.5.3.2.1). Because of the north Delta diversions, salmonids migrating down the Sacramento River generally will experience lower migration flows compared to existing conditions. It is important to emphasize that *CM1 Water Facilities and Operation* includes bypass flow criteria that will be managed in real time to minimize adverse effects of diversions at the north Delta intakes on downstream-migrating salmonids. As with winter-run Chinook salmon, it was assumed with high certainty that Plan Area flows have critical importance for migrating juvenile spring-run Chinook salmon. Agency biologist opinion during the August 2013 workshops generally thought high or moderate importance may be warranted. High importance was assumed for foraging juvenile spring-run Chinook salmon, with moderate certainty, for reasons discussed in the analysis of winter-run Chinook salmon.

The combined result of several important conservation measures on survival in the lower Sacramento River was examined with the DPM. These results, which do not directly account for habitat restoration (but do incorporate hydrodynamic changes in river flows caused by changes in tidal influence), suggest that overall through-Delta survival of spring-run Chinook salmon smolts would be similar or slightly lower under the BDCP than under existing conditions (Table 5.5.4-5) (Appendix 5.C, *Flow, Passage, Salinity, and Turbidity,* Section 5.C.5.3.4.1, *Overall Survival through the Delta*). The observed patterns represented tradeoffs between positive and negative changes from the BDCP relative to the existing conditions: under the BDCP, there would be the positive effect of greater Yolo Bypass entry (with relatively high survival) and reduced interior Delta mortality because of lower entrainment loss from the south Delta export facilities, versus less survival through the Sacramento River and Steamboat/Sutter Slough pathways because of lower flows on the Sacramento River (See Table 5.C.5.3-40, *Percentage Use and Survival of Spring-Run Chinook Salmon Smolts Migrating Down Different Through-Delta Pathways under EBC and ESO Scenarios, based on Delta Passage Model*, in Appendix 5.C, for pathway-specific survival estimates). Because the spring-run Chinook salmon smolt migration period assumed in the DPM has some overlap with spring (March–May), estimated average survival through the Plan Area under HOS_LLT (30.7%) would be similar or slightly greater than average survival under EBC2_LLT (30.3%) (Appendix 5.C, *Flow, Passage, Salinity, and Turbidity,* Section 5.C.5.3.4.7.2), and greater than survival under ESO_LLT (29.1%; Table 5.5.4-5). The results of the analysis using the method based on Newman (2003) also suggest that the combination of less Sacramento River flow below the north Delta intakes versus less south Delta export pumping would result in similar or slightly lower estimated proportional survival through the Delta under ESO_LLT (average = 0.64) compared to EBC2_LLT (average = 0.65), whereas HOS_LLT had similar or slightly higher average survival (0.67) (Appendix 5.C, *Flow, Passage, Salinity, and Turbidity,* Section 5.C.5.3.5). Estimated survival in the Sacramento River mainstem from the divergence with the Delta Cross Channel and Georgiana Slough to Chipps Island under ESO_LLT averaged around 92% of survival estimated under EBC2_LLT scenario, based on applying the flow-survival relationship of Perry (2010), whereas HOS_LLT survival averaged around

97% of the EBC2_LLT survival value (Appendix 5.C, Section 5.C.5.3.6.1.2, *Spring-Run Chinook Salmon*). It is concluded that overall, there is a low negative change to Plan Area flows for foraging and migrating spring-run Chinook salmon, with high certainty for migrating juveniles and moderate certainty for foraging juveniles, reflecting the relative difference in knowledge about what the change may mean to these different juvenile behavior types.

Table 5.5.4-5. Percentage Through-Delta Survival Estimates for Spring-Run Chinook Salmon Smolts[a], Based on the Delta Passage Model

Water Year (Type[b])	By Scenario[b]			Change[c] under ESO_LLT	
	EBC2	EBC2_LLT	ESO_LLT	EBC2 vs. ESO_LLT	EBC2_LLT vs. ESO_LLT
1976 (C)	19.3	21.6	21.6	2.3 (12%)	0.1 (0%)
1977 (C)	17.8	17.4	18.0	0.2 (1%)	0.6 (3%)
1978 (AN)	49.1	45.9	37.4	-11.7 (-24%)	-8.5 (-19%)
1979 (BN)	25.6	24.4	22.3	-3.2 (-13%)	-2.1 (-9%)
1980 (AN)	32.5	31.6	28.4	-4.2 (-13%)	-3.2 (-10%)
1981 (D)	27.5	25.4	24.5	-3.0 (-11%)	-0.9 (-4%)
1982 (W)	50.6	49.4	49.8	-0.8 (-2%)	0.4 (1%)
1983 (W)	53.7	53.4	53.4	-0.3 (-1%)	0.0 (0%)
1984 (W)	31.7	30.1	28.1	-3.7 (-12%)	-2.0 (-7%)
1985 (D)	25.1	23.7	24.0	-1.0 (-4%)	0.3 (1%)
1986 (W)	34.6	32.2	30.7	-3.9 (-11%)	-1.5 (-5%)
1987 (D)	25.7	25.8	25.7	0.0 (0%)	-0.1 (0%)
1988 (C)	18.6	18.2	18.6	0.0 (0%)	0.5 (3%)
1989 (D)	37.3	37.6	36.5	-0.9 (-2%)	-1.2 (-3%)
1990 (C)	22.3	21.8	21.9	-0.4 (-2%)	0.1 (1%)
1991 (C)	26.6	27.0	24.3	-2.3 (-9%)	-2.7 (-10%)
Average	31.1	30.3	29.1	-2.0 (-7%)	-1.3 (-4%)
Median	27.0	26.4	25.1	-0.9 (-4%)	-0.5 (-2%)

[a] Percentages only apply to spring-run Chinook salmon that originate from natal tributaries upstream of Fremont Weir.
[b] W = wet; C = critical; AN = above normal; BN = below normal; D = dry
[c] For descriptions of scenarios, see Table 5.2-3.
[d] Negative differences indicate lower values under the BDCP.

5.5.4.2.2 Reduced Attraction Flows in the Sacramento River

Sacramento River attraction flows for migrating adult spring-run Chinook salmon will be lower from operations of the north Delta diversions under the BDCP.

Adult salmonids migrating through the delta use flow and olfactory cues for navigation to their natal streams (Marston et al. 2012). As noted by Marston et al. (2012), the straying rate for Sacramento River region hatchery-origin adult Chinook salmon is low and so, as assumed for winter-run Chinook salmon, the importance of Plan Area flows to currently affect these cues is assumed to be low with high certainty that reflects the study by Marston et al. (2012). As noted in the analysis for winter-run Chinook salmon, agency biologists during the August 2013 workshops thought low or moderate importance with low certainty may be warranted.

Changes to flow below the north Delta intakes could affect the homing ability of salmonids, including spring-run Chinook (as discussed in Section 5.5.3.2.2 with respect to winter-run Chinook salmon). Sacramento River flows downstream of the proposed north Delta intakes generally will be lower under BDCP operations relative to existing conditions, with differences between water-year types because of differences in the relative proportion of water being exported from the north Delta and south Delta facilities. As assessed by DSM2 fingerprinting analysis, the average percentage of Sacramento River–origin water at Collinsville, where the Sacramento and San Joaquin Rivers converge in the West Delta subregion, was always slightly lower under the BDCP than for existing conditions (Table 5.C.5.3-194, *Monthly Average (With Range in Parentheses) Percentage of Water at Collinsville Originating in the Sacramento River during April-May under EBC and ESO Scenarios*, Appendix 5.C, *Flow, Passage, Salinity, and Turbidity,*). For spring-run Chinook salmon adults, the difference in Sacramento River flow at Rio Vista in April–May was more than 20% less in wet and above-normal years and similar in other water-year types under the ESO; as described for winter-run Chinook salmon, flows in March–May were similar or greater under HOS_LLT compared to EBC2_LLT (Table 5.C.5.3-235, *Mean Monthly Flows (cfs) in Sacramento River at Rio Vista for EBC2, HOS, and LOS Scenarios*, and Table 5.C.5.3-236, *Differences between EBC2 Scenarios and HOS and LOS Scenarios in Mean Monthly Flows (cfs) in Sacramento River at Rio Vista*, in Appendix 5.C). The importance of these changes to the homing ability of spring-run Chinook is unknown. In considering the results of the DSM2 fingerprinting results and the CALSIM flow analyses, it is concluded with low certainty that there will be a low negative change to adult migration Plan Area flows under the BDCP for upstream migrating adult spring-run Chinook salmon. The low certainty in these conclusions would be informed by monitoring and targeted research under the BDCP (e.g., examining migration success of tagged adult Chinook salmon under different flow regimes), with any adverse effects being addressed by adaptive management.

5.5.4.2.3 Exposure to In-Water Construction and Maintenance Activities

In-water construction and maintenance effects of the BDCP could affect spring-run Chinook salmon.

As described for other species, the main in-water construction activities at the proposed north Delta intakes (*CM1 Water Facilities and Operation*) will be limited to one construction season during the months of June–October (Appendix 5.H, *Aquatic Construction and Maintenance Effects*). Possible construction effects include noise associated with pile driving, temporarily reduced water quality and accidental spills. These impacts are discussed more fully in Appendix 5.H. Implementation of *CM22 Avoidance and Minimization Measures* will reduce the likelihood of adverse effects from in-water activities related to construction and maintenance on juvenile and adult salmonids. Therefore, it is concluded with high certainty that construction and maintenance associated with the BDCP represent a minor adverse effect on spring-run Chinook salmon adults and juveniles.

5.5.4.2.4 Exposure to Contaminants

The BDCP will contribute to a reduction in spring-run Chinook salmon exposure to contaminants in the late long-term, although localized increases in contaminant exposure may occur as a result of tidal habitat and floodplain restoration.

The BDCP could adversely affect spring-run Chinook salmon life stages occurring in the Plan Area through changes in contaminants as a result of changes in water operations (*CM1 Water Facilities and Operation, CM2 Yolo Bypass Fisheries Enhancement*) and habitat restoration (principally, *CM4 Tidal Natural Communities Restoration*). Analyses presented in Appendix 5.D, *Contaminants*, suggests that there is low potential for increased contaminant exposure from the BDCP, and there may be a beneficial effect in the late long-term because of reduced contaminants from restoration of areas previously used for agriculture. It is concluded with low certainty that this represents a low negative change to this attribute for juvenile (foragers and migrant) spring-run Chinook salmon in the Plan Area. As noted for winter-run Chinook salmon, the importance of contaminants to these life stages of spring-run Chinook salmon was assumed to be low, with low certainty, which generally captured the limited agency biologist opinion during the August 2013 workshops.

5.5.4.3 Impact of Take on Species

The BDCP may result in incidental take of spring-run Chinook from several mechanisms. Construction and maintenance at the proposed north Delta intakes, restoration sites, conservation hatcheries, and nonphysical barriers may result in adverse effects on salmonids, including disturbance from in-water activity and hydrodynamic changes, physical injury from riprap/rock placement and noise and vibration, exposure to fuel or oil, and elevated turbidity levels (Appendix 5.H, *Aquatic Construction and Maintenance Effects*). These effects, however, will be temporary and are unlikely to be considerable on salmonids because a number of measures will be taken, including timing of in-water work to minimize potential adverse effects on juvenile salmonids. *CM6 Channel Margin Enhancement* restores 20 miles of channel margin habitat and should more than offset the loss of about 2.6 miles of channel margin habitat due to the construction of the North Delta intakes. As a result, there will be minimal impact of take from these activities.

In relation to existing conditions, the BDCP will reduce overall entrainment of spring-run Chinook salmon as a result of dual conveyance. Use of the south Delta pumps will be reduced in favor of the north Delta intakes, which will be designed to limit impingement and mortality of juvenile salmonids. The north Delta intakes will be used to export more water in wetter years, as dictated by Sacramento River at Hood bypass flow criteria.

Lower river flow downstream of the north Delta intakes under the BDCP may reduce survival of juvenile spring-run Chinook salmon during downstream migration along the Sacramento River and also could negatively affect upstream migration of adult spring-run Chinook salmon by changing attraction flows/olfactory cues. These effects are not readily quantifiable in terms of take, however, and will need to be evaluated through research and adaptive management.

5.5.4.4 Abundance, Productivity, Life-History Diversity, and Spatial Diversity

The analysis presented for winter-run Chinook salmon, Section 5.5.3.4, includes spring-run Chinook salmon.

5.5.4.5 Net Effects

Figure 5.5.4-1 shows the relative population-level outcomes, by attribute, for spring-run Chinook life stages, that are concluded to result from implementation of the BDCP. The graph illustrates the effect of the BDCP, by considering the change to an attribute for each life stage in light of the importance of the attribute to that life stage. The positive effects of the BDCP are concluded to outweigh the negative effects, so that the net effect of the BDCP is expected to benefit spring-run Chinook salmon. As noted for winter-run Chinook salmon, most of the concluded effects are made with moderate certainty, whereas the benefit of enhanced floodplain availability for foraging juveniles is assessed to be of high certainty. As noted above, the assumption of a relatively smaller proportion of foraging juveniles in the Plan Area compared to migrating juveniles for spring-run Chinook salmon, in relation to other runs (fall-run and winter-run Chinook, in particular) means that the benefit of greater Yolo Bypass floodplain availability, while still very important, is somewhat less than for these other runs. Many effect conclusions are made with low certainty that reflect low certainty about the current importance of the attribute, low certainty about the magnitude of the change that BDCP may provide, or low certainty regarding both the importance and change to the attribute. As described for winter-run Chinook salmon, the negative change in Plan Area flows for migrating juvenile spring-run Chinook salmon is also made with high certainty; it is again emphasized here that real-time operations would aim to minimize any potential adverse effects of the north Delta intakes on Plan Area flows in relation to migrating juvenile salmonids.

The BDCP plans to increase considerably the amount of shallow-water tidal habitat that benefits foraging spring-run Chinook salmon. Restoration of tidal habitat under *CM4 Tidal Natural Communities Restoration* is expected to appreciably increase the amount of tidal habitat in the Plan Area, in particular intertidal habitat. Restoration should provide a large quantity of habitat with conditions suitable for foraging salmon in Suisun Marsh, Cache Slough, and West Delta ROAs. Restored habitat in the South Delta and Cosumnes/Mokelumne ROAs is of little relevance to Sacramento River region spring-run Chinook salmon because their geographic distribution and origin means occupation of these ROAs would be less frequent than the other ROAs. Conditions in the South Delta ROA may be more relevant to San Joaquin River spring-run Chinook that may develop in the future as a result of the San Joaquin River Restoration Program. Juvenile salmonids forage in shallow-water habitat where they eat a variety of planktonic and benthic prey (McLain and Castillo 2009). This type of habitat is planned to be restored under the BDCP, and is expected to provide an appreciable direct habitat benefit for foraging salmonids, including spring-run Chinook salmon.

The BDCP also includes restoration of channel marsh and floodplain habitats that may provide direct habitat benefits for foraging and migrating spring-run Chinook salmon. In particular, *CM2 Yolo Bypass Fisheries Enhancement* is expected to enhance conditions in the Yolo Bypass, which has been shown to be a highly beneficial habitat for juvenile salmonids (Sommer et al. 2001a). As shown in the analyses presented above, implementation of CM2 would considerably increase the inundated annual acreage of floodplain habitat in the Yolo Bypass and provide greater access for migrating spring-run Chinook salmon juveniles to this relatively high-survival, alternative migratory pathway (as also shown in the empirical analysis by Roberts et al. [2013]). The BDCP is also expected to provide improved adult and juvenile salmonid passage at Fremont Weir, increase the inundation period of the bypass, and enhance habitat conditions across the bypass itself.

In addition to the direct habitat benefits, restoration of tidal areas should augment the Plan Area foodweb, by providing greater substrate area for benthic/epibenthic prey as well as insects (via marsh creation), and potentially enhancing pelagic food supply. This will benefit both foraging and migrating juvenile spring-run Chinook salmon. Production of phytoplankton is greatest in shallow-water areas, and restored shallow-water habitats have been shown to enhance phytoplankton production in many cases (Jassby and Cloern 2000), although as noted elsewhere in this effects analysis, some uncertainty exists because of potential consumption of primary productivity by invasive clams (Lucas and Thompson 2012). Restoration of tidal habitats and the increase in inundation of the Yolo Bypass, with probable export of food from the floodplain, also should enhance feeding conditions for juvenile salmonids in the Delta, including spring-run Chinook salmon.

The BDCP is expected to decrease entrainment of spring-run Chinook salmon at the south Delta export facilities. The new north Delta intakes are designed with screens and velocity criteria that, in combination with pulse flow protection, should limit adverse effects to spring-run Chinook salmon juveniles, although the potential for negative interactions remains and will be informed by targeted research and adaptive management. The north Delta intakes bypass flows under the BDCP, coupled with altered hydrodynamics from downstream restoration, are expected to limit incidences of reverse flows at the Georgiana Slough entrance to the interior Delta which, in combination with nonphysical barriers, has the potential to reduce interior Delta entry and therefore lessen the use of this relatively low-survival Plan Area migration pathway by spring-run Chinook salmon. *CM15 Localized Reduction of Predatory Fish* has the potential to improve juvenile spring-run Chinook salmon at localized predation hotspots and/or mitigate the effects of potentially increased predation in locations such as the new north Delta intakes, with much targeted research and adaptive management required to inform the relatively low certainty in the effectiveness of this measure.

As noted for winter-run Chinook salmon, a potential adverse effect of the BDCP on adult spring-run Chinook salmon will be the reduction in flow downstream of the north Delta diversions on the Sacramento River. Use of dual conveyance means that some water will be exported directly from the Sacramento River, reducing river flow below the north Delta intakes. This will also affect those emigrating juvenile spring-run Chinook that are not diverted into the Yolo Bypass. It is concluded that the intakes will somewhat reduce survival of spring-run Chinook salmon juveniles migrating past the intakes, with the effects more likely to occur in the less tidally influenced reaches where river flow dominates migration flows. Because the intakes do not exist, this conclusion carries a low certainty. The reduced Sacramento River flow during the spring-run adult migration period along with the possible change in olfactory signals due to the change in flow mixture could affect upstream migration. The certainty of this adverse effect is very low, however, but should be monitored and evaluated during implementation. Contaminants and other negative effects from restoration and construction activities may occur but are anticipated to be low.

Covered salmonid species, including spring-run Chinook salmon, may benefit from reduced operations of the Suisun Marsh salinity control gates (*CM1 Water Facilities and Operation*), although there is some uncertainty related to the frequency of the changes and to what extent the gates delay adult salmonids under existing conditions (Appendix 5.C, *Flow, Passage, Salinity, and Turbidity,* Section 5.C.5.3.10, *Suisun Marsh Salinity Control Structure*). The potential positive effect of changes to the Suisun Marsh salinity control gates for adult spring-run Chinook salmon are assumed for this effects analysis to be captured under the high change associated with passage improvements at Fremont Weir (Section 5.5.4.1.1, *Restored Floodplain, Tidal, and Channel Margin Habitat*).

Category	Appendix	Attributes	Definition	Eggs	Foragers	Migrants	Adults
Food	E	Zooplankton community	Species composition of the zooplankton community and presence of suitable prey species	NA	Zero	Zero	
		Zooplankton abundance	The abundance of zooplankton	NA	Low	Low	
		Benthic & Epibenthic prey abundance	The abundance of epibenthic prey species such as amphipods	NA	High	Low	
		Insect abundance	The abundance of insect prey	NA	High	Low	
Entrainment & Impingement	B	North Delta Intakes	Potential entrainment/impingement from the proposed North Delta intakes	NA	Very Low -	Very Low -	
		South Delta Pumps	Pumping rate from the CVP/SWP south Delta export facilities and resulting entrainment	NA	Moderate	Moderate	
		North Bay Aqueduct	Entrainment from the SWP NBA facilities	NA			
		Ag Diversions	Entrainment from Agriculture Diversions	NA	Very Low	Very Low	
Migration & Movement	C	Plan Area Flows	Magnitude, timing, direction, and duration of flows during migratory periods throughout the Plan Area	NA	Low-	Moderate-	Very Low -
		Interior Delta Entry	Entry of fish into the interior Delta from the mainstem Sacramento or San Joaquin Rivers through channels such as Georgiana Slough or Old River	NA	Low	Low	NA
		Passage Barriers	Structures or conditions that potentially block upstream or downstream migration	NA			Moderate
Habitat	C, E	Inter-tidal habitat	Intertidal area from the mean low low water level to the extreme high water level that may support intertidal vegetation and form mudflats; dynamic elements of habitat such as appropriate salinity are considered on a species-specific basis	NA	High	Low	
		Channel Margin	The extent of shallow water, low slope habitat that generally is characterized by structural complexity, native emergent vegetation and riparian shading cover	NA	Moderate	Moderate	
		Floodplains	The interface between upland topography and river hydrology during high flow events	NA	High	Moderate	
		Riparian	Forest and scrub that occurs along the margins of river channels and within floodplains	NA	NA	NA	NA
		Sub-tidal habitat	Extent and location of sub-tidal area in the Plan Area, including the low salinity zone (LSZ); dynamic elements of habitat such as appropriate salinity are considered on a species-specific basis	NA	Low	Low	
Sediment	C	Water clarity	Water clarity in the Plan Area as influenced by amount of suspended material within the water column	NA	Zero	Zero	
Temperature	C	Temperature	Adverse effects of high temperatures within the Plan Area	NA			
DO	C	Dissolved Oxygen	Adverse effects of low dissolved oxygen level within the Plan Area	NA			
Toxins	D, F	Contaminants	Adverse effects of methylated mercury, selenium, pesticides and other pollutants	NA	Very Low -	Very Low -	
		Microcystis	The abundance of Microcystis aeruginosa blooms that are toxic to covered fish species and their food	NA			
Predation	F	Predation	The species-specific consumption of covered fish species by predatory fish (e.g., striped bass, Sacramento pikeminnow, centrarchid bass species, catfish, and inland silversides); note that the attribute aims to isolate predation effects that may not be captured by other attributes, e.g., at manmade structures such as the north Delta diversions	NA	Low	Low	
		Illegal Harvest	Illegal harvest of covered fish species in the Plan Area	NA	Low	Low	Moderate

In-stream Habitat	C	Sacramento R. Habitat	Flows in the Sacramento River mainstem (below Keswick Dam to the Plan Area) that influence spawning, egg incubation, rearing, or holding habitat	Zero	Zero	Zero	Zero
		Feather R. Habitat	Flows in the Feather River (below Oroville Dam to the confluence with the Sacramento River) that influence spawning, egg incubation, rearing, or holding habitat	Zero	Low	Low	Zero
		American R. Habitat	Flows in the American River (below Nimbus Dam to the confluence with the Sacramento River) that influence spawning, egg incubation, rearing, or holding habitat	NA	NA	NA	NA
Migration & Movement	C	Sacramento R. Migration Flows	Flows in the Sacramento River mainstem (below Keswick Dam to the Plan Area) that influence migration and movement	NA	Zero	Zero	Zero
		Feather R. Migration Flows	Flows in the Feather River (below Oroville Dam to the confluence with the Sacramento River) that influence migration and movement	NA	Zero	Zero	Zero
		American R. Migration Flows	Flows in the American River (below Nimbus Dam to the confluence with the Sacramento River) that influence migration and movement	NA	NA	NA	NA
Temperature	C	Sacramento R. Temperature	Adverse effects of high water temperatures in the Sacramento River mainstem (below Keswick Dam to the Plan Area)	Zero			Zero
		Feather R. Temperature	Adverse effects of high water temperatures in the Feather River (below Oroville Dam to the confluence with the Sacramento River)	Zero			Zero
		American R. Temperature	Adverse effects of high water temperatures in the American River (below Nimbus Dam to the confluence with the Sacramento River)	NA	NA	NA	NA

Certainty

- No effect conclusion made because attribute assumed not to have importance as a current constraint
- NA — Life stage not present or not applicable
- Low certainty
- Moderate certainty
- High certainty
- Very high certainty

Figure 5.5.4-1. Effect of the Covered Activities on Spring-Run Chinook Salmon

Water temperature was examined at the subregional scale in the Plan Area, and showed little difference between existing conditions and the BDCP for the number of days within the suboptimal, optimal, supraoptimal, and lethal ranges for spring-run Chinook salmon (Appendix 5.C, *Flow, Passage, Salinity, and Turbidity*, Attachment 5C.C, *Water Temperature*). As noted above, climate change is a driver that will have increasing importance for the species into the future. DO also was found to be similar between existing conditions and the BDCP (Appendix 5.C, Section 5.C.5.4.3, *Dissolved Oxygen*).

As discussed above for winter-run Chinook salmon, changes in turbidity/water clarity that may result from implementation of the BDCP are uncertain (Appendix 5.C, *Flow,* Attachment 5C.D, *Water Clarity—Suspended Sediment Concentration and Turbidity*). Turbidity in newly restored areas may be relatively high as a result of factors such as water depth and wind fetch resuspending sediments, whereas turbidity outside the restored areas could be affected by the north Delta intakes and restoration areas capturing sediment that otherwise would have moved downstream. In contrast to estuary-resident species such as delta smelt, for which much of the juvenile population would be in downstream areas such as Suisun Bay that are reliant on resuspension of sediment during low-flow periods (e.g., summer/fall), spring-run Chinook salmon may occur in the mid-upper portions of the Delta (e.g., North Delta, Cache Slough, and West Delta subregions) during relatively high-flow times of the year, so it is concluded with low certainty that there would be no change to the water clarity attribute for any life stage. As described above for winter-run Chinook salmon, agency biologist opinion during the August 2013 workshops suggested a potential zero or low negative change, with low certainty, reflecting the potential for less sediment in the system as well as lower river velocity downstream of the north Delta intakes to affect water clarity.

In conclusion, the magnitude of benefits of the BDCP for spring-run Chinook salmon at the population level cannot be quantified with certainty. Nonetheless, the overall net effect of the BDCP is expected to be a positive change that has the potential to increase the resiliency and abundance of spring-run Chinook salmon relative to existing conditions. This conclusion is made with moderate certainty. The BDCP should conserve the species and may help it cope with expected climate change and the ongoing threats to recovery and possibly perpetuation. Katz et al. (2012) point to the likelihood of extinction of many California salmon populations. Increasing air and water temperatures as well as a general shift in hydrologic regime (rain-dominated rather than snow-dominated) will increase stresses to Central Valley salmonids regardless of the BDCP. Although the BDCP generally is not expected to change water temperatures in the Plan Area, climate change is predicted to result in increasingly difficult conditions for salmonids in the future; this issue is discussed further in Section 5.5.3.5, *Net Effects*, with regard to winter-run Chinook salmon. Spring-run Chinook salmon are particularly vulnerable because, as adults, they must oversummer before spawning, and will be vulnerable in all the tributaries that they inhabit (Moyle et al. 2008). The BDCP will not directly address the main effects of climate change (i.e., increased temperature) but, by expanding habitat, increasing habitat diversity, and increasing the number of productive habitat patches in the Delta, the BDCP may lead to a more robust spring-run Chinook salmon population with the resiliency and diversity necessary to cope with a changing environment.

Therefore, the BDCP will minimize and mitigate impacts to the maximum extent practicable and provide for the conservation and management of the spring-run Chinook salmon in the Plan Area.

5.5.5 Chinook Salmon, Central Valley Fall-Run/Late Fall–Run ESU

5.5.5.1 Introduction

The Central Valley fall-run/late fall–run Chinook salmon ESU (*Oncorhynchus tshawytscha*) is listed as a "Species of Concern" by NMFS under the ESA (National Marine Fisheries Service 2011). As the name implies, there are two segments of this ESU. While both fall-run and late fall–run Chinook enter freshwater and spawn in the fall, they differ in their juvenile life history and spawn timing. Historically, fall-run/late fall–run Chinook spawned in all 7 major tributaries, as well as the mainstem of the Sacramento and San Joaquin Rivers. Regarding fall-run Chinook salmon, Moyle et al. (2008: 138) stated: "Central Valley fall run Chinook historically spawned in all major rivers of the Central Valley, migrating as far as the Kings River in the south and the Upper Sacramento, McCloud, and Pit Rivers to the north. There were also small, presumably intermittent runs, in smaller streams such as Putah and Cache Creeks. Today they spawn upstream as far as the first impassible dam (e.g., Keswick Dam on the Sacramento River), although on the San Joaquin side of the Central Valley they are only allowed as high up as the Merced River because Friant Dam has cut off all natural flows to the lower San Joaquin River." Yoshiyama et al. (1998: 508), in their review of Central Valley Chinook salmon, noted: "The late-fall run evidently ascended and spawned originally in the upper main-stem reaches of the Sacramento River above Shasta Dam and probably also in the San Joaquin River in the vicinity of Friant Dam and in several Central Valley tributaries…Late-fall run fish presently spawn mainly in the main-stem Sacramento River downstream from Keswick Dam to just below Red Bluff." While fall-run Chinook currently are present in both the Sacramento and San Joaquin systems, late fall–run Chinook are currently only present in the Sacramento system. A detailed species account of fall-run and late fall–run Chinook salmon is presented in Appendix 2.A, *Covered Species Accounts*.

The abundance of fall-run Chinook in the Sacramento River has been consistently higher than abundance in the San Joaquin River. Escapement on the Sacramento River has been characterized by relatively high interannual variability ranging from approximately 100,000 to over 800,000 fish. Sacramento River escapement showed a marked increase in abundance between 1990 and 2003 followed by a sharp decline in abundance from 2004 to 2009 and the start of a rebound in 2010 through present. Long-term trends in adult escapement estimates for late fall–run Chinook salmon returning to the Sacramento River from 1971 through 2009 have ranged from several hundred adults to over 40,000 adults.

Adult fall-run Chinook salmon from both the Sacramento and San Joaquin systems migrate through the Delta and into Central Valley rivers from June through December and spawn from September through December, with peak spawning activity occurring in October and November. Spawning mainly occurs in the mainstem upper Sacramento River and Battle Creek. As juveniles, fall-run Chinook emigrate mainly as sub-yearling fish and most enter the delta in their first spring; a few fall-run juveniles may rear in freshwater up to a year and emigrate quickly as smolts. For the BDCP analysis, it was assumed that 75% of the fall-run juveniles enter the Plan Area as foragers and 25% entered as migrant smolts, as developed from discussions during the August 2013 agency biologist workshops. In this effects analysis, Mokelumne River fall-run Chinook salmon are included in the analysis of San Joaquin River fall-run Chinook salmon; this grouping is used because the Mokelumne River is a downstream tributary of the San Joaquin River (and meets the San Joaquin River within the Plan Area), although it should be noted that NMFS (2009b) classifies the Mokelumne River within the Northern Sierra Nevada salmonid diversity group (primarily from the perspective of the listed spring-run Chinook salmon and its historical distribution), which includes streams tributary to the Sacramento River from the east; NMFS (2009b: 53) noted the division of the North and South Sierra Nevada diversity groups to be "split somewhat arbitrarily south of the Mokelumne River", whereas the analysis by Lindley et al. (2004)—cited by NMFS (2009b) in determining diversity group—included the Mokelumne River in the Southern Sierra Diversity Group (Lindley et al. 2004: 18). Regardless, while the present effects analysis includes the Mokelumne River fall-run Chinook salmon in the San Joaquin River section of the analysis, results for the Mokelumne River fish are considered separately as appropriate.

Sacramento River late fall–run Chinook salmon migrate into the Sacramento River from October through April and may wait 1 to 3 months before spawning from December through April. Although the spawn timing of the late-fall segment is distinct from the fall-run, the spawning locations of the two run segments overlap in the upper Sacramento River and Battle Creek. The life history characteristics of Sacramento late fall–run Chinook salmon are not well understood; however, they are thought to have a more stream-type behavior than the fall-run (Snider and Titus 2000). The BDCP analysis assumes that 25% of late fall–run juveniles enter the Plan Area as foragers and 75% enter as migrant smolts, also as developed from review of the literature and discussions during the August 2013 agency biologist workshops These proportions were used to qualitatively weight the effects of the BDCP on each ESU. Scoring of BDCP net effects (Section 5.5.5.5) considered the beneficial and adverse effects of the BDCP on foragers and migrants separately.

5.5.5.2 Sacramento River Fall-Run/Late Fall–Run

5.5.5.2.1 Beneficial Effects

Restored Floodplain, Tidal, and Channel Margin Habitat

Floodplain Habitat

The BDCP will change the configuration and operation of Fremont Weir and the Yolo Bypass, which will increase floodplain availability and usage and improve conditions for juvenile and adult Sacramento River region fall-run and late fall–run Chinook salmon.

More detailed background on the importance of floodplain habitat for juvenile Chinook salmon is described in the net effects analysis for winter-run Chinook salmon (Section 5.5.3.5). Fall-run Chinook salmon foragers have received the most study for the importance of floodplain habitat, particularly in the Yolo Bypass (e.g., Sommer et al. 2001a, 2001b). For this effects analysis, floodplain habitat availability is considered an attribute of critical importance for foraging Sacramento River region fall-run and late fall–run Chinook salmon with high certainty, and an attribute of moderate importance with moderate certainty for migrating fall-run and late fall–run Chinook salmon because there may be some benefit from floodplains as an alternative migration pathway to the mainstem Sacramento River. As noted for winter-run and spring-run Chinook salmon (above), during the August 2013 workshops with agency biologists, there was consensus regarding the critical or high importance of floodplain habitat for foraging Sacramento River region Chinook salmon in the Plan Area but some thought that the importance for migrants should be low.

Based on median escapement results over 2002–2011, just over 40% of the entire fall-run/late fall–run Chinook salmon ESU spawns upstream of the Yolo Bypass and therefore could benefit from *CM2*

Yolo Bypass Fisheries Enhancement (Appendix 5.C, *Flow, Passage, Salinity, and Turbidity*, Section 5.C.5.4.1.3, *Proportion of Chinook Salmon That Could Benefit from CM2 Yolo Bypass Fisheries Enhancement*). Specific to the Sacramento River region, all late fall–run Chinook salmon spawn upstream of the weir, whereas just over 40% of fall-run Chinook salmon do so—there are also major fall-run populations in the Feather, Yuba, and American Rivers that would not derive an increased access benefit from CM2 above existing conditions, although fish from the Feather/Yuba Rivers would benefit from the increased duration of floodplain inundation. Modifications to Fremont Weir under CM2 will considerably increase the frequency and duration of inundated area of floodplain in the Yolo Bypass (Table 5.5.3-1, in Section 5.5.3, *Chinook Salmon, Sacramento River Winter-Run ESU*), to the potential benefit of juvenile fall and late fall–run Chinook salmon (in particular the juvenile foragers) as a result of increased access (for populations upstream of Fremont Weir) and longer floodplain duration (including those from the Feather/Yuba Rivers as well as the upstream populations); all late fall–run juveniles would have the potential to benefit because of spawning locations all being upstream of Fremont Weir. As noted for winter-run Chinook salmon, the relative increase in area is estimated to be greatest in below-normal and dry years, particularly in the months of January and March/April, when the extent of inundated area was modeled to be two to three times greater than under existing conditions. Rearing benefit for foraging fall-run Chinook salmon would be a result of increases in inundation during the winter/spring (primarily January–March). The Yolo Bypass Fry Rearing Model (Appendix 5.C, *Flow, Passage, Salinity, and Turbidity*, Section 5.C.5.4.1.4.1, *Yolo Bypass Fry Rearing Model Results*) for Sacramento River region fall-run Chinook salmon foragers integrated the combined effects of CM2 to show how, relative to existing conditions, the BDCP's combination of a greater percentage of foragers entering the Yolo Bypass, longer duration of inundation of the floodplain, better growth and survival, and larger size at ocean entry, result in greater potential for survival to adulthood, as expressed as ocean fishery returns attributable to fry (foragers). The results from this model suggest that across all water years there would be 14% greater adult fall-run Chinook salmon abundance (expressed as ocean fishery returns) under the BDCP compared to existing conditions, ranging from 2% more in critical years to 28% more in wet years. These results are most applicable to the approximately 40% of fall-run Chinook salmon juveniles originating in tributaries upstream of Fremont Weir (as noted above) and of these, 75% are assumed to be foragers.

In addition to the modeling analyses of Yolo Bypass effects provided by the Yolo Bypass Fry Rearing Model and the DPM (see below), the recent empirical analysis by Roberts et al. (2013) provides an important perspective on the potential benefits of CM2 for enhanced access to the Yolo Bypass. Roberts et al. (2013) estimated that notching of Fremont Weir to the specifications proposed under CM2 would have resulted in an annual average of nearly 18% of fall-run Chinook salmon juveniles entering the Yolo Bypass at Fremont Weir during 1997–2011, compared to an estimated 7.4% that actually occurred (Table 5.5.5-1). For late fall–run Chinook juveniles, Roberts et al. (2013) estimated that the annual average 10% of juveniles entering under existing conditions from 1997–2011 would have been nearly doubled (19%) with a Fremont Weir notch (Table 5.5.5-1).

Table 5.5.5-1. Annual Percentage of Fall-Run and Late Fall–Run Chinook Salmon Juveniles Entrained Onto the Yolo Bypass Under Existing Conditions and with Notching of Fremont Weir[a]

Water Year	Water-Year Type	Fall-Run		Late Fall–Run	
		Existing Conditions	With Notch	Existing Conditions	With Notch
1997	W	16.0	18.4	22.3	28.2
1998	W	20.4	28.1	10.5	17.8
1999	W	11.3	20.3	0.0	11.9
2000	AN	12.4	24.5	0.6	6.5
2001	D	0.0	5.6	0.0	1.9
2002	D	0.9	12.7	0.0	5.3
2003	AN	2.9	16.2	0.4	12.8
2004	BN	7.1	17.0	0.0	7.7
2005	AN	0.1	14.6	6.5	18.4
2006	W	27.1	33.8	33.2	37.7
2007	D	0.0	12.2	0.0	3.9
2008	C	0.0	15.2	0.0	11.8
2009	D	0.0	14.2	0.0	0.0
2010	BN	0.8	12.6	0.0	10.0
2011	W	11.5	22.2	6.4	16.9
Average (1997–2011)		7.4	17.8	5.3	12.7
Wet and above-normal water year average		12.7	22.3	10.0	18.8
Dry and critical water year average		0.2	12.0	0.0	4.6

Source: Roberts et al. 2013.

[a] Assumed a Fremont Weir notch similar to that proposed under the BDCP.

As noted for winter-run Chinook salmon, there is a small risk of juvenile Chinook salmon stranding as a result of increased Yolo Bypass inundation, although the DRERIP (Essex Partnership 2009) evaluation of Yolo Bypass operations under the BDCP assessed the benefits of increased inundation to considerably outweigh this potential effect (Appendix 5.C, *Flow, Passage, Salinity, and Turbidity,* Section 5.C.5.4.1.2, *Stranding (Steelhead, Chinook Salmon, Sacramento Splittail, White Sturgeon, and Green Sturgeon)*), and adaptive management of the floodplain would address potential design issues during the implementation period. Overall, it is concluded with high certainty that the BDCP will provide a high positive change to the floodplain attribute for foraging fall-run and late fall–run Chinook salmon.

Survival and migration pathways through the Delta for smolt-sized fall-run/late fall–run Chinook salmon migrants, including entry into the Yolo Bypass, were assessed with the DPM (Appendix 5.C, *Flow, Passage, Salinity, and Turbidity,* Section 5.C.5.3.4.2, *Spring-Run Chinook Salmon*). As represented by the DPM, migrants from these runs tend to occur nearer to the beginning and end of the main period of inundation of the Yolo Bypass, resulting in a modest positive change to the percentage of individuals entering the bypass under the BDCP compared to existing conditions (Table 5.5.5-2 and Table 5.5.5-3). The average percentage of fall-run Chinook salmon smolts entering the Yolo Bypass in the late long-term would be 3.6% and 5.5% under ESO_LLT and

HOS_LLT, and 3.5 to 3.6% for late fall–run Chinook under these scenarios, compared to 1% or less under existing conditions; in addition, the Yolo Bypass migration pathway was available in all modeled years under the BDCP compared to only 3 of 16 modeled years under existing conditions that had entry of more than 0.1% of smolts. These percentages are appreciably lower than the percentages estimated for all sizes of fall- and late fall–run Chinook salmon estimated by Roberts et al. (2013). Based on the analyses conducted, and in accordance with the agency biologist opinion expressed during the August 2013 workshops, it is concluded with moderate certainty that the BDCP would provide a medium positive change to the floodplain attribute for migrating juvenile fall-run and late fall–run Chinook salmon,. Ongoing studies of survival through the Yolo Bypass for smolt-sized Chinook salmon coupled with further refinement to the actual design of the Yolo Bypass and Fremont Weir operations, will provide additional information that may further enhance these benefits.

Table 5.5.5-2. Percentage of Sacramento River Region Fall-Run Chinook Salmon[a] Smolts Migrating from Fremont Weir to Chipps Island via the Yolo Bypass Pathway under Four Scenarios[b], Based on the Delta Passage Model

Water Year	Scenario[b]			
	EBC2	EBC2_LLT	ESO_LLT	HOS_LLT
1976	0.0	0.0	1.6	1.6
1977	0.0	0.0	2.2	2.2
1978	0.0	0.0	5.8	5.8
1979	0.0	0.0	2.5	2.3
1980	0.0	0.0	2.2	22.6
1981	0.0	0.0	2.2	2.5
1982	8.6	9.0	10.4	10.4
1983	0.6	1.6	9.4	9.4
1984	0.0	0.0	2.6	14.0
1985	0.0	0.0	2.1	2.2
1986	0.2	0.2	2.7	2.7
1987	0.0	0.0	1.5	1.7
1988	0.0	0.0	2.4	2.5
1989	0.0	0.0	3.2	2.1
1990	0.0	0.0	2.9	3.0
1991	0.0	0.0	3.1	3.3
Average	0.6	0.7	3.6	5.5
Median	0.0	0.0	2.6	2.6

[a] Percentages only apply to fall-run Chinook salmon that originate from natal tributaries upstream of Fremont Weir.

[b] For descriptions of scenarios, see Table 5.2-3.

Table 5.5.5-3. Percentage of Sacramento River Region Late Fall–Run Chinook Salmon Smolts Migrating from Fremont Weir to Chipps Island via the Yolo Bypass Pathway under Four Scenarios[a], Based on the Delta Passage Model

Water Year	Scenario[a]			
	EBC2	**EBC2_LLT**	**ESO_LLT**	**HOS_LLT**
1976	0.0	0.0	1.5	1.5
1977	0.0	0.0	1.9	1.8
1978	0.4	0.6	4.4	4.4
1979	0.0	0.0	2.0	2.1
1980	0.8	0.7	4.3	4.2
1981	0.0	0.0	1.9	1.7
1982	3.5	3.5	7.5	7.8
1983	1.7	1.8	7.7	8.2
1984	8.0	8.7	10.7	10.9
1985	0.0	0.0	1.1	1.1
1986	0.2	0.3	2.7	2.8
1987	0.0	0.0	2.0	2.0
1988	0.0	0.0	2.8	2.9
1989	0.0	0.0	1.6	1.6
1990	0.0	0.0	2.0	2.0
1991	0.0	0.0	2.6	2.5
Average	0.9	1.0	3.5	3.6
Median	0.0	0.0	2.3	2.3

[a] For descriptions of scenarios, see Table 5.2-3.

As noted for winter-run and spring-run Chinook salmon, adult fall-run and late fall–run Chinook salmon entering the Yolo Bypass can become trapped throughout the Yolo Bypass and in the concrete apron of the Fremont Weir. Reflecting agency biologist from the August 2013 workshops, the attribute of passage barriers was rated of low importance to fall–run Chinook salmon adults with high certainty because the main migration period generally does not coincide with periods of Yolo Bypass inundation (thus attraction into the bypass may be less) and the fall-run population size is greater than other runs; low importance with moderate certainty was assumed for passage barrier importance to late fall–run Chinook salmon.

As described for winter-run Chinook salmon, the suite of actions proposed to improve adult fish passage as part of *CM2 Yolo Bypass Fisheries Enhancement* will benefit Sacramento River adult salmonids by reducing stranding and delay in the Yolo Bypass (Appendix 5.C, *Flow, Passage, Salinity, and Turbidity,* Section 5.C.5.3.12, *Fremont Weir Adult Fish Passage (CM2 Yolo Bypass Fisheries Enhancement)*). The efficacy of the passage improvements at the Fremont Weir and other locations in the Yolo Bypass (e.g., Lisbon Weir and Putah Creek realignment, the latter being important to the fall-run Chinook salmon population in that system) cannot be estimated, but will be monitored, and adjustments will be made through adaptive management. The DRERIP (Essex Partnership 2009) evaluation of improved passage at Fremont Weir suggested that the benefits of increased passage will greatly outweigh potential risks (e.g., increased stranding as a result of increased attraction into the bypass). Accordingly, it is concluded with moderate certainty that CM2 will provide a high positive change to passage barriers for adult fall-run/late fall–run Chinook salmon. Agency biologist opinion during the August 2013 workshops were consistent in suggesting a moderate or high positive change, with moderate or high certainty.

Tidal Habitat

The BDCP will greatly increase the extent of tidal habitat that is suitable for Sacramento River region fall-run/late fall–run Chinook salmon juveniles, particularly in the Cache Slough and Suisun Marsh subregions.

As described further for winter-run Chinook salmon (Section 5.5.3), in this effects analysis, it was assumed with high certainty that intertidal habitat is an attribute of high importance for foraging salmonid juveniles. It was assumed with moderate certainty that intertidal habitat has low importance for migrating salmonid juveniles. which was consistent with agency biologist thinking during the August 2013 workshops. For fall-run Chinook salmon, in particular, the high proportion of foraging juveniles (assumed to be 75%) points to this habitat being of prime importance; a lower proportion (25%) of foraging late fall–run Chinook salmon juveniles is assumed. It was assumed with moderate certainty that subtidal habitat has low importance as a current constraint for foraging and migrating fall-/late fall–run Chinook salmon juveniles (agency biologists thought zero importance would be appropriate for both life-history stages). Both intertidal and subtidal habitat was assumed with very high certainty to have zero importance as a current constraint for adult salmonids, consistent with agency biologist opinion on the level of importance.

The most relevant tidal habitat to assess changes for fall-run and late fall–run Chinook salmon juveniles is found in the Cache Slough, North Delta, West Delta, Suisun Bay, and Suisun Marsh subregions. As noted for winter-run Chinook salmon, the results of the HSI approach (Appendix 5.E, *Habitat Restoration,* Section 5.E.4..4.1.1, *Habitat Suitability Analysis*) suggest that tidal habitat in these subregions will change from just over 30,000 HUs under existing conditions to over 50,000 HUs under the BDCP in the late long-term (a two-thirds increase), with much of the change being driven by restoration in the Cache Slough ROA and Suisun Marsh ROA and to a lesser extent in the West Delta ROA (Table 5.5.5-4 in Section 5.5.3).

As noted for winter-run and spring-run Chinook salmon, the relative increase in intertidal habitat area proposed under the BDCP with CM4 is considerably greater than the relative change in subtidal area that would result from restoration under CM4, particularly in the subregions most relevant to fall- and late fall–run Chinook salmon juveniles (especially Cache Slough, West Delta, and Suisun Marsh).

As with winter-run and spring-run Chinook salmon, it is concluded that the change to intertidal habitat for fall-run and late fall–run Chinook salmon juveniles represents a very high positive change for foraging juveniles and a moderate positive change for migrant juveniles, recognizing that foragers make up the majority of fall-run Chinook salmon juveniles entering the Plan Area, and that migrants make up the majority of late fall–run Chinook juveniles entering the Plan Area. These conclusions both have moderate certainty. As noted for winter-run Chinook salmon, agency biologist opinion during the August 2013 workshops suggested that intertidal habitat for migrant juvenile Chinook salmon should receive a low or zero change; note that the relative lack of importance of intertidal habitat is captured in its assumed low importance (described above). It is concluded with moderate certainty that the change in subtidal habitat will be moderate for both foragers and migrants. Uncertainties related to tidal habitat restoration in the Plan Area are discussed in Appendix 5.E, *Habitat Restoration*, Attachment 5.E.B, *Review of Restoration in the Delta.* Examples of uncertainty include how much restored habitats may be reduced in value because of colonization by IAV and associated nonnative fish species that may prey on juvenile Chinook salmon or compete for food. *CM13 Invasive Aquatic Vegetation Control* aims to control IAV in the ROAs, which may limit predation, but there is uncertainty related to the ability to do so effectively.

Channel Margin Habitat

Channel margin enhancement will improve the extent of higher value nearshore habitat in the Plan Area for Sacramento River region fall-run/late fall–run Chinook salmon juveniles.

The background and rationale for the importance of the channel margin habitat attribute presented in the winter-run effects analysis is directly applicable to Sacramento River region fall-run/late fall–run Chinook salmon. For this effects analysis, it was assumed with high certainty that channel margin habitat represents an attribute of high importance for foraging juvenile fall-run and late fall–run Chinook salmon juveniles and an attribute of moderate importance for migrating juvenile fall-run Chinook salmon (with moderate certainty) and low importance for migrating juvenile late fall–run Chinook salmon (because they tend to be larger smolts that may not need as much refuge in channel margin habitat as the other Chinook salmon runs). During the August 2013 workshops, some agency opinion concurred with these assumptions (albeit with lower certainty), whereas other agencies felt moderate importance for foragers and low importance for migrants to be more appropriate. As discussed for winter-run Chinook salmon, if 75% of the 20 miles of channel margin enhancement proposed in the Plan Area under *CM6 Channel Margin Enhancement* is undertaken in the North Delta subregion, then this represents approximately 9% of the length of the channels most relevant to juvenile fall-run and late fall–run Chinook salmon in the Plan Area, i.e., the mainstem Sacramento River, Sutter/ Steamboat Sloughs, and Miner Slough (Figure 5.E.6-1, *Revetment within Channels of the Plan Area*, in Appendix 5.E, *Habitat Restoration*). Further discussion of considerations related to CM6 is provided in the winter-run Chinook salmon analysis.

It is concluded with moderate certainty that there will be a moderate positive change to the channel margin attribute for foraging and migrating fall-run and late fall–run Chinook salmon. As noted above for floodplain habitat, the high proportion of foraging juveniles for fall-run Chinook salmon suggests particular importance of CM6 for this run.

Food Benefits from Restored Habitat

Tidal, floodplain, and channel margin habitat restoration under the BDCP has considerable potential to greatly increase the quantity of food available for juvenile Sacramento River region fall-run/late fall–run Chinook salmon.

It was assumed that the potential food benefits of proposed tidal marsh (*CM4 Tidal Natural Communities Restoration*), channel margin (*CM6 Channel Margin Enhancement*), floodplain (*CM5 Seasonally Inundated Floodplain Restoration*), and riparian restoration (*CM7 Riparian Natural Community Restoration*) for Sacramento River region fall-run/late fall–run Chinook salmon foragers and migrants is similar to that of winter-run Chinook salmon foragers and migrants. Accordingly, for this effects analysis, it was assumed with moderate certainty that benthic/epibenthic prey abundance and insect abundance have high importance for foraging fall-run and late fall–run Chinook salmon juveniles and low importance for migrating juveniles. As noted above for winter-run Chinook salmon, during the August 2013 workshops some agency biologists felt that the lack of information regarding food limitation warranted an assumption of moderate importance for benthic/epibenthic abundance and insect abundance; others agreed with an assumption of high importance. For this effects analysis, it was assumed with moderate certainty that zooplankton abundance has moderate importance for foraging fall-run Chinook salmon and low importance for migrating juveniles. The moderate degree of certainty is due to the relatively few number of studies of food limitation.

As discussed above under *Floodplain Habitat*, fall-run Chinook salmon foragers and the smaller proportion of late fall–run Chinook salmon juveniles that are foragers will benefit from additional floodplain inundation on the Yolo Bypass under the BDCP. Riparian and channel margin habitat enhancement also hold potential for increase of food resources. Restoration of tidal natural communities under CM4 holds perhaps the greatest potential benefit for food resources, because, as noted for winter-run Chinook salmon, it is estimated that there are large potential benefits to both phytoplankton-based and detritus-based elements of the juvenile Chinook salmon foodweb (Appendix 5.E, *Habitat Restoration*, Section 5.E.4.4.2.5, *Food in the Delta and the Effect of the Conservation Measures on Food for Covered Fish Species*). Considering the subregions most relevant to fall-run and late fall–run Chinook salmon (i.e., excluding the East Delta and South Delta regions), phytoplankton production potential (prod-acres) would increase by 50% under the BDCP (nearly 100,000 prod-acres) compared to existing conditions (around 65,000 prod-acres), largely because of restoration in the Cache Slough and Suisun Marsh ROAs (Table 5.5.3-6, in Section 5.5.3, *Chinook Salmon, Sacramento River Winter-Run ESU*).

It is concluded with high certainty that there will be a high positive change to benthic/epibenthic and insect abundance for foraging and migrating juvenile fall-run Chinook salmon. For late fall–run Chinook salmon, the positive change is concluded to be moderate, reflecting earlier occurrence of juveniles. It is concluded that there would be a low positive change in zooplankton abundance with low certainty for foraging fall-run and late fall–run Chinook salmon that reflects seasonality of zooplankton occurrence and uncertainty related to consumption of primary productivity by nonnative clams. The positive change in zooplankton abundance for migrant fall-run Chinook salmon is concluded to be moderate, reflecting later occurrence during warmer conditions, again with low certainty for the reasons described above.

Reduced Entrainment

Entrainment loss of juvenile Sacramento River region fall-run/late fall–run Chinook salmon under the BDCP will be appreciably lower than under existing conditions because the north Delta diversion operations will reduce reliance on south Delta export facilities.

The importance of entrainment at the south Delta export facilities appears to differ between fall-run and late fall–run Chinook salmon, at least to the extent that inferences from tagged hatchery-origin fish can be made. Williams (2012:10–11) noted that the ratio of salvaged hatchery-origin fall-run Chinook salmon juveniles at the south Delta export facilities compared to the catch in Chipps Island trawls was very low compared to other Sacramento River runs, whereas for late fall–run, the ratio of salvage to catch at Chipps Island is relatively high. An additional consideration is the restrictions on export pumping during sensitive periods that presumably has lessened the importance of south Delta entrainment in recent years. For this effects analysis, it was assumed with moderate certainty that the south Delta entrainment attribute is of moderate importance under existing conditions for foraging and migrating juvenile late fall–run Chinook salmon and of low importance for foraging and migrating juvenile fall-run Chinook salmon (Sacramento River region). Agency biologist opinion during the August 2013 workshops concurred with these assumptions, and noted in particular that the relatively high abundance of fall-run Chinook salmon also justifies an assumption of low importance for this run.

Modeled changes in south Delta export pumping were weighted for seasonal occurrence of fall-run and late fall–run Chinook salmon with the salvage density method, the results of which suggest that entrainment of juveniles of these runs at the SWP/CVP south Delta export facilities will be lower under the BDCP than under existing conditions. The salvage density method estimates that in the late long-term, juvenile fall-run Chinook salmon entrainment will decrease appreciably overall (just over 40% decrease in average entrainment across all water years), with the decrease from EBC2 or EBC2_LLT to ESO_LLT being least in dry water years (approximately 9 to 17%) and most in wet water years (over 60%), with other water years intermediate (Table 5.5.5-4) (Appendix 5.B, *Entrainment*, Section 5.B.6.1.4.2, *Delta Passage Model Salvage Estimates*). As noted for winter-run Chinook salmon, this reflects a greater proportion of export pumping at the north Delta diversions in wetter years and a greater proportion of export pumping at the south Delta diversions in drier years (Appendix 5.B, Section 5.B.4.1, *Relative Contribution of North and South Delta Intakes under the BDCP*). For late fall–run Chinook salmon, the salvage density method results suggest between 30 and 40% less average entrainment across all water-year types at the south Delta export facilities under the BDCP compared to existing conditions, ranging from around 25 to 30% in critical and dry years (ESO_LLT vs. EBC2_LLT) up to nearly 50% less in wet years on average (Table 5.5.5-5).

Table 5.5.5-4. Difference in Average Annual Entrainment Index[a] of Juvenile Fall-Run Chinook Salmon at the SWP/CVP South Delta Export Facilities under Future Conditions with the BDCP (Compared to Existing Conditions and to Future Conditions without the BDCP), Based on the Salvage Density Method

Water-Year Type	Change[b] under ESO_LLT[c]	
	Compared to EBC2[c]	Compared to EBC2_LLT[c]
Wet	-85,538 (-64%)[c]	-80,786 (-63%)
Above normal	-12,714 (-40%)	-13,962 (-42%)
Below normal	-3,108 (-24%)	-3,864 (-28%)
Dry	-1,779 (-9%)	-3,538 (-17%)
Critical	-10,702 (-28%)	-7,626 (-21%)
All years	-24,481 (-44%)	-24,016 (-44%)

[a] Number of fish lost to entrainment

[b] Negative values indicate lower entrainment under the BDCP compared to existing conditions or future conditions without the BDCP. Values are based on normalized salvage density (Appendix 5.B, Section 5.B.6.1.4.1, *Salvage-Density Method*).

[c] For descriptions of scenarios, see Table 5.2-3.

Table 5.5.5-5. Difference in Average Annual Entrainment Index[a] of Juvenile Late Fall–Run Chinook Salmon at the SWP/CVP South Delta Export Facilities under Future Conditions with the BDCP (Compared to Existing Conditions and to Future Conditions without the BDCP), Based on the Salvage Density Method

Water-Year Type	Change[b] under ESO_LLT[c]	
	Compared to EBC2[c]	Compared to EBC2_LLT[c]
Wet	-2,891 (-48%)[c]	-2,714 (-46%)
Above normal	-252 (-44%)	-245 (-44%)
Below normal	-22 (-39%)	-18 (-34%)
Dry	-40 (-30%)	-29 (-24%)
Critical	-51 (-31%)	-38 (-25%)
All years	-746 (-38%)	-627 (-34%)

[a] Number of fish lost to entrainment

[b] Negative values indicate lower entrainment under the BDCP compared to existing conditions or future conditions without the BDCP. Values are based on normalized salvage density (Appendix 5.B, Section 5.B.6.1.4.1, *Salvage-Density Method*).

[c] For descriptions of scenarios, see Table 5.2-3.

The DPM was used to estimate the percentage of fall-run and late fall–run Chinook salmon smolts (greater than 70-mm fork length) salvaged at the south Delta export facilities (Appendix 5.B, Section 5.B.5.7, *Delta Passage Model Salvage Estimates: Juvenile Chinook Salmon (SWP/CVP South Delta Export Facilities)*). For fall-run Chinook salmon, the results were quite similar to the salvage density method, with average salvage under the BDCP being 45 to 50% less than existing conditions (Table 5.5.5-6; Appendix 5.B, Section 5.B.6.1.4.2, *Delta Passage Model Salvage Estimates*). Based on the DPM, the average salvage for late fall–run Chinook salmon would be 64 to 70% less under the BDCP than existing conditions, which is partly attributable to a somewhat different timing in assumed Delta entry under the DPM compared to the historical salvage timing upon which the salvage density method is based. Nevertheless, both methods suggest appreciably lower south Delta entrainment under the BDCP (Table 5.5.5-7).

Table 5.5.5-6. Estimated Percentage Salvage at the SWP/CVP South Delta Export Facilities of Sacramento River Region Fall-Run Chinook Salmon Smolts Entering the Plan Area, Based on the Delta Passage Model

Water Year (Type[a])	By Scenario[b]			Change[c] under ESO_LLT	
	EBC2	EBC2_LLT	ESO_LLT	Compared to EBC2	Compared to EBC2_LLT
1976 (C)	0.013	0.012	0.009	-0.004 (-29%)	-0.003 (-22%)
1977 (C)	0.013	0.011	0.009	-0.004 (-30%)	-0.002 (-20%)
1978 (AN)	0.023	0.022	0.008	-0.015 (-65%)	-0.014 (-63%)
1979 (BN)	0.014	0.014	0.010	-0.004 (-30%)	-0.004 (-28%)
1980 (AN)	0.019	0.016	0.009	-0.010 (-52%)	-0.007 (-43%)
1981 (D)	0.014	0.013	0.012	-0.002 (-12%)	-0.001 (-6%)
1982 (W)	0.042	0.036	0.011	-0.031 (-75%)	-0.026 (-71%)
1983 (W)	0.059	0.057	0.006	-0.053 (-90%)	-0.051 (-89%)
1984 (W)	0.013	0.013	0.009	-0.003 (-27%)	-0.004 (-28%)
1985 (D)	0.013	0.012	0.010	-0.003 (-26%)	-0.002 (-18%)
1986 (W)	0.020	0.016	0.009	-0.011 (-56%)	-0.007 (-45%)
1987 (D)	0.014	0.012	0.010	-0.004 (-28%)	-0.002 (-13%)
1988 (C)	0.013	0.012	0.009	-0.004 (-31%)	-0.003 (-25%)
1989 (D)	0.013	0.012	0.010	-0.003 (-26%)	-0.002 (-17%)
1990 (C)	0.011	0.011	0.008	-0.003 (-28%)	-0.003 (-26%)
1991 (C)	0.014	0.014	0.011	-0.002 (-17%)	-0.003 (-18%)
Average	0.019	0.018	0.009	-0.010 (-51%)	-0.008 (-47%)

[a] Abbreviations of water-year types: W = wet; C = critical; AN = above normal; BN = below normal; D = dry
[b] For descriptions of scenarios, see Table 5.2-3.
[c] Negative values indicate lower values under the BDCP compared to existing conditions and future conditions without the BDCP.

Table 5.5.5-7. Estimated Percentage Salvage at the SWP/CVP South Delta Export Facilities of Sacramento River Region Late Fall–Run Chinook Salmon Smolts Entering the Plan Area, Based on the Delta Passage Model

Water Year (Type[a])	By Scenario[b]			Change[c] under ESO_LLT	
	EBC2	EBC2_LLT	ESO_LLT	Compared to EBC2	Compared to EBC2_LLT
1976 (C)	0.090	0.071	0.033	-0.058 (-64%)	-0.038 (-54%)
1977 (C)	0.033	0.036	0.017	-0.016 (-48%)	-0.019 (-52%)
1978 (AN)	0.075	0.072	0.025	-0.051 (-67%)	-0.047 (-66%)
1979 (BN)	0.112	0.093	0.024	-0.088 (-78%)	-0.069 (-74%)
1980 (AN)	0.131	0.085	0.028	-0.104 (-79%)	-0.057 (-67%)
1981 (D)	0.097	0.074	0.025	-0.072 (-74%)	-0.049 (-66%)
1982 (W)	0.117	0.095	0.024	-0.094 (-80%)	-0.071 (-75%)
1983 (W)	0.149	0.185	0.029	-0.120 (-81%)	-0.156 (-84%)
1984 (W)	0.112	0.084	0.009	-0.102 (-92%)	-0.075 (-89%)
1985 (D)	0.125	0.092	0.033	-0.092 (-73%)	-0.059 (-64%)
1986 (W)	0.113	0.074	0.028	-0.085 (-75%)	-0.046 (-62%)
1987 (D)	0.063	0.054	0.033	-0.030 (-48%)	-0.022 (-40%)
1988 (C)	0.038	0.032	0.024	-0.014 (-37%)	-0.009 (-27%)
1989 (D)	0.059	0.048	0.029	-0.030 (-50%)	-0.018 (-39%)
1990 (C)	0.057	0.037	0.041	-0.016 (-27%)	0.005 (13%)
1991 (C)	0.029	0.023	0.014	-0.015 (-52%)	-0.009 (-40%)
Average	0.088	0.072	0.026	-0.062 (-70%)	-0.046 (-64%)

[a] Abbreviations of water-year types: W = wet; C = critical; AN = above normal; BN = below normal; D = dry
[b] For descriptions of scenarios, see Table 5.2-3.
[c] Negative values indicate lower values under the BDCP compared to existing conditions and future conditions without the BDCP.

The above assessment was based on the ESO scenario. The low-outflow scenario (LOS) results in similar patterns for spring salvage estimates of fall-run Chinook salmon from the DPM (i.e., 1976–1991 annual average salvage of 0.009%), but somewhat higher estimates of fall salvage for late fall–run Chinook salmon smolts (i.e., 0.0032% under LOS_LLT compared to 0.0026% under ESO_LLT), because more south Delta export pumping would occur in the fall in the absence of the Fall X2 requirement. HOS_LLT results of salvage (0.0026%) under the DPM in the fall are similar to the ESO_LLT for late fall–run Chinook salmon, because both include the Fall X2 requirement; HOS_LLT gives slightly less salvage of fall-run Chinook salmon in spring (0.008% compared to 0.009% under ESO_LLT) because of higher outflow and less south Delta export pumping (Appendix 5.B, *Entrainment*, Section 5.B.4.5, *Differences Between Evaluated Starting Operations, High-Outflow Scenario, and Low-Outflow Scenario*).

Considering the results of the salvage density method, which includes all sizes of juvenile fall-run and late fall–run Chinook salmon (i.e., foragers and migrants), and the DPM, which includes only smolts (i.e., migrants), it is concluded that the BDCP will result in a moderate positive change to the south Delta entrainment attribute for foraging and migrating fall-run and late fall–run Chinook salmon juveniles. As with winter-run and spring-run Chinook salmon, this conclusion is made with moderate certainty that reflects the limited ability to model real-time water operations management decisions under existing conditions and the BDCP, which could result in differences from the results observed here. However, as also noted for winter-run Chinook salmon, it is anticipated that the BDCP will have an appreciable positive change to this attribute for Sacramento River region fall-run and late fall–run Chinook salmon juveniles. Limited agency opinion during the August 2013 workshops suggested a low positive change to be appropriate.

As with other Chinook salmon runs, it was assumed with low certainty that entrainment at agricultural diversions is an attribute with low importance for foraging and migrating fall-run and late fall–run Chinook salmon. Decommissioning of agricultural diversions in lands restored as tidal habitat under CM4 and screen removal/modification/screening under *CM21 Nonproject Diversions* is expected to reduce the number of unscreened diversions in the Plan Area (Appendix 5.B, Entrainment, Section 5.B.6.4.3.1, *Delta Regional Ecosystem Restoration Implementation Plan Analysis of Nonproject Diversions*), so that, consistent with the DRERIP analysis of CM21, it is concluded with low certainty that the BDCP will provide a low positive change to this attribute. As noted for winter-run and spring-run Chinook salmon, agency biologist opinion during the August 2013 workshops suggested high certainty may be warranted. Changes to the North Bay Aqueduct's Barker Slough Pumping Plant and its proposed alternative intake on the Sacramento River will represent no change to this attribute for fall-run and late fall–run Chinook salmon because the intake is currently screened and will remain so in the future, at both locations.

Reduced Entry into Interior Delta

Nonphysical barriers, north Delta intake bypass flows, and changed Delta hydrodynamics under the BDCP have the potential to reduce entry into the interior Delta for juvenile Sacramento River region fall-run/late fall–run Chinook salmon.

The rationale for the importance of entry into the interior Delta for Sacramento River region fall-run and late fall–run Chinook salmon is provided in the winter-run Chinook salmon discussion and, for this effects analysis, it was assumed with high certainty that the attribute of interior Delta entry is of high importance for migrating and foraging juvenile fall-run and late fall–run Chinook salmon.

CM16 Nonphysical Fish Barriers aims to inhibit juvenile salmonids from entering the interior Delta, potentially increasing through-Delta survival. As described in greater detail in the winter-run Chinook salmon account, recent studies of deterrence by a nonphysical barrier at the divergence of Georgiana Slough from the Sacramento River found good effectiveness for the relatively large, hatchery-origin late fall–run Chinook salmon smolts that were tested (Perry et al. 2012). Under an assumption of 67% deterrence from entering Georgiana Slough based on Perry et al. (2012) (i.e., if 30% of fish approaching the Georgiana Slough divergence would have entered Georgiana Slough without the barrier, then it was assumed that only 10% would have done so with a nonphysical barrier installed), sensitivity analyses of the DPM results suggest that Sacramento River region fall-run Chinook salmon smolt survival through the Delta under the BDCP could be an average 7 to 8% greater in relative terms compared to no barrier (and nearly the same amount greater than existing conditions; Appendix 5.C, *Flow, Passage, Salinity, and Turbidity,* Section 5.C.5.3.4.3.2, *Effects of Nonphysical Fish Barriers and Predation*). For late fall–run Chinook salmon, the sensitivity analysis of a nonphysical barrier deterring smolts from entering the interior Delta suggests that survival through the Delta on average would be 11 to 14% greater with the barrier than without (and also a similar amount greater than existing conditions) (Appendix 5.C, Section 5.C.5.3.4.4.2, *Effects of Nonphysical Fish Barriers and Predation*). This relatively high difference is the result of the DPM's late fall–run smolt migration period overlapping periods of the Delta Cross Channel being open, so that the sensitivity analysis of deterrence away from the interior Delta involved both Georgiana Slough and the Delta Cross Channel because these reaches are combined in the DPM. As noted for winter-run Chinook salmon, there are uncertainties related to effectiveness of deterrence of wild-origin fall-run and late fall–run Chinook salmon based on the testing for larger, hatchery-origin fish, as well as the potential for predation at the in-water structure comprising the nonphysical barrier.

As discussed for winter-run Chinook salmon, and demonstrated in Appendix 5.C, *Flow, Passage, Salinity, and Turbidity,* Section 5.C.5.3.8, *Sacramento River Reverse Flows Entering Georgiana Slough*, the existing evidence does not suggest that entry into the interior Delta would be exacerbated by the north Delta intakes, because of adequate bypass flows under *CM1 Water Facilities and Operation* and the effect of downstream restoration under the BDCP reducing tidal hydrodynamics at the Georgiana Slough divergence in comparison to existing conditions. These modeling results, coupled with the potential effectiveness of nonphysical barriers, leads to the conclusion that there will be a low positive change to the interior Delta entry attribute for migrating juvenile fall-run and late fall–run Chinook salmon, with moderate certainty based on existing nonphysical barrier tests on smolts (Perry et al. 2012). The same low positive change is concluded for foraging fall-run and late fall–run Chinook salmon but with low certainty because the effectiveness for small fish has not been assessed. As noted for winter-run and spring-run Chinook salmon above, during the August 2013 workshops agency opinion was divided on conclusions regarding the potential change to the interior Delta entry attribute for juvenile salmonids, ranging from a low or medium positive change (with low certainty) to zero or a low negative change (again with low certainty), primarily reflecting the uncertainty concerning the influence of tidal habitat restoration in muting tidal influence and its potential to offset lower Sacramento River flows below the proposed north Delta intakes.

As noted for winter-run Chinook salmon, upstream migration of adult fall-run and late fall–run Chinook salmon could be affected by nonphysical barriers. In order to cover the main downstream migration period of salmonids, nonphysical barriers may be installed from October to June and therefore would overlap the upstream migration of both of these runs. At a location such as Georgiana Slough, the water is sufficiently deep that there is ample room for adult salmonids to pass beneath the barrier if a mid-depth configuration is adopted, such as was used during pilot testing in 2011 (California Department of Water Resources 2012). The monitoring and adaptive management program will assess the risk to adult salmonids from delay at nonphysical barriers.

Reduced Predation

The BDCP could reduce losses of juvenile Sacramento River fall-run and late fall–run Chinook salmon at existing localized areas where predation is intense.

As noted for winter-run and spring-run Chinook salmon above, the importance of the predation attribute generated a wide range of agency biologist opinion during the August 2013 workshops, from low importance with low certainty to high importance with medium or high certainty. For fall-run Chinook salmon foragers and migrants, by far the most numerous of the Sacramento River region Chinook salmon, it was assumed with moderate certainty that predation has moderate importance; for the less numerous late fall–run Chinook salmon foragers and migrants predation was assumed with moderate certainty to be of high importance. As noted in the winter-run Chinook salmon discussion of predation, a number of elements within the conservation strategy have the potential to change this attribute: CM1 (less south Delta export facility predation caused by lower entrainment at the facilities; potential for aggregation of predators and juvenile Chinook salmon at the north Delta intakes); *CM2 Yolo Bypass Fisheries Enhancement* (greater access to Yolo Bypass, less use of low-survival migration pathways); *CM4 Tidal Natural Communities Restoration*, *CM5 Seasonally Inundated Floodplain Restoration*, and *CM6 Channel Margin Enhancement* (more shallow-water habitat with less predators, in association with implementation of *CM13 Invasive Aquatic Vegetation Control* as necessary); *CM15 Localized Reduction of Predatory Fishes* (various measures, such as habitat modification and capture/relocation, to reduce predators); *CM16 Nonphysical Fish Barriers* (nonphysical barriers to direct fish away from low-survival pathways, as discussed above); and *CM21 Nonproject Diversions* (screening/reconfiguration/removal of nonproject water intakes in the Plan Area). Consistent with winter-run Chinook salmon, it is concluded for fall-run and late fall–run Chinook salmon foragers and migrants that there will be a low positive change to predation under the BDCP (i.e., less predation under the BDCP), but with low certainty that will be addressed through targeted research and adaptive management. As noted above for winter-run and spring-run Chinook salmon, this conclusion was consistent with some agency biologist opinion during the August 2013 workshops, in contrast to other opinion expressed during the workshops that suggested zero or a low negative change would be appropriate; this opinion reflect the view that enhanced predation in the vicinity of the proposed north Delta intakes may be greater than any potential positive effects from CM15.

Reduced Illegal Harvest

The BDCP will help reduce illegal harvest of Sacramento River region fall-run and late fall–run Chinook salmon.

Details of the potential for *CM17 Illegal Harvest Reduction* to reduce illegal harvest on Sacramento River-region fall-run and late fall–run Chinook salmon are presented in the winter-run Chinook salmon effects analysis, which outlines the main points made by Roberts and Laughlin (2013) in explaining the expected effectiveness of CM17. In contrast to winter-run and spring-run Chinook salmon, which hold in upstream areas for relatively long periods prior to spawning and have relatively low population sizes, it was assumed with low certainty that illegal harvest is an attribute of low importance for both fall-run and late fall–run Chinook salmon adults and foraging/migrating juveniles. These conclusions are consistent with agency biologist views expressed during the August 2013 workshops, as is the high certainty conclusion that CM17 will provide a high positive change to the illegal harvest attribute (i.e., less illegal harvest) for fall-run and late fall–run Chinook salmon adults and foraging/migrating juveniles.

Upstream Habitat Changes

Fall-run Chinook salmon juvenile and fry rearing habitat conditions would be substantially improved in the Feather River, and slightly improved in the American River. Sacramento River spawning conditions for fall-run Chinook salmon would be improved, although there is some risk of increased redd scour, which would not affect overall juvenile production in the Sacramento River. There would be moderate reductions under BDCP in flows during the adult fall-run Chinook salmon migration period, although no relationships have been developed that quantify adult attraction and flows in the lower American River. There would generally be no flow- or water temperature-related effects of BDCP on spawning and egg incubation, juvenile and adult migration, and adult holding habitat for late fall–run Chinook salmon in the Sacramento River,.

Upstream flows and water temperatures define the quantity and quality of adult spawning, egg incubation, fry and juvenile rearing, juvenile and adult migration, and adult holding habitat for fall-run and late fall–run Chinook salmon in rivers upstream of the Plan Area. Reduced quantity or quality of spawning habitat could cause increased competition for remaining habitat, redd superimposition, and reduced spawning success. This attribute was assumed with moderate certainty to be of high importance. Reduced quantity or quality of juvenile rearing habitat could cause reduced juvenile growth and survival or delay or reduce successful smoltification and downstream migration. This attribute was assumed with moderate certainty to be of high importance. Reduced quantity and quality of juvenile migration habitat could delay or reduce successful entry into the Delta and ocean, which could reduce survival in these locations. This attribute was assumed with moderate certainty to be of moderate importance. Reduced quantity and quality of adult migration and holding habitat could delay or reduce successful adult migration and spawning or staging. This attribute was assumed with moderate certainty to be of high importance.

BDCP does not propose any changes in Shasta operating criteria, and BDCP does not affect upstream temperatures or flows in ways that would require a change in Shasta operations. Modeling results show that in the Sacramento River, there would be no major flow- or water temperature-related effects of BDCP on fall-run Chinook salmon spawning and egg incubation, fry and juvenile rearing, juvenile and adult migration, and adult holding habitat. Modeling results indicate that there would be a moderate increase in spawning habitat availability under BDCP due to increased flows during the spawning period, and a small increase in the risk of redd scour due to wider fluctuations in flow rates. However, as described above, there would be no change in end of May or end of September storage in Shasta, and the modeled results could be managed in real-time under the existing criteria to avoid any consequential changes. After extensive investigation of these results, they appear to be a function of high model sensitivity to relatively small changes in estimated upstream conditions. Therefore, BDCP does not change the ability of Shasta Reservoir to meet its operating criteria for cold water pool and downstream temperature, including end of September and end of May storage. These criteria are required by the 2009 BiOp to ensure that there are no unacceptable flow- or temperature-related effects on Sacramento River covered fish species, including fall-run Chinook. Appendix 5.C, *Flow, Passage, Salinity, and Turbidity* includes analysis of fall-run Chinook salmon habitat for upstream holding, spawning, egg incubation, and rearing, or for downstream migration flows in the upper Sacramento River, based on a variety of analyses conducted. Additionally, an important biological objective for fall-run Chinook salmon is to avoid degradation of upstream habitat, which the modeling results suggest has been achieved through maintenance of the operational criteria from the NMFS (2009a) BiOp for Shasta Reservoir and upper Sacramento River flows. As such, the combination of these modeled effects is not expected to affect fall-run Chinook salmon at a population level, which is further corroborated by similarities in juvenile production in the Sacramento River as predicted by SALMOD. In addition, NMFS flow and water temperature threshold criteria for the Sacramento River (National Marine Fisheries Service 2009a, 2009b) would be met under ESO_LLT at similar frequencies as without BDCP. SacEFT predicts that there would be small negative effects on juvenile rearing habitat, driven by a reduction in juvenile rearing habitat area. There would generally be no flow- or water temperature-related effects of BDCP on spawning and egg incubation, juvenile and adult migration, and adult holding habitat for late fall–run Chinook salmon.

Fall-run Chinook salmon spawn and rear in both high- and low-flow channels of the Feather River. Feather River flows would change under all of the BDCP outflow scenarios, with higher flows in the spring and lower flows in the summer, compared to conditions without BDCP. There would generally be no effect of BDCP on fall-run Chinook salmon spawning and egg incubation and adult migration and holding. Flows under BDCP during the latter half of the fry and juvenile rearing period would be substantially (up to 79%) higher in the high-flow channel and similar the rest of the period, although model results predicted small increases in flows in the high-flow channel during the juvenile migration period. There would be no differences in flows in the low-flow channel throughout the fry and juvenile rearing period. Collectively, these results indicate, with moderate certainty, a low benefit to fall-run Chinook salmon juveniles rearing in the Feather River. There would be no differences in water temperatures during the presence of any fall-run Chinook salmon life stage. Further, NMFS flow and water temperature threshold criteria for the Feather River (National Marine Fisheries Service 2009a, 2009b, 2012) would be met under BDCP at similar frequencies to those without BDCP.

The BDCP does not include any changes in Folsom operating criteria, and avoids changes in end of May storage to ensure that there are no unacceptable flow- or temperature-related effects of the BDCP on American River covered fish species, including fall-run Chinook. Modeling results indicate that in the American River, there would be no flow- or water temperature-related effects of BDCP on fall-run Chinook salmon spawning and egg incubation or juvenile migration. There would be small to moderate increases in flows under BDCP during some months of the fry and juvenile rearing period, potentially resulting in a small benefit to fall-run Chinook salmon. There would be moderate reductions under BDCP in flows during the September through October adult migration period, although no relationships have been developed that quantify the attraction of adult fall-run Chinook salmon and flows, or other flow-survival thresholds for adult migration, in the lower American River. NMFS flow threshold criteria for the American River (National Marine Fisheries Service 2009a, 2009b) would be met at a 7% to 10% greater frequency in dry and critical water years under BDCP than those under conditions without BDCP, suggesting a small benefit of BDCP on American River flows in these years. Further, NMFS water temperature threshold criteria for the American River (National Marine Fisheries Service 2009a, 2009b) would be met under BDCP at similar frequencies to those under conditions without BDCP.

There would be no flow- or water temperature-related effects of BDCP on fall-run Chinook salmon spawning and egg incubation, fry and juvenile rearing, juvenile and adult migration, and adult holding habitat in the Trinity River or Clear Creek.

5.5.5.2.2 Adverse Effects

Near-Field and Far-Field Effects of the North Delta Diversions on Juvenile Sacramento River Region Fall-Run/Late Fall–Run Chinook Salmon

Operation of the proposed north Delta intakes under the BDCP has the potential to adversely affect juvenile fall-run/late fall–run Chinook salmon through near-field (physical contact with the screens and aggregation of predators) and far-field (reduced downstream flows leading to greater probability of predation) effects.

Juvenile fall-run/late fall–run Chinook salmon entering the Plan Area from the Sacramento River as foragers or migrants would pass in the vicinity of the three intakes proposed for construction and operation under *CM1 Water Facilities and Operation*. As noted above, the percentage of juveniles entering the Yolo Bypass would be greater under the BDCP than existing conditions (see Table 5.5.5-2 and Table 5.5.5-3 for estimates of migrating juvenile entry into Yolo Bypass); however, for fall-run Chinook salmon there are appreciable populations in the Feather and American Rivers that would not experience enhanced access to the Yolo Bypass, because their natal tributaries are downstream of Fremont Weir (Table 5.C.5.4-3, *Escapement of Fall-Run and Late Fall–Run Chinook*

Salmon To Tributaries Based on Enhanced Access of Outmigrating Juveniles to the Yolo Bypass through a Notch in Fremont Weir, in Appendix 5.C, *Flow, Passage, Salinity, and Turbidity*). As described for winter-run Chinook salmon, the north Delta intakes may have near-field (screen contact/impingement and predation) and far-field (reduced flow-related survival) effects on juvenile fall-run/late fall–run Chinook salmon. The average percentage of river flow diverted at the three intakes during the typical Sacramento River region fall-run Chinook salmon downstream migration and Plan Area rearing period (December through June) was modeled to vary from around 4 to 30% depending on water-year type, and for late fall–run (October through February) the average percentage also varied around 4 to 30% (Appendix 5.B, *Entrainment,* Section 5.B.6.2.1.1, *Occurrence near the Proposed North Delta Intakes*). It is uncertain the extent to which downstream migrating juvenile fall-run/late fall–run Chinook would be aggregated towards the intakes in response to these diversion percentages. As noted for juvenile winter-run Chinook salmon, fall-run and late fall–run Chinook salmon juveniles would be greater than 30-mm standard length and therefore exceed the minimum size for exclusion by the north Delta intake screens (Appendix 5.B, Section 5.B.6.2.1.2, *Entrainment (Screening Effectiveness Analysis)*). As also described for winter-run Chinook salmon, the potential for impingement-related injury and mortality is not readily predicted from available laboratory data for Chinook salmon. (Swanson et al. 2004). Approach velocity will be less than or equal to 0.33 fps (the criterion for salmonid fry) and may at times be limited to 0.2 fps (the existing criterion for juvenile delta smelt). As with winter-run Chinook salmon, it was assumed with low certainty that the north Delta intakes have low importance for foraging and migrating fall-run/late fall–run Chinook salmon juveniles. It is concluded that there will be a low negative change to the north Delta intakes entrainment and impingement attribute to foraging and migrating juvenile salmonids as a result of contact and impingement at the north Delta diversions, with moderate certainty to be informed by monitoring of impingement and targeted studies of juvenile salmonid behavior in relation to the intakes following implementation. Agency biologist opinion during the August 2013 workshops was in accordance with this conclusion, with some suggesting that high certainty may be warranted. The conclusion does not include consideration of potential predation near the intakes, discussed further below. It is not anticipated that there will be any adverse effects of the north Delta diversions on adult fall-run/late fall–run Chinook salmon with respect to impingement or screen contact.

As noted in the winter-run Chinook salmon account (Section 5.5.3), Plan Area flows within less tidally influenced reaches have been shown to correlate with juvenile Chinook salmon through-Delta survival. Therefore, for this effects analysis, it was assumed with high certainty that Plan Area flows for migration and movement have critical importance for migrating juvenile fall-run/late fall–run Chinook salmon (as previously noted, agency biologist opinion during the August 2013 workshops ranged from moderate to critical importance for this attribute) and it was assumed with moderate certainty that this attribute has high importance for foragers of both runs. The north Delta intakes result in lower migration flows for fall-run/late fall–run Chinook salmon migrating down the Sacramento River. As previously described for winter-run Chinook salmon, *CM1 Water Facilities and Operation* includes bypass flow criteria that will be managed in real time to minimize adverse effects of diversions at the north Delta intakes in response to pulses of downstream-migrating salmonids.

Mean monthly river flows simulated from CALSIM-II varied considerably between different water-year types and months during the main fall-run Chinook salmon downstream migration and rearing period (December–June). Average flows in the Sacramento River below the north Delta intakes generally were approximately 13 to 26% lower under the ESO scenario compared to existing conditions or future conditions without the BDCP when averaged across all water years, with averages by individual water years ranging from not greatly different (critical years, when the north Delta intakes would be used less in favor of the south Delta intakes) to around 30% lower under the BDCP in some months of wetter year types (Table 5.5.3-9). Under the HOS, the above patterns were generally true except for the months of April and May, when less diversion at the north Delta intakes resulted in flows below the north Delta intakes that were similar or slightly lower than existing conditions, and appreciably greater than the ESO in wetter years, which is of importance to migrating fall-run Chinook salmon. Under the LOS, average outflow was lower during the fall months than under the ESO, because the LOS does not include fall outflow; this period coincides to some extent with the fall downstream migration of late fall–run Chinook salmon juveniles.

The results of the DPM, which inform effects of flow-related changes under the BDCP but not measures such as habitat restoration, suggest that overall through-Delta survival of fall-run Chinook salmon smolts (i.e., migrants) would be similar under the BDCP compared to existing conditions (Table 5.5.5-8) (Appendix 5.C, *Flow, Passage, Salinity, and Turbidity,* Section 5.C.5.3.4.3, *Sacramento River Fall-Run Chinook Salmon*). Higher spring flows under the HOS led to estimates of slightly higher average annual survival under HOS_LLT (25.5%) than EBC2_LLT (24.7%) (Appendix 5.C, Section 5.C.5.3.4.7.3, *Sacramento River Fall-Run Chinook Salmon*). As noted for winter-run Chinook salmon, the observed patterns represented tradeoffs between positive and negative changes from the BDCP relative to the existing conditions such as greater Yolo Bypass entry (with relatively high survival) and reduced interior Delta mortality because of lower entrainment loss from the south Delta export facilities, versus less survival through the Sacramento River and Steamboat/Sutter Slough pathways because of lower flows on the Sacramento River (See Table 5.C.5.3-45, *Percentage Use and Survival of Sacramento River Fall-Run Chinook Salmon Smolts Migrating Down Different Through-Delta Pathways under EBC and ESO Scenarios, based on Delta Passage Model*, in Appendix 5.C, for pathway-specific survival estimates).

A second analysis, based on modeling results from Newman (2003; see Appendix 5.C., Section 5.C.4.3.2.3, *Juvenile Spring-Run and Fall-Run Chinook Salmon Smolt Through-Delta Survival (Newman 2003)*), applies to fall-run Chinook salmon juveniles entering the Plan Area on the Sacramento River (Yolo Bypass is not included) and estimated that the average through-Delta survival under the ESO scenario would be 14% lower than under existing conditions (EBC2) and would change little compared to future conditions without the BDCP accounting for climate change (EBC2_LLT; Table 5.5.5-9); HOS_LLT had marginally higher average annual proportional survival (0.50) than EBC2_LLT (0.48) (Appendix 5.C, Section 5.C.5.3.5.3, *HOS-LOS Scenarios*).

An assessment of changes in Plan Area migration flows for fry-sized fall-run Chinook salmon migrants from the Sacramento River was undertaken with the particle tracking nonlinear regression analysis and found little difference in the estimated percentage of particles reaching Chipps Island from the Sacramento River (representing mainstem migrants) or Cache Slough (representing fish existing the Yolo Bypass) (Appendix 5.C, Section 5.C.5.3.1.5, *Particle Tracking Modeling Nonlinear Regression Analyses (Chinook Salmon Fry/Parr)*), which, as with the DPM and through-Delta survival based on Newman (2003) analyses, was a reflection of trade-offs between changed Plan Area flows and less south Delta entrainment. Estimated survival of fall-run Chinook salmon smolts in the Sacramento River mainstem from the divergence with the Delta Cross Channel and Georgiana Slough to Chipps Island under ESO_LLT averaged around 94% of survival estimated under EBC2_LLT, based on applying the flow-survival relationship of Perry (2010), whereas HOS_LLT survival averaged around 98% of the EBC2_LLT survival value (Appendix 5.C, Section 5.C.5.3.6.1.3, *Fall-Run Chinook Salmon*). For late fall–run Chinook salmon, the results of the DPM suggest similar through-Delta survival under the BDCP compared to existing conditions (Table 5.5.5-10; Appendix

5.C, Section 5.C.5.3.4. 4, *Late Fall–Run Chinook Salmon*); this reflects a greater proportion of the population entering the interior Delta than other Chinook salmon runs because of the greater overlap of the migration period with periods when the Delta Cross Channel is open, so that a greater proportion of the run derives benefit from less south Delta exports under the BDCP. Estimated survival of late fall–run Chinook salmon smolts in the Sacramento River mainstem from the divergence with the Delta Cross Channel and Georgiana Slough to Chipps Island under ESO_LLT and HOS_LLT averaged around 95% of survival estimated under EBC2_LLT, based on applying the flow-survival relationship of Perry (2010) (Appendix 5.C, Section 5.C.5.3.6.1.4, *Late Fall–Run Chinook Salmon*). It is concluded that there is a low negative change to Plan Area flows for foraging and migrating fall-run/late fall–run Chinook salmon, with high certainty for migrating juveniles and moderate certainty for foraging juveniles, reflecting the relative difference in knowledge about what the change may mean to these different juvenile behavior types. This conclusion reflects changes in migration and movement Plan Area flows on the Sacramento River, the primary migration route. Benefits of the BDCP to other aspects of through-Delta survival such as use of the Yolo Bypass and entry into the interior Delta were assessed separately above, and improved habitat conditions were not included in any of these assessments.

Table 5.5.5-8. Percentage Through-Delta Survival Estimates for Sacramento River Region Fall-Run Chinook Salmon Smolts[a], Based on the Delta Passage Model

Water Year[b]	By Scenario[c]			Change[d] under ESO_LLT	
	EBC2	EBC2_LLT	ESO_LLT	Compared to EBC2	Compared to EBC2_LLT
1976 (C)	15.5	21.2	22.7	7.2 (46%)	1.6 (7%)
1977 (C)	17.4	17.2	18.4	1.0 (6%)	1.2 (7%)
1978 (AN)	35.7	31.1	26.4	-9.4 (-26%)	-4.7 (-15%)
1979 (BN)	24.8	21.2	20.5	-4.3 (-17%)	-0.8 (-4%)
1980 (AN)	26.5	25.1	24.4	-2.1 (-8%)	-0.6 (-3%)
1981 (D)	20.2	19.6	21.8	1.6 (8%)	2.2 (11%)
1982 (W)	44.9	39.2	35.0	-9.9 (-22%)	-4.1 (-11%)
1983 (W)	52.5	51.0	47.2	-5.3 (-10%)	-3.8 (-7%)
1984 (W)	21.1	18.4	18.9	-2.2 (-10%)	0.5 (3%)
1985 (D)	24.2	23.5	24.7	0.5 (2%)	1.2 (5%)
1986 (W)	24.4	22.0	22.0	-2.4 (-10%)	0.1 (0%)
1987 (D)	21.5	22.9	24.0	2.5 (11%)	1.0 (4%)
1988 (C)	17.9	17.6	18.3	0.4 (2%)	0.7 (4%)
1989 (D)	27.1	28.5	29.2	2.1 (8%)	0.7 (2%)
1990 (C)	19.6	18.5	19.2	-0.4 (-2%)	0.7 (4%)
1991 (C)	17.1	17.5	18.0	0.9 (5%)	0.5 (3%)
Average	25.7	24.7	24.4	-1.2 (-5%)	-0.2 (-1%)
Median	22.8	21.6	22.4	0.0 (0%)	0.6 (3%)

[a] Percentages only apply to fall-run Chinook salmon that originate from natal tributaries upstream of Fremont Weir.

[b] Abbreviations of water-year types: W = wet; C = critical; AN = above normal; BN = below normal; D = dry

[c] For descriptions of scenarios, see Table 5.2-3.

[d] Negative differences indicate lower values under the BDCP compared to existing conditions and future conditions without the BDCP.

Table 5.5.5-9. Proportional Through-Delta Survival Estimates[a] for Sacramento River Region Fall-Run Chinook Salmon Smolts[b]

Water Year[c]	By Scenario[d]			Change[e] under ESO_LLT	
	EBC2	EBC2_LLT	ESO_LLT	Compared to EBC2	Compared to EBC2_LLT
1976 (C)	0.36	0.51	0.52	0.16 (44%)	0.01 (2%)
1977 (C)	0.37	0.32	0.32	-0.05 (-14%)	0.00 (0%)
1978 (AN)	0.71	0.57	0.53	-0.18 (-25%)	-0.04 (-7%)
1979 (BN)	0.60	0.44	0.41	-0.19 (-32%)	-0.03 (-7%)
1980 (AN)	0.62	0.46	0.43	-0.19 (-31%)	-0.03 (-7%)
1981 (D)	0.44	0.39	0.42	-0.02 (-5%)	0.03 (8%)
1982 (W)	0.88	0.77	0.72	-0.16 (-18%)	-0.05 (-6%)
1983 (W)	0.96	0.86	0.90	-0.06 (-6%)	0.04 (5%)
1984 (W)	0.51	0.38	0.36	-0.15 (-29%)	-0.02 (-5%)
1985 (D)	0.56	0.49	0.50	-0.06 (-11%)	0.01 (2%)
1986 (W)	0.54	0.36	0.35	-0.19 (-35%)	-0.01 (-3%)
1987 (D)	0.45	0.47	0.48	0.03 (7%)	0.01 (2%)
1988 (C)	0.45	0.42	0.41	-0.04 (-9%)	-0.01 (-2%)
1989 (D)	0.59	0.57	0.58	-0.01 (-2%)	0.01 (2%)
1990 (C)	0.39	0.30	0.29	-0.10 (-26%)	-0.01 (-3%)
1991 (C)	0.38	0.34	0.32	-0.06 (-16%)	-0.02 (-6%)
Average	0.55	0.48	0.47	-0.08 (-14%)	-0.01 (-1%)

[a] Based on Newman 2003.

[b] Percentages apply to fall-run Chinook salmon entering the Plan Area in the mainstem Sacramento River.

[c] Abbreviations of water-year types: W = wet; C = critical; AN = above normal; BN = below normal; D = dry

[d] For descriptions of scenarios, see Table 5.2-3.

[e] Negative differences indicate lower values under the BDCP compared to existing conditions and future conditions without the BDCP.

Table 5.5.5-10. Percentage Through-Delta Survival Estimates for Late Fall–Run Chinook Salmon Smolts, Based on the Delta Passage Model

Water Year (Type[a])	By Scenario[a]			Change[c] under ESO_LLT	
	EBC2	EBC2_LLT	ESO_LLT	Compared to EBC2	Compared to EBC2_LLT
1976 (C)	25.0	23.0	20.0	-5.0 (-20%)	-3.0 (-13%)
1977 (C)	15.3	16.7	18.3	3.0 (20%)	1.7 (10%)
1978 (AN)	18.9	19.1	20.1	1.2 (7%)	1.0 (5%)
1979 (BN)	19.6	20.0	19.0	-0.5 (-3%)	-1.0 (-5%)
1980 (AN)	21.5	21.7	24.1	2.6 (12%)	2.4 (11%)
1981 (D)	20.9	21.2	21.5	0.6 (3%)	0.3 (1%)
1982 (W)	30.6	30.8	31.4	0.8 (3%)	0.6 (2%)
1983 (W)	38.7	35.0	31.4	-7.3 (-19%)	-3.6 (-10%)
1984 (W)	40.6	37.7	35.8	-4.8 (-12%)	-1.9 (-5%)
1985 (D)	29.4	28.6	25.8	-3.7 (-12%)	-2.9 (-10%)
1986 (W)	20.1	19.8	21.2	1.1 (5%)	1.4 (7%)
1987 (D)	20.1	21.1	21.9	1.8 (9%)	0.7 (3%)
1988 (C)	19.9	20.1	21.5	1.6 (8%)	1.4 (7%)
1989 (D)	17.3	17.8	18.4	1.1 (7%)	0.6 (3%)
1990 (C)	17.1	18.4	20.4	3.3 (19%)	2.0 (11%)
1991 (C)	15.0	15.1	17.7	2.7 (18%)	2.7 (18%)
Average	23.1	22.9	23.0	-0.1 (0%)	0.2 (1%)
Median	20.1	20.6	21.3	1.1 (5%)	0.7 (3%)

[a] Abbreviations of water-year types: W = wet; C = critical; AN = above normal; BN = below normal; D = dry
[b] For descriptions of scenarios, see Table 5.2-3.
[c] Negative differences indicate lower values under the BDCP compared to existing conditions and future conditions without the BDCP.

As outlined in the winter-run Chinook salmon account (Section 5.5.3) and described in detail in Appendix 5.F, *Biological Stressors on Covered Fish* (Section 5.F.4.2.1, *Bioenergetics Model for the North Delta Diversion*), a bioenergetics model was used to provide an estimate of the percentage of migrating fall-run and late fall–run Chinook salmon juveniles entering the Plan Area that might be consumed by striped bass near the north Delta diversions, under various assumptions. This analysis suggests that 0.5% or less of fall-run and 1.3% or less of late fall–run Chinook salmon could be preyed upon, although there is appreciable uncertainty in the parameters used in the model. In addition, the baseline mortality in the reach is not known. Sensitivity analyses were conducted with the results of the DPM to estimate the effect of a reduction on overall through-Delta survival to 95% of the survival that otherwise would have occurred (a stressor reduction target specified as part of the biological goals and objectives in Chapter 3, Section 3.3.7.5.3, *Species-Specific Goals and Objectives*). This suggests that overall through-Delta survival would be around 5% less (in relative terms; 1% in absolute terms) than survival without the assumed additional mortality in the north Delta intakes reach (Appendix 5.C, *Flow, Passage, Salinity, and Turbidity,* Section 5.C.5.3.4.4.1, *Overall Survival through the Delta*, and Section 5.C.5.3.4.4.2, *Effects of Nonphysical Fish Barriers and*

Predation). As discussed for winter-run Chinook salmon, another scenario of predation loss explored further in Appendix 5.F, *Biological Stressors on Covered Fish*, Section 5.F.6.3.1.1, *CM1 Water Facilities and Operation*, is a 5% loss of Chinook salmon at each of the three north Delta intakes based on losses in association with the Glenn Colusa Irrigation District diversion and screen in the upper Sacramento River, which would result in a cumulative loss of around 13% across three BDCP intakes for fall-run/late fall–run Chinook salmon juveniles. The applicability of the Glenn Colusa Irrigation District situation to the BDCP is uncertain for the reasons discussed in the winter-run Chinook salmon analysis. As noted above, it is possible that the BDCP will reduce localized predation at areas with relatively intense predation, and this includes the north Delta intakes should they be found to harbor predators. The uncertainty associated with predation at the north Delta intakes will be addressed with targeted research and adaptive management during implementation of the BDCP, including *CM15 Localized Reduction of Predatory Fishes* as discussed above, and will also be informed by early implementation studies currently in the planning stage.

Reduced Attraction Flows in the Sacramento River

Sacramento River attraction flows for migrating adult fall-run and late fall–run Chinook salmon will be lower from operations of the north Delta diversions under the BDCP.

As discussed in the winter-run Chinook salmon net effects analysis (Section 5.5.3.2.2, *Reduced Attraction Flows in the Sacramento River*), the straying rate of Sacramento River region Chinook salmon appears low based on hatchery-origin fish released upstream of the Plan Area (Marston et al. 2012). In hatchery-origin fish, straying rate has been linked to release location, so that fish released far from the hatchery are more likely to stray (Lasko 2012; Marston et al. 2012). Therefore, for this effects analysis, it was assumed with high certainty that Plan Area migration flows (including factors such as olfactory cues) for adult fall-run and late fall–run Chinook salmon are of low importance as an attribute that has been changed from its historical condition. As noted in the analysis for winter-run Chinook salmon, agency biologists during the August 2013 workshops thought low or moderate importance with low certainty may be warranted.

For both fall-run and late fall–run adult Chinook salmon, the DSM2 fingerprinting analysis suggests that the average percentage of Sacramento River–origin water at Collinsville under the BDCP would be similar to or slightly lower than under existing conditions (Appendix 5.C, *Flow, Passage, Salinity, and Turbidity,* Section 5.C.5.3.13.1.5, *Fall-Run Chinook Salmon*, and Section 5.C.5.3.13.1.6, *Late Fall–Run Chinook Salmon*). For fall-run Chinook salmon (September–October migration period), averages for the BDCP in the late long-term were 63% in September and 67% in October compared to 67% and 63% under existing conditions, and 65% and 68% for the late long-term reference point for existing conditions (Table 5.C.5.3-196, *Monthly Average (With Range in Parentheses) Percentage of Water at Collinsville Originating in the Sacramento River during September–October under EBC and ESO Scenarios*, in Appendix 5.C). For late fall–run Chinook salmon (December–February migration period), averages for the BDCP in the late long-term were 66 to 73% compared to 68 to 77% under existing conditions, and 66 to 75% for the late long-term reference point for existing conditions (Table 5.C.5.3-200, *Monthly Average (With Range in Parentheses) Percentage of Water at Collinsville Originating in the Sacramento River during September–October under EBC and ESO Scenarios*, in Appendix 5.C).The effects of flow reduction in the lower reach of the Sacramento River on the attraction and upstream migration of adult salmonids are uncertain. As described in Appendix 5.C, 5.C.5.3.13.1.6, differences between the BDCP and existing conditions in average net flows at Rio Vista during the late fall–run upstream migration months generally were below 10%, whereas for fall-run Chinook salmon the average net flows were up to 50% lower than existing conditions under the ESO scenario in some water-year types. As described for winter-run Chinook salmon, flows in the lower Sacramento River are influenced by tidal hydrodynamics and caution is warranted when assessing changes in net flows at locations such as Rio Vista in the context of adult upstream migration (*Context for Monthly Average Flow Changes in Tidally Influenced Areas of the Plan Area (Delta Region)* in Appendix 5.C, Section 5.C.5.3.13.1.11, *Context for Monthly Average Flow Changes in Tidally Influenced Areas of the Plan Area (Delta Region)*). This may indicate that flow differences estimated for fall-run and late fall–run Chinook salmon under the BDCP will not be of considerable importance, although this is uncertain. In considering the results of the DSM2 fingerprinting results and the CALSIM flow analyses, as well as the literature discussed in the winter-run analysis, it is concluded with low certainty that there will be a low negative change to adult migration flows under the BDCP for upstream migrating adult fall-run and late fall–run Chinook salmon. The low certainty in these conclusions would be informed by monitoring and targeted research under the BDCP (e.g., examining migration success of tagged adult Chinook salmon under different flow regimes), with any adverse effects being addressed by adaptive management.

Exposure to In-Water Construction and Maintenance Activities

In-water construction and maintenance effects of the BDCP could affect fall-run/late fall–run Chinook salmon.

As described for other species, the main in-water construction activities at the proposed north Delta intakes (*CM1 Water Facilities and Operation*) will be limited to one construction season during the months of June–October (Appendix 5.H, *Aquatic Construction and Maintenance Effects*). The construction area is directly on the main migration route for fall-run/late fall–run Chinook salmon juveniles and adults. The seasonality of construction is intended to minimize adverse effects, although the final month of the in-water construction window (October) coincides with the peak of the fall-run Chinook salmon adult upstream migration period and the start of the main juvenile migration period for late fall–run Chinook salmon (Appendix 5.H, *Aquatic Construction and Maintenance Effects*, Section 5.H.3, *Information on Covered Fish Species*). As described for winter-run Chinook salmon (Section 5.5.3.2.3), any fall-run/late fall–run Chinook salmon present during in-water work may experience adverse effects from underwater sound (pile driving), entrapment within enclosed areas (e.g., cofferdams), exposure to temporary water quality deterioration (e.g., suspended sediment, suspension of toxic materials), and accidental spills. Temporary and permanent changes to habitat involve generally poor-quality habitat along existing leveed banks (Appendix 5.H, Section 5.H.6.1.4 *Habitat Modification*). Maintenance dredging also may decrease water quality temporarily. Habitat restoration activities associated with *CM4 Tidal Natural Communities Restoration, CM5 Seasonally Inundated Floodplain Restoration*, *CM6 Channel Margin Enhancement* and *CM7 Riparian Natural Community Restoration* may contribute to reduced water quality. Breaching of levees to create tidal habitat may reduce areas of channel margin, but there will be considerable gains of habitat caused by the breaching. As described for winter-run Chinook salmon, in-water activities associated with *CM14 Stockton Deep Water Ship Channel Dissolved Oxygen Levels, CM15 Localized Reduction of Predatory Fish, CM16 Nonphysical Fish Barriers,* and *CM21 Nonproject Diversions* will have little to no effect on salmonids because of the small scale of the work. Implementation of *CM22 Avoidance and Minimization Measures* will reduce the likelihood of adverse effects from in-water activities related to construction and maintenance on juvenile and adult salmonids. Therefore, it is concluded with high certainty that construction and maintenance associated with the BDCP represent a minor adverse effect on fall-run/late fall–run Chinook salmon adults and juveniles.

Exposure to Contaminants and Blue-Green Alga *Microcystis*

The BDCP will contribute to a reduction in fall-run/late fall–run Chinook salmon exposure to contaminants in the late long-term, although localized increases in contaminant exposure may occur as a result of tidal habitat and floodplain restoration. Late fall–run Chinook salmon juveniles may be exposed to greater incidence of *Microcystis.*

The BDCP could adversely affect fall-run/late fall–run Chinook salmon life stages occurring in the Plan Area through changes in contaminants as a result of changes in water operations (*CM1 Water Facilities and Operation, CM2 Yolo Bypass Fisheries Enhancement*) and habitat restoration (principally, *CM4 Tidal Natural Communities Restoration*). For this effects analysis, contaminants are considered to be of low importance with low certainty for juvenile (foragers and migrant) and not important to adult fall-run and late fall–run Chinook salmon; this generally captured the limited agency biologist opinion during the August 2013 workshops (although, as noted for winter-run Chinook salmon, one agency biologist opinion suggested that low importance for adults may be warranted, based on effects to olfaction). As noted for winter-run Chinook salmon, analyses presented in Appendix 5.D, *Contaminants*, suggest a low potential for increased contaminant exposure from the BDCP and the potential for a beneficial effect in the late long-term from reduced contaminants resulting from the restoration of areas previously used for agriculture. It is concluded with low certainty that this represents a low negative change to this attribute for juvenile (foragers and migrant) and adult fall-run and late fall–run Chinook salmon in the Plan Area.

Most juvenile salmonids in the Plan Area occur at times of the year when the direct and indirect effects of *Microcystis* toxicity are limited, because *Microcystis* tends to be abundant in summer-fall. Late fall–run Chinook salmon juveniles (foragers and migrants) occurring during the fall may have some overlap with the period of *Microcystis* toxicity in the Plan Area. Research into the potential effects of *Microcystis* has not included salmonids—more attention has been paid to estuary-resident species such as striped bass, threadfin shad, and silverside (Lehman et al. 2010)—and it is assumed with low certainty that *Microcystis* has low importance to late fall–run foragers and migrants. As discussed in Appendix 5.F, *Biological Stressors on Covered Fish*, Section 5.F.7.3, *Potential Effects: Benefits and Risks*, changes in water operations under *CM1 Water Facilities and Operation* and restoration under *CM4 Tidal Natural Communities Restoration* would lead to longer water residence time within some portions of the Plan Area where *Microcystis* tends to be most likely to occur. As noted in the delta smelt effects analysis (Section 5.5.1.2.3, *Blue-Green Alga Microcystis Direct and Indirect Effects*), this has the potential to result in greater likelihood of blooms, particularly in the late long-term with warmer water temperatures, a key predictor of bloom occurrence (Appendix 5.F, Section 5.F.8.1.1, *Cyanobacteria Microcystis*). Given that toxins from *Microcystis* often increase in September/October with bloom die-off (Lehman pers. comm. cited by USFWS 2008a), it is concluded with low certainty that there is the potential for a low negative change to the *Microcystis* attribute for foraging and migrating juvenile late fall–run Chinook salmon. Agency biologist opinion during the August 2013 workshops was limited on the issue of *Microcystis* toxicity, but concurred that there was potential for a very low negative effect to occur to late fall–run Chinook salmon juveniles.

5.5.5.2.3 Impact of Take on Species

As described for winter-run Chinook salmon, the BDCP may result in incidental take of fall-run and late fall–run Chinook salmon from a number of factors. Construction and maintenance at the proposed north Delta intakes and other locations, including restoration areas, may result in a number of adverse effects on salmonids, including disturbance from in-water activity and hydrodynamic changes, physical injury from riprap/rock placement and noise and vibration, exposure to fuel or oil, and elevated turbidity levels (Appendix 5.H, *Aquatic Construction and Maintenance Effects*). These temporary effects are unlikely to be considerable on fall-run and late fall–run Chinook salmon with application of appropriate avoidance and minimization measures. As a result, there will be minimal impact of take from these activities.

In relation to existing conditions, the BDCP will reduce overall entrainment of fall-run and late fall–run Chinook salmon as a result of less south Delta export pumping and screening of the north Delta intakes, which will be designed to limit impingement and mortality of juvenile salmonids through incorporation of appropriate approach and sweeping velocity criteria. As noted for winter-run Chinook salmon, lower river flow downstream of the north Delta intakes under the BDCP may affect survival of juvenile fall-run and late fall–run Chinook salmon during downstream migration along the Sacramento River and also could negatively affect upstream migration through changes in flows/olfactory cues. These effects are challenging to quantify in terms of take, however, and will need to be evaluated through research and adaptive management.

5.5.5.2.4 Abundance, Productivity, Life-History Diversity, and Spatial Diversity

The analysis presented for winter-run Chinook salmon (Section 5.5.3.4) also includes fall-run/late fall–run Chinook.

5.5.5.2.5 Net Effects

Figure 5.5.5-1 and Figure 5.5.5-2 show the relative population-level outcomes, by attribute, for Sacramento River region fall-run and late fall–run Chinook salmon that will result from implementation of the BDCP. The positive effects of the BDCP outweigh the negative effects, so that the net effect of the BDCP is expected to be beneficial to these runs of Chinook salmon. The net effects discussion presented for winter-run Chinook salmon is also relevant to fall-run and late fall–run Chinook salmon, particularly because it is challenging to differentiate the effects of a number of conservation measures between Chinook salmon runs based on existing information. As noted for winter-run and spring-run Chinook salmon, most of the concluded effects are made with moderate certainty, whereas the benefit of enhanced floodplain availability for foraging juveniles is assessed to be of high certainty. The assumption of a relatively large proportion of foraging juvenile fall-run Chinook salmon in the Plan Area compared to migrating juveniles means that the benefit of greater Yolo Bypass floodplain availability that should be facilitated by CM2 is of particular importance to this run; a relatively low proportion of foraging juveniles for late fall–run Chinook salmon means that the benefit to this run from enhanced Yolo Bypass floodplain habitat is concluded to be lower than for fall-run Chinook salmon (although there is still considerable benefit), but there is appreciable importance as an alternative migration route. As described in the net effects analyses for winter- and spring-run Chinook salmon, many effect conclusions are made with low certainty that reflect low certainty about the current importance of the attribute, low certainty about the magnitude of the change that BDCP may provide, or low certainty regarding both the importance and change to the attribute. As described for winter-run and spring-run Chinook salmon, the negative change in Plan Area flows for migrating juvenile spring-run Chinook salmon is also made with high certainty; it is again emphasized here that real-time operations would aim to minimize any potential adverse effects of the north Delta intakes on Plan Area flows in relation to migrating juvenile salmonids. For fall-run Chinook salmon in particular, the overlap of the juvenile migratory period with the spring period of enhanced flows under HOS is of importance in relation to flows under existing conditions.

Category	Appendix	Attributes	Definition	Eggs	Foragers	Migrants	Adults
Food	E	Zooplankton community	Species composition of the zooplankton community and presence of suitable prey species	NA	Zero	Zero	
		Zooplankton abundance	The abundance of zooplankton	NA	Low	Low	
		Benthic & Epibenthic prey abundance	The abundance of epibenthic prey species such as amphipods	NA	High	Low	
		Insect abundance	The abundance of insect prey	NA	High	Low	
Entrainment & Impingement	B	North Delta Intakes	Potential entrainment/impingement from the proposed North Delta intakes	NA	Very Low -	Very Low -	
		South Delta Pumps	Pumping rate from the CVP/SWP south Delta export facilities and resulting entrainment	NA	Low	Low	
		North Bay Aqueduct	Entrainment from the SWP NBA facilities	NA			
		Ag Diversions	Entrainment from Agriculture Diversions	NA	Very Low	Very Low	
Migration & Movement	C	Plan Area Flows	Magnitude, timing, direction, and duration of flows during migratory periods throughout the Plan Area	NA	Low-	Moderate-	Very Low -
		Interior Delta Entry	Entry of fish into the interior Delta from the mainstem Sacramento or San Joaquin Rivers through channels such as Georgiana Slough or Old River	NA	Low	Low	NA
		Passage Barriers	Structures or conditions that potentially block upstream or downstream migration	NA			Low
Habitat	C, E	Inter-tidal habitat	Intertidal area from the mean low low water level to the extreme high water level that may support intertidal vegetation and form mudflats; dynamic elements of habitat such as appropriate salinity are considered on a species-specific basis	NA	High	Low	
		Channel Margin	The extent of shallow water, low slope habitat that generally is characterized by structural complexity, native emergent vegetation and riparian shading cover	NA	Moderate	Moderate	
		Floodplains	The interface between upland topography and river hydrology during high flow events	NA	High	Moderate	
		Riparian	Forest and scrub that occurs along the margins of river channels and within floodplains	NA	NA	NA	NA
		Sub-tidal habitat	Extent and location of sub-tidal area in the Plan Area, including the low salinity zone (LSZ); dynamic elements of habitat such as appropriate salinity are considered on a species-specific basis	NA	Low	Low	
Sediment	C	Water clarity	Water clarity in the Plan Area as influenced by amount of suspended material within the water column	NA	Zero	Zero	
Temperature	C	Temperature	Adverse effects of high temperatures within the Plan Area	NA			
DO	C	Dissolved Oxygen	Adverse effects of low dissolved oxygen level within the Plan Area	NA			
Toxins	D, F	Contaminants	Adverse effects of methylated mercury, selenium, pesticides and other pollutants	NA	Very Low -	Very Low -	
		Microcystis	The abundance of Microcystis aeruginosa blooms that are toxic to covered fish species and their food	NA			
Predation	F	Predation	The species-specific consumption of covered fish species by predatory fish (e.g, striped bass, Sacramento pikeminnow, centrarchid bass species, catfish, and inland silversides); note that the attribute aims to isolate predation effects that may not be captured by other attributes, e.g., at manmade structures such as the north Delta diversions	NA	Low	Low	
		Illegal Harvest	Illegal harvest of covered fish species in the Plan Area	NA	Low	Low	Low

In-stream Habitat	C	Sacramento R. Habitat	Flows in the Sacramento River mainstem (below Keswick Dam to the Plan Area) that influence spawning, egg incubation, rearing, or holding habitat	Zero	Zero	Zero	Zero
		Feather R. Habitat	Flows in the Feather River (below Oroville Dam to the confluence with the Sacramento River) that influence spawning, egg incubation, rearing, or holding habitat	Zero	Low	Low	Zero
		American R. Habitat	Flows in the American River (below Nimbus Dam to the confluence with the Sacramento River) that influence spawning, egg incubation, rearing, or holding habitat	Zero	Zero	Zero	Zero
Migration & Movement	C	Sacramento R. Migration Flows	Flows in the Sacramento River mainstem (below Keswick Dam to the Plan Area) that influence migration and movement	NA	Zero	Zero	Zero
		Feather R. Migration Flows	Flows in the Feather River (below Oroville Dam to the confluence with the Sacramento River) that influence migration and movement	NA	Low	Low	Low-
		American R. Migration Flows	Flows in the American River (below Nimbus Dam to the confluence with the Sacramento River) that influence migration and movement	NA	Zero	Zero	Zero
Temperature	C	Sacramento R. Temperature	Adverse effects of high water temperatures in the Sacramento River mainstem (below Keswick Dam to the Plan Area)				Zero
		Feather R. Temperature	Adverse effects of high water temperatures in the Feather River (below Oroville Dam to the confluence with the Sacramento River)	Zero			Zero
		American R. Temperature	Adverse effects of high water temperatures in the American River (below Nimbus Dam to the confluence with the Sacramento River)	Zero			Zero

Certainty

- No effect conclusion made because attribute assumed not to have importance as a current constraint
- NA — Life stage not present or not applicable
- Low certainty
- Moderate certainty
- High certainty
- Very high certainty

Figure 5.5.5-1. Effect of the Covered Activities on Sacramento River Region Fall-Run Chinook Salmon

Category	Appendix	Attributes	Definition	Eggs	Foragers	Migrants	Adults
Food	E	Zooplankton community	Species composition of the zooplankton community and presence of suitable prey species	NA	Zero	Zero	
		Zooplankton abundance	The abundance of zooplankton	NA	Low	Very Low	
		Benthic & Epibenthic prey abundance	The abundance of epibenthic prey species such as amphipods	NA	Moderate	Low	
		Insect abundance	The abundance of insect prey	NA	Moderate	Low	
Entrainment & Impingement	B	North Delta Intakes	Potential entrainment/impingement from the proposed North Delta intakes	NA	Very Low -	Very Low -	
		South Delta Pumps	Pumping rate from the CVP/SWP south Delta export facilities and resulting entrainment	NA	Moderate	Moderate	
		North Bay Aqueduct	Entrainment from the SWP NBA facilities	NA			
		Ag Diversions	Entrainment from Agriculture Diversions	NA	Very Low	Very Low	
Migration & Movement	C	Plan Area Flows	Magnitude, timing, direction, and duration of flows during migratory periods throughout the Plan Area	NA	Low-	Moderate-	Very Low -
		Interior Delta Entry	Entry of fish into the interior Delta from the mainstem Sacramento or San Joaquin Rivers through channels such as Georgiana Slough or Old River	NA	Low	Low	NA
		Passage Barriers	Structures or conditions that potentially block upstream or downstream migration	NA			Low
Habitat	C, E	Inter-tidal habitat	Intertidal area from the mean low low water level to the extreme high water level that may support intertidal vegetation and form mudflats; dynamic elements of habitat such as appropriate salinity are considered on a species-specific basis	NA	High	Low	
		Channel Margin	The extent of shallow water, low slope habitat that generally is characterized by structural complexity, native emergent vegetation and riparian shading cover	NA	Moderate	Low	
		Floodplains	The interface between upland topography and river hydrology during high flow events	NA	High	Moderate	
		Riparian	Forest and scrub that occurs along the margins of river channels and within floodplains	NA	NA	NA	NA
		Sub-tidal habitat	Extent and location of sub-tidal area in the Plan Area, including the low salinity zone (LSZ); dynamic elements of habitat such as appropriate salinity are considered on a species-specific basis	NA	Low	Low	
Sediment	C	Water clarity	Water clarity in the Plan Area as influenced by amount of suspended material within the water column	NA	Zero	Zero	
Temperature	C	Temperature	Adverse effects of high temperatures within the Plan Area	NA			
DO	C	Dissolved Oxygen	Adverse effects of low dissolved oxygen level within the Plan Area	NA			
Toxins	D, F	Contaminants	Adverse effects of methylated mercury, selenium, pesticides and other pollutants	NA	Very Low -	Very Low -	
		Microcystis	The abundance of Microcystis aeruginosa blooms that are toxic to covered fish species and their food	NA	Very Low -	Very Low -	
Predation	F	Predation	The species-specific consumption of covered fish species by predatory fish (e.g., striped bass, Sacramento pikeminnow, centrarchid bass species, catfish, and inland silversides); note that the attribute aims to isolate predation effects that may not be captured by other attributes, e.g., at manmade structures such as the north Delta diversions	NA	Low	Low	
		Illegal Harvest	Illegal harvest of covered fish species in the Plan Area	NA	Low	Low	Low

Category	Appendix	Attributes	Definition	Eggs	Foragers	Migrants	Adults
In-stream Habitat	C	Sacramento R. Habitat	Flows in the Sacramento River mainstem (below Keswick Dam to the Plan Area) that influence spawning, egg incubation, rearing, or holding habitat	Zero	Zero	Zero	Zero
		Feather R. Habitat	Flows in the Feather River (below Oroville Dam to the confluence with the Sacramento River) that influence spawning, egg incubation, rearing, or holding habitat	NA	NA	NA	NA
		American R. Habitat	Flows in the American River (below Nimbus Dam to the confluence with the Sacramento River) that influence spawning, egg incubation, rearing, or holding habitat	NA	NA	NA	NA
Migration & Movement	C	Sacramento R. Migration Flows	Flows in the Sacramento River mainstem (below Keswick Dam to the Plan Area) that influence migration and movement	NA	Zero	Zero	Zero
		Feather R. Migration Flows	Flows in the Feather River (below Oroville Dam to the confluence with the Sacramento River) that influence migration and movement	NA	NA	NA	NA
		American R. Migration Flows	Flows in the American River (below Nimbus Dam to the confluence with the Sacramento River) that influence migration and movement	NA	NA	NA	NA
Temperature	C	Sacramento R. Temperature	Adverse effects of high water temperatures in the Sacramento River mainstem (below Keswick Dam to the Plan Area)				
		Feather R. Temperature	Adverse effects of high water temperatures in the Feather River (below Oroville Dam to the confluence with the Sacramento River)	NA	NA	NA	NA
		American R. Temperature	Adverse effects of high water temperatures in the American River (below Nimbus Dam to the confluence with the Sacramento River)	NA	NA	NA	NA

Certainty

- (grey) No effect conclusion made because attribute assumed not to have importance as a current constraint
- NA — Life stage not present or not applicable
- (green) Low certainty
- (light blue) Moderate certainty
- (dark blue) High certainty
- (purple) Very high certainty

Figure 5.5.5-2. Effect of the Covered Activities on Late Fall–Run Chinook Salmon

As discussed for winter-run Chinook salmon, under *CM4 Tidal Natural Communities Restoration* the BDCP plans to increase considerably the amount of shallow-water tidal habitat in the Plan Area, in particular in areas that are important for Chinook salmon from the Sacramento River region, i.e., the Cache Slough, West Delta, and Suisun Marsh ROAs. Among all the covered salmonids, Sacramento River region fall-run Chinook salmon probably will benefit the most from the restoration under CM4 and the other habitat restoration and enhancement measures such as *CM2 Yolo Bypass Fisheries Enhancement* and *CM6 Channel Margin Enhancement.* This is because fall-run Chinook salmon have the greatest proportion of foraging juveniles that spend relatively long durations of time within the Plan Area for rearing; the BDCP will provide substantial additional habitat for occupancy, provision of food resources, and refuge from predators, thus allowing a greater expression of life-history diversity for a run that has historically been managed with an emphasis on migrant survival (Miller et al. 2010). Late fall–run Chinook salmon, in contrast, largely occupy the Plan Area as migrants, but still are expected to derive benefit from habitat restoration and other conservation measures.

The BDCP is expected to decrease entrainment of fall-run and late fall–run Chinook salmon juveniles at the south Delta export facilities through implementation of dual conveyance. As noted for winter-run Chinook salmon, pulse protection flows in combination with appropriate approach/sweeping velocity criteria and small-aperture screens at the new north Delta intakes are intended to limit adverse effects on fall-run and late fall–run Chinook salmon juveniles, with the potential for negative effects to be informed by targeted research and adaptive management. Entry into the interior Delta through Georgiana Slough may be less under the BDCP than existing conditions through the installation of nonphysical barriers under *CM16 Nonphysical Fish Barriers*, coupled with appropriate bypass flows past the north Delta intakes under *CM1 Water Facilities and Operation* to lessen risk of increased flow reversals in the Sacramento River in the vicinity of Georgiana Slough. As noted for winter-run Chinook salmon, *CM15 Localized Reduction of Predatory Fish* has the potential to improve juvenile fall-run and late fall–run Chinook salmon at localized predation hotspots and/or mitigate the effects of potentially increased predation in locations such as the new north Delta intakes, with much targeted research and adaptive management required to inform the relatively low certainty in this measure. Improvement of passage at Fremont Weir has the potential to improve upstream passage for late fall–run Chinook salmon, as the migration period coincides with times when the Yolo Bypass floods, whereas fall-run Chinook salmon migrate earlier than the period of typical flooding and therefore may not derive as much benefit.

Less flow in the Sacramento River below the north Delta intakes under the BDCP may have adverse effects on fall-run and late fall–run Chinook salmon. This is concluded to somewhat reduce survival of fall-run and late fall–run Chinook salmon juveniles migrating past the intakes, with the effects more likely to occur in the less tidally influenced reaches where river flow dominates migration flows, as opposed to the tidally influenced reaches further downstream. The reduced outflow from the Sacramento River during the adult migration periods along with the possible change in olfactory signals due to the change in flow mixture could affect upstream migration, although the certainty of this adverse effect is low, however, and requires monitoring and evaluation during implementation of the BDCP. Contaminants and other negative effects from restoration and construction activities may occur but are anticipated to be low. Fall-run Chinook salmon juvenile and fry rearing habitat conditions would be substantially improved in the Feather River, and may be somewhat improved in the American River during some months and water-year types. Sacramento River spawning conditions for fall-run Chinook salmon would be improved, although there is some risk of increased redd scour, which would not affect overall juvenile production in the Sacramento River. There would generally be no flow- or water temperature–related effects of the BDCP on spawning and egg incubation and adult migration and holding habitat for late fall–run Chinook salmon in the Sacramento River, although there would be some small negative effect on juvenile rearing habitat, driven by a reduction in juvenile rearing habitat area as predicted by SacEFT. However, as described above, there would be no change in end of May or end of September storage in Shasta, and existing operating criteria would not be affected. Modeled results could be managed in real-time under the existing criteria to avoid any consequential changes in the Sacramento River.

As noted in the winter-run Chinook salmon discussion, a qualitative assessment of Central Valley salmonids covered by the BDCP suggested that late fall–run Chinook salmon were among the covered species that will be vulnerable to climate change in all watersheds they inhabit, whereas fall-run Chinook salmon will be vulnerable in portions of the watersheds that they inhabit, because they tend to leave tributaries during warmer months because of their ocean-type life history (Moyle et al. 2008). Water temperature was examined at the subregional scale in the Plan Area, and showed little difference between existing conditions and the BDCP for the number of days within the suboptimal, optimal, supraoptimal, and lethal ranges for fall-run and late fall–run Chinook salmon (Appendix 5.C, Attachment 5C.C, *Water Temperature*). Climate change is the main driver on temperature within the Plan Area, and it will have increasing importance for the species into the future. DO also was found to be similar between existing conditions and the BDCP (Appendix 5.C, *Flow, Passage, Salinity, and Turbidity*, Section 5.C.5.4.3, *Dissolved Oxygen*).

As described for delta smelt, there is uncertainty about the nature of changes in water clarity that may result from implementation of the BDCP (Appendix 5.C, Attachment 5C.D *Water Clarity—Suspended Sediment Concentration and Turbidity*); the issue appears of greater importance for delta smelt. Water clarity in newly restored areas may be relatively high as a result of factors such as water depth and wind fetch resuspending sediments, whereas water clarity outside the restored areas could be affected by the north Delta intakes and restoration areas capturing sediment that otherwise would have moved downstream. Fall-run Chinook salmon juveniles occur in the Plan Area during winter-spring when flows and turbidity tend to be higher. A sensitivity analysis of the proportional through-Delta survival method based on Newman (2003) was undertaken to investigate the effects on through-Delta survival of an increase in water clarity (decrease in turbidity) as estimated from less river flow below the north Delta intakes under the BDCP; this analysis showed very little difference in survival based on the estimated change in turbidity (Appendix 5.C, Section 5.C.5.3.5, *Juvenile Spring-Run and Fall-Run Chinook Salmon Smolt through-Delta Survival (Newman 2003)*). Late fall–run Chinook salmon have a juvenile outmigration period that overlaps the low-flow fall period when water clarity tends to be higher and may have more potential to be affected by any changes in downstream water clarity because of the BDCP.

The magnitude of benefits of the BDCP for Sacramento River region fall-run and late fall–run Chinook salmon at the population level cannot be quantified with certainty, but it is concluded with moderate certainty that the overall net effect of the BDCP will be positive. As described for winter-run Chinook salmon, provision of a greater diversity of habitat, in particular, should encourage greater life-history diversity that is expected to benefit the species as circumstances change in the future with climate change.

Therefore, the BDCP will minimize and mitigate impacts to the maximum extent practicable and provide for the conservation and management of the Sacramento River fall-run/late fall–run salmon in the Plan Area.

5.5.5.3 San Joaquin River Fall-Run

5.5.5.3.1 Beneficial Effects

Restored Floodplain, Tidal, and Channel Margin Habitat

Floodplain and Channel Margin Habitat

The BDCP will provide extensive floodplain habitat and associated channel margin and riparian habitat in the South Delta subregion, which will increase floodplain availability and channel complexity, leading to an improvement in conditions for juvenile San Joaquin River region fall-run Chinook salmon.

As noted for winter-run Chinook salmon, in Section 5.5.3.5, *Net Effects*, loss of floodplain habitat in the Central Valley has been extensive. The San Joaquin Valley is no exception, with Williams (2006: 170) noting that only vestiges of overbank habitat remaining within the levees. In addition, loss of suitable channel margin and riparian habitat has also been extensive because of flood control armoring of river banks and other activities. For this effects analysis, it was assumed for San Joaquin River region fall-run Chinook salmon that floodplain habitat and channel margin habitat availability are attributes of critical importance for foragers (high certainty) and moderate importance for migrating juveniles (high certainty).

CM5 Seasonally Inundated Floodplain Restoration plans to restore up to 10,000 acres of floodplain habitat within the South Delta subregion, with at least 1,000 acres restored by year 15 of the BDCP and a further 9,000 acres by year 40 (Appendix 5.E, *Habitat Restoration*, Section 5.E.5, *Conservation Measure 5 Seasonally Inundated Floodplain Restoration*). Several conceptual floodplain restoration corridors have been analyzed for their potential to provide floodplain habitat that would be suitable for juvenile Chinook salmon rearing (i.e., foraging) in the lower San Joaquin River and South Delta subregion, i.e., with San Joaquin River at Vernalis flows of at least 10,634 cfs for at least 14 days every 3 years during December 1 to May 31 (Appendix 5.E, Section 5.E.5.5.2, *Results*; Attachment 5E.A, *BDCP South Delta Habitat and Flood Corridor Planning*). The analysis suggests that within the conceptual corridors around 1,700 acres of floodplain meet the Chinook salmon rearing criteria under existing conditions every 3 years, which is around 20% of the total corridor footprint excluding riverine habitat; the majority is found in corridors 1A and 1B, in the lower San Joaquin River between Vernalis and Interstate 5 (Table 5.5.5-11; Figure 5.E.5-3, *Overview of the South Delta Subregion*, in Appendix 5.E). Within the floodplain restoration corridor footprints, there are nearly 37,000 additional acres of potential, restorable floodplain habitat, of which over 10,000 acres (approximately 25%) is floodplain meeting the above Chinook salmon rearing criteria every 3 years. To illustrate the potential magnitude of change in the extent of floodplain that could occur under the BDCP, if the BDCP restores 10,000 acres of floodplain habitat (as is planned for CM5) and approximately 25% meets Chinook salmon rearing criteria every 3 years (per the ratio of additional acres to rearing criteria shown above), this would represent an increase in floodplain habitat for San Joaquin River region Chinook salmon juveniles from around 1,700 acres under existing conditions to 4,200 acres under the BDCP, a relative difference of over 2.5 times. Associated with these corridors are various extents of potential passive and active channel margin enhancement, along with riparian habitat (Table 5.5.5-12).

Table 5.5.5-11. Estimated Extent of Seasonally Inundated Floodplain in the South Delta Subregion with Conceptual Restoration Corridors, with Extent of Floodplain Meeting Chinook Salmon Rearing Criteria[a]

Corridor	Existing Conditions		Conceptually Restored Corridor Conditions		Potential Increase in Floodplain Inundation from Restoration	
	Corridor Footprint (acres)	Floodplain Meeting Salmon Criteria (acres)	Corridor Footprint (acres)	Floodplain Meeting Salmon Criteria (acres)	Increase in Corridor Footprint (acres)	Increase in Floodplain Meeting Salmon Criteria (acres)
1A	2,524	910	11,741	1,565	9,217	655
1B	1,593	532	5,380	930	3,787	398
2A	1,189	46	2,289	223	1,100	177
2B (Fabian Tract)	484	29	6,710	3,827	6,226	3,798
3	706	88	5,174	1,396	4,468	1,308
4	252	26	5,881	2,182	5,629	2,156
Total	8,421	1,706	37,175	10,123		

[a] Chinook salmon rearing criteria are at least approximately 10,634 cfs in the San Joaquin River at Vernalis flow for at least 14 days every 3 years during December 1 to May 31.

Table 5.5.5-12. Potential Channel Margin Enhancement and Riparian Habitat Restoration in Association with the Potential South Delta BDCP Floodplain Restoration Corridors in the South Delta Subregion

Corridor	Channel Margin Enhancement (Miles)		Riparian Habitat (Acres)	
	Passive	Active	Existing Conditions	With Floodplain Restoration
1A	16 LB + 16 RB	0	1,191	8,219
1B	8.5 RB	0	588	3,228
2A	0	0	263	1,145
Fabian Tract	11.5 MC	0	189	235
2B	11.5 MC	0	452	2,295
3	11 LB	11 RB	297	1,480
4	12 LB	12 RB	168	2,061

LB = left bank; RB = right bank; MC = multiple channels along one bank; Passive = passive enhancement; active = active enhancement.

Some of the main benefits of floodplain and associated habitat restoration include greater extent of habitat for rearing; increased food production that may be consumed in situ or that may be exported for consumption in nearby areas, leading to improving growth and greater survival upon emigration from the area; and better connectivity between areas of good quality habitat along migration routes, enhancing survival and growth opportunities. A modified DRERIP evaluation of the potential restoration corridors 1A, 1B, 2A, 2B, and 4 was undertaken to evaluate ecological outcomes of the potential south Delta corridors on San Joaquin River region fall-run Chinook salmon and other species (Appendix 5.E, *Habitat Restoration*, Section 5.E.5.5.2, *Results*; Attachment 5E.A, *BDCP South Delta Habitat and Flood Corridor Planning*, Section 5.E.A.4.2). In keeping with previous DRERIP evaluations, ecological outcomes were scored for magnitude and certainty, with magnitude ranging from minimal (little effect) to high (expected sustained major population level effect from a large-scale action). Of the potential restoration corridors evaluated, corridor 4 (Head of Old River to Stockton) was assessed to provide the greatest potential positive outcomes for Chinook salmon.

The modified DRERIP assessment suggested with moderate certainty that there would be moderate positive change to rearing habitat under the BDCP; an assumption made was that a Head of Old River barrier would be installed, as is proposed under the BDCP, to increase the proportion of the population passing the area. Note, however, that the installation of an operable barrier under the BDCP is assumed to allow opening of the barrier, so that in a number of months during which San Joaquin River Chinook salmon would be present, the barrier may be open part of the time (and always open at Vernalis flows greater than 10,000 cfs), although the frequency and timing of operation would be dictated through adaptive management and based on actual presence of fish and hydrologic conditions. Associated with corridor 4 was around 24 miles of channel margin enhancement, for which the modified DRERIP evaluation suggested that there would be a moderate positive outcome for juvenile Chinook salmon (with moderate certainty) from increasing channel complexity (including in-channel and channel margin riparian vegetation, large woody debris, and emergent vegetation). Floodplain habitat in some corridors may, because of physical constraints, be limited to small patches of edge or margin habitat rather than large contiguous areas. It is important to note that the modified DRERIP results are for one of a number of potential restoration areas; nevertheless, the results are useful in terms of being indicative of potential change to the south Delta floodplain and associated habitat from BDCP restoration that is relevant to San Joaquin River fall-run Chinook salmon.

It is concluded that south Delta floodplain restoration under CM5 and associated channel margin enhancement and riparian restoration will provide a low positive change to the floodplain and channel margin habitat attributes for San Joaquin River fall-run Chinook salmon foraging and migrating juveniles, with low certainty for floodplain habitat because of the relatively infrequent inundation (although still occurring frequently enough to provide some benefit) and moderate certainty for channel margin habitat. During the August 2013 workshops, agency biologists felt that low or zero change was warranted for both the floodplain and channel margin attributes, generally with low certainty, although one comment suggested high certainty for channel margin. As noted under adverse effects, there are a number of potential negative changes that may result from the restoration activities, but positive changes are concluded to outweigh the negative changes. Efforts to assess potential south Delta restoration areas will consider factors such as the location of floodplain habitat in relation to risk of entrainment at the south Delta export facilities, which may occur if restored floodplains are draining into Old or Middle Rivers.

Tidal Habitat

The BDCP will greatly increase the extent of tidal habitat that is suitable for San Joaquin River region fall-run Chinook salmon juveniles, particularly in the South Delta subregion.

As noted in the winter-run net effects analysis, loss of tidal habitat because of land reclamation facilitated by levee construction is a major stressor on juvenile salmonids in the DRERIP conceptual model (Williams 2009). Attribute importance and certainty scores described under winter-run Chinook salmon are assumed to be applicable for San Joaquin River region fall-run Chinook salmon: intertidal habitat was assumed to be an attribute with high importance for foraging San Joaquin River region Chinook salmon juveniles (with high certainty) and low importance with moderate certainty for migrating juveniles, which was consistent with agency biologist thinking during the August 2013 workshops. It was assumed with moderate certainty that subtidal habitat has low importance as a current constraint for foraging and migrating salmonid juveniles (agency biologists thought zero importance would be appropriate for both life-history stages). Both intertidal and subtidal habitat was assumed to have zero importance as current constraint for adult salmonids, with very high certainty, consistent with agency biologist opinion on the level of importance.

The subregions most relevant to consider from the habitat suitability analysis (Appendix 5.E, *Habitat Restoration,* Section 5.E.4.4.1.1, *Habitat Suitability Analysis*) for San Joaquin River region fall-run Chinook salmon (including Mokelumne River fall-run Chinook) include the South Delta, East Delta, West Delta, Suisun Bay, and Suisun Marsh. The results of the habitat suitability analysis suggest that, in the late long-term, tidal HUs under the BDCP in these subregions would be more than 50% greater than under existing conditions for foraging juvenile Chinook salmon, including fall-run Chinook from the San Joaquin River region (Table 5.5.3-4 in Section 5.5.3). Of the additional nearly 20,000 HUs from restoration under the BDCP, nearly 14,000 HUs were from the south Delta ROA alone, and the relative change was over twofold in the South Delta subregion as a whole, which is of importance given that most San Joaquin River region fall-run Chinook are from tributaries of the San Joaquin River upstream of the Plan Area. For migrating juvenile Chinook salmon, including San Joaquin River region fall-run, the same subregions were estimated to provide just over 50,000 HUs under existing conditions and 65,000 HUs under the BDCP, in the late long-term (Table 5.5.3-5, in Section 5.5.3). Considering the Mokelumne River fall-run Chinook salmon population separately, the estimated extent of tidal habitat the BDCP in the late long-term in the most relevant subregions (i.e., the East Delta, West Delta, Suisun Marsh, and Suisun Bay) would be approximately 35,000 HUs for foraging juveniles and nearly 51,000 HUs for migrating juveniles; this compared to future conditions without the BDCP (i.e., accounting for sea level rise) of around 26,500 HUs for foragers and approximately 44,000 HUs for migrants.

The proportional increase in intertidal habitat area proposed under the BDCP (*CM4 Tidal Natural Communities Restoration*) is considerably greater than the proportional change in subtidal area that would result from restoration under CM4: for the subregions most relevant to San Joaquin River region fall-run Chinook salmon juveniles (South Delta, East Delta, West Delta, Suisun Bay, and Suisun Marsh), it is estimated that the intertidal acreage under existing conditions is around 20,000 acres (nearly 23,000 acres under EBC2_LLT), which compares to nearly 41,000 acres under the BDCP in the late long-term; for subtidal habitat, the estimated area under existing conditions (66,000–67,000 acres) is estimated to increase to nearly 87,000 acres under the BDCP in the late long-term. Considering Mokelumne River fish separately, intertidal acreage in relevant subregions (i.e., the subregions relevant to San Joaquin River salmonids as a whole but excluding the South Delta subregion) amounted to approximately 18,000 acres under EBC2_LLT, compared to nearly

26,000 acres under the BDCP in the late long-term (ESO_LLT); subtidal acreage in these subregions under EBC2_LLT is estimated to be around 51,000 acres, compared to over 60,000 acres with the BDCP.

It is concluded that the change to intertidal habitat for San Joaquin River region fall-run Chinook salmon juveniles represents a very high positive change for foraging juveniles and a moderate positive change for migrant juveniles; as noted for Sacramento River region fall-run Chinook salmon, it is assumed that foragers make up the majority (75%) of San Joaquin River fall-run Chinook salmon juveniles in the Plan Area. These conclusions both have moderate certainty. As noted for winter-run Chinook salmon, agency biologist opinion during the August 2013 workshops suggested that intertidal habitat for migrant juvenile Chinook salmon should receive a low or zero change; note that the relative lack of importance of intertidal habitat is captured in its assumed low importance (described above). The change in subtidal habitat is concluded to be moderate for both foragers and migrants, again with moderate certainty. Uncertainties related to tidal habitat restoration in the Plan Area are discussed in Appendix 5.E, *Habitat Restoration*, Attachment 5.E.B, *Review of Restoration in the Delta.* Examples of uncertainty include how much restored habitats may be reduced in value because of colonization by IAV and associated nonnative fish species that may prey on juvenile Chinook salmon or compete for food. *CM13 Invasive Aquatic Vegetation Control* aims to control IAV in the ROAs, which may limit predation, but there is uncertainty related to the ability to do so effectively.

Food Benefits from Restored Habitat

Tidal, floodplain, and channel margin habitat restoration under the BDCP has considerable potential to greatly increase the quantity of food available for juvenile San Joaquin River region fall-run Chinook salmon.

Background on the importance and characteristics of food for juvenile San Joaquin River region fall-run Chinook salmon is the same as described for winter-run Chinook salmon (Section 5.5.3.1.1, *Restored Floodplain, Tidal, and Channel Margin Habitat*). Consistent with that analysis, it was assumed with moderate certainty that benthic /epibenthic prey abundance and insect abundance have high importance for foraging San Joaquin River region fall-run Chinook salmon juveniles and low importance for migrating juveniles. As noted above for winter-run Chinook salmon, during the August 2013 workshops some agency biologists felt that the lack of information regarding food limitation warranted an assumption of moderate importance for benthic/epibenthic abundance and insect abundance; others agreed with an assumption of high importance. Also consistent with winter-run Chinook salmon, it was assumed with moderate certainty that zooplankton abundance has moderate importance for foraging San Joaquin River region fall-run Chinook salmon and low importance for migrating juveniles. The moderate degree of certainty is due to the relatively few number of studies of food limitation.

Because of their geographic location, food benefits from restored habitat in the South Delta and East Delta subregions are perhaps most relevant for San Joaquin River region fall-run Chinook salmon (including Mokelumne River fall-run Chinook, for which the changes in the East Delta subregion are most relevant). As described above, there would be appreciably more intertidal and floodplain habitat under the BDCP compared to under existing conditions, which, as discussed for winter-run Chinook salmon, has considerable potential to augment benthic/epibenthic and insect abundance. Along the potential rearing and migration corridor through the Plan Area (including the South Delta, West Delta, East Delta, Suisun Bay, and Suisun Marsh subregions), there were estimated to be just over 70,000 prod-acres under existing conditions (and under future conditions without the BDCP including late long-term sea level rise) compared to over 110,000 prod-acres under the BDCP in the late long-term, a 50% increase (Table 5.5.3-6 in Section 5.5.3). For Mokelumne River fish alone, in the most relevant subregions (East Delta, West Delta, Suisun Bay, and Suisun Marsh), there were estimated to be around 57,000 prod-acres under future conditions without the BDCP in the late long-term, compared to nearly 74,000 prod-acres under the BDCP in the late long-term (a difference of nearly 30%).

It is concluded with high certainty that there will be a high positive change to benthic/epibenthic and insect abundance for foraging and migrating juvenile fall-run Chinook salmon. During the August 2013 workshops, agency biologist comments specific to San Joaquin River fall-run Chinook salmon were limited, but one noted that changes in food for San Joaquin River Chinook salmon could be categorized as moderate on the basis of these fish perhaps not encountering restored areas as frequently as Sacramento River region Chinook salmon runs. It is concluded that there would be a low positive change in zooplankton abundance with low certainty for foraging fall-run salmon that reflects seasonality of zooplankton occurrence and uncertainty related to consumption of primary productivity by nonnative clams. The positive change in zooplankton abundance for migrant fall-run Chinook salmon is concluded to be moderate, reflecting later occurrence during warmer conditions, again with low certainty for the reasons described above.

Decreased Adult Straying into the Sacramento River Region

San Joaquin River upstream migration cues for migrating adult San Joaquin River region fall-run Chinook salmon will be greater from reduced operations of the south Delta export facilities under the BDCP, with considerable potential to reduce straying into the Sacramento River region.

As noted in the net effects discussion of winter-run Chinook salmon, olfactory cues and attraction flows are important in determining homing of adult Chinook salmon to natal tributaries (Marston et al. 2012). Straying rates of adult fall-run Chinook salmon from the San Joaquin River region—the southern tributaries of the San Joaquin River including the Stanislaus, Tuolumne, and Merced Rivers—into tributaries of the Sacramento River region were estimated by Marston et al. (2012) under the assumption that in-river releases of Merced River hatchery fall-run Chinook salmon juveniles would be representative of wild-origin Chinook from these tributaries. Estimated annual straying rates averaged 18% and ranged from 0% to more than 70%. Marston et al. (2012) found that both San Joaquin River inflow and south Delta exports were correlated to straying rate, as discussed further below. The relatively high straying rate of San Joaquin River region fall-run Chinook salmon is a hindrance to the achievement of population goals in the basin (Marston et al. 2012). Therefore, for this effects analysis, it was assumed with high certainty that the attribute of Plan Area flows (including olfactory cues associated with such flows) is of high importance to adult San Joaquin River fall-run Chinook salmon. The high degree of certainty is based primarily on the work of Marston et al. (2012). Limited agency biologist comment during the August 2013 workshops suggested moderate importance with moderate certainty for the Plan Area flows attribute for San Joaquin River region fall-run Chinook salmon adults.

Marston et al. (2012) compared various statistical models to explain straying rate as a function of various flow terms hypothesized to be relevant during the San Joaquin River region fall-run Chinook salmon adult upstream migration period, including San Joaquin River pulse flows, south Delta exports, Old and Middle River flows, and the ratio of exports to San Joaquin River pulse flows. The analyses suggested that models including exports and pulse flow, either as a ratio, or as separate terms, appear to explain as much or more of the variability in stray rate as models with other hydrological variables.

The present effects analysis of the BDCP used Equation 2 of Marston et al. (2012:14) to estimate potential changes in straying rate as a function of south Delta combined exports to San Joaquin River inflow ratio (E:I), as described in detail in Appendix 5.C, *Flow, Passage, Salinity, and Turbidity,* Section 5.C.4.3.1.1, *Attraction and Upstream Migration Flows*. The BDCP has the potential to benefit adult San Joaquin River region Chinook salmon by allowing more San Joaquin River water to reach the West Delta subregion, possibly enhancing cues for attraction back to natal tributaries. The changes under the BDCP occur because of generally less south Delta exports facilitated by exports from the proposed north Delta intakes, particularly during the fall D-1641 pulse flow period, for which there would be no south Delta exports under the BDCP. Under existing conditions, the estimated stray rate averaged 12 to 16% across all water years, and ranged from 11 to 18% depending on water-year type (Table 5.5.5-13; see also Appendix 5.C, *Flow, Passage, Salinity, and Turbidity,* Section 5.C.5.3.13.1.5, *Fall-Run Chinook Salmon*). Estimates of the average stray rate for the ESO scenario were 8 to 12% lower than existing conditions across all water years combined, and ranged from around 6 to 18% lower depending on water-year type. This represented a relative difference of just over 50% to 80% lower straying under the BDCP. LOS does not include the Fall X2 requirement of the USFWS (2008a) BiOp and so was modeled to have somewhat greater south Delta exports than the ESO scenario; this resulted in somewhat lower (43 to 70%) relative differences between LOS and existing conditions and future conditions without the BDCP. To illustrate the potential consequences of straying at these rates, consider a hypothetical 10,000 upstream-migrating adult San Joaquin River region fall-run Chinook salmon. Under the 12% average straying rate for EBC2_LLT (Table 5.5.5-13), an estimated 8,800 adults would reach the spawning grounds in the San Joaquin River region. Under the ESO scenario average stray rate of 4%, an estimated 9,600 spawners would reach the spawning grounds, a relative difference of 800 (10%) more adults on the spawning grounds in the San Joaquin River region.

Table 5.5.5-13. Estimated San Joaquin River Region Fall-Run Chinook Salmon Adult Straying Rates to the Sacramento River

Water-Year Type[a]	By Scenario[b]				Change[c] under ESO_LLT		Change[c] under LOS_LLT	
	EBC2[b]	EBC2_LLT	ESO_LLT	LOS_LLT	Compared to EBC2	Compared to EBC2_LLT	Compared to EBC2	Compared to EBC2_LLT
All	16%	12%	4%	6%	-12% (-74%)	-8% (-67%)	-10% (-63%)	-6% (-52%)
Wet	18%	14%	4%	6%	-14% (-80%)	-11% (-76%)	-12% (-69%)	-9% (-62%)
Above normal	18%	12%	5%	7%	-13% (-74%)	-7% (-62%)	-11% (-61%)	-5% (-43%)
Below normal	16%	12%	4%	6%	-13% (-78%)	-9% (-70%)	-11% (-64%)	-6% (-52%)
Dry	14%	11%	4%	6%	-9% (-68%)	-6% (-59%)	-8% (-59%)	-5% (-47%)
Critical	13%	11%	5%	6%	-8% (-60%)	-6% (-53%)	-7% (-52%)	-5% (-44%)

[a] Water-year types do not account for the overlap of the fall months with the Fall X2 management period.

[b] For descriptions of scenarios, see Table 5.2-3.

[c] Negative values indicate lower straying under the BDCP compared to existing conditions or future conditions without the BDCP.

In addition to the above analysis based on Marston et al. (2012), DSM2 fingerprinting provided some perspective on changes in the proportion of water in the West Delta subregion (Collinsville) that is contributed by the San Joaquin River, which may provide an indication of the change in olfactory cues (Appendix 5.C, *Flow, Passage, Salinity, and Turbidity,* Section 5.C.5.3.13.1.5, *Fall-Run Chinook Salmon*). The average percentage of water at Collinsville originating in the San Joaquin River for the month of October (possibly the most important month affecting migration, based on Mesick's [2001] interpretation of data collected by Hallock et al. [1970]) was 0.2% under existing conditions, 0.3% under EBC2_LLT, and 3.3% under the BDCP in the late long-term. Results for September and November were around fivefold greater under the BDCP compared to existing conditions. For the rivers on the east of the Delta (i.e., the Mokelumne, Cosumnes, and Calaveras Rivers), which are relevant to Mokelumne River fall-run Chinook salmon, the DSM2 fingerprinting results also suggest a severalfold increase in the contribution to water composition at Collinsville: under EBC2_LLT, the average percentage of water from the east Delta rivers was 0.1% (range 0.0–1.5%) in September, 0.3% (0.0–1.5%) in October, and 0.4% (0.0–2.1%) in November; for ESO_LLT, the average percentage of water from the east Delta rivers was 0.7% (0.0–4.3%) in September, 1.0% (0.1–3.7%) in October, and 0.9% (0.1–3.7%) in November.

In light of the analyses presented above on straying and water composition at Collinsville, it is concluded that the BDCP will provide a moderate positive change to the Plan Area flows attribute that has the potential to reduce straying of San Joaquin River region fall-run Chinook salmon adults. There is a moderate certainty associated with this conclusion because, although the results of Marston et al. (2012) suggested a potential mechanism for south Delta export effects, an equally predictive model was obtained based on San Joaquin River inflow alone; the BDCP does not change San Joaquin River inflow. The uncertainty in the analysis would be informed by targeted research, including studies such as those suggested by Marston et al. (2012:19) on the relative roles of San Joaquin River inflow and south Delta exports on straying rate, timing of pulse flows and export reductions, and the role of pulse flows versus base flows. Agency biologist comments received during the August 2013 workshops also suggested that a conclusion of a moderate positive change with moderate certainty was warranted.

Reduced Entrainment

Entrainment loss of juvenile San Joaquin River region fall-run Chinook salmon under the BDCP will be lower than under existing conditions because the north Delta diversion operations will reduce reliance on south Delta export facilities.

As noted for other species, a major component of the covered activities will be a switch from export pumping solely in the south Delta to dual conveyance. A large proportion of San Joaquin River region fall-run Chinook salmon from the San Joaquin River are entrained at the south Delta export facilities, as illustrated by salvage data in relation to Chipps Island trawling data (Williams 2012). Although the NMFS (2009a) BiOp includes various measures to reduce entrainment loss, it is concluded that south Delta entrainment remains an attribute of high importance with high certainty for fall-run Chinook salmon juveniles (foragers and migrants).

The salvage density method was applied to fall-run Chinook salmon without regard to the region of origin of the salmon (Appendix 5.B, *Entrainment*, Section 5.B.5.4, *Salvage-Density Method (SWP/CVP South Delta Export Facilities)*), so that it is not clear from these data to what extent the fish represent San Joaquin River subregion fall-run. Hatchery-origin fall-run Chinook salmon released upstream in the Sacramento River region are salvaged in relatively low number compared to the number that reaches Chipps Island, whereas the number of hatchery-origin fall-run Chinook from the San Joaquin River region reaching Chipps Island is much less than the number salvaged (Williams 2012). This may indicate that San Joaquin River fall-run entrainment rates are much higher than entrainment rates of Sacramento River fall-run Chinook. In addition, San Joaquin River region fall-run Chinook salmon may be more likely to enter the CVP export facility via the Delta Mendota Canal than enter Clifton Court Forebay because the CVP entrance is located on Old River upstream of the SWP intake at Clifton Court Forebay. Results of differences in entrainment between the BDCP and existing conditions from the salvage density method are presented in Table 5.5.5-14 for both facilities combined, and for the CVP alone. The relative differences are very similar and suggest that, based on modeled changes in pumping weighted by seasonal and annual occurrence of fall-run-size Chinook salmon (i.e., the salvage density method), entrainment of juvenile San Joaquin River fall-run Chinook salmon at the SWP/CVP south Delta export facilities would be around 40% lower under the BDCP than under existing conditions, ranging from around 10% lower under the BDCP in dry years to around 60% lower under the BDCP in wet years, because of the ability to divert water from the north Delta intakes (Appendix 5.B, Section 5.B.6.1.4.1, *Salvage-Density Method*).

Table 5.5.5-14. Difference in Average Annual Entrainment Index[a] of Juvenile Sacramento River Region Fall-Run Chinook Salmon at the SWP/CVP South Delta Export Facilities under Future Conditions with the BDCP (Compared to Existing Conditions and to Future Conditions without the BDCP), Based on the Salvage Density Method

Water-Year Type	Change[b] under ESO_LLT[c] (SWP + CVP)		Change[b] under ESO_LLT[c] (CVP Only)	
	Compared to EBC2[c]	Compared to EBC2_LLT[c]	Compared to EBC2[c]	Compared to EBC2_LLT[c]
Wet	-85,538 (-64%)[c]	-80,786 (-63%)	-30,574 (-60%)	-29,206 (-59%)
Above normal	-12,714 (-40%)	-13,962 (-42%)	-3,777 (-41%)	-4,223 (-44%)
Below normal	-3,108 (-24%)	-3,864 (-28%)	-1,524 (-28%)	-1,570 (-29%)
Dry	-1,779 (-9%)	-3,538 (-17%)	-249 (-10%)	-267 (-11%)
Critical	-10,702 (-28%)	-7,626 (-21%)	-2,069 (-18%)	-1,362 (-13%)
All years	-24,481 (-44%)	-24,016 (-44%)	-8,127 (-42%)	-7,609 (-41%)

a Number of fish lost to entrainment

b Negative values indicate lower entrainment under the BDCP compared to existing conditions or future conditions without the BDCP. Values are based on normalized salvage density (Appendix 5.B, *Entrainment,* Section 5.B.6.1.4.1, *Salvage-Density Method*).

c For descriptions of scenarios, see Table 5.2-3.

The DPM was used to estimate the percentage of fall-run Chinook salmon smolts (greater than 70-mm fork length) from the San Joaquin River and Mokelumne River salvaged at the south Delta export facilities (Appendix 5.B, Section 5.B.5.7, *Delta Passage Model Salvage Estimates: Juvenile Chinook Salmon (SWP/CVP South Delta Export Facilities)*). The DPM estimated that average salvage of San Joaquin Chinook smolts would be around 20 to 25% less than salvage under existing conditions, with greater differences in wetter years and lower differences in drier years (Table 5.5.5-15; Appendix 5.B, Section 5.B.6.1.4.2, *Delta Passage Model Salvage Estimates*), reflecting the relative ability to use the north Delta versus south Delta export facilities. The data for the Mokelumne River fall-run were skewed, so that the average difference was around 35 to 40% lower under the BDCP whereas the median difference was around 6 to 13% lower under the BDCP (Table 5.5.5-16). The above examination considered the ESO scenario; results for estimated salvage from the DPM under LOS_LLT were the same as those of ESO_LLT (i.e., average annual salvage of 0.37% for San Joaquin fish and 0.11% for Mokelumne fish); whereas slightly lower entrainment was estimated under HOS_LLT compared to ESO_LLT (for San Joaquin fish: 0.35% under HOS_LLT; for Mokelumne fish: 0.10%).

Table 5.5.5-15. Estimated Percentage Salvage at the SWP/CVP South Delta Export Facilities of San Joaquin River Region Fall-Run Chinook Salmon Smolts Entering the Plan Area, Based on the Delta Passage Model

Water Year (Type[a])	By Scenario[b]			Change[c] under ESO_LLT	
	EBC2	EBC2_LLT	ESO_LLT	Compared to EBC2	Compared to EBC2_LLT
1976 (C)	0.493	0.481	0.431	-0.062 (-13%)	-0.050 (-10%)
1977 (C)	0.459	0.429	0.403	-0.056 (-12%)	-0.025 (-6%)
1978 (AN)	0.424	0.427	0.265	-0.159 (-38%)	-0.162 (-38%)
1979 (BN)	0.422	0.411	0.334	-0.088 (-21%)	-0.077 (-19%)
1980 (AN)	0.426	0.419	0.303	-0.123 (-29%)	-0.117 (-28%)
1981 (D)	0.475	0.470	0.446	-0.029 (-6%)	-0.024 (-5%)
1982 (W)	0.559	0.539	0.252	-0.307 (-55%)	-0.287 (-53%)
1983 (W)	0.696	0.682	0.162	-0.534 (-77%)	-0.520 (-76%)
1984 (W)	0.416	0.423	0.345	-0.071 (-17%)	-0.079 (-19%)
1985 (D)	0.472	0.463	0.419	-0.053 (-11%)	-0.044 (-9%)
1986 (W)	0.431	0.424	0.297	-0.133 (-31%)	-0.127 (-30%)
1987 (D)	0.508	0.472	0.455	-0.053 (-10%)	-0.018 (-4%)
1988 (C)	0.496	0.467	0.411	-0.085 (-17%)	-0.056 (-12%)
1989 (D)	0.509	0.494	0.456	-0.053 (-10%)	-0.038 (-8%)
1990 (C)	0.471	0.471	0.422	-0.049 (-10%)	-0.050 (-11%)
1991 (C)	0.486	0.488	0.497	0.012 (2%)	0.009 (2%)
Average	0.484	0.473	0.369	-0.115 (-24%)	-0.104 (-22%)

[a] Abbreviations of water-year types: W = wet; C = critical; AN = above normal; BN = below normal; D = dry

[b] For descriptions of scenarios, see Table 5.2-3.

[c] Negative values indicate lower values under the BDCP compared to existing conditions or future conditions without the BDCP.

Table 5.5.5-16. Estimated Percentage Salvage at the SWP/CVP South Delta Export Facilities of Mokelumne River Fall-Run Chinook Salmon Smolts Entering the Plan Area, Based on the Delta Passage Model

Water Year (Type[a])	By Scenario[b]			Change[c] under ESO_LLT	
	EBC2	EBC2_LLT	ESO_LLT	Compared to EBC2	Compared to EBC2_LLT
1976 (C)	0.116	0.116	0.110	-0.006 (-5%)	-0.007 (-6%)
1977 (C)	0.108	0.094	0.099	-0.009 (-8%)	0.004 (5%)
1978 (AN)	0.204	0.203	0.106	-0.098 (-48%)	-0.096 (-48%)
1979 (BN)	0.139	0.126	0.113	-0.025 (-18%)	-0.012 (-10%)
1980 (AN)	0.164	0.150	0.115	-0.049 (-30%)	-0.035 (-23%)
1981 (D)	0.131	0.121	0.147	0.016 (12%)	0.026 (21%)
1982 (W)	0.346	0.285	0.117	-0.229 (-66%)	-0.168 (-59%)
1983 (W)	0.702	0.703	0.076	-0.626 (-89%)	-0.626 (-89%)
1984 (W)	0.121	0.121	0.110	-0.011 (-9%)	-0.011 (-9%)
1985 (D)	0.126	0.115	0.113	-0.014 (-11%)	-0.002 (-2%)
1986 (W)	0.194	0.140	0.112	-0.083 (-42%)	-0.029 (-20%)
1987 (D)	0.138	0.116	0.109	-0.028 (-21%)	-0.007 (-6%)
1988 (C)	0.119	0.103	0.099	-0.020 (-17%)	-0.004 (-4%)
1989 (D)	0.126	0.116	0.123	-0.003 (-2%)	0.006 (5%)
1990 (C)	0.112	0.112	0.108	-0.003 (-3%)	-0.003 (-3%)
1991 (C)	0.115	0.117	0.122	0.007 (6%)	0.006 (5%)
Average	0.185	0.171	0.111	-0.074 (-40%)	-0.060 (-35%)

[a] Abbreviations of water-year types: W = wet; C = critical; AN = above normal; BN = below normal; D = dry

[b] For descriptions of scenarios, see Table 5.2-3.

[c] Negative values indicate lower abundance under the BDCP compared to existing conditions or future conditions without the BDCP.

It is concluded with moderate certainty that the BDCP will provide a moderate positive change (i.e., reduction) to the south Delta export entrainment of San Joaquin River region fall-run Chinook salmon juveniles (foragers and migrants). The level of certainty is related to the attributes of interior Delta entry and Plan Area flow for migration, discussed further below. Uncertainty is related to the fact that there is very little information available to inform a situation of low or no south Delta export pumping in the south Delta, as may occur under the BDCP in wetter years. As noted further below, there is some evidence to suggest that export pumping has a positive relationship to survival (Newman 2010; see Appendix 5.C, *Flow, Passage, Salinity, and Turbidity,* Section 5.C.4.3.2.2, *Juvenile Chinook Salmon Smolt through-Delta Survival (Delta Passage Model)*, for a description of the DPM). This complicates the interpretation of changes in south Delta export pumping and necessitates consideration of interior Delta entry and the effects of the proposed operable barrier at the Head of Old River, discussed below. Limited agency biologist opinion during the August 2013 workshops also suggested a moderate positive change to the south Delta entrainment attribute to be appropriate.

Consistent with other Chinook salmon runs, it was assumed with low certainty that entrainment at agricultural diversions is an attribute with low importance for foraging and migrating juvenile San Joaquin River region fall-run Chinook salmon. Decommissioning of agricultural diversions in lands restored as tidal habitat under *CM4 Tidal Natural Communities Restoration* and screen removal/modification/screening under *CM21 Nonproject Diversions* will reduce the number of unscreened diversions in the Plan Area (Appendix 5.B, *Entrainment,* Section 5.B.6.4.3.1, *Delta Regional Ecosystem Restoration Implementation Plan Analysis of Nonproject Diversions*) and it is concluded that the BDCP will provide a small positive change to this attribute, with low certainty, reflecting the relative lack of study of the issue. Changes to the North Bay Aqueduct Barker Slough pumping plant and its proposed alternative intake on the Sacramento River are considered not to be relevant to San Joaquin River region fall-run Chinook salmon because their geographic distribution and probable emigration routes from the Plan Area make encounter with these screened facilities unlikely.

Reduced Entry into the Interior Delta and Positive Changes to San Joaquin River Flows in the South Delta Subregion

An operable barrier at the Head of Old River will reduce entry into the interior Delta and will direct more river flow down the San Joaquin River, giving greater potential for juvenile San Joaquin River region fall-run Chinook salmon survival through the Plan Area.

San Joaquin River region fall-run Chinook salmon emigrating from tributaries upstream of the Plan Area encounter the San Joaquin River-Old River divergence at the Head of Old River. Around half or more of smolts enter Old River if there is no physical barrier in place (Baker and Morhardt 2001; San Joaquin River Group Authority 2010, 2011). Previous studies based on coded-wire-tagged fish have found survival through the Plan Area (i.e., to Chipps Island) to be higher for fish remaining in the San Joaquin River pathway compared to the Old River pathway (Newman 2010). Model-averaged coefficients from Newman (2010) are incorporated into the DPM (Appendix 5.C, *Flow, Passage, Salinity, and Turbidity,* Section 5.C.4.3.2.2, *Juvenile Chinook Salmon Smolt through-Delta Survival (Delta Passage Model)*) and suggest that at average levels of flow and exports observed in the modeled data, survival through the San Joaquin River pathway would be nearly double that of the Old River pathway. For this effects analysis, it was assumed with high certainty that entry into the interior Delta (i.e., Old River in this case) of San Joaquin River region fall-run Chinook salmon is an attribute of high importance for migrants and foragers. During the August 2013 workshops, some agency biologists felt that this attribute is of critical importance (with high certainty), whereas others felt that the importance and certainty would be less than high because of the relatively low survival of those fish remaining in the main stem San Joaquin River.

Under *CM1 Water Facilities and Operation*, an operable barrier will be installed at the Head of Old River that would prevent fish passage into Old River when closed. The barrier was modeled to be open 50% of the time from January to mid-June, the main juvenile Chinook salmon outmigration period, and was assumed to be open if Vernalis flows were greater than 10,000 cfs; actual operations would differ from the 50% open assumption, as they would be based on real-time monitoring and adaptive management. The results of the DPM for the percentage of smolts entering Old River reflect the modeling assumption of fish entering Old River in proportion to the flow split at the divergence. Overall, the average or median percentage of smolts entering Old River under existing conditions was around 52 to 57% compared to 27 to 30% under the BDCP in the late long-term (Table 5.5.5-17). Similar percentages of smolts were estimated to enter Old River under the BDCP and existing conditions in the wetter years of 1978, 1982, and 1983, when the barrier was not closed because of high Vernalis flows. It is concluded that the installation of the barrier will be a moderate positive change with moderate certainty to the interior Delta entry attribute. Additional studies will provide further information regarding the survival down the Old River pathway to see if these patterns remain evident when an operable barrier is in place.

Table 5.5.5-17. Percentage of San Joaquin River Region Fall-Run Chinook Salmon Smolts Entering the Interior Delta via Old River under Three Scenarios[a], Based on the Delta Passage Model

Water Year (Type[a])	Scenario[b]		
	EBC2[a]	EBC2_LLT	ESO_LLT
1976 (C)	57.4	61.6	26.1
1977 (C)	60.0	62.1	27.4
1978 (AN)	52.4	51.5	49.1
1979 (BN)	51.2	51.7	25.4
1980 (AN)	51.4	51.8	26.2
1981 (D)	52.1	56.8	25.2
1982 (W)	43.1	43.5	41.7
1983 (W)	41.0	39.6	39.5
1984 (W)	51.1	52.2	25.1
1985 (D)	52.3	57.1	24.9
1986 (W)	52.0	52.1	31.0
1987 (D)	58.3	61.6	26.0
1988 (C)	57.6	61.1	25.9
1989 (D)	61.6	64.8	28.7
1990 (C)	62.1	64.4	28.0
1991 (C)	62.2	65.5	31.1
Average	54.1	56.1	30.1
Median	52.3	56.9	26.8

[a] Abbreviations of water-year types: W = wet; C = critical; AN = above normal; BN = below normal; D = dry
[b] For descriptions of scenarios, see Table 5.2-3.

It is important to note that the BDCP does not change the San Joaquin River flow entering the Plan Area (i.e., at Vernalis). The operable physical barrier at the Head of Old River allows more flow to remain in the San Joaquin River below Old River, however, which is a potential positive change to Plan Area flows from the perspective of San Joaquin River region fall-run Chinook salmon juveniles. There are positive relationships between flow and survival down both the Old River and San Joaquin River pathways, as expressed in the flow-survival relationships that are included in the DPM based on data from Newman (2010) (Appendix 5.C, *Flow, Passage, Salinity, and Turbidity,* Section 5.C.4.3.2.2, *Juvenile Chinook Salmon Smolt through-Delta Survival (Delta Passage Model)*). Note, however, that one recent study did not find support for a flow or export effect on the ocean recovery of coded-wire tagged fall-run Chinook salmon smolts from the San Joaquin River region (Zeug and Cavallo 2013). For this effects analysis, it was assumed that Plan Area flows are of critical importance for San Joaquin River region fall-run Chinook salmon juvenile migrants (high certainty level) and high importance for juvenile foragers (moderate certainty level; lower certainty level due to less available information on this attribute/life stage). As described in the winter-run Chinook salmon analysis, it was noted during the August 2013 workshops with agency biologists that different portions of the Plan Area have different levels of importance, depending on the origin and abundance (population status) of the fish. The only explicit comment for Plan Area flows received in relation to San Joaquin River juvenile salmonids suggested high importance was warranted in relation to Old and Middle River flows (which in the present analysis is dealt with to some extent in the analysis of entrainment above, although there is also overlap with survival through the Plan Area).

Two analyses inform the potential changes to the Plan Area flows attributes and resulting survival effects on San Joaquin River region fall-run Chinook. The DPM estimated that through-Delta survival under existing conditions would be similar to the BDCP, largely as a result of survival under existing conditions being considerably greater in three wet years when the operable Head of Old River barrier would not have been closed and most export pumping would have been from the north Delta intakes (Table 5.5.5-18; see further discussion in Appendix 5.C, *Flow, Passage, Salinity, and Turbidity,* Section 5.C.5.3.4.5, *San Joaquin River Fall-Run Chinook Salmon*). Median survival through the Delta was 8 to 11% greater under the BDCP than existing conditions, reflecting the general tendency for survival to be greater under the BDCP (Table 5.5.5-18; Figure 5.C.5.3-29, *San Joaquin River Fall-Run Chinook Salmon through-Delta Smolt Survival, Based on Delta Passage Model Results*, in Appendix 5.C). Results of the particle tracking modeling nonlinear regression analyses showed that estimates of the proportion of particles reaching Chipps Island from Mossdale for a winter-spring entry period (representative of fall-run fry migrants) under the BDCP generally were more than double those under existing conditions, although the proportions were low (Table 5.5.5-19; Table 5.C.5.3-123, *Weighted Annual Average Proportion of Particles Reaching Chipps Island after 30 Days from the San Joaquin River at Mossdale Release Location for EBC and ESO Scenarios*, in Appendix 5.C). Results of the same analytical technique for the March–May period (more representative of smolt timing) found that around 20 to 100% more particles would reach Chipps Island under the BDCP (Appendix 5.C, Section 5.C.5.3.7.3, *March–May Differences*).

Table 5.5.5-18. Percentage Through-Delta Survival Estimates for San Joaquin River Region Fall-Run Chinook Salmon Smolts, Based on the Delta Passage Model

Water Year (Type[a])	By Scenario[b]			Change[c] under ESO_LLT	
	EBC2	EBC2_LLT	ESO_LLT	Compared to EBC2	Compared to EBC2_LLT
1976 (C)	9.7	9.4	10.6	1.0 (10%)	1.2 (13%)
1977 (C)	9.2	8.9	10.2	1.0 (11%)	1.3 (15%)
1978 (AN)	16.9	18.7	15.8	-1.1 (-6%)	-3.0 (-16%)
1979 (BN)	11.8	11.2	13.3	1.5 (13%)	2.1 (19%)
1980 (AN)	12.4	13.0	15.8	3.3 (27%)	2.8 (22%)
1981 (D)	10.9	10.3	12.7	1.8 (17%)	2.4 (23%)
1982 (W)	31.4	30.2	23.0	-8.4 (-27%)	-7.2 (-24%)
1983 (W)	34.5	35.6	19.7	-14.8 (-43%)	-15.9 (-45%)
1984 (W)	10.8	10.5	12.8	2.0 (19%)	2.2 (21%)
1985 (D)	10.7	10.2	11.6	0.9 (8%)	1.4 (13%)
1986 (W)	15.0	13.4	15.0	0.0 (0%)	1.6 (12%)
1987 (D)	9.4	8.9	10.4	0.9 (10%)	1.5 (17%)
1988 (C)	9.7	9.5	10.2	0.5 (5%)	0.7 (8%)
1989 (D)	9.0	8.7	9.9	0.9 (10%)	1.2 (14%)
1990 (C)	9.3	9.2	10.1	0.9 (9%)	0.9 (10%)
1991 (C)	9.3	9.2	10.6	1.3 (15%)	1.4 (16%)
Average	13.7	13.5	13.2	-0.5 (-4%)	-0.3 (-2%)
Median	10.7	10.3	12.1	0.9 (8%)	1.3 (11%)

[a] Abbreviations of water-year types: W = wet; C = critical; AN = above normal; BN = below normal; D = dry
[b] For descriptions of scenarios, see Table 5.2-3.
[c] Negative differences indicate lower values under the BDCP.

Table 5.5.5-19. Average Proportion of Particles Reaching Chipps Island from the San Joaquin River at Mossdale, Based on the Particle Tracking Modeling Nonlinear Regression Analysis for Fall-Run Chinook Salmon

Water-Year Type	By Scenario[a]			Change[b] under ESO_LLT	
	EBC2	EBC2_LLT	ESO_LLT	Compared to EBC2	Compared to EBC2_LLT
All	0.08	0.07	0.17	0.10 (128%)	0.10 (136%)
Wet	0.18	0.18	0.36	0.18 (105%)	0.18 (104%)
Above normal	0.06	0.07	0.19	0.13 (214%)	0.12 (182%)
Below normal	0.03	0.02	0.09	0.06 (168%)	0.07 (373%)
Dry	0.02	0.01	0.05	0.03 (203%)	0.04 (314%)
Critical	0.02	0.01	0.04	0.02 (121%)	0.03 (187%)

[a] For descriptions of scenarios, see Table 5.2-3.
[b] Negative differences indicate lower values under the BDCP compared to existing conditions and future conditions without the BDCP.

The results of the DPM for Mokelumne River fall-run Chinook salmon suggest that there is little difference between the BDCP and existing conditions for through-Delta survival across all water years examined (Table 5.5.5-20; Appendix 5.C, Section 5.C.5.3.4.6, *Mokelumne River Fall-Run Chinook Salmon*). This reflects the model assumptions of survival being negatively influenced by exports, but because the model calculates the survival as a ratio in relation to survival on the Sacramento River (Newman and Brandes 2010), lower Sacramento River flow offsets lower south Delta exports (see additional discussion in Appendix 5.C, Section 5.C.5.3.4.6). Particle tracking nonlinear modeling results for the fry period estimated that under the BDCP a similar or slightly greater proportion of particles would reach Chipps Island compared to existing conditions, and during March–May, the proportion would be lower under the BDCP (Table 5.5.5-21). This appears to reflect the restoration in the Cosumnes/Mokelumne ROA, resulting in particles being spread out and complicating the interpretation for migration effects (see additional discussion in Appendix 5.C, Section 5.C.5.3.7.3, *March–May Differences*).

In light of the above analyses, it is concluded that there would be a low positive change to the Plan Area flows attribute for foraging and migrating San Joaquin River fall-run Chinook salmon juveniles. There is moderate certainty attached to this conclusion because of factors discussed above and in Appendix 5.C, Section 5.C.5.3.4.6, *Mokelumne River Fall-Run Chinook Salmon*). Targeted research and adaptive management will reduce uncertainty and increase knowledge of the importance of the entrainment, interior Delta entry, and Plan Area flows attributes for San Joaquin River fall-run Chinook salmon. Agency biologist comments received during the August 2013 workshops suggested that a low or moderate positive change was warranted, with the low positive change reflecting net Old and Middle River flows being frequently negative under both existing conditions and the BDCP.

Table 5.5.5-20. Percentage Through-Delta Survival Estimates for Mokelumne River Fall-Run Chinook Salmon Smolts, Based on the Delta Passage Model

Water Year (Type[a])	By Scenario[b]			Change[c] under ESO_LLT	
	EBC2	EBC2_LLT	ESO_LLT	Compared to EBC2	Compared to EBC2_LLT
1976 (C)	11.9	13.2	13.4	1.2 (15%)	0.3 (3%)
1977 (C)	18.9	19.4	19.2	0.2 (2%)	-0.1 (-1%)
1978 (AN)	11.1	10.0	10.7	-0.3 (-4%)	0.4 (6%)
1979 (BN)	18.3	17.9	17.8	-0.4 (-3%)	-0.2 (-1%)
1980 (AN)	22.2	21.2	21.8	-0.5 (-3%)	0.5 (3%)
1981 (D)	21.1	21.4	20.5	-0.4 (-3%)	-0.6 (-4%)
1982 (W)	16.4	13.8	13.6	-1.3 (-12%)	0.0 (0%)
1983 (W)	19.2	18.5	25.5	4.6 (35%)	5.1 (41%)
1984 (W)	12.4	11.9	11.9	-0.3 (-4%)	0.0 (0%)
1985 (D)	14.0	14.2	14.5	0.4 (4%)	0.2 (3%)
1986 (W)	18.9	19.0	20.0	0.8 (6%)	0.7 (5%)
1987 (D)	12.5	13.3	13.3	0.6 (7%)	0.0 (0%)
1988 (C)	12.1	12.4	12.4	0.2 (2%)	0.0 (0%)
1989 (D)	21.4	21.9	21.6	0.1 (1%)	-0.3 (-2%)
1990 (C)	13.9	13.6	13.4	-0.4 (-4%)	-0.2 (-2%)
1991 (C)	12.2	12.1	11.9	-0.2 (-3%)	-0.1 (-1%)
Average	16.0	15.9	16.3	0.3 (2%)	0.4 (3%)
Median	15.2	14.0	14.1	0.0 (0%)	0.0 (0%)

[a] Abbreviations of water-year types: W = wet; C = critical; AN = above normal; BN = below normal; D = dry
[b] For descriptions of scenarios, see Table 5.2-3.
[c] Negative differences indicate lower survival estimates under the BDCP compared to existing conditions or future conditions without the BDCP.

Table 5.5.5-21. Average Proportion of Particles Reaching Chipps Island from the Mokelumne River below the Cosumnes River Confluence, Based on the Particle Tracking Modeling Nonlinear Regression Analysis for Fall-Run Chinook Salmon

Water-Year Type	By Scenario[a]			Change[b] under ESO_LLT	
	EBC2	EBC2_LLT	ESO_LLT	Compared to EBC2	Compared to EBC2_LLT
All	0.29	0.29	0.31	0.01 (5%)	0.02 (6%)
Wet	0.58	0.59	0.63	0.06 (10%)	0.05 (8%)
Above normal	0.36	0.37	0.39	0.04 (10%)	0.02 (6%)
Below normal	0.19	0.16	0.17	-0.02 (-8%)	0.01 (7%)
Dry	0.08	0.07	0.06	-0.02 (-22%)	-0.01 (-11%)
Critical	0.05	0.04	0.04	-0.01 (-27%)	0.0 (-10%)

[a] For descriptions of scenarios, see Table 5.2-3.
[b] Negative differences indicate lower values under the BDCP compared to existing conditions or future conditions without the BDCP.

Improved Upstream Passage

Improved Stockton Deep Water Ship Channel DO conditions will increase upstream passage of adult San Joaquin River region fall-run Chinook salmon.

Adult San Joaquin River region fall-run Chinook salmon may experience upstream migration delays because of low DO in the Stockton Deep Water Ship Channel and at the Suisun Marsh Salinity Control Gates (Appendix 5.C, *Flow, Passage, Salinity, and Turbidity,* Section 5.C.5.3.11, *Passage Improvements at the Stockton Deep Water Ship Channel*, and Section 5.C.5.3.10, *Suisun Marsh Salinity Control Structure*). For this effects analysis, it was assumed with moderate certainty that these impediments have moderate importance to the passage attribute for adult San Joaquin River region fall-run Chinook salmon. *CM14 Stockton Deep Water Ship Channel Dissolved Oxygen* will provide funding for the existing installed aeration facility to continue operations into the future. It is concluded with moderate certainty that these measures provide a low positive change to adult San Joaquin River region fall-run Chinook salmon adults. During the August 2013 workshops, agency biologists suggested that this attribute is of low importance with low-moderate certainty, and limited agency opinion noted that the change as a result of the BDCP would be moderately positive.

Reduced Predation

The BDCP could reduce losses of juvenile San Joaquin River region fall-run Chinook salmon at existing and potential future localized areas where predation is intense. For this effects analysis, it was assumed with high certainty that predation of San Joaquin River region fall-run Chinook salmon juveniles (migrants and foragers) is of critical importance. This assumption is based on plentiful evidence of very poor survival through the Plan Area during studies of tagged fall-run Chinook salmon smolts. For example, although comparison of different brood years is problematic in 2010, the Vernalis Adaptive Management Program study found survival from Durham Ferry to Chipps Island of 5% (San Joaquin River Group Authority 2011), which compares to estimates from Sacramento to Chipps Island of 35 to 54% in 2006–2007 (Perry et al. 2010). Certain areas appear to have particularly high losses, e.g., Bowen et al. (2012) estimated predation at the Head of Old River to be 12 to 40% in 2009. Other areas of high predation, as inferred from high densities of immobile acoustic tags (presumably smolts consumed by predators, followed by tag defecation), include Old River near the entrances to the south Delta export facilities, Grant Line Canal, and the San Joaquin River in the vicinity of the Stockton Deep Water Ship Channel and Turner Cut (San Joaquin River Group Authority 2011). A number of experimental releases have found poor survival of Chinook salmon smolts from test releases in Clifton Court Forebay (Gingras 1987). As noted for Sacramento River region fall-run Chinook salmon above, the importance of the predation attribute generated a wide range of agency biologist opinion during the August 2013 workshops, from low importance with low certainty to high importance with medium or high certainty. There was limited reference by agency biologists to San Joaquin River region runs, with the only specific comment suggesting that critical importance (with high certainty) would be warranted for migrating juveniles, and that critical importance (with moderate certainty) would be warranted for foraging juveniles.

As noted for other Chinook salmon runs analyzed in this effect analysis, several different conservation measures have the potential to influence predation of juvenile salmonids under the BDCP (Appendix 5.F, *Biological Stressors on Covered Fish*, Section 5.F.6, *Fish Predation*). *CM1 Water Facilities and Operation* will have potential beneficial effects (reduction of predation associated with entrainment at the south Delta export facilities; see entrainment discussion above) and potential adverse effects (possible predation at the Head of Old River operable gate). As discussed for other runs, implementation of habitat restoration measures (*CM4 Tidal Natural Communities Restoration*, *CM5 Seasonally Inundated Floodplain Restoration*, and *CM6 Channel Margin Enhancement*) in association with IAV removal (*CM13 Invasive Aquatic Vegetation Control*) may increase rearing habitat, and decommissioning or modification of water diversion structures in ROAs and other areas also will decrease predatory fish habitat. *CM15 Localized Reduction of Predatory Fish* will aim to limit predation at problem areas through habitat alterations and other actions such as predator relocation.

It is concluded that there will be a low positive change to predation for foraging and migrating fall-run Chinook salmon juveniles under the BDCP, but with low certainty because there has been relatively little study of the feasibility of undertaking such actions. Targeted research and monitoring will inform the efficacy of the conservation measure.

Reduced Illegal Harvest

The BDCP will help reduce illegal harvest of adult San Joaquin River fall-run Chinook salmon.

Consistent with fall-run Chinook salmon from the Sacramento River region, it was assumed with low certainty that illegal harvest of San Joaquin River fall-run Chinook salmon juveniles and adults is an attribute of low importance. The certainty level is low, because little is known of the issue. *CM17 Illegal Harvest Reduction* is expected to decrease poaching of covered salmonids and other covered fishes, as described in more detail for winter-run Chinook salmon based on the information provided by Roberts and Laughlin (2013), and so it is concluded that there will be a low positive change to the harvest attribute for juvenile and adult San Joaquin River region fall-run Chinook salmon, with high certainty for the same reasons given for fall-run Chinook salmon above.

5.5.5.3.2 Adverse Effects

Exposure to In-Water Effects from Restoration Activities and Construction of the Operable Gate at the Head of Old River

In-water effects of the BDCP, primarily restoration activities and construction of the Head of Old River operable gate, could affect San Joaquin River region fall-run Chinook salmon.

In contrast to some of the Sacramento River region salmonids, San Joaquin River region fall-run Chinook salmon would not be exposed to the major construction occurring in the north Delta subregion in the vicinity of the north Delta intakes. Construction occurring in the south Delta subregion mostly focuses on the Head of Old River operable gate. Standard minimization measures would be employed to limit the potential for adverse effects on San Joaquin River region fall-run Chinook salmon during construction and maintenance, including timing in-water work to periods of no or low occurrence of covered fish. Habitat restoration activities associated with *CM4 Tidal Natural Communities Restoration, CM5 Seasonally Inundated Floodplain Restoration*, *CM6 Channel Margin Enhancement* and *CM7 Riparian Natural Community Restoration* may contribute to temporarily reduced water quality. In-water activities associated with other *CM14 Stockton Deep Water Ship Channel Dissolved Oxygen Levels, CM15 Localized Suppression of Predatory Fish, CM16 Nonphysical Fish Barriers,* and *CM21 Nonproject Diversions* will have little to no effect on salmonids because of the small scale of the work. Implementation of *CM22 Avoidance and Minimization Measures* will limit the likelihood of adverse effects from in-water activities related to construction and maintenance on juvenile and adult San Joaquin River region fall-run Chinook salmon juveniles. Therefore, it is concluded with high certainty that in-water effects of construction, maintenance, and restoration activities associated with the BDCP represent a minor adverse effect on San Joaquin River region fall-run Chinook salmon adults and juveniles.

Exposure to Contaminants

The BDCP will contribute to a reduction in San Joaquin River region fall-run Chinook salmon exposure to contaminants in the late long-term, although localized increases in contaminant exposure may occur as a result of tidal habitat and floodplain restoration.

Changes in contaminant concentration as a result of changes in water operations (*CM1 Water Facilities and Operation, CM2 Yolo Bypass Fisheries Enhancement*) and habitat restoration (principally, *CM4 Tidal Natural Communities Restoration*) could occur under the BDCP. For this effects analysis, it was assumed with low certainty that contaminants represent an attribute of low importance for adult and foraging and migrating juvenile salmonids. Analyses presented in Appendix 5.D, *Contaminants*, suggest that there is low potential for increased contaminant exposure from the BDCP, and there may be a beneficial effect in the late long-term because of reduced contaminants from restoration of previously cultivated areas. It is concluded with low certainty that this represents a low negative change to this attribute for juvenile (foragers and migrant) San Joaquin River region fall-run Chinook salmon in the Plan Area. This generally concurs with agency biologist opinion on the subject, as expressed during the August 2013 workshops.

5.5.5.3.3 Impact of Take on Species

The BDCP may result in incidental take of San Joaquin River fall-run Chinook salmon from several mechanisms, as discussed for other salmonid runs. Construction and maintenance may result in disturbance from in-water activity and hydrodynamic changes, physical injury from riprap/rock placement and noise and vibration, exposure to fuel or oil, and elevated turbidity levels (Appendix 5.H, *Aquatic Construction and Maintenance Effects*). These temporary effects will be minimized through standard measures and as a result, there will be minimal impact of take from these activities.

Although entrainment will be substantially reduced, take at the south Delta export facilities will continue to occur. Other flow-related effects discussed above include the potential for higher effective Plan Area flows as a result of the Head of Old River operable gate, which may reduce adult straying to the Sacramento River region and improve flows in the San Joaquin River to facilitate migration of juveniles through the Plan Area. These would be reductions in take of the species.

5.5.5.3.4 Abundance, Productivity, Life-History Diversity, and Spatial Diversity

The analysis presented for winter-run Chinook salmon, Section 5.5.3.4, also includes San Joaquin River fall-run Chinook.

5.5.5.3.5 Net Effects

Figure 5.5.5-3 shows the relative population-level outcomes, by attribute, for San Joaquin River region fall-run Chinook salmon, that will result from implementation of the BDCP. The graph illustrates the effect of the BDCP, by considering the change to an attribute for each life stage in light of the importance of the attribute to that life stage. The positive effects of the BDCP outweigh the negative effects, so that the net effect of the BDCP is expected to be beneficial to San Joaquin River region fall-run Chinook salmon. Most of the concluded effects are made with moderate certainty, as with other covered Chinook salmon runs for the BDCP; however, there are important differences. Whereas for Sacramento River region Chinook salmon runs there are some possible adverse effects to Plan Area flows below the north Delta intakes, the combination of less south Delta exports and a Head of Old River operable gate have the potential to effectively augment Plan Area flows in the South Delta subregion that have relevance to San Joaquin River fall-run Chinook salmon. Juvenile migration and adult straying are expected to be improved under the BDCP. Less certain are the benefits from floodplain restoration under *CM5 Seasonally Inundated Floodplain Restoration* because there are no changes in the San Joaquin River flows entering the Plan Area under the BDCP so that there is relatively less of a benefit than is expected for the Sacramento River region runs because of enhanced Yolo Bypass access from CM2 *Yolo Bypass Fisheries Enhancements*.

South Delta tidal natural communities restoration under *CM4 Tidal Natural Communities Restoration* would considerably increase the extent of suitable habitat for San Joaquin River region fall-run Chinook salmon juveniles. Appreciable extents of channel margin and floodplain habitat will also be restored under *CM5 Seasonally Inundated Floodplain Restoration* and *CM6 Channel Margin Enhancement.* Habitat restoration has considerable potential to provide food benefits for San Joaquin River region fall-run Chinook salmon juveniles.

Under *CM1 Water Facilities and Operation*, changes in south Delta export operations and the construction and operation of an operable gate at the Head of Old River have the potential to improve through-Delta survival by keeping fish and flow in the mainstem San Joaquin River. A greater proportion of San Joaquin River water leaving the South Delta subregion has the potential to reduce straying of adult San Joaquin River fall-run Chinook salmon to the Sacramento River region, which would result in more adults returning to natal tributaries. *CM15 Localized Reduction of Predatory Fish* has the potential to improve juvenile San Joaquin River fall-run Chinook salmon survival at localized predation hotspots, and as noted for other runs, much research and adaptive management will be involved with this measure to address the considerable uncertainty in its efficacy.

As noted for other Chinook salmon runs, contaminants and other negative effects from restoration and construction activities may occur although the effects are concluded to be low.

Funding for construction, operation, and maintenance of the Stockton Deep Water Ship Channel aeration facility into the future will ensure maintenance of the pilot facility's benefits for San Joaquin River watershed adult salmonids that migrate upstream during periods of low DO (Appendix 5.C, *Flow, Passage, Salinity, and Turbidity*, Section 5.C.5.3.10, *Passage Improvements at the Stockton Deep Water Ship Channel*). In conclusion, the overall net effect of the BDCP on San Joaquin River region fall-run Chinook salmon is expected to be positive, even though the magnitude of benefits of the BDCP at the population level cannot be quantified with certainty. The conclusion of a positive effect is made with moderate certainty, based on the reduced entrainment, improved migration conditions, and increased suitable habitat. Future changes in the Plan Area because of climate change and other factors are likely to be stressful to San Joaquin River region fall-run Chinook salmon, but the positive effects on viable salmonid population criteria from the BDCP will improve the ability of the species to adapt to changes.

Therefore, the BDCP will minimize and mitigate impacts to the maximum extent practicable and provide for the conservation and management of the San Joaquin River fall-run salmon in the Plan Area.

Category	Appendix	Attributes	Definition	Eggs	Foragers	Migrants	Adults
Food	E	Zooplankton community	Species composition of the zooplankton community and presence of suitable prey species	NA	Zero	Zero	
		Zooplankton abundance	The abundance of zooplankton	NA	Low	Low	
		Benthic & Epibenthic prey abundance	The abundance of epibenthic prey species such as amphipods	NA	High	Low	
		Insect abundance	The abundance of insect prey	NA	High	Low	
Entrainment & Impingement	B	North Delta Intakes	Potential entrainment/impingement from the proposed North Delta intakes	NA			
		South Delta Pumps	Pumping rate from the CVP/SWP south Delta export facilities and resulting entrainment	NA	Moderate	Moderate	
		North Bay Aqueduct	Entrainment from the SWP NBA facilities	NA			
		Ag Diversions	Entrainment from Agriculture Diversions	NA	Very Low	Very Low	
Migration & Movement	C	Plan Area Flows	Magnitude, timing, direction, and duration of flows during migratory periods throughout the Plan Area	NA	Low	Moderate	Moderate
		Interior Delta Entry	Entry of fish into the interior Delta from the mainstem Sacramento or San Joaquin Rivers through channels such as Georgiana Slough or Old River	NA	Moderate	Moderate	NA
		Passage Barriers	Structures or conditions that potentially block upstream or downstream migration	NA			Low
Habitat	C, E	Inter-tidal habitat	Intertidal area from the mean low low water level to the extreme high water level that may support intertidal vegetation and form mudflats; dynamic elements of habitat such as appropriate salinity are considered on a species-specific basis	NA	High	Low	
		Channel Margin	The extent of shallow water, low slope habitat that generally is characterized by structural complexity, native emergent vegetation and riparian shading cover	NA	Low	Low	
		Floodplains	The interface between upland topography and river hydrology during high flow events	NA	Moderate	Low	
		Riparian	Forest and scrub that occurs along the margins of river channels and within floodplains	NA	NA	NA	NA
		Sub-tidal habitat	Extent and location of sub-tidal area in the Plan Area, including the low salinity zone (LSZ); dynamic elements of habitat such as appropriate salinity are considered on a species-specific basis	NA	Low	Low	
Sediment	C	Water clarity	Water clarity in the Plan Area as influenced by amount of suspended material within the water column	NA	Zero	Zero	
Temperature	C	Temperature	Adverse effects of high temperatures within the Plan Area	NA			
DO	C	Dissolved Oxygen	Adverse effects of low dissolved oxygen level within the Plan Area	NA			
Toxins	D, F	Contaminants	Adverse effects of methylated mercury, selenium, pesticides and other pollutants	NA	Very Low -	Very Low -	
		Microcystis	The abundance of Microcystis aeruginosa blooms that are toxic to covered fish species and their food	NA			
Predation	F	Predation	The species-specific consumption of covered fish species by predatory fish (e.g., striped bass, Sacramento pikeminnow, centrarchid bass species, catfish, and inland silversides); note that the attribute aims to isolate predation effects that may not be captured by other attributes, e.g., at manmade structures such as the north Delta diversions	NA	Moderate	Moderate	
		Illegal Harvest	Illegal harvest of covered fish species in the Plan Area	NA	Low	Low	Low

In-stream Habitat	C	Sacramento R. Habitat	Flows in the Sacramento River mainstem (below Keswick Dam to the Plan Area) that influence spawning, egg incubation, rearing, or holding habitat	NA	NA	NA	NA
		Feather R. Habitat	Flows in the Feather River (below Oroville Dam to the confluence with the Sacramento River) that influence spawning, egg incubation, rearing, or holding habitat	NA	NA	NA	NA
		American R. Habitat	Flows in the American River (below Nimbus Dam to the confluence with the Sacramento River) that influence spawning, egg incubation, rearing, or holding habitat	NA	NA	NA	NA
Migration & Movement	C	Sacramento R. Migration Flows	Flows in the Sacramento River mainstem (below Keswick Dam to the Plan Area) that influence migration and movement	NA	NA	NA	NA
		Feather R. Migration Flows	Flows in the Feather River (below Oroville Dam to the confluence with the Sacramento River) that influence migration and movement	NA	NA	NA	NA
		American R. Migration Flows	Flows in the American River (below Nimbus Dam to the confluence with the Sacramento River) that influence migration and movement	NA	NA	NA	NA
Temperature	C	Sacramento R. Temperature	Adverse effects of high water temperatures in the Sacramento River mainstem (below Keswick Dam to the Plan Area)	NA	NA	NA	NA
		Feather R. Temperature	Adverse effects of high water temperatures in the Feather River (below Oroville Dam to the confluence with the Sacramento River)	NA	NA	NA	NA
		American R. Temperature	Adverse effects of high water temperatures in the American River (below Nimbus Dam to the confluence with the Sacramento River)	NA	NA	NA	NA

Certainty

- (grey) No effect conclusion made because attribute assumed not to have importance as a current constraint
- NA Life stage not present or not applicable
- (green) Low certainty
- (light blue) Moderate certainty
- (blue) High certainty
- (purple) Very high certainty

Figure 5.5.5-3. Effect of the Covered Activities on San Joaquin River Region Fall-Run Chinook Salmon.

5.5.6 Steelhead, Central Valley DPS

5.5.6.1 Introduction

Central Valley steelhead (*Oncorhynchus mykiss*) were once widely distributed throughout the Sacramento and San Joaquin Rivers (Busby et al. 1996; McEwan 2001). Steelhead inhabited waterways from the upper Sacramento and Pit River systems (now inaccessible because of Shasta and Keswick Dams) south to the Kings River and possibly the Kern River systems, and in both east- and west-side Sacramento River tributaries (Yoshiyama et al. 1996). The geographic distribution of Central Valley steelhead has been greatly reduced by the construction of dams (McEwan and Jackson 1996; McEwan 2001). As a result of the loss of habitat as well as other factors such as the influence of hatcheries, steelhead in the Central Valley are much diminished (Lindley et al. 2006). In recent years, the proportion of hatchery produced juvenile steelhead in the Chipps Island trawl has exceeded 90%, and in 2010 was 95% of the catch. The Central Valley steelhead DPS[8] is listed as a threatened species under ESA (National Marine Fisheries Service 2012). Existing wild steelhead stocks in the Central Valley inhabit the upper Sacramento River and its tributaries, including Antelope, Deer, and Mill Creeks and the Yuba River. Populations may exist in Big Chico and Butte Creeks, and a few wild steelhead are produced in the American and Feather Rivers (McEwan and Jackson 1996). Wild steelhead are also found in small numbers in all the tributaries of the San Joaquin River. The exception is the Mokelumne River that has a California Department of Fish and Wildlife hatchery that raises steelhead stock from the Mokelumne River and additional out of basin stock other than American River Hatchery stock. A detailed species account of Steelhead, including life history and status, is presented in Appendix 2.A, *Covered Species Accounts*.

Steelhead in the Central Valley are termed winter-run based on the timing of entry into Central Valley rivers and streams (McEwan and Jackson 1996). Peak immigration seems to have occurred historically in the fall from late September to late October, with some creeks such as Mill Creek showing a small run in mid-February (Hallock 1989). Peak spawning typically occurs from January through March in small streams and tributaries (Hallock et al. 1961; McEwan and Jackson 1996). Unlike Pacific salmon, steelhead are iteroparous, or capable of spawning more than once before death. However, it is rare for steelhead to spawn more than twice before dying; most individuals that do spawn more than twice are females (Busby et al. 1996) Although, one-time spawners are the great majority, Shapovalov and Taft (1954) reported that repeat spawners are relatively numerous (17.2%) in California streams. Historically, about 70% of Central Valley steelhead spent 2 years within their natal streams before migrating out of the Sacramento-San Joaquin system as smolts, with small percentages (29%) and (1%) spending 1 or 3 years, respectively (Hallock et al. 1961); in contrast, more recent data for the American River suggests that most fish are yearlings (Sogard et al. 2012). For the BDCP analysis it was assumed that 95% of the juvenile steelhead entering the Plan Area are migrant smolts and 5% were smaller foraging fish. These proportions are likely heavily influenced by hatchery smolts that make up the bulk of the outmigrating fish. These proportions were based on literature review and discussions with agency biologists at workshops in August 2013. These proportions were used to qualitatively weight the effects of BDCP on each ESU. Scoring of BDCP net effects (Section 5.5.6.2.5 and Section 5.5.6.3.5) considered the beneficial and adverse effects of the BDCP on foragers and migrants separately. Juvenile steelhead emigrate episodically from natal streams during fall, winter, and spring high flows. Hallock et al. (1961) found that

[8] For ESA purposes, NMFS distinguishes evolutionarily significant units (ESUs) for salmon population groups and distinct population segments (DPSs) for steelhead population groups.

juvenile steelhead in the Sacramento River basin migrate downstream during most months of the year, but the peak emigration period occurred in the spring, with a much smaller peak in the fall.

5.5.6.2 Sacramento River Region

5.5.6.2.1 Beneficial Effects

Restored Floodplain, Tidal, and Channel Margin Habitat

Floodplain Habitat

The BDCP will change the configuration and operation of Fremont Weir and the Yolo Bypass, which will increase floodplain availability and usage and improve conditions for juvenile and adult Sacramento River region steelhead.

For this effects analysis, it was assumed with low certainty that floodplain habitat availability is an attribute of high importance for foraging Sacramento River steelhead and an attribute of low importance for migrating Sacramento River steelhead, because there may be some benefit from floodplains as an alternative migration pathway to the mainstem Sacramento River. More information on the importance of floodplain habitat to juvenile salmonids is provided in the winter-run Chinook salmon account. During the August 2013 agency workshops, agency biologists generally indicated that the importance of floodplain habitat is low for Sacramento River region steelhead, reflecting most juveniles in the Plan Area being migrating juveniles; certainty was also felt to be low.

Very little information exists of the abundance of Sacramento River region steelhead by tributary, although historical information suggests that a large proportion of Sacramento River region steelhead spawn upstream of the Yolo Bypass in the upper Sacramento River and tributaries such as Mill and Deer Creek (Busby et al. 1996:145); steelhead from these locations therefore have the potential to benefit from *CM2 Yolo Bypass Fisheries Enhancement*. Modifications to Fremont Weir under CM2 considerably will increase the frequency and duration of inundated area of floodplain in the Yolo Bypass, which is expected to increase food production and shallow-water, low-velocity rearing area for emigrating juvenile steelhead during winter and spring, the rearing and outmigrating period (Table 5.5.3-1 in Section 5.5.3, *Chinook Salmon, Sacramento River Winter-Run ESU*). As described for winter-run Chinook salmon, the potential risk of stranding on the floodplain is greatly outweighed by increased access to the floodplain under the BDCP, and adaptive management during the implementation period would address any areas of concern related to stranding on the floodplain. It is concluded with low certainty that the BDCP would result in a high positive change to the floodplain attribute for Sacramento River steelhead foraging juveniles and moderate positive change for migrant juveniles; as noted above, nearly all juvenile steelhead in the Plan Area are assumed to be migrants. These conclusions are consistent with agency biologist opinion from the August 2013 workshops.

As described for winter-run Chinook salmon, a portion of the Sacramento River region steelhead population may experience blockage or delay at the Fremont Weir if migrating up the Yolo Bypass. For this effects analysis, it was assumed with moderate certainty that passage barriers are an attribute of low importance to Sacramento River steelhead adults, mostly because the timing of upstream migration is prior to the main period of Yolo Bypass inundation (as noted for fall-run Chinook salmon from the Sacramento River region). The moderate degree of certainty reflects the lack of information on the percentage of Sacramento steelhead currently taking this pathway and experiencing delay. The level of importance and certainty was consistent with limited agency biologist opinion from the August 2013 workshops. As described in Appendix 5.C, *Flow, Passage, Salinity, and Turbidity,* Section 5.C.5.3.12, *Fremont Weir Adult Fish Passage (CM2 Yolo Bypass Fisheries Enhancement)*, the BDCP will improve passage at Fremont Weir. In accordance with the DRERIP (Essex Partnership 2009) evaluation of improved passage at Fremont Weir, it is concluded with moderate certainty that CM2 will provide a high positive change to passage barriers for adult Sacramento River steelhead. During the August 2013 workshops, agency biologists felt that a conclusion of moderate positive change with moderate or high certainty was warranted.

Tidal Habitat

The BDCP will greatly increase the extent of tidal habitat that is suitable for Sacramento River region steelhead juveniles, particularly in the Cache Slough and Suisun Marsh subregions.

Tidal areas, including intertidal and subtidal areas, form important rearing habitat for some species of foraging juvenile salmonids. It is unknown how long foraging juvenile steelhead fry may spend in the Plan Area, and they were assumed for this effects analysis to only be a very small proportion of the overall juvenile steelhead population in the Plan Area. Other salmonids that rear in the Plan Area (e.g., fall-run Chinook salmon [Kjelson et al. 1982], winter-run Chinook salmon [Del Rosario et al. 2013]) may spend several months within the Plan Area. Migratory (yearling) juvenile steelhead spend much less time in Plan Area compared to foraging juvenile salmonids; migration rates are on the order of 17 to 30 km/day in Mokelumne River steelhead (Del Real et al. 2012; Kurth 2013), suggesting, for example, that fish passing straight through the Plan Area on the mainstem Sacramento River from Freeport (157 km from the Golden Gate) to Carquinez (56 km from the Golden Gate) could do so in around 3-6 days. Loss of tidal habitat because of land reclamation facilitated by levee construction is a major stressor on juvenile salmonids in the DRERIP conceptual model (Williams 2009). For this effects analysis, it was assumed with moderate certainty that intertidal habitat is an attribute of high importance for foraging steelhead juveniles and low importance for migrating steelhead juveniles, which is consistent with agency biologist opinion regarding the level of importance from the August 2013 workshops. It was assumed with low certainty, for this effects analysis, that subtidal habitat is an attribute of low importance to both foraging and migrating juvenile steelhead; agency biologists thought low or zero importance for foragers and zero importance for migrants may be warranted (with low certainty). As noted above, for Sacramento River region steelhead juveniles entering the Plan Area, it was assumed that 5% are foraging juveniles and 95% are migrant juveniles.

The most relevant tidal habitat to assess changes for Sacramento River region steelhead juveniles is found in the Cache Slough, North Delta, West Delta, Suisun Bay, and Suisun Marsh subregions. The results of the HSI approach (Appendix 5.E, *Habitat Restoration,* Section 5.E.4.4.1.1, *Habitat Suitability Analysis*) suggest that tidal habitat for foragers in these subregions would change from just over 32,000 HUs under existing conditions to over 50,000 HUs under the BDCP in the late long-term (a two-thirds increase), which was largely because of restoration in the Cache Slough ROA and Suisun Marsh ROA (Table 5.5.3-4 in Section 5.5.3, *Chinook Salmon, Sacramento River Winter-Run ESU*). For migrant juveniles (i.e., the bulk of steelhead juveniles assumed to be in the Plan Area), tidal habitat HUs were estimated to be around 50,000 HUs under existing conditions and nearly 65,000 HUs under the BDCP in the late long-term (Table 5.5.3-5 in Section 5.5.3). As noted in the winter-run Chinook analysis, the Plan Area subregions most relevant to steelhead (i.e., Cache Slough, North

Delta, West Delta, Suisun Bay, and Suisun Marsh subregions; see description above), the intertidal area is estimated at around 19,000 acres under existing conditions (21,000 acres under EBC2_LLT) and around 37,000 acres with the proposed restoration (ESO_LLT) ; for subtidal habitat, HUs were estimated to be around 57,000 acres under existing conditions (58,000 acres under EBC2_LLT) and nearly 73,000 acres with the proposed restoration (ESO_LLT).

It is concluded that the overall change related to tidal habitat restoration for foraging Sacramento River region steelhead juveniles is very high, with moderate certainty related to uncertainties explored further in the winter-run Chinook salmon effects analysis. The change is assumed to be moderate for migrant steelhead juveniles, again with moderate certainty. Agency biologist comment during the August 2013 workshops suggested the change to be zero or low for steelhead (with high certainty), reflecting the majority of steelhead being migrants; note that low importance of this habitat was assumed. For subtidal habitat, it is concluded that the positive change is moderate, with moderate certainty, for both foraging and migrant juvenile Sacramento River region steelhead—this was consistent with limited agency biologist opinion from the August 2013 workshops.

Channel Margin Habitat

Channel margin enhancement will improve the extent of higher value nearshore habitat in the Plan Area for Sacramento River region steelhead juveniles.

The background and rationale for the importance of the channel margin habitat attribute presented in the winter-run Chinook salmon effects analysis is directly applicable to Sacramento River region steelhead juveniles although, as noted above, the great majority of steelhead are assumed to be migrants. Although steelhead migrants have less tendency to occupy nearshore areas than Chinook salmon migrants, they do occupy (hold in) nearshore habitat (Zajanc et al. 2013). For this effects analysis, it was assumed that channel margin habitat represents an attribute of high importance to foraging juvenile steelhead (with high certainty) and low importance to migrating juvenile steelhead (with low certainty). For salmonids in general, some agency biologists concurred with these assumptions (albeit with lower certainty) during the August 2013 workshops, whereas other agency biologists felt moderate importance for foragers to be warranted. As discussed for winter-run Chinook salmon, undertaking 75% of the 20 miles of the channel margin enhancement in the Plan Area proposed under *CM6 Channel Margin Enhancement* within the channels most relevant to Sacramento River region salmonids (i.e., the mainstem Sacramento River, Sutter/Steamboat Sloughs, and Miner Slough; see for example Figure 5.E.6-1, *Revetment within Channels of the Plan Area*, in Appendix 5.E, *Habitat Restoration*) would represent around 9% of the total length of these channels. Further discussion of considerations related to CM6 is provided in the winter-run Chinook salmon analysis. It is concluded with moderate certainty that there will be a moderate positive change to the channel margin attribute for foraging and migrating Sacramento River region steelhead. This level of change was consistent with agency biologist opinion related to salmonid juveniles in general during the August 2013 workshops.

Food Benefits from Restored Habitat

Tidal, floodplain, and channel margin habitat restoration under the BDCP has considerable potential to greatly increase the quantity of food available for juvenile Sacramento River region steelhead.

It was assumed that the potential food benefits of proposed tidal marsh (*CM4 Tidal Natural Communities Restoration*), channel margin (*CM6 Channel Margin Enhancement*), floodplain (*CM5 Seasonally Inundated Floodplain Restoration*), and riparian restoration (*CM7 Riparian Natural Community Restoration*) for Sacramento River region steelhead juveniles is similar to that of winter-run Chinook salmon juveniles. Accordingly, for this effects analysis, it was assumed with moderate certainty that all food abundance-related attributes (zooplankton abundance, benthic and epibenthic prey abundance, and insect abundance) have low importance for migrant steelhead juveniles; for foragers, high importance was assumed for abundance of benthic/epibenthic prey and insects, whereas moderate importance was assumed for zooplankton abundance, all with moderate certainty. As noted for winter-run Chinook salmon, during the August 2013 workshops, some agency biologists felt that the lack of information regarding food limitation warranted an assumption of moderate importance for benthic/epibenthic abundance and insect abundance for foragers; others agreed with an assumption of high importance.

Additional floodplain inundation on the Yolo Bypass under the BDCP, coupled with riparian restoration and channel margin enhancement, holds potential for increase of food resources. Restoration of tidal habitat under CM4 holds perhaps the greatest potential benefit for food resources, because, as noted for winter-run Chinook salmon, large potential benefits were estimated to both phytoplankton-based and detritus-based elements of the juvenile salmonid foodweb (Appendix 5.E, *Habitat Restoration*, Section 5.E.4.4.2.1, *Physical Habitat Extent*). Considering the subregions most relevant to Sacramento River region steelhead (i.e., Cache Slough, North Delta, West Delta, Suisun Bay, and Suisun Marsh), the estimated change in phytoplankton production potential (prod-acres) from CM4 was a 50% increase under the BDCP (nearly 100,000 prod-acres) compared to existing conditions (around 65,000 prod-acres), largely because of restoration in the Cache Slough and Suisun Marsh ROAs (Table 5.5.3-6 in Section 5.5.3, *Chinook Salmon, Sacramento River Winter-Run ESU*). It is concluded with high certainty that there will be a high positive change to the benthic/epibenthic and insect prey abundance attributes for foraging and migrating Sacramento River region steelhead, again noting that migrants were assumed to comprise nearly all steelhead juveniles in the Plan Area. There is also concluded to be a low positive change to zooplankton abundance for foragers and a moderate positive change for migrants (reflecting seasonal differences in occurrences, with migrants occurring later when productivity is greater because of warmer temperatures), and both conclusions are made with low certainty because of the potential for nonnative clams to consume enhanced primary production in restored tidal areas (Lucas and Thompson 2012) and therefore limit the benefit to the phytoplankton-based food sources.

Reduced Entrainment

Entrainment loss of juvenile Sacramento River region steelhead under the BDCP will be appreciably lower than under existing conditions because the north Delta diversion operations will reduce reliance on south Delta export facilities.

As noted for other salmonids, it is anticipated that the implementation of dual conveyance and shift in water exports to the north Delta intakes will result in entrainment levels of juvenile steelhead below the levels seen in recent years with the implementation of the NMFS (2009a) BiOp. Nobriga and Cadrett (2001) used ratios of wild and hatchery-origin steelhead and known numbers of steelhead released from hatcheries to estimate that less than 0.1% to almost 1% of juvenile steelhead may have been salvaged at the south Delta export facilities from 1997 to 2000. Given that appreciable prescreen losses to predation occur in Clifton Court Forebay (Clark et al. 2009), losses associated with entrainment and related predation possibly were several times larger than the above estimates. Salvage of juvenile wild-origin steelhead at the SWP/CVP south Delta export facilities from 2008 to 2011 was around 1,000 fish or less and was lower than any other year from 1999–2007 (Llaban 2011); this in part may be because of pumping restrictions from the implementation of the NMFS (2009a) BiOp. For this effects analysis, it was assumed with moderate certainty that entrainment under existing conditions is an attribute of moderate importance for foraging and migrating juvenile steelhead.

Modeled changes in south Delta export pumping were weighted for seasonal occurrence of steelhead with the salvage density method, which estimated that entrainment of steelhead juveniles at the SWP/CVP south Delta export facilities would be lower under the BDCP than under existing conditions. Entrainment under the BDCP averaged over all years in the simulation was approximately 50% lower than existing conditions, with the difference being least in critical water years (16 to 24% lower average entrainment under the BDCP) and greatest in wet water years (almost 70% lower average entrainment under the BDCP), and other water-year types intermediate (Table 5.5.6-1) (Appendix 5.B, *Entrainment*, Section 5.B.6.1.1.1, *Salvage-Density Method*). As noted for winter-run Chinook salmon, this reflects a greater proportion of export pumping at the north Delta diversions in wetter years and relatively more export pumping at the south Delta diversions in drier years (Appendix 5.B, Section 5.B.4.1, *Relative Contribution of North and South Delta Intakes under the BDCP*). These results reflect the ESO scenario, but are also applicable to LOS because of the similarity in spring flows between ESO and LOS (Appendix 5.B, Section 5.B.4.5, *Differences Between Evaluated Starting Operations, High-Outflow Scenario, and Low-Outflow Scenario*), whereas under HOS there would be less south Delta export pumping from March through May and, therefore, potentially less steelhead entrainment than under the ESO because of the overlap of the typical steelhead salvage period with this period (Figure 5.B.6-1, *Mean Monthly Salvage of Juvenile Steelhead Calculated from Observed Salvage Monitoring at the (a) SWP and (b) CVP South Delta Export Facilities, Water Years 1996–2009*, in Appendix 5.B). Note that seasonality shown in Figure 5.B.6-1 reflects both hatchery- and wild-origin steelhead; wild-origin steelhead migrate mostly in spring (Nobriga and Cadrett 2001; Kurth 2013) and therefore may benefit more from the HOS. It is concluded with moderate certainty that the BDCP would result in a high positive change to the south Delta entrainment attribute for migrating steelhead juveniles, which constitute the great majority of the population inhabiting the Plan Area. The moderate degree of certainty reflects the limited ability to model real-time water operations management decisions under existing conditions and the BDCP (e.g., weekly changes in export pumping that could occur because of observed pulses of fish entering the Plan Area from monitoring), which could result in differences from the results observed here. Nevertheless, it is anticipated that the BDCP will have an appreciable positive change to this attribute for steelhead juveniles. This same conclusion is drawn for foragers, but with low certainty reflecting the lack of information about foragers, recognizing that foragers form a very small proportion of the Plan Area population of steelhead juveniles. Limited agency comment suggested that a low positive change would be appropriate for juvenile salmonid entrainment in general; the conclusion assumed here is a reflection of the modeled changes presented above.

Table 5.5.6-1. Difference in Average Annual Entrainment Index[a] of Juvenile Steelhead (Sacramento River Region) at the SWP/CVP South Delta Export Facilities under Future Conditions with the BDCP (Compared to Existing Conditions and to Future Conditions without the BDCP), Based on the Salvage Density Method

Water-Year Type	Change[b] under ESO_LLT[c]	
	Compared to EBC2[c]	Compared to EBC2_LLT[c]
Wet	-4,353 (-68%)	-4,271 (-68%)
Above normal	-7,157 (-55%)	-7,389 (-55%)
Below normal	-4,372 (-37%)	-3,638 (-33%)
Dry	-2,163 (-29%)	-1,591 (-23%)
Critical	-1,444 (-24%)	-858 (-16%)
All years	-4,755 (-52%)	-4,506 (-51%)

[a] Number of fish lost to entrainment

[b] Negative values indicate lower entrainment under the BDCP compared with existing conditions or future conditions without the BDCP.

[c] For descriptions of scenarios, see Table 5.2-3.

The rationale applied to winter-run Chinook salmon (Section 5.5.3.1.2) in relation to agricultural diversions is also applicable to juvenile steelhead in the Plan Area. Because there does not appear to be much evidence of an effect under existing conditions, for this effects analysis, it was assumed with low certainty that entrainment at agricultural diversions is an attribute of low importance to migrating and foraging juvenile steelhead. It is concluded with low certainty that there is the potential for a low positive change to this attribute for foraging and migrating juvenile steelhead as a result of *CM4 Tidal Natural Communities Restoration* and *CM21 Nonproject Diversions*, as discussed further for winter-run Chinook salmon. Changes to the North Bay Aqueduct's Barker Slough Pumping Plant and its proposed alternative intake on the Sacramento River will represent no change to this attribute for juvenile steelhead, because the intake is currently screened and will remain so in the future, at both locations.

Reduced Entry into Interior Delta

Nonphysical barriers, north Delta intake bypass flows, and changed Delta hydrodynamics under the BDCP together have the potential to reduce entry into the interior Delta for Sacramento River region steelhead.

Juvenile Sacramento River region steelhead may enter the interior Delta from the mainstem Sacramento River through Georgiana Slough; the Delta Cross Channel is generally closed during their migration period. In comparison to Sacramento River region Chinook salmon, there has been relatively little study of survival through the interior Delta for steelhead. Singer et al. (2013) found that proportional survival of acoustically tagged steelhead from Sacramento to the ocean (Golden Gate bridge) was lower for those entering the interior Delta through Georgiana Slough (0.10 to 0.19) than for those remaining in the mainstem Sacramento River (0.25–0.33). As noted in the winter-run effects analysis, the need to reduce entry into the interior Delta by juvenile salmonids was recognized in the NMFS (2009a) BiOp, which requires that engineering solutions such as physical and nonphysical barriers be investigated to lessen the issue. For this effects analysis, it was assumed with high certainty that the attribute of interior Delta entry has high importance for migrating and foraging juvenile Sacramento River region steelhead.

CM16 Nonphysical Fish Barriers aims to inhibit juvenile salmonids from entering the interior Delta at locations such as Georgiana Slough, potentially increasing through-Delta survival. As described in greater detail in the winter-run Chinook salmon account, recent studies of deterrence by a nonphysical barrier at the divergence of Georgiana Slough from the Sacramento River found good effectiveness for the relatively large, hatchery-origin late fall–run Chinook salmon smolts that were tested (Perry et al. 2012). These larger Chinook salmon smolts (110- to 140-mm fork length) are smaller than juvenile steelhead, which tend to migrate through the Plan Area as yearlings (or older) that are appreciably larger than Chinook salmon smolts (i.e., greater than 200-mm fork length; Nobriga and Cadrett 2001). Nonphysical barrier effectiveness may be a function of fish size, with larger fish having better swimming ability (Appendix 5.C, *Flow, Passage, Salinity, and Turbidity,* Section 5.C.5.3.9, *Nonphysical Barriers*). Some characteristics of downstream migration differ between juvenile Chinook salmon and steelhead; for example, through-Delta migration of Chinook salmon was found to be 70% nocturnal compared to just over 50% nocturnal for steelhead (Chapman et al. 2013). However, there was little difference in the probability of entrance into Georgiana Slough by day or night for Chinook salmon tested by Perry et al. (2012).

A straightforward sensitivity analysis of available data was used to assess the potential benefit to Sacramento Region steelhead of a nonphysical barrier at the entrance to Georgiana Slough, assuming a 67% deterrence based on Perry et al. (2012). Singer et al. (2013) estimated proportional survival of steelhead from Freeport to the Golden Gate Bridge in 2009 and 2010 for each of three pathways through the Plan Area, together with the proportion of fish taking each pathway. For this effects analysis, the overall proportional survival from Freeport to the Golden Gate Bridge was calculated by weighting pathway-specific survival by the proportion of steelhead taking that pathway. The calculations were then repeated but with an assumed deterrence of 67% of fish that had taken the interior Delta pathway through Georgiana Slough. Conceptually, this is a simplified version of the sensitivity analysis conducted by Perry et al. (2013) on Chinook salmon pathway sensitivity. The results of this simple analysis showed that a nonphysical barrier at Georgiana Slough would have given very little change in survival to the ocean in 2009, whereas in 2010, there would have been a 0.03 increase in survival to the ocean, or 10% in relative terms (Table 5.5.6-2). These results reflected the poorer survival to the ocean through the interior Delta pathway in 2010 compared to 2009, whereas the opposite was true for the other pathways. Note that this analysis focused only on a change in interior Delta entry and did not attempt to account for any other changes that could have resulted from the conservation strategy such as habitat restoration or flow changes downstream of the north Delta intakes.

Table 5.5.6-2. Proportional Survival and Pathway Use of Acoustically Tagged Steelhead[a], with Sensitivity Analysis, Based on 67% Deterrence away from Georgiana Slough by a Nonphysical Barrier

Pathway		Observed Data		Sensitivity Analysis (67% Deterrence from Interior Delta Pathway)	
		2009	2010	2009	2010
Sutter/Steamboat[b]	Proportion using pathway	0.23	0.29	0.23	0.29
	Survival to ocean	0.10	0.30	0.10	0.30
Interior Delta[c]	Proportion using pathway	0.17	0.19	0.06	0.06
	Survival to ocean	0.19	0.10	0.19	0.10
Mainstem Sacramento River[d]	Proportion using pathway	0.60	0.52	0.71	0.65
	Survival to ocean	0.25	0.33	0.25	0.33
Overall Survival		0.21	0.28	0.21	0.31

[a] Reported by Singer et al. (2013).
[b] Originally called West Delta by Singer et al. (2013).
[c] Originally called East Delta.
[d] Originally called Mainstem.

As discussed for winter-run Chinook salmon, and demonstrated in Appendix 5.C, *Flow, Passage, Salinity, and Turbidity,* Section 5.C.5.3.8, *Sacramento River Reverse Flows Entering Georgiana Slough*, the existing evidence does not suggest that entry into the interior Delta would be exacerbated by the north Delta intakes, because of adequate bypass flows under *CM1 Water Facilities and Operation* and the effect of downstream restoration under the BDCP reducing tidal hydrodynamics at the Georgiana Slough divergence in comparison to existing conditions. Based on these modeling results, coupled with the potential effectiveness of nonphysical barriers discussed above, it is concluded with moderate certainty that the BDCP would result in a low positive change to the interior Delta entry attribute for migrating juvenile steelhead. The certainty level is based on existing tests on Chinook salmon smolts (Perry et al. 2012). The same positive change is concluded for foraging steelhead but with low certainty, because the effectiveness for smaller, foraging fish has not been assessed. As described above for winter-run Chinook salmon, during the August 2013 workshops agency opinion was divided on conclusions regarding the potential change in the interior Delta entry attribute for juvenile salmonids, ranging from a low or moderate positive change (with low certainty) to zero or a low negative change (again with low certainty), primarily reflecting the uncertainty concerning the influence of tidal habitat restoration in muting tidal influence and its potential to offset lower Sacramento River flows below the proposed north Delta intakes.

There is potential for adult steelhead to encounter nonphysical barriers during upstream migration because of the relatively shallow depths that they occupy during migration (Teo et al. 2013). A nonphysical barrier tested at Georgiana Slough had ample room below it to allow passage of upstream migrating fish beneath it (California Department of Water Resources 2012), which would allow adult salmonids to pass. The monitoring and adaptive management program will assess the risk to adult salmonids from delay at nonphysical barriers.

Reduced Predation

The BDCP could reduce losses of juvenile Sacramento River region steelhead at existing localized areas where predation is intense.

NMFS (2009b) ranked predation as a stressor of high importance to the decline of Central Valley Chinook salmon and steelhead. Survival of hatchery-origin steelhead through the Plan Area (Freeport to Benicia) was not statistically different from hatchery-origin Chinook salmon smolts released at the same time during experiments conducted in 2009 and 2010 (Singer et al. 2013). For this effects analysis, it was assumed with moderate certainty that predation of foraging and migrating juvenile steelhead is an attribute of high importance. As noted for winter-run Chinook salmon, this attribute generated a wide range of agency biologist opinion during the August 2013 workshops, with some believing that it was of low importance with low certainty, and others suggesting that it was of high importance with medium or high certainty. Water operations under *CM1 Water Facilities and Operation* may result in less south Delta export facility predation caused by lower entrainment at the facilities but there is potential for aggregation of predators and juvenile Chinook salmon at the north Delta intakes. Greater access to Yolo Bypass under *CM2 Yolo Bypass Fisheries Enhancement* would facilitate greater use of an alternative, relatively high-survival migration pathway. Habitat restoration measures (*CM4 Tidal Natural Communities Restoration*, *CM5 Seasonally Inundated Floodplain Restoration*, and *CM6 Channel Margin Enhancement*) would provide more shallow-water habitat with less predators, in association with *CM13 Invasive Aquatic Vegetation Control* for IAV removal as necessary. There would also be removal of water intakes in restored areas, around which predatory fish may aggregate. Predation suppression under *CM15 Localized Reduction of Predatory Fishes* would involve habitat modification or removal of predators from areas of intense predation. As discussed above, *CM16 Nonphysical Fish Barriers* would provide nonphysical barriers to direct fish away from low-survival pathways in the interior Delta. *CM21 Nonproject Diversions* would involve screening/reconfiguration/removal of nonproject water intakes in the Plan Area.

It is concluded with low certainty that the BDCP would result in a low positive change to predation, with the rationale being the same as for other salmonids. As noted for winter-run Chinook salmon, this conclusion was consistent with some agency biologist opinion during the August 2013 workshops, whereas there was also the opinion expressed during the workshops that suggested zero or a low negative change would be appropriate, because of factors such as enhanced predation in the vicinity of the proposed north Delta intakes that may be greater than any potential positive effects from CM15. Low certainty in the changes to predation, particularly with respect to CM15, will be informed through targeted research and adaptive management.

Reduced Illegal Harvest

The BDCP will help reduce illegal harvest of adult Sacramento River region steelhead.

CM17 Illegal Harvest Reduction will decrease poaching of covered salmonids and other covered fishes. Details of CM17 are provided in the winter-run Chinook salmon discussion. It is hypothesized that enhanced enforcement on poaching will reduce mortality and potentially increase populations of steelhead (California Department of Fish and Game 2007, 2008; Moyle et al. 2008). For this effects analysis, it was assumed with low certainty (based on relatively little information) that illegal harvest of steelhead juveniles and adults is an attribute of low importance. It is concluded that there will be a high positive change to the illegal harvest attribute for steelhead under the BDCP, with high certainty based on the analysis presented by Roberts and Laughlin (2013) that is discussed further in the winter-run Chinook salmon analysis.

5.5.6.2.2 Adverse Effects

Near-Field and Far-Field Effects of the North Delta Diversions on Juvenile Sacramento River Region Steelhead

Operation of the proposed north Delta diversions under the BDCP has the potential to adversely affect juvenile Sacramento River region steelhead through near-field (physical contact with the screens and aggregation of predators) and far-field (reduced downstream flows leading to greater probability of predation) effects.

Although a portion of downstream migrating Sacramento River region steelhead from tributaries upstream of Fremont Weir would enter the Yolo Bypass and avoid the new north Delta intakes, the majority would continue down the Sacramento River and pass in the vicinity of the north Delta intakes. Most Feather River and American River steelhead downstream migrants also would pass the north Delta intakes, except in situations where high Feather River flows lead to spilling of the river into the Sutter Bypass and entry into the Yolo Bypass. As described for winter-run Chinook salmon, the north Delta intakes may have near-field (screen contact/impingement and predation) and far-field (reduced flow-related survival) effects on juvenile steelhead. Steelhead juveniles would not be entrained because of their size and their strong swimming ability, suggesting negative effects from screen contact and impingement to be of low probability; results of preliminary laboratory experiments with steelhead parr at a simulated fish screen found similar results to Chinook salmon smolts in terms of no relationship between velocity parameters and rates or severity of injury (Swanson et al. 2004). There may be potential for aggregation of predators near the north Delta intakes, although there is uncertainty regarding the extent to which the juvenile steelhead may occur near the intakes in response to diversions during winter and spring. Diversions at the north Delta intakes were modeled to average around 11 to 18% of the Freeport flow across all water-year types (ranging from an average of 6% in critical water years up to an average of approximately 25% in wetter years (Appendix 5.B *Entrainment*, Section 5.B.6.2.1.1, *Occurrence near the Proposed North Delta Intakes*). Overall, it is concluded that the BDCP would not result in an effect for steelhead migrant juveniles from entrainment or impingement at the north Delta intakes; this is expressed as no importance of this attribute to steelhead juveniles (with high certainty) and reflects the larger size of steelhead migrants compared to other migrating salmonid juveniles in the Plan Area; this conclusion was in agreement with agency biologist opinion from the August 2013 workshops. Any smaller Sacramento River region steelhead (i.e., foragers) that occur in the Plan Area near the north Delta intakes may be subject to impingement and related effects; only a small proportion (5%) of steelhead juveniles are assumed to be foragers for this effects analysis. It is concluded with moderate certainty that the BDCP would have a low negative change to the entrainment/impingement attribute for this life stage, consistent with the potential concluded for foraging juvenile Chinook salmon. The conclusions regarding the potential entrainment/impingement effects from the north Delta intakes on foraging steelhead are consistent with agency biologist opinion from the August 2013 workshops and reflect an assumed low importance (with moderate certainty) based on the proposed screening and operational criteria.

As described in Section 5.5.6.2.1, *Beneficial Effects*, Plan Area flows within less tidally influenced reaches have been shown to correlate with juvenile Chinook salmon through-Delta survival. Singer et al. (2013) found through-Delta survival of acoustically tagged steelhead and Chinook salmon released at the same time was greater during a lower flow year (2009) than a higher flow year (2010) and attributed the counterintuitive result to the high-flow release being made 1 month later in the year, when warmer temperatures may have influenced predation in addition to any flow effect. For this effects analysis, it was assumed with moderate certainty that Plan Area flows for migration and movement have critical importance for migrating juvenile steelhead and high importance for foraging steelhead. Agency biologist opinion during the August 2013 workshops generally thought high or moderate importance may be warranted.

Monthly river flows for the main steelhead winter/spring juvenile migration period (December to June) from CALSIM for the Sacramento River below the north Delta intakes showed that under ESO_LLT, the overall average flow across all water-year types was 12 to 25% lower compared to existing conditions or EBC2_LLT (Table 5.5.6-3). The greatest negative change was in May of wet years (over 40% lower under the BDCP compared to existing conditions), whereas in drier years there was less difference in flows between the BDCP and existing conditions. The particle-tracking modeling nonlinear regression analysis presented in Appendix 5.C. *Flows, Salinity, Turbidity, and Passage*, Section 5.C.5.3.7, *Particle Tracking Modeling Nonlinear Regression Analyses (Chinook Salmon Fry/Parr)*, provides an assessment of the estimated proportion of particles reaching Chipps Island after 30 days as a function of Plan Area flows and diversions for the March through May period in order to illustrate differences between existing conditions and the BDCP scenarios. March to May also overlaps the main period for emigration of natural-origin steelhead (February to April) (Nobriga and Cadrett 2001; Kurth 2013). It is acknowledged that particle tracking of neutrally buoyant particles may not be representative of steelhead emigration patterns, but does provide a somewhat more refined accounting of potential changes in water movement through the system than examination of monthly average flows. This analysis showed that the estimated annual average proportion of particles reaching Chipps Island from the Sacramento River above Sutter Slough generally was lower under the ESO scenario compared to existing conditions (9% less across all water years, ranging from 2% less in critical years to 14% less in below-normal water years) (Table 5.5.6-3). There was less difference between the ESO_LLT and EBC2_LLT, with an overall average of 5% less under the BDCP, ranging from 1 to 7% less by water-year type. Similar results were obtained for LOS in relation to existing conditions, reflecting the similarity of spring flows with the ESO. The proportion of particles reaching Chipps Island after 30 days under HOS_LLT was similar to EBC2_LLT (Table 5.5.6-3). The decision tree includes the investigation of the importance and necessity for increased flows during this time of year.

Table 5.5.6-3. Weighted Annual Average Proportion of Particles Reaching Chipps Island after 30 Days from the Sacramento River at Sutter Slough Release Location under Five Scenarios[a], from the Particle Tracking Modeling Nonlinear Regression Analysis Applying an Equal Weighting to March through May over the 1922–2003 CALSIM Modeling Period, Averaged by Water-Year Type

Water-Year Type	EBC2	EBC2_LLT	ESO_LLT	HOS_LLT	LOS_LLT	EBC2 vs. ESO_LLT	EBC2_LLT vs. ESO_LLT	EBC2_LLT vs. HOS_LLT	EBC2_LLT vs. LOS_LLT
All	0.73	0.70	0.67	0.72	0.67	-0.07 (-9%)[b]	-0.04 (-5%)	0.02 (2%)	-0.03 (-5%)
Wet	0.94	0.91	0.87	0.93	0.87	-0.07 (-8%)	-0.04 (-5%)	0.02 (2%)	-0.04 (-5%)
Above normal	0.88	0.85	0.80	0.88	0.80	-0.09 (-10%)	-0.05 (-6%)	0.03 (3%)	-0.05 (-6%)
Below normal	0.73	0.68	0.63	0.72	0.64	-0.10 (-14%)	-0.05 (-7%)	0.04 (6%)	-0.04 (-6%)
Dry	0.57	0.55	0.52	0.54	0.52	-0.05 (-9%)	-0.02 (-5%)	-0.01 (-1%)	-0.03 (-5%)
Critical	0.39	0.38	0.38	0.38	0.38	-0.01 (-2%)	0.0 (-1%)	0.0 (0%)	0.0 (0%)

[a] For descriptions of scenarios, see Table 5.2-3.
[b] Negative numbers indicate lower proportion of particles reaching Chipps Island under the BDCP scenarios.

In light of the above analyses, it is concluded that the BDCP could result in a low negative change to Plan Area flows for foraging and migrating steelhead, with high certainty for migrating juveniles and moderate certainty for foraging juveniles, reflecting the relative difference in knowledge about what the change may mean to these different juvenile behavior types. As noted above for winter-run Chinook salmon, limited agency biologist opinion during the August 2013 workshops suggested a moderate negative change to the Plan Area flows attribute would be justified on the basis of some large negative changes in flow during February and March.

Reduced Attraction Flows in the Sacramento River

Sacramento River attraction flows for migrating adult Sacramento River region steelhead will be lower from operations of the north Delta diversions under the BDCP.

Straying rates of adult hatchery-origin Chinook salmon that were released upstream of the Delta are low (Marston et al. 2012), as discussed further under the winter-run Chinook salmon analysis. Although straying rates for hatchery-origin steelhead apparently have not been examined in detail, for this effects analysis, it was assumed with high certainty (based on Chinook salmon rates), that Plan Area flows in relation to straying have low importance under existing conditions for adult Sacramento River region steelhead. This assumption was generally in accordance with agency biologist opinion during the August 2013 workshops, with a minority comment suggesting moderate importance (with low certainty felt to be appropriate, regardless of importance).

Sacramento River flows downstream of the proposed north Delta intakes generally will be lower under BDCP operations relative to existing conditions, with differences between water-year types because of differences in the relative proportion of water being exported from the north Delta and south Delta facilities. As assessed by DSM2 fingerprinting analysis, the average percentage of Sacramento River–origin water at Collinsville, where the Sacramento and San Joaquin Rivers converge in the West Delta subregion, was always slightly lower under the BDCP than for existing conditions during the September–March steelhead upstream migration period (Appendix 5.C, *Flow, Passage, Salinity, and Turbidity,* Section 5.C.5.3 13.1.2, *Steelhead*). The average monthly percentage of Sacramento River water at the confluence during September to March was modeled at 63 to 73%

under the BDCP (ESO_LLT) compared to 65 to 78% under existing conditions (EBC2) and 65 to 76% under future conditions without the BDCP (EBC2_LLT) (Table 5.C.5.3-191, *Monthly Average (With Range in Parentheses) Percentage of Water at Collinsville Originating in the Sacramento River during September–March under EBC and ESO Scenarios*, in Appendix 5.C). Because these differences are relatively low, it is concluded with low certainty that the BDCP would result in a low negative change to adult Plan Area migration flows for upstream migrating adult Sacramento River region steelhead. The low certainty in these conclusions would be informed by monitoring and targeted research under the BDCP (e.g., examining migration success of tagged adult steelhead or Chinook salmon under different flow regimes), with any adverse effects being addressed by adaptive management.

Exposure to In-Water Construction and Maintenance Activities

In-water construction and maintenance effects of the BDCP could affect Sacramento River region steelhead.

The main in-water construction activities at the proposed north Delta intakes (*CM1 Water Facilities and Operation*) will be limited to one construction season during the months of June through October, which would overlap with the early part of the main steelhead adult upstream migration period but would avoid the main juvenile downstream migration period (Appendix 5.H, *Aquatic Construction and Maintenance Effects*). As noted for winter-run Chinook salmon and other species, potential adverse effects could arise from underwater sound (pile driving), entrapment within cofferdams, exposure to suspended sediment or toxin materials, and accidental spills. Habitat restoration activities may result in temporary adverse changes to steelhead habitat, whereas small-scale activities such installation of nonphysical barriers would result in very little change. Implementation of *CM22 Avoidance and Minimization Measures* would reduce the likelihood of adverse effects from in-water activities related to construction and maintenance on juvenile and adult Sacramento River region steelhead. Thus, it is concluded with high certainty that construction and maintenance associated with the BDCP would result in a low negative change to the species.

Exposure to Contaminants

The BDCP will contribute to a reduction in Sacramento River region steelhead exposure to contaminants in the late long-term, although localized increases in contaminant exposure may occur as a result of tidal habitat and floodplain restoration.

The BDCP could adversely affect Sacramento River region steelhead life stages occurring in the Plan Area through changes in contaminants as a result of changes in water operations (*CM1 Water Facilities and Operation, CM2 Yolo Bypass Fisheries Enhancement*) and habitat restoration (principally, *CM4 Tidal Natural Communities Restoration*). As noted for winter-run Chinook salmon, analyses presented in Appendix 5.D, *Contaminants*, suggest that the potential for increased contaminant exposure under the BDCP would be low, and a beneficial effect in the late long-term could result from reduced contaminants from restoration of areas previously used for agriculture. It is concluded with low certainty that the BDCP would result in a low negative change to this attribute for foraging and migrating juvenile steelhead, for similar reasons as given for other salmonid races such as winter-run Chinook salmon.

Changes in Upstream Habitat

No upstream temperature-related effects are expected for steelhead and all NMFS criteria would be met at the same frequency or more often than conditions without BDCP. Although there are some small to moderate reductions in mean flow in the American River, the NMFS minimum flow criteria are met at least as frequently as conditions without BDCP, and no overall change in habitat conditions is expected.

Upstream flows and water temperatures define the quantity and quality of steelhead adult spawning, egg incubation, fry and juvenile rearing, juvenile and adult migration, and adult holding habitat for steelhead in rivers upstream of the Plan Area. Reduced quantity or quality of spawning habitat could cause increased competition for remaining habitat, redd superimposition, and reduced spawning success. It was assumed with moderate certainty that spawning habitat is an attribute of high importance. Reduced quantity or quality of juvenile rearing habitat could cause reduced juvenile growth and survival or delay or reduce successful smoltification and downstream migration. It was assumed with moderate certainty that juvenile rearing habitat is an attribute of high importance. Reduced quantity and quality of juvenile migration habitat could delay or reduce successful entry into the Delta and ocean, which could reduce survival in these locations. It was assumed with moderate certainty that juvenile migration habitat is an attribute of moderate importance. Reduced quantity and quality of adult and kelt migration and adult holding habitat could delay or reduce successful adult migration and spawning or staging. It was assumed with moderate certainty that this habitat is an attribute of high importance.

The BDCP does not propose any changes in Shasta operating criteria, and BDCP does not affect upstream temperatures or flows in ways that would require a change in Shasta operations. Modeling results show that in the Sacramento River, there would generally be no flow- or water temperature-related effects of BDCP on steelhead spawning and egg incubation, fry and juvenile rearing, juvenile, adult, and kelt migration, or holding habitat. However, one method used, SacEFT, predicted a 10% reduction in the amount of available juvenile rearing habitat. However, no other spawning, egg incubation, or fry and juvenile rearing habitat characteristics are predicted to be affected by BDCP by the other methods used to evaluate upstream habitat conditions for steelhead. Further, all NMFS flow threshold criteria for the Sacramento River (National Marine Fisheries Service 2009a, 2009b) would be met in the late long-term at similar frequencies to those under conditions without BDCP. It is concluded with moderate certainty that the BDCP would have no effect on this attribute. After extensive investigation of these results, they appear to be a function of high model sensitivity to relatively small changes in estimated upstream conditions. Therefore, BDCP does not change the ability of Shasta Reservoir to meet its operating criteria for cold water pool and downstream temperature, including end of September and end of May storage. These criteria are required by the 2009 BiOp to ensure that there are no unacceptable flow- or temperature-related effects on Sacramento River covered fish species, including steelhead. Appendix 5.C, *Flow, Passage, Salinity, and Turbidity* includes analysis of steelhead habitat for upstream holding, spawning, egg incubation, and rearing, or for downstream migration flows in the upper Sacramento River, based on a variety of analyses conducted. Besides SacEFT, these models predict that there would be no change on upstream habitat. Additionally, an important biological objective for steelhead is to avoid degradation of upstream habitat, which the modeling results suggest has been achieved through maintenance of the operational criteria from the NMFS (2009a) BiOp for Shasta Reservoir and upper Sacramento River flows.

Feather River flows would change under all of the BDCP outflow scenarios, with higher flows in the spring and lower flows in the summer, compared to conditions without BDCP. In the Feather River low-flow channel, in which the vast majority of steelhead spawn and rear, there would be no flow- or water temperature-related effects of BDCP on steelhead spawning and egg incubation, fry and juvenile rearing, or adult holding habitat.

There would be small to moderate increases in flows under BDCP during juvenile and adult migration periods in the high-flow channel, but no differences during the kelt migration period. In the high-flow channel, there would be no flow-related effects on spawning or egg incubation habitat, but there would be up to 50% reductions in flows during July through September, during the year-round juvenile rearing period. However, there would be no temperature-related effects of BDCP on any life stage in the high-flow channel. The river channel downstream of Thermalito (high-flow channel) offers few of the habitat types upon which steelhead appear to rely in the low-flow channel. Experiments and fish observations also suggest that predation risk for juvenile steelhead is higher downstream of the Thermalito outlet (California Department of Water Resources 2004). Thus, the reduction in flows in the high-flow channel due to BDCP would reduce conditions in an already unsuitable habitat. Therefore, it is concluded with moderate certainty that the BDCP would result in a low negative change to this attribute.

The BDCP does not include any changes in Folsom operating criteria, and avoids changes in end of May storage to ensure that there are no unacceptable flow- or temperature-related effects of the BDCP on American River covered fish species, including steelhead. Modeling results show that in the American River, there could be up to 28% flow reductions under ESO and HOS in fall and summer months, during the juvenile rearing period. However, NMFS flow threshold criteria for the American River (National Marine Fisheries Service 2009a, 2009b) would be met under ESO_LLT at similar (in wet, above-normal, and below-normal water years) or 7% to 10% higher frequencies (in dry and critical water years) than those under EBC2_LLT. These results are similar for HOS. Therefore, despite these flow reductions, flows under BDCP would be great enough to maintain or enhance critical habitat features in the American River for upstream salmonids life stages. There would be no water temperature-related effects on steelhead spawning or egg incubation, juvenile rearing, juvenile, adult, and kelt migration, and adult holding habitat. Further, there would be no flow-related effects of BDCP on steelhead spawning or egg incubation habitat or adult holding habitat. It is concluded with moderate certainty that the BDCP would have no effect on this attribute.

There would be no flow- or water temperature-related effects of BDCP on steelhead spawning and egg incubation, fry and juvenile rearing, juvenile, adult, and kelt migration, and adult holding habitat in Clear Creek.

5.5.6.2.3 Impact of Take on Species

Take of Sacramento River region steelhead, either direct or indirect, may occur from construction and maintenance at the proposed north Delta intakes, restoration sites, conservation hatcheries, and nonphysical barriers. Adverse effects are described in Appendix 5.H, *Aquatic Construction and Maintenance Effects*, and will be temporary and unlikely to be considerable on Sacramento River region steelhead because avoidance and minimization measures will be taken, e.g., timing of in-water work to minimize potential adverse effects on juvenile salmonids. There will be minimal impact of take from these activities.

It is anticipated that the BDCP will reduce overall entrainment of Sacramento River region steelhead by implemented dual conveyance: south Delta exports will be reduced in favor of north Delta exports, with the north Delta intakes being screened to prevent entrainment and limit screen contact or impingement of juvenile steelhead. The north Delta intakes will be used to export water most frequently in wetter years, as dictated by Sacramento River at Hood bypass flow criteria.

Lower river flow downstream of the north Delta intakes under the BDCP may reduce survival of juvenile Sacramento River region steelhead during downstream migration and also could negatively affect upstream migration of adult winter-run Chinook salmon by changing attraction flows/olfactory cues. Such effects are not readily quantifiable in terms of take. Evaluation of these effects will be made through research and adaptive management.

5.5.6.2.4 Abundance, Productivity, Life-History Diversity, and Spatial Diversity

The analysis presented for winter-run Chinook salmon, Section 5.5.3.4, also includes Sacramento River region steelhead.

5.5.6.2.5 Net Effects

Figure 5.5.6-1 shows the relative population-level outcomes, by attribute, for Sacramento River region steelhead, that will result from implementation of the BDCP. The positive effects of the BDCP are concluded to outweigh the negative effects, so that the net effect of the BDCP is expected to be beneficial to Sacramento River region steelhead. In general there is less certainty regarding the benefits of the Plan than for Sacramento River region Chinook salmon runs. This reflects less certainty about the importance of different attributes as current constraints on steelhead, and less certainty related to the benefits of the various habitat-related conservation measures proposed under the BDCP for steelhead, which are assumed to be largely migrating through the Plan Area quite rapidly as juveniles or adults.

As noted above, steelhead are assumed to occur within the Plan Area for relatively short periods of time as both juveniles and adults. As noted for other salmonids, the benefits of the BDCP include a substantial increase in tidal, floodplain, channel margin, and riparian habitat, which is anticipated to provide improved habitat for occupancy and appreciably greater food production for juvenile steelhead; however, because most juvenile steelhead are assumed to be migrants passing quite quickly through the Plan Area, the effect of food benefits and habitat change would be limited for rearing. Juvenile steelhead are also expected to benefit from less south Delta entrainment and reduced entry into the low-survival interior Delta. There are potential benefits from reduced predation through *CM15 Localized Reduction of Predatory Fishes* and reduced illegal harvest, although the benefits of these measures are challenging to assess.

Near-field and far-field effects of the north Delta intakes on juvenile steelhead include the potential for negative interactions at the north Delta intakes, in addition to lowered flow-related survival downstream of the intakes. Less flow below the intakes may affect adult upstream migration, though this is uncertain. Restoration and other covered activities may result in temporary water quality and disturbance issues, while restoration has some potential to increase contaminants (although over the long term, less contaminants may occur in restored areas because of the change in land use). Upstream habitat generally is not anticipated to change from any differences in reservoir releases under the BDCP, with the exception of the high-flow channel of the Feather River.

The magnitude of benefits of the BDCP for Sacramento River region steelhead cannot be quantified with certainty; however, it is concluded with low to moderate certainty that the net effect of the BDCP would be positive for Sacramento River region steelhead.

Therefore, the BDCP will minimize and mitigate impacts to the maximum extent practicable and provide for the conservation and management of the steelhead in the Sacramento River region of the Plan Area.

5.5.6.3 San Joaquin River Region

Consistent with Sacramento River region steelhead, it is assumed that 95% of juveniles are migrants that spend relatively little time in the Plan Area; foragers were assumed to represent only 5% of the steelhead juveniles entering the Plan Area. This was based on literature review and discussions with agency biologists at workshops in August 2013. These proportions were used to qualitatively weight the effects of the BDCP on each ESU. Scoring of BDCP net effects (Section 5.5.6.3.5) considered the beneficial and adverse effects of the BDCP on foragers and migrants separately. Much of the inference about effects of the BDCP on San Joaquin River region steelhead is made from the analysis of San Joaquin River region fall-run Chinook salmon. Consistent with the analysis for San Joaquin River region fall-run Chinook salmon, which includes the Mokelumne River fall-run Chinook salmon population, the present analysis of San Joaquin River region steelhead also includes Mokelumne River (and Cosumnes River) steelhead but discusses available results separately as appropriate.

5.5.6.3.1 Beneficial Effects

Restored Floodplain, Tidal, and Channel Margin Habitat

Floodplain and Channel Margin Habitat

The BDCP will provide extensive floodplain habitat and associated channel margin and riparian habitat in the South Delta subregion, which will increase floodplain availability and channel complexity, leading to an improvement in conditions for juvenile San Joaquin River Region Central Valley steelhead.

As noted for San Joaquin River region fall-run Chinook salmon, loss of floodplain habitat in the San Joaquin Valley has been extensive (Williams 2006). More information on the importance of floodplain habitat to juvenile salmonids is provided in the winter-run Chinook salmon analysis. It was assumed with low certainty that floodplain habitat availability is an attribute of high importance for foraging San Joaquin River region steelhead and low importance for migrating San Joaquin River steelhead juveniles; note that most (95%) of juveniles are assumed to be migrants. During the August 2013 agency workshops, agency biologists generally suggested (with low certainty) that the importance of floodplain habitat was low or moderate for San Joaquin River region steelhead, reflecting most juveniles in the Plan Area being migrating juveniles. As noted for Sacramento River region steelhead, for this effects analysis it was assumed that channel margin habitat represents an attribute of high importance to foraging juvenile steelhead (with high certainty) and low importance to migrating juvenile steelhead (with low certainty). For salmonids in general, some agency biologists concurred with these assumptions (albeit with lower certainty) during the August 2013 workshops, whereas other agency biologists felt moderate importance for foragers to be warranted. Further discussion of channel margin habitat importance is provided above in the Sacramento River region steelhead analysis.

Category	Appendix	Attributes	Definition	Eggs	Foragers	Migrants	Adults
Food	E	Zooplankton community	Species composition of the zooplankton community and presence of suitable prey species	NA	Zero	Zero	
		Zooplankton abundance	The abundance of zooplankton	NA	Low	Low	
		Benthic & Epibenthic prey abundance	The abundance of epibenthic prey species such as amphipods	NA	High	Low	
		Insect abundance	The abundance of insect prey	NA	High	Low	
Entrainment & Impingement	B	North Delta Intakes	Potential entrainment/impingement from the proposed North Delta intakes	NA	Very Low -		
		South Delta Pumps	Pumping rate from the CVP/SWP south Delta export facilities and resulting entrainment	NA	Moderate	Moderate	
		North Bay Aqueduct	Entrainment from the SWP NBA facilities	NA			
		Ag Diversions	Entrainment from Agriculture Diversions	NA	Very Low	Very Low	
Migration & Movement	C	Plan Area Flows	Magnitude, timing, direction, and duration of flows during migratory periods throughout the Plan Area	NA	Low-	Moderate-	Very Low -
		Interior Delta Entry	Entry of fish into the interior Delta from the mainstem Sacramento or San Joaquin Rivers through channels such as Georgiana Slough or Old River	NA	Low	Low	NA
		Passage Barriers	Structures or conditions that potentially block upstream or downstream migration	NA			Low
Habitat	C, E	Inter-tidal habitat	Intertidal area from the mean low low water level to the extreme high water level that may support intertidal vegetation and form mudflats; dynamic elements of habitat such as appropriate salinity are considered on a species-specific basis	NA	High	Low	
		Channel Margin	The extent of shallow water, low slope habitat that generally is characterized by structural complexity, native emergent vegetation and riparian shading cover	NA	Moderate	Low	
		Floodplains	The interface between upland topography and river hydrology during high flow events	NA	High	Low	
		Riparian	Forest and scrub that occurs along the margins of river channels and within floodplains	NA	NA	NA	NA
		Sub-tidal habitat	Extent and location of sub-tidal area in the Plan Area, including the low salinity zone (LSZ); dynamic elements of habitat such as appropriate salinity are considered on a species-specific basis	NA	Low	Low	
Sediment	C	Water clarity	Water clarity in the Plan Area as influenced by amount of suspended material within the water column	NA	Zero	Zero	
Temperature	C	Temperature	Adverse effects of high temperatures within the Plan Area	NA			
DO	C	Dissolved Oxygen	Adverse effects of low dissolved oxygen level within the Plan Area	NA			
Toxins	D, F	Contaminants	Adverse effects of methylated mercury, selenium, pesticides and other pollutants	NA	Very Low -	Very Low -	
		Microcystis	The abundance of Microcystis aeruginosa blooms that are toxic to covered fish species and their food	NA			
Predation	F	Predation	The species-specific consumption of covered fish species by predatory fish (e.g., striped bass, Sacramento pikeminnow, centrarchid bass species, catfish, and inland silversides); note that the attribute aims to isolate predation effects that may not be captured by other attributes, e.g., at manmade structures such as the north Delta diversions	NA	Low	Low	
		Illegal Harvest	Illegal harvest of covered fish species in the Plan Area	NA	Low	Low	Low

In-stream Habitat	C	Sacramento R. Habitat	Flows in the Sacramento River mainstem (below Keswick Dam to the Plan Area) that influence spawning, egg incubation, rearing, or holding habitat	Zero	Zero	Zero	Zero
		Feather R. Habitat	Flows in the Feather River (below Oroville Dam to the confluence with the Sacramento River) that influence spawning, egg incubation, rearing, or holding habitat		Zero	Zero	Zero
		American R. Habitat	Flows in the American River (below Nimbus Dam to the confluence with the Sacramento River) that influence spawning, egg incubation, rearing, or holding habitat	Zero	Zero	Zero	Zero
Migration & Movement	C	Sacramento R. Migration Flows	Flows in the Sacramento River mainstem (below Keswick Dam to the Plan Area) that influence migration and movement	NA	Zero	Zero	Zero
		Feather R. Migration Flows	Flows in the Feather River (below Oroville Dam to the confluence with the Sacramento River) that influence migration and movement	NA	Low	Low	Zero
		American R. Migration Flows	Flows in the American River (below Nimbus Dam to the confluence with the Sacramento River) that influence migration and movement	NA	Zero	Zero	Zero
Temperature	C	Sacramento R. Temperature	Adverse effects of high water temperatures in the Sacramento River mainstem (below Keswick Dam to the Plan Area)		Zero	Zero	
		Feather R. Temperature	Adverse effects of high water temperatures in the Feather River (below Oroville Dam to the confluence with the Sacramento River)		Zero		
		American R. Temperature	Adverse effects of high water temperatures in the American River (below Nimbus Dam to the confluence with the Sacramento River)		Zero		

Certainty

- (grey) No effect conclusion made because attribute assumed not to have importance as a current constraint
- NA Life stage not present or not applicable
- (green) Low certainty
- (light blue) Moderate certainty
- (blue) High certainty
- (purple) Very high certainty

Figure 5.5.6-1. Effect of the Covered Activities on Sacramento River Region Steelhead

As described for San Joaquin River fall-run Chinook salmon, *CM5 Seasonally Inundated Floodplain Restoration* would restore up to 10,000 acres of floodplain habitat within the South Delta subregion, with at least 1,000 acres restored by year 15 of the BDCP and a further 9,000 acres by year 40 (Appendix 5.E *Habitat Restoration*, Section 5.E.5, *Conservation Measure 5 Seasonally Inundated Floodplain Restoration*). Several conceptual floodplain restoration corridors have been analyzed for their potential to provide floodplain habitat that would be suitable for juvenile Chinook salmon rearing (Appendix 5.E, Section 5.E.5.5.2, *Results*, and Attachment 5.E.A, *BDCP South Delta Habitat and Flood Corridor planning Corridor Description*). It is assumed that the analysis is of most relevance to steelhead foragers, although as noted above, most steelhead juveniles are migrants in the Plan Area as opposed to foragers. As described for San Joaquin River fall-run Chinook salmon (Section 5.5.5.3), potential changes in habitat characteristics could result in a more than doubling of South Delta subregion floodplain habitat over existing conditions for foraging San Joaquin River region fall-run Chinook salmon juveniles (Table 5.5.5-11 in Section 5.5.5.3), which may also be of benefit to steelhead rearing in the Plan Area. Associated with these conceptual corridors are various extents of potential passive and active channel margin enhancement, along with riparian habitat (Table 5.5.5-12 in Section 5.5.5.3).

Consistent with the conclusion for fall-run Chinook salmon, it is concluded that south Delta floodplain restoration under CM5 and associated channel margin enhancement and riparian restoration will provide a low positive change to the floodplain and channel margin habitat attributes for San Joaquin River fall-run Chinook salmon foraging and migrating juveniles, with low certainty for floodplain habitat because of the relatively infrequent inundation (although still occurring frequently enough to provide some benefit) and moderate certainty for channel margin habitat. As also described for fall-run Chinook salmon, during the August 2013 workshops agency biologists felt that low or zero change was warranted for both the floodplain and channel margin attributes, generally with low certainty. As described below under adverse effects, there are a number of potential negative changes that may result from the restoration activities, but positive changes are concluded to outweigh the negative changes. As previously discussed for San Joaquin River region fall-run Chinook salmon, efforts to assess potential south Delta restoration areas will consider factors such as the location of floodplain habitat in relation to risk of entrainment at the south Delta export facilities, which may occur if restored floodplains are draining into Old or Middle Rivers.

Tidal Habitat

The BDCP will greatly increase the extent of tidal habitat that is suitable for San Joaquin River region steelhead juveniles, particularly in the South Delta subregion.

Loss of tidal habitat as a result of land reclamation facilitated by levee construction is a major stressor on juvenile salmonids in the DRERIP conceptual model (Williams 2009). Attribute importance and certainty scores described under Sacramento River region steelhead are assumed to be applicable to San Joaquin River region steelhead: for this effects analysis, it was assumed with moderate certainty that intertidal habitat is an attribute of high importance for foraging steelhead juveniles and low importance for migrating steelhead juveniles, which is consistent with agency biologist opinion regarding the level of importance from the August 2013 workshops. It was assumed with low certainty, for this effects analysis, that subtidal habitat is an attribute of low importance to both foraging and migrating juvenile steelhead; agency biologists thought low or zero importance for foragers and zero importance for migrants may be warranted (with low certainty).

Changes in tidal habitat (combining intertidal and subtidal) as expressed as HUs for foraging and migrating juvenile salmonids are described in more detail in Appendix 5.E, *Habitat Restoration,* Section 5.E.4.4.1.1, *Habitat Suitability Analysis*, and in the analysis of San Joaquin River region fall-run Chinook salmon. The results of the analysis for subregions relevant to San Joaquin River region steelhead (South Delta, East Delta, West Delta, Suisun Bay, and Suisun Marsh) suggest that under the BDCP there would be around 50% more tidal habitat than under existing conditions for foragers (Table 5.5.3-4 in Section 5.5.3, *Chinook Salmon, Sacramento River Winter-Run ESU*) and around 30% more tidal habitat for migrants (Table 5.5.3-5, in Section 5.5.3). For Mokelumne River steelhead alone, changes in the most relevant subregions (i.e., the East Delta, West Delta, Suisun Marsh, and Suisun Bay) were estimated at over 30% greater under the BDCP for foragers and around 15% greater under the BDCP for migrants.

As noted for San Joaquin River region fall-run Chinook salmon, the proportional increase in intertidal habitat area proposed under the BDCP with CM4 is considerably greater than the proportional change in subtidal area that would result from restoration under CM4: for the subregions most relevant to San Joaquin River region steelhead juveniles (South Delta, East Delta, West Delta, Suisun Bay, and Suisun Marsh), it is estimated that the intertidal acreage under existing conditions would approximately double under the BDCP in the late long-term; for subtidal habitat, the estimated area under existing conditions was estimated to increase by nearly one-third under the BDCP in the late long-term. Considering Mokelumne River fish separately, intertidal acreage in relevant subregions (i.e., the subregions relevant to San Joaquin River salmonids as a whole but excluding the South Delta subregion) was estimated to nearly double under the BDCP in the late long-term; whereas subtidal habitat was estimated to be nearly 20% greater under the BDCP in the late long-term.

Consistent with the conclusion for San Joaquin River fall-run Chinook salmon, it is concluded that the change to intertidal habitat for San Joaquin River steelhead juveniles represents a very high positive change for foraging juveniles and a moderate positive change for migrant juveniles; the assumption is that migrants make up nearly all (95%) of San Joaquin River fall-run Chinook salmon juveniles in the Plan Area. These conclusions both have moderate certainty. Agency biologist comment during the August 2013 workshops suggested the change to be zero or low for steelhead (with high certainty), reflecting the majority of steelhead being migrants; note that low importance of this habitat was assumed. For subtidal habitat, it is concluded that the positive change is moderate, with moderate certainty, for both foraging and migrant juvenile Sacramento River region steelhead—this was consistent with limited agency biologist opinion from the August 2013 workshops. Uncertainties related to tidal habitat restoration in the Plan Area are discussed in Appendix 5.E, *Habitat Restoration*, Attachment 5.E.B, *Review of Restoration in the Delta.* Examples of uncertainty include how much restored habitats may be reduced in value because of colonization by IAV and associated nonnative fish species that may prey on juvenile steelhead or compete for food. *CM13 Invasive Aquatic Vegetation Control* aims to control IAV in the ROAs, which may limit predation, but there is uncertainty related to the ability to do so effectively.

Food Benefits from Restored Habitat

Tidal, floodplain, and channel margin habitat restoration under the BDCP has considerable potential to greatly increase the quantity of food available for juvenile San Joaquin River region steelhead.

Background on the importance and characteristics of food for juvenile San Joaquin River region steelhead is provided in the effects analysis for Sacramento River region steelhead and other salmonids covered in this effects analysis. Consistent with those analyses, it was assumed with moderate certainty that benthic/epibenthic prey abundance and insect abundance have high importance for foraging San Joaquin River region steelhead juveniles and low importance for migrating juveniles. As noted above for winter-run Chinook salmon, during the August 2013 workshops some agency biologists felt that the lack of information regarding food limitation warranted an assumption of moderate importance for benthic/epibenthic abundance and insect abundance; others agreed with an assumption of high importance. Also consistent with winter-run Chinook salmon, it was assumed with moderate certainty that zooplankton abundance has moderate importance for foraging San Joaquin River region steelhead and low importance for migrating juveniles. The moderate degree of certainty is due to the relatively few number of studies of food limitation.

Because of their geographic location, food benefits from restored habitat in the South Delta and East Delta are perhaps most relevant for San Joaquin River region steelhead (including Mokelumne River and Cosumnes River steelhead). The subregions along the potential rearing and migration corridor through the Plan Area (including the South Delta, West Delta, East Delta, Suisun Bay, and Suisun Marsh subregions) were estimated to provide over 70,000 prod-acres under existing conditions (and under future conditions without the BDCP in the late long-term) compared to over 110,000 prod-acres with the BDCP in the late long-term, which represents a 50% increase (Table 5.5.3-6 in Section 5.5.3). For Mokelumne and Cosumnes River steelhead alone, in the most relevant subregions (East Delta, West Delta, Suisun Bay, and Suisun Marsh) there were estimated to be around 57,000 prod-acres in the late long-term future without BDCP, compared to nearly 74,000 prod-acres with the BDCP in the late long-term (a difference of nearly 30%).

The prod-acres analysis focuses on potential changes in phytoplankton productivity because of restoration in tidal habitat, whereas potential changes in the other food-related attributes (benthic/epibenthic and insect prey abundance) are informed by the restoration of tidal habitat and floodplain acreage, described above. Consistent with the conclusion for San Joaquin River region fall-run Chinook salmon, it is concluded with high certainty that there will be a high positive change to benthic/epibenthic and insect abundance for foraging and migrating juvenile San Joaquin River region steelhead. During the August 2013 workshops, agency biologist comments specific to San Joaquin River region fish were limited, but one noted that changes in food for San Joaquin River Chinook salmonids could be categorized as moderate on the basis of these fish perhaps not encountering restored areas as frequently as Sacramento River region Chinook salmon runs. It is concluded that there would be a low positive change in zooplankton abundance with low certainty for foraging steelhead that reflects seasonality of zooplankton occurrence and uncertainty related to consumption of primary productivity by nonnative clams. The positive change in zooplankton abundance for migrant San Joaquin River region steelhead juveniles is concluded to be moderate, reflecting later occurrence during warmer conditions, again with low certainty for the reasons described above.

Decreased Adult Straying into the Sacramento River Region

San Joaquin River upstream migration cues for migrating adult San Joaquin River region steelhead will be greater from reduced operations of the south Delta export facilities under the BDCP, with considerable potential to reduce straying into the Sacramento River region.

Little information currently exists as to the importance of Plan Area flows on the straying of adult San Joaquin River region steelhead, in contrast to San Joaquin River fall-run Chinook salmon (Marston et al. 2012). Although information specific to steelhead is not available, for this effects analysis, it was assumed with moderate certainty that the attribute of Plan Area flows (including olfactory cues associated with such flows) is of high importance to adult San Joaquin River region steelhead adults as well. The moderate certainty level is based primarily on the work of Marston et al. (2012) for fall-run Chinook salmon. Limited agency biologist comment during the August 2013 workshops suggested moderate importance with moderate certainty for the Plan Area flows attribute for San Joaquin River region adult steelhead.

As described in the analysis of San Joaquin River region fall-run Chinook salmon, less reliance on the south Delta export facilities for water supply under the BDCP (e.g., Figure 5.B.4-2, *Percentage Change in South Delta Export Pumping under the Evaluated Starting Operations (ESO) Compared to Existing Biological Conditions (EBC)*, in Appendix 5.B, *Entrainment*) has the potential to increase the proportion of water contributed by the San Joaquin River at the Sacramento-San Joaquin River confluence. The same is true for San Joaquin River region steelhead, for which DSM2 fingerprinting analyses estimated that the average percentage of water at Collinsville contributed by San Joaquin flow during the September–March upstream migration period would be around two to ten times greater under the BDCP than for existing conditions and future conditions without the BDCP (Table 5.5.6-4). Relevant to steelhead adults from the Mokelumne/Cosumnes Rivers, DSM2 fingerprinting indicated there is also a greater average percentage of water at Collinsville contributed by the East Delta rivers (Mokelumne, Cosumnes, and Calaveras) during September–December under ESO_LLT (0.7–1.0%) compared to EBC2_LLT (0.1–0.4%); for January–March, there was little difference in average percentage of water at Collinsville contributed by the East Delta rivers between these scenarios (the average percentage for both was around 0.7–1.9%). Results of the analysis for fall-run Chinook salmon estimating straying rate to the Sacramento River region as a function of the ratio of south Delta exports to San Joaquin River inflow suggest that the BDCP could lower straying by 50 to 80%. The fall-run migration period has some overlap with the early part of the steelhead migration period (September to March), so that the results for fall-run Chinook salmon may be indicative of steelhead to some extent. It is concluded with low certainty that the BDCP would result in a moderate positive change to the Plan Area flows attribute, reducing straying of San Joaquin River region steelhead adults. Agency biologist comments received during the August 2013 workshops also suggested that a conclusion of a moderate positive change with moderate certainty was warranted. Uncertainty in the analysis would be informed by targeted research, including studies such as those suggested by Marston et al. (2012:19) on the relative roles of San Joaquin River inflow and south Delta exports on straying rate, timing of pulse flows and export reductions, and the role of pulse flows versus base flows.

Table 5.5.6-4. San Joaquin River Flows as a Percentage of Water at Collinsville during the September through March Adult Steelhead Migration Period under Three Scenarios[a]: Existing Conditions, Future Conditions without the BDCP, and Future Conditions with the BDCP

Month	EBC2	EBC2_LLT	ESO_LLT
September	0.2	0.1	1.2
October	0.2	0.3	3.3
November	0.6	1.0	4.9
December	0.9	1.0	2.9
January	1.6	1.7	3.1
February	1.5	1.5	3.4
March	2.6	2.8	5.5

[a] For descriptions of scenarios, see Table 5.2-3.

Reduced Entrainment

Entrainment loss of juvenile San Joaquin River region steelhead under the BDCP will be lower than under existing conditions because the north Delta diversion operations will reduce reliance on south Delta export facilities.

Consistent with the rationale for San Joaquin River region fall-run Chinook salmon, for this effects analysis, it was assumed with high certainty that south Delta entrainment is an attribute of high importance for foraging and migrating juvenile San Joaquin River region steelhead. This assumption was generally consistent with the agency biologist comments received during the August 2013 workshops, which suggested medium or high importance to be warranted. The salvage density method was used for steelhead without differentiating between Sacramento and San Joaquin River populations (Appendix 5.B, *Entrainment*, Section 5.B.5.4, *Salvage-Density Method (SWP/CVP South Delta Export Facilities)*). As described for fall-run Chinook salmon, CVP entrainment may be indicative of trends specific to San Joaquin River region fish migrating down Old River. However, the relative changes in estimated entrainment from the salvage density method between the BDCP and existing conditions were in any case similar when comparing data for the CVP alone with data for the SWP and CVP combined (Table 5.5.6-5). The relative differences are very similar and suggest that, based on modeled changes in pumping weighted by seasonal and annual occurrence of steelhead at salvage as applied with the salvage density method, entrainment of juvenile San Joaquin River region steelhead at the SWP/CVP south Delta export facilities would average around 50% lower under the BDCP than under existing conditions, ranging from around 15 to 20% lower under the BDCP in critical years to around 60 to 70% lower under the BDCP in wet years, because of the ability to divert water from the north Delta intakes (Appendix 5.B, Section 5.B.6.1.1.1, *Salvage-Density Method*). It is concluded that the BDCP will provide a moderate positive change to entrainment of San Joaquin River region steelhead juveniles (foragers and migrants). There is moderate certainty in this assessment that is related to the attributes of interior Delta entry and Plan Area flow for migration, discussed further below. As described for fall-run Chinook salmon, the uncertainty lies in the lack of information available to inform a situation of low or no south Delta export pumping in the south Delta, as may occur under the BDCP in wetter years. Further discussion is provided below in relation to interior Delta entry and the effects of the proposed operable barrier at the Head of Old River. Limited agency biologist opinion during the August 2013 workshops also suggested a moderate positive change to the south Delta entrainment attribute to be appropriate.

Table 5.5.6-5. Difference in Average Annual Entrainment Index[a] of Juvenile Steelhead (San Joaquin River Region) at the SWP/CVP South Delta Export Facilities under Future Conditions with the BDCP (Compared to Existing Conditions and to Future Conditions without the BDCP), Based on the Salvage Density Method

	Change[b] under ESO_LLT[c] (SWP + CVP)		Change[b] under ESO_LLT[c] (CVP Only)	
Water-Year Type	**Compared to EBC2[c]**	**Compared to EBC2_LLT[c]**	**Compared to EBC2[c]**	**Compared to EBC2_LLT[c]**
Wet	-4,353 (-68%)	-4,271 (-68%)	-624 (-62%)	-631 (-62%)
Above normal	-7,157 (-55%)	-7,389 (-55%)	-800 (-43%)	-814 (-44%)
Below normal	-4,372 (-37%)	-3,638 (-33%)	-738 (-31%)	-769 (-32%)
Dry	-2,163 (-29%)	-1,591 (-23%)	-321 (-25%)	-236 (-20%)
Critical	-1,444 (-24%)	-858 (-16%)	-189 (-22%)	-141 (-17%)
All years	-4,755 (-52%)	-4,506 (-51%)	-643 (-46%)	-626 (-45%)

[a] Entrainment Index = Number of fish lost to entrainment
[b] For descriptions of scenarios, see Table 5.2-3.
[c] Negative values indicate lower entrainment under the BDCP compared to existing conditions or future conditions without the BDCP.
SWP = State Water Project, CVP = Central Valley Project.

Consistent with other salmonids, for this effects analysis, it was assumed with moderate certainty (because of the lack of study) that entrainment at agricultural diversions is an attribute with low importance for foraging and migrating juvenile San Joaquin River region steelhead. Decommissioning of agricultural diversions in lands restored as tidal habitat under *CM4 Tidal Natural Communities Restoration* and screen removal/modification/screening under *CM21 Nonproject Diversions* would reduce the number of unscreened diversions in the Plan Area (Appendix 5.B, *Entrainment,* Section 5.B.6.4.3.1, *Delta Regional Ecosystem Restoration Implementation Plan Analysis of Nonproject Diversions*). Thus, it is concluded with low certainty that the BDCP would result in a small positive change to this attribute. The low certainty level reflects the relative lack of study of the issue. Changes to the North Bay Aqueduct Barker Slough pumping plant and its proposed alternative intake on the Sacramento River are not relevant to San Joaquin River region steelhead because of the population's geographic distribution.

Reduced Entry into the Interior Delta and Positive Changes to San Joaquin River Flows in the South Delta Subregion

An operable barrier at the Head of Old River will reduce entry into the interior Delta and will direct more river flow down the San Joaquin River, giving greater potential for juvenile San Joaquin River region steelhead survival through the Plan Area.

As described for San Joaquin River fall-run Chinook salmon, survival through the Plan Area for salmonids originating in the San Joaquin River region tends to be lower when entering the interior Delta through Old River (see additional discussion in the San Joaquin River region fall-run Chinook salmon analysis). Installation of an operable barrier at the Head of Old River under *CM1 Water Facilities and Operation* would block entry into the interior Delta for foraging and migrating juvenile steelhead. Modeling assumed that the barrier would be closed 50% of the time from January to mid-June, the main steelhead outmigration period, and open for Vernalis flows greater than 10,000 cfs; actual operations would be based on real-time monitoring and adaptive management. It is concluded with moderate certainty that the construction and operation of the operable gate would provide a moderate positive change to the interior Delta entry attribute for foraging and migrating San Joaquin River region steelhead. In addition to the Head of Old River operable gate proposed under CM1, *CM16 Nonphysical Fish Barriers* has the potential to guide juvenile salmonids away from through-Delta survival pathways with relatively low survival, as described for Sacramento River region salmonids in this effects analysis. As discussed in the description of CM16 (Chapter 3, Section 3.4.16.2, *Implementation*), nonphysical barriers may be tested at a number of locations, including channel divergences from the San Joaquin River in the South Delta subregion that lead to the south Delta export facilities (e.g., Columbia Cut and Turner Cut). These locations have the potential to improve survival. The potential of a nonphysical barrier installed at the divergence of Georgiana Slough from the Sacramento River to limit interior Delta entry was analyzed under the winter-run Chinook salmon analysis above. Installation of a nonphysical barrier at this location generally would not be anticipated to affect downstream-migrating San Joaquin River-origin steelhead, including fish from the Mokelumne/Cosumnes Rivers, assuming fish are generally going in a downstream direction (flow in Georgiana Slough generally being downstream). However, Del Real et al. (2012) found that a portion (20%) of acoustically tagged wild steelhead juveniles migrating from the Mokelumne River to Chipps Island migrated upstream through Georgiana Slough to the Sacramento River before moving towards Chipps Island. As noted for winter-run Chinook salmon adults, should juvenile steelhead migrate up Georgiana Slough during a nonphysical barrier deployment period, there may be potential for impedance or migration delay from the nonphysical barrier's deterrence. The ability to swim under the nonphysical barrier would be good at Georgiana Slough if the pilot configuration of the barrier tested in 2011 were used (California Department of Water Resources 2012), wherein the sound stimulus and bubble-generating apparatus were in the middle of the water column. The monitoring and adaptive management program will assess the risk to salmonids from delay at nonphysical barriers.

San Joaquin River flow entering the Plan Area would not change under the BDCP, but the operable physical barrier at the Head of Old River would allow more flow to remain in the San Joaquin River below Old River, which is a potential positive change to Plan Area flows from the perspective of San Joaquin River region fall-run Chinook salmon juveniles. It was assumed with moderate certainty that Plan Area flows are of high importance for San Joaquin River region steelhead foragers and critical importance for migrants. The moderate certainty level is based on the rationale provided for fall-run Chinook salmon, and limited agency biologist comments specific to Plan Area flows for San Joaquin River juvenile salmonids suggested high importance was warranted in relation to Old and Middle River flows (which in the present analysis is dealt with to some extent in the analysis of entrainment above, although there is also overlap with survival through the Plan Area). Results of the DPM for fall-run Chinook salmon provide information on the potential through-Delta survival benefits of more flow remaining in the San Joaquin River, because of a positive relationship between flow and survival and greater survival down the San Joaquin River pathway compared to Old River. However, steelhead are not currently represented in the DPM. To the extent that modeling of neutrally buoyant particles provides some information on water movement through the South Delta and West Delta subregions, the particle tracking modeling nonlinear regression analysis perhaps provides some insight into the relative change in through-Delta migration potential for juvenile steelhead. It is acknowledged that the recent Report of the 2012 Delta Science Program Independent Review Panel (IRP) on the Long-term Operations Opinions Annual Review suggests that it is inappropriate to rely on particle tracking modeling to direct water operations intended to protect outmigrating steelhead based on the results of a spring 2012 study comparing particle tracking modeling results to actual movements of acoustically tagged steelhead. For want of more appropriate information, however, it is felt that the results of the particle tracking modeling nonlinear regression provides preliminary information of some use in this effects analysis that will be refined through more detailed studies.

The results of analyses for the March through May period particle tracking modeling nonlinear regressions provide an indication of differences between the BDCP and existing conditions during an important portion of the juvenile steelhead migration period. These results showed that the overall average estimated proportion of particles reaching Chipps Island from Mossdale under ESO_LLT was around 30% greater than under existing conditions, and 50% greater than under EBC2_LLT (Table 5.5.6-6; Appendix 5.C, Section 5.C.5.3.7, *Particle Tracking Modeling Nonlinear Regression Analyses (Chinook Salmon Fry/Parr)*). This pattern was also true for LOS, whereas an overall average of 60% more particles reached Chipps Island under HOS. The least differences occurred in wet years, reflecting less operation of the Head Old River barrier. Also of relevance to steelhead are results for the Mokelumne River, because as noted above there is a steelhead population in that system that enters the San Joaquin River within the Plan Area. The particle tracking modeling nonlinear regression analysis for the Mokelumne River estimated that the overall average proportion of particles reaching Chipps Island was around 5 to 25% less under the BDCP than existing conditions or future conditions without the BDCP (Table 5.5.6-7). This is a reflection of the effects of tidal habitat restoration in the Cosumnes/Mokelumne ROA (which increases the dispersal of neutrally buoyant particles in the simulation and therefore slows them down) coupled with less flow entering the interior Delta through Georgiana Slough from the Sacramento River, as discussed further in Appendix 5.C, Section 5.C.5.3.7.

Table 5.5.6-6. Average Proportion of Particles Reaching Chipps Island from the San Joaquin River at Mossdale under Five Scenarios[a], Based on the Particle Tracking Modeling Nonlinear Regression Analysis for the March through May Period

Water-Year Type	EBC2	EBC2_LLT	ESO_LLT	HOS_LLT	LOS_LLT	EBC2 vs. ESO_LLT	EBC2_LLT vs. ESO_LLT	EBC2_LLT vs. HOS_LLT	EBC2_LLT vs. LOS_LLT
All	0.19	0.16	0.24	0.26	0.25	0.06 (31%)	0.08 (49%)	0.09 (58%)	0.09 (52%)
Wet	0.39	0.37	0.49	0.51	0.51	0.11 (27%)	0.13 (35%)	0.14 (39%)	0.14 (39%)
Above normal	0.16	0.15	0.26	0.28	0.26	0.10 (59%)	0.11 (79%)	0.13 (89%)	0.11 (78%)
Below normal	0.13	0.08	0.15	0.18	0.15	0.03 (20%)	0.07 (83%)	0.10 (115%)	0.07 (85%)
Dry	0.06	0.03	0.07	0.08	0.07	0.01 (23%)	0.04 (110%)	0.04 (133%)	0.04 (108%)
Critical	0.04	0.03	0.06	0.06	0.06	0.02 (41%)	0.03 (91%)	0.03 (97%)	0.03 (90%)

[a] For descriptions of scenarios, see Table 5.2-3.

Table 5.5.6-7. Average Proportion of Particles Reaching Chipps Island from the Mokelumne River below the Cosumnes River Confluence under Five Scenarios[a], Based on the Particle Tracking Modeling Nonlinear Regression Analysis for the March through May Period

Water-Year Type	EBC2	EBC2_LLT	ESO_LLT	HOS_LLT	LOS_LLT	EBC2 vs. ESO_LLT	EBC2_LLT vs. ESO_LLT	EBC2_LLT vs. HOS_LLT	EBC2_LLT vs. LOS_LLT
All	0.41	0.36	0.31	0.34	0.31	-0.10 (-24%)[b]	-0.05 (-15%)	-0.02 (-6%)	-0.05 (-14%)
Wet	0.72	0.69	0.63	0.67	0.63	-0.10 (-13%)	-0.06 (-9%)	-0.02 (-3%)	-0.05 (-8%)
Above normal	0.50	0.46	0.38	0.43	0.39	-0.11 (-23%)	-0.07 (-16%)	-0.03 (-6%)	-0.07 (-15%)
Below normal	0.35	0.27	0.19	0.24	0.20	-0.15 (-44%)	-0.07 (-28%)	-0.02 (-9%)	-0.07 (-27%)
Dry	0.16	0.11	0.07	0.08	0.07	-0.09 (-55%)	-0.04 (-35%)	-0.03 (-25%)	-0.04 (-35%)
Critical	0.08	0.06	0.04	0.04	0.04	-0.04 (-49%)	-0.02 (-36%)	-0.02 (-34%)	-0.02 (-36%)

[a] For descriptions of scenarios, see Table 5.2-3.
[b] Negative numbers indicate lower proportion of particles reaching Chipps Island under BDCP scenarios.

It is concluded with moderate certainty that the BDCP would result in a low positive change in the Plan Area flows attribute for foraging and migrating San Joaquin River region steelhead juveniles. Agency biologist comments received during the August 2013 workshops suggested that a low or moderate positive change was warranted, with the low positive change reflecting net Old and Middle River flows being frequently negative under both existing conditions and the BDCP. Targeted research and adaptive management would reduce uncertainty and increase knowledge of the importance of the entrainment, interior Delta entry, and Plan Area flows attributes for San Joaquin River region steelhead, particularly in light of ongoing studies of steelhead migration (e.g., as part of the Reclamation 6-Year Tagging Study required under the NMFS [2009a] BiOp).

Improved Upstream Passage

Improved Stockton Deep Water Ship Channel dissolved oxygen conditions and maintenance or increase in passage at the Suisun Marsh Salinity Control Gates will increase upstream passage of adult San Joaquin River region steelhead.

Adult San Joaquin River region steelhead may experience upstream migration delays because of low DO in the Stockton Deep Water Ship Channel and at the Suisun Marsh Salinity Control Gates (Appendix 5.C, *Flow, Passage, Salinity, and Turbidity,* Section 5.C.5.3.11, *Passage Improvements at the Stockton Deep Water Ship Channel*, and Section 5.C.5.3.10, *Suisun Marsh Salinity Control Structure*), as noted previously for fall-run Chinook salmon. It was assumed with moderate certainty that these impediments have moderate importance in relation to the upstream passage attribute for adult San Joaquin River region steelhead. *CM14 Stockton Deep Water Ship Channel Dissolved Oxygen Levels* will provide funding for the existing installed aeration facility to continue operations into the future. It is concluded with moderate certainty that these measures would result in a low positive change for adult San Joaquin River region steelhead adults. During the August 2013 workshops, agency biologists suggested that this attribute was of low importance with low-moderate certainty, and limited agency opinion noted that the change as a result of the BDCP would be moderately positive.

Reduced Predation

The BDCP could reduce losses of juvenile San Joaquin River region steelhead at localized areas where predation is intense.

It was assumed with high certainty that predation of San Joaquin River region steelhead migrants and foragers is of critical importance, based on the rationale provided for San Joaquin River fall-run Chinook salmon and existing studies suggesting predation losses similar to those for Chinook salmon (e.g., Clark et al. [2009] for steelhead compared to Gingras [1997] for Chinook salmon; Singer et al. [2013]). As noted for San Joaquin River region fall-run Chinook salmon above, the importance of the predation attribute generated a wide range of agency biologist opinion (ranging from low to critical importance) and the only specific comment for the San Joaquin River suggested that critical importance (with high certainty) would be warranted for migrating juveniles, and that critical importance (with moderate certainty) would be warranted for foraging juveniles. As noted for San Joaquin River fall-run Chinook salmon, several different conservation measures have the potential to influence predation of juvenile salmonids under the BDCP (Appendix 5.F, *Biological Stressors on Covered Fish*, Section 5.F.6, *Fish Predation*). *CM1 Water Facilities and Operation* will have potential beneficial effects (reduction of predation associated with entrainment at the south Delta export facilities; see entrainment discussion above) and potential adverse effects (possible predation at the Head of Old River operable gate). As discussed for other runs, implementation of habitat restoration measures (*CM4 Tidal Natural Communities Restoration*, *CM5 Seasonally Inundated Floodplain Restoration*, and *CM6 Channel Margin Enhancement*) in association with IAV removal (*CM13 Invasive Aquatic Vegetation Control*) may increase rearing habitat, and decommissioning or modification of water diversion structures in ROAs and other areas also will decrease predatory fish habitat. *CM15 Localized Reduction of Predatory Fish* will aim to limit predation at problem areas through habitat alterations and other actions such as predator relocation. It is concluded with low certainty that the BDCP would result in a low positive change in predation for foraging and migrating San Joaquin River region steelhead juveniles. The low certainty level is based on the fact that relatively little study of the feasibility of undertaking such actions has occurred (see discussion under winter-run Chinook salmon). Targeted research and monitoring would inform the efficacy of the conservation measure.

Reduced Illegal Harvest

The BDCP will help reduce illegal harvest of adult San Joaquin River region steelhead.

Consistent with other salmonids, it was assumed with low certainty that Plan Area harvest (including illegal harvest) of San Joaquin River region steelhead foragers, juveniles, and adults is an attribute of low importance. The low certainty level is based on the fact that little is known about the issue. *CM17 Illegal Harvest Reduction* is expected to decrease poaching of covered salmonids and other covered fishes, as described in more detail for winter-run Chinook salmon based on the information provided by Roberts and Laughlin (2013). Thus, it is concluded with high certainty that the BDCP would result in a low positive change to the harvest attribute for San Joaquin River region steelhead juveniles and adults.

5.5.6.3.2 Adverse Effects

Exposure to In-Water Effects from Restoration Activities and Construction of the Operable Gate at the Head of Old River

In-water effects of the BDCP, primarily restoration activities and construction of the Head of Old River operable gate, could affect San Joaquin River region steelhead.

As noted for San Joaquin River region fall-run Chinook salmon, San Joaquin River region steelhead would not be exposed to the major construction occurring in the north Delta subregion in the vicinity of the north Delta intakes. Construction occurring in the south Delta subregion mostly focuses on the Head of Old River operable gate. Standard minimization measures would be employed to limit the potential for adverse effects on San Joaquin River region steelhead during construction and maintenance, including timing in-water work to periods of no or low occurrence of covered fish. Habitat restoration activities (*CM4 Tidal Natural Communities Restoration, CM5 Seasonally Inundated Floodplain Restoration*, *CM6 Channel Margin Enhancement* and *CM7 Riparian Natural Community Restoration*) may contribute to temporarily reduced water quality. In-water activities associated with other activities (*CM14 Stockton Deep Water Ship Channel Dissolved Oxygen Levels, CM15 Localized Reduction of Predatory Fish, CM16 Nonphysical Fish Barriers,* and *CM21 Nonproject Diversions*) would have little to no effect on salmonids because of the small scale of the work. Implementation of *CM22 Avoidance and Minimization Measures* would limit the likelihood of adverse effects from in-water activities related to construction and maintenance on juvenile and adult San Joaquin River region steelhead. It is concluded with high certainty that in-water effects of construction, maintenance, and restoration activities associated with the BDCP would result in a low negative change.

Exposure to Contaminants

The BDCP will contribute to a reduction in San Joaquin River region steelhead exposure to contaminants in the late long-term, although localized increases in contaminant exposure may occur as a result of tidal habitat and floodplain restoration.

Changes in contaminant concentration as a result of changes in water operations (*CM1 Water Facilities and Operation, CM2 Yolo Bypass Fisheries Enhancement*) and habitat restoration (principally, *CM4 Tidal Natural Communities Restoration*) could occur under the BDCP. It was assumed with low certainty that contaminant exposure is an attribute of low importance for foraging and migrating San Joaquin River steelhead juveniles. Analyses presented in Appendix 5.D, *Contaminants*, suggest that there is low potential for increased contaminant exposure under the BDCP, and there may be a beneficial effect in the late long-term because of reduced contaminants from restoration of previously cultivated areas. It is concluded with low certainty that this represents a low negative change to this attribute for juvenile (foragers and migrant) San Joaquin River region steelhead in the Plan Area.

5.5.6.3.3 Impact of Take on Species

The BDCP may result in incidental take of San Joaquin River steelhead from several mechanisms, as discussed for other salmonid runs. Construction and maintenance may result in disturbance from in-water activity and hydrodynamic changes, physical injury from riprap/rock placement and noise and vibration, exposure to fuel or oil, and elevated turbidity levels (Appendix 5.H, *Aquatic*

Construction and Maintenance Effects). These temporary effects will be minimized through standard measures and as a result, there will be minimal impact of take from these activities.

Although entrainment will be substantially reduced, take at the south Delta export facilities will continue to occur. Other flow-related effects discussed above include the potential for higher effective Plan Area flows as a result of the Head of Old River operable gate and less south Delta exports, which may reduce adult straying to the Sacramento River region and improve flows in the San Joaquin River to facilitate migration of juveniles through the Plan Area. Take of San Joaquin River region steelhead would be lower as a result of these effects.

5.5.6.3.4 Abundance, Productivity, Life-History Diversity, and Spatial Diversity

The analysis presented for winter-run Chinook salmon, Section 5.5.3.4, also applies includes San Joaquin River region steelhead.

5.5.6.3.5 Net Effects

Figure 5.5.6-2 shows the relative population-level outcomes, by attribute, for San Joaquin River region steelhead, that will result from implementation of the BDCP. The graph illustrates the effect of the BDCP, by considering the change to an attribute for each life stage in light of the importance of the attribute to that life stage. The net effect of the BDCP is expected to be beneficial to San Joaquin River region steelhead, as the positive effects outweigh the negative effects. As noted for San Joaquin River region fall-run Chinook salmon, the combination of less south Delta exports and a Head of Old River operable gate have the potential to effectively augment Plan Area flows in the South Delta subregion that have relevance to San Joaquin River region steelhead. Juvenile migration and adult straying are expected to be improved under the BDCP, as is south Delta entrainment. Less certain are the benefits from floodplain restoration under *CM5 Seasonally Inundated Floodplain Restoration* because there are no changes in the San Joaquin River flows entering the Plan Area under the BDCP so that there is relatively less of a benefit than is expected for the Sacramento River region runs because of enhanced Yolo Bypass access from CM2 *Yolo Bypass Fisheries Enhancements*; this uncertainty is greater for steelhead than for fall-run Chinook salmon because there is less certainty regarding their use of floodplain habitats.

South Delta tidal habitat restoration under *CM4 Tidal Natural Communities Restoration* would considerably increase the extent of suitable habitat for San Joaquin River region steelhead juveniles. Appreciable extents of channel margin and floodplain habitat will also be restored under *CM5 Seasonally Inundated Floodplain Restoration* and *CM6 Channel Margin Enhancement.* Habitat restoration has considerable potential to provide food benefits for San Joaquin River region steelhead juveniles. In contrast to San Joaquin River fall-run Chinook, steelhead juveniles are mostly migrants that spend little time in the Plan Area. The benefits of habitat restoration primarily will accrue from more suitable habitat to traverse the Plan Area, in contrast to the poor quality habitat that currently dominates, particularly in the South Delta subregion where habitat restoration efforts under the BDCP would be focused.

Category	Appendix	Attributes	Definition	Eggs	Foragers	Migrants	Adults
Food	E	Zooplankton community	Species composition of the zooplankton community and presence of suitable prey species	NA	Zero	Zero	
		Zooplankton abundance	The abundance of zooplankton	NA	Low	Low	
		Benthic & Epibenthic prey abundance	The abundance of epibenthic prey species such as amphipods	NA	High	Low	
		Insect abundance	The abundance of insect prey	NA	High	Low	
Entrainment & Impingement	B	North Delta Intakes	Potential entrainment/impingement from the proposed North Delta intakes	NA			
		South Delta Pumps	Pumping rate from the CVP/SWP south Delta export facilities and resulting entrainment	NA	Moderate	Moderate	
		North Bay Aqueduct	Entrainment from the SWP NBA facilities	NA			
		Ag Diversions	Entrainment from Agriculture Diversions	NA	Very Low	Very Low	
Migration & Movement	C	Plan Area Flows	Magnitude, timing, direction, and duration of flows during migratory periods throughout the Plan Area	NA	Low	Moderate	Moderate
		Interior Delta Entry	Entry of fish into the interior Delta from the mainstem Sacramento or San Joaquin Rivers through channels such as Georgiana Slough or Old River	NA	Moderate	Moderate	NA
		Passage Barriers	Structures or conditions that potentially block upstream or downstream migration	NA			Low
Habitat	C, E	Inter-tidal habitat	Intertidal area from the mean low low water level to the extreme high water level that may support intertidal vegetation and form mudflats; dynamic elements of habitat such as appropriate salinity are considered on a species-specific basis	NA	High	Low	
		Channel Margin	The extent of shallow water, low slope habitat that generally is characterized by structural complexity, native emergent vegetation and riparian shading cover	NA	Low	Very Low	
		Floodplains	The interface between upland topography and river hydrology during high flow events	NA	Low	Very Low	
		Riparian	Forest and scrub that occurs along the margins of river channels and within floodplains	NA	NA	NA	NA
		Sub-tidal habitat	Extent and location of sub-tidal area in the Plan Area, including the low salinity zone (LSZ); dynamic elements of habitat such as appropriate salinity are considered on a species-specific basis	NA	Low	Low	
Sediment	C	Water clarity	Water clarity in the Plan Area as influenced by amount of suspended material within the water column	NA	Zero	Zero	
Temperature	C	Temperature	Adverse effects of high temperatures within the Plan Area	NA			
DO	C	Dissolved Oxygen	Adverse effects of low dissolved oxygen level within the Plan Area	NA			
Toxins	D, F	Contaminants	Adverse effects of methylated mercury, selenium, pesticides and other pollutants	NA	Very Low -	Very Low -	
		Microcystis	The abundance of Microcystis aeruginosa blooms that are toxic to covered fish species and their food	NA			
Predation	F	Predation	The species-specific consumption of covered fish species by predatory fish (e.g., striped bass, Sacramento pikeminnow, centrarchid bass species, catfish, and inland silversides); note that the attribute aims to isolate predation effects that may not be captured by other attributes, e.g., at manmade structures such as the north Delta diversions	NA	Moderate	Moderate	
		Illegal Harvest	Illegal harvest of covered fish species in the Plan Area	NA	Low	Low	Low
In-stream Habitat	C	Sacramento R. Habitat	Flows in the Sacramento River mainstem (below Keswick Dam to the Plan Area) that influence spawning, egg incubation, rearing, or holding habitat	NA	NA	NA	NA
		Feather R. Habitat	Flows in the Feather River (below Oroville Dam to the confluence with the Sacramento River) that influence spawning, egg incubation, rearing, or holding habitat	NA	NA	NA	NA
		American R. Habitat	Flows in the American River (below Nimbus Dam to the confluence with the Sacramento River) that influence spawning, egg incubation, rearing, or holding habitat	NA	NA	NA	NA
Migration & Movement	C	Sacramento R. Migration Flows	Flows in the Sacramento River mainstem (below Keswick Dam to the Plan Area) that influence migration and movement	NA	NA	NA	NA
		Feather R. Migration Flows	Flows in the Feather River (below Oroville Dam to the confluence with the Sacramento River) that influence migration and movement	NA	NA	NA	NA
		American R. Migration Flows	Flows in the American River (below Nimbus Dam to the confluence with the Sacramento River) that influence migration and movement	NA	NA	NA	NA
Temperature	C	Sacramento R. Temperature	Adverse effects of high water temperatures in the Sacramento River mainstem (below Keswick Dam to the Plan Area)	NA	NA	NA	NA
		Feather R. Temperature	Adverse effects of high water temperatures in the Feather River (below Oroville Dam to the confluence with the Sacramento River)	NA	NA	NA	NA
		American R. Temperature	Adverse effects of high water temperatures in the American River (below Nimbus Dam to the confluence with the Sacramento River)	NA	NA	NA	NA

Certainty

- No effect conclusion made because attribute assumed not to have importance as a current constraint
- NA — Life stage not present or not applicable
- Low certainty
- Moderate certainty
- High certainty
- Very high certainty

Figure 5.5.6-2. Effect of the Covered Activities on San Joaquin River Region Steelhead

Less south Delta export operations and the construction and operation of an operable gate at the Head of Old River under *CM1 Water Facilities and Operation* have the potential to improve through-Delta survival of San Joaquin River region steelhead juveniles during migration through the Plan Area through keeping fish and flow in the mainstem San Joaquin River. By allowing a greater proportion of San Joaquin River water to leave the South Delta subregion, the BDCP has the potential to reduce straying of adult San Joaquin River region steelhead to the Sacramento River region, which would result in more adults returning to natal tributaries. *CM15 Localized Reduction of Predatory Fish* has the potential to improve juvenile San Joaquin River steelhead survival at localized predation hotspots, and as noted for other runs, much research and adaptive management will be involved with this measure to address the considerable uncertainty in its efficacy.

Funding for construction, operation, and maintenance of the Stockton Deep Water Ship Channel aeration facility under *CM14 Stockton Deep Water Ship Channel Dissolved Oxygen Levels* into the future will ensure maintenance of the pilot facility's benefits for San Joaquin River watershed adult salmonids that migrate upstream during periods of low DO (Appendix 5.C, *Flow, Passage, Salinity, and Turbidity*, Section 5.C.5.3.10, *Passage Improvements at the Stockton Deep Water Ship Channel*). As noted for other salmonids in this effects analysis, contaminants and other negative effects from restoration and construction activities may occur although the effects are concluded to be minor.

It is concluded with moderate certainty that the BDCP would result in an overall positive change for San Joaquin River region steelhead, even though the magnitude of benefits at the population level cannot be quantified with certainty. Benefits primarily are based on the reduced entrainment, improved migration conditions, and increased suitable habitat. Future changes in the Plan Area resulting from climate change and other factors are likely to be stressful to San Joaquin River region steelhead, but the positive effects on viable salmonid population criteria from the BDCP would improve the ability of the species to adapt to changes.

Conclusions presented above for San Joaquin River region steelhead as a whole apply to some extent to Mokelumne/Cosumnes River steelhead. Augmented tidal habitat for rearing and enhanced food productivity are expected from the Cosumnes-Mokelumne ROA. Improved South Delta flows are expected to reduce entrainment. The results of the particle tracking nonlinear regression also illustrate the importance of tidal restoration, with a lower percentage of particles reaching Chipps Island after 30 days during March–May, which may indicate potential for reduced migration success. Monitoring and adaptive management would be used to assess the effects, positive or negative, of nonphysical barriers to Mokelumne/Cosumnes River steelhead. Similar to San Joaquin River fall-run Chinook salmon, a greater proportion of water from the natal tributaries at points downstream may improve attraction and homing cues for Mokelumne/Cosumnes River steelhead adults.

Therefore, the BDCP will minimize and mitigate impacts to the maximum extent practicable and provide for the conservation and management of the steelhead in the San Joaquin River region of the Plan Area.

5.5.7 Sacramento Splittail

The Sacramento splittail (*Pogonichthys macrolepidotus*) is a large (up to 40 centimeters standard length) cyprinid native to California and is the only surviving member of its genus (Moyle 2002). The species is endemic to the San Francisco estuary and its associated watershed. Its range entirely encompasses the Plan Area, reaching to Mud Slough on the San Joaquin River and the Red Bluff Diversion Dam on the Sacramento River (Feyrer et al. 2005). There are two genetically distinct populations: one inhabiting the Napa and Petaluma Rivers and marshes and one inhabiting the Central Valley (Baerwald et al. 2007). Splittail young-of-year production is strongly related to hydrologic conditions, with wet years with more frequent and longer floodplain inundation typically producing much stronger year classes than dry years (Sommer et al. 1997). Consequently, splittail young-of-year production can vary greatly from year to year. In 1999, following a 6-year drought, the Sacramento splittail was listed as threatened under the ESA. However, the ruling was remanded in 2003, after a return to wet conditions in the late 1990s that produced record numbers of acres inundated for long periods of time, resulting in record abundance indices for the species (Sommer et al. 2007).

Splittail can live 5 to 9 years and tolerate a wide range of water quality conditions, including salinity, temperature, and DO levels (Moyle et al. 2004). Adult splittail occur predominantly in Suisun Marsh and Suisun Bay, but also inhabit other brackish marshes in the San Francisco estuary, as well as the fresher Delta. While in these areas, splittail feed on a wide variety of invertebrates and detritus. In the spring, when California's Central Valley experiences large amounts of snowmelt runoff, adult splittail will move onto inundated floodplains in the valley to spawn. The Yolo Bypass provides the largest spawning area. In drier years, most spawning occurs in river channel margins, primarily upstream of the Plan Area (Feyrer et al. 2005). After they spawn, the adult fish return to their marsh habitats. The eggs, which are laid on submerged vegetation, begin to hatch in 3 to 7 days, and the larval fish grow at an accelerated rate in the warm and food-rich environment of the floodplain (Moyle et al. 2004). They develop into juveniles about a month after hatching. When the juveniles reach a size of about 30 to 40 mm total length, they begin moving off of the floodplain and downstream into areas similar to those inhabited by the adults (Feyrer et al. 2006). Their emigration peaks in May and June (Feyrer et al. 2005). The juveniles rear in the marsh habitats for 2 to 3 years before becoming sexually mature (Moyle et al. 2004).

A detailed species account of Sacramento splittail is presented in Appendix 2.A, *Covered Species Accounts*. The principal potential beneficial and adverse effects of the covered activities on attributes (stressors) important to the Sacramento splittail population are described and evaluated in the sections below. The attributes are separately evaluated for the egg, larval, juvenile, and adult life stages. However, for purposes of these evaluations, the young juveniles rearing in their floodplain and channel margin nursery habitats are included with the larval stage because the ecology of these juveniles is more similar to that of larval splittail than to that of juveniles that have already migrated from the nursery habitats. The attributes are presented in terms of their perceived importance to the splittail population under existing conditions, and are analyzed for the potential changes that may occur as a result of the covered activities. The combination of the estimated importance of an attribute and its potential change as a result of the covered activities is used to estimate the effect of the change on each life stage.

In evaluating the effects of the covered activities on splittail, it is important to distinguish between total effects and per capita effects. Because of several habitat enhancement measures, the BDCP has the potential to increase the abundance of splittail, especially the early life stages. Consequently, the number of splittail affected by an attribute would increase even if the BDCP did not change the attribute. However, the effect on any individual splittail (i.e., the per capita effect) would remain unchanged. This distinction is particularly important in evaluating attributes that affect mortality rates such as entrainment and stranding.

5.5.7.1 Beneficial Effects

5.5.7.1.1 Floodplain, Tidal, Channel Margin, and Riparian Habitats, including Foodweb Effects

Inundated floodplain enhancement (*CM2 Yolo Bypass Fisheries Enhancement*) and restoration (*CM5 Seasonally Inundated Floodplain Restoration*) and restoration of tidal wetlands (*CM4 Tidal Natural Communities Restoration*), channel margins (*CM6 Channel Margin Enhancement*), and riparian vegetation (*CM7 Riparian Natural Community Restoration*) are expected to benefit the Sacramento splittail population. CM2 is expected to increase the frequency, duration, and surface area of Yolo Bypass inundation, resulting in substantial increases in availability of inundated floodplain habitat to splittail. CM5 will restore up to 10,000 acres of new seasonally inundated floodplain in the south Delta. An analysis of inundation and frequency was conducted for different San Joaquin River flows, including the 30-day minimum for splittail spawning. (Table 5.E.5-2, *HEC-EFM Inundation Acreage Results for Sacramento Splittail Ecologically Relevant Flow Criteria*, Appendix 5.E, *Habitat Restoration*). CM4 will increase the amount of tidal natural communities in the Plan Area, substantially increasing suitable habitat for juvenile and adult splittail. CM6 will restore and enhance 20 miles of channel margin in the Delta, primarily benefitting juvenile and adult splittail during their migrations and increasing spawning and larval rearing habitat in dry years, when inundated floodplain habitat is largely unavailable under existing conditions. These measures also will increase food resources for local consumption and potentially export surpluses to the Delta. Several factors create uncertainty regarding the potential benefits of the measures, including flows needed to trigger migration of adults to the Yolo Bypass, and potential effects of colonization by predatory fish, IAV, and invasive mollusks on habitat value. The potential benefits are articulated in the sections below.

Floodplain Habitat

Increased inundated floodplain, which is the major limiting stressor for splittail, will substantially increase splittail abundance in the Plan Area. Enhancements of the Yolo Bypass floodplain will also reduce splittail stranding and improve passage.

The most important attribute of the egg, larval, and pre-migratory juvenile life stages of the splittail population is a limited availability of habitat for spawning and the rearing of larvae and young juveniles, especially in dry years when floodplains are not inundated (Sommer et al. 1997, 2007; Moyle et al. 2004; Feyrer et al. 2006). Abundance of young splittail is almost always high in years of extensive and prolonged floodplain inundation. Inundation of the Yolo Bypass, the largest floodplain in the Central Valley, is especially effective in providing habitat for splittail (Sommer et al. 1997; Feyrer et al. 2006). It was assumed with very high certainty that the availability of floodplain habitat is of critical importance to the egg and larval life stages, and of high importance to premigratory juvenile life stages. Adult splittail forage primarily in Suisun Marsh (Sommer et al. 2007; Moyle et al. 2004), but they also forage on the floodplain for a period prior to spawning, and this foraging may affect their fecundity and post-spawning survival (Moyle et al. 2004). Thus, it was assumed with very high certainty that floodplain habitat is an attribute of moderate importance for adult splittail. During the August 2013 workshops with agency biologists, there was consensus regarding the critical or high importance of floodplain habitat for splittail eggs, larvae and juveniles. It was agreed that although critical for spawning, adults receive less benefit as they spend most of their time in brackish marshes.

CM2 Yolo Bypass Fisheries Enhancement is expected, with high certainty, to increase the frequency, duration, and surface area of Yolo Bypass inundation, resulting in substantial increases in splittail HUs (Table 5.5.7-1). The HU is an index of HSI-weighted inundated floodplain surface area on the Yolo Bypass suitable for splittail spawning and rearing that was estimated by computer modeling (Appendix 5.C, *Flow, Passage, Salinity, and Turbidity,* Section 5.C.5.4.1.1, *Sacramento Splittail Habitat Area*). An important modeling assumption is that the benefit of greater splittail habitat area is realized only if inundation persists for at least 30 days, the estimated time needed for development to the juvenile stage that emigrates from the floodplain (Sommer pers. comm.). In the model, floodplain enhancement was quantified only after 30 days of continuous inundation, as indicated by results of hydrologic modeling. The habitat model results indicate that the covered activities will result in increases in splittail HUs on the Yolo Bypass ranging from about 50% in wet water-year types to almost 200% in below-normal water years (Table 5.5.7-1). The increases for dry and critical years (Figure 5.C.5.4-4, *Frequencies (a) and Cumulative Frequencies (b) of Splittail Daily Average Weighted Habitat Area in the Yolo Bypass, for EBC and ESO Scenarios*, in Appendix 5.C) result from only occasional expected availability of splittail habitat with CM2. Percentage increases cannot be computed for these water-year types because splittail HUs were estimated to be zero under existing conditions.

Table 5.5.7-1. Annual Average Splittail Habitat Units in Yolo Bypass for by Water-Year Type, under Two Scenarios[a]: Existing Conditions and Future Conditions with the BDCP

	By Scenario[a]		
Water-Year Type	**EBC2**	**ESO_LLT**	**Difference (% Difference)**
Wet	1,684	2,516	832 (49%)
Above normal	1,154	1,798	644 (56%)
Below normal	127	371	244 (192%)
Dry	0	7	7 (NA)
Critical	0	5	5 (NA)

[a] For descriptions of scenarios, see Table 5.2-3.

CM2 Yolo Bypass Fisheries Enhancement is also expected to reduce the per capita risk of stranding in the Yolo Bypass, although the total number of stranded splittail likely will increase because of the expected increase in number of young splittail present. Several factors are expected to contribute to a reduced stranding risk. Most important is the increased duration of inundation, which will increase the time available for young splittail to develop sufficiently to emigrate from the floodplain. In addition, CM2 will include a number of actions designed, in part, to reduce stranding and improve fish passage, such as grading; modifying berms, levees, and water control structures; and reworking agricultural delivery channels and the Tule Canal/Toe Drain (Appendix 5.C, *Flow, Passage, Salinity, and Turbidity,* Section 5.C.5.4.1.2, *Stranding (Steelhead, Chinook Salmon, Sacramento Splittail, White Sturgeon, and Green Sturgeon)*). The measure will modify structures at selected locations on Tule Canal and the Toe Drain, such as Lisbon Weir, that are believed to impede fish passage currently.

Although stranding and fish passage are not considered to be major factors for splittail under existing conditions (Sommer et al. 2008; Feyrer et al. 2004) (Appendix 5.C, Section 5.C.5.4.1.2), the expected reduction in the stranding rate and improved passage will result in even greater benefit to splittail from CM2.

CM5 Seasonally Inundated Floodplain Restoration will restore up to 10,000 acres of seasonally inundated floodplain in the South Delta subregion (Appendix 5.E, *Habitat Restoration,* Section 5.E.5.1, *Description*). Several conceptual floodplain restoration corridors were analyzed for their potential to provide floodplain habitat that would be suitable for splittail spawning and rearing in the lower San Joaquin River and South Delta subregion, i.e., with San Joaquin River at Vernalis flows of at least 11,600 cfs for at least 20 days (for existing conditions[9]) and for at least 30 days (under the BDCP), every 4 years during February 1 to May 31 (Appendix 5.E, Section 5.E.5.5, *Evaluation*). The analysis suggests that within the conceptual corridors under existing conditions around 680 acres of floodplain meet the splittail spawning and rearing criteria every 4 years (Table 5.E.5-4, *HEC-EFM Inundation Acreage Results, Comparison between Existing Conditions and Conceptual Corridors for Sacramento Splittail Ecologically Relevant Flow Criteria*, in Appendix 5.E). The relative difference in floodplain extent within the conceptual corridors meeting the criterion of ≥30-day inundation during February–May every 4 years ranges from around 40% greater under Corridor 2A (Paradise Cut: 275 additional acres) to nearly seven times greater under Corridor 2B (Corridor 2A + levee removal around Fabian Tract): almost 4,000 additional acres). Although these are appreciable differences, the frequency of inundation is still relatively low compared to inundation frequency of the Yolo Bypass.

Overall, it is concluded with high certainty that the BDCP would result in a very high positive change to the floodplain habitat attribute for all life stages of splittail. This conclusion is based primarily on the large positive change resulting from CM2 on splittail spawning and rearing habitat availability on the Yolo Bypass floodplain, and secondarily because of the lesser benefit from CM5 in relation to floodplain restoration in the South Delta subregion. During the August 2013 workshops with agency biologists, there was general consensus of a very high positive change (with very high certainty), although in one case it was felt that a moderate positive change for juveniles (with high certainty) was warranted because they tend to be downstream, off the floodplains.

Tidal Habitat

Restoration of tidal natural communities (CM4) will substantially increase the availability of intertidal and subtidal habitat in the Plan Area which will increase suitable rearing and foraging habitat for Sacramento splittail juveniles and adults, primarily in the Cache Slough and Suisun Marsh subregions, and thereby enhance survival of the large year classes typically produced in wet years through the entire splittail life cycle.

After their first few weeks in their natal habitats, juvenile splittail emigrate to tidal wetland habitats in the Delta and Suisun Bay. The juveniles and adults rear in these habitats until the adults are ready to spawn. Despite the importance of tidal wetland habitat for older juveniles and adults, its

[9] The previous analysis, described in Appendix 5.E, *Habitat Restoration*, Attachment 5.E.A, *BDCP South Delta Habitat and Flood Corridor Planning: Corridor Description and Assessment Document*, was updated only for the conceptual corridors' potential restoration to address comments received. Assumption of a 20-day inundation requirement under existing conditions (i.e., based on the previous analysis, which was not updated for existing conditions) and a 30-day inundation requirement for BDCP potential restoration scenarios, results in a conservative assessment of the potential change under the BDCP.

availability probably has little effect on population abundance in most years because, as previously described, the abundance of splittail year classes is determined largely by the availability of inundated floodplain habitat for spawning and rearing. However, if availability of tidal wetland habitat becomes limiting because of the high abundance of juveniles and adults from one or more large year classes, increased availability of this habitat potentially will improve growth and survival of older juveniles and adults, ultimately resulting in more adult fish and thereby sustaining the benefits of increased young-of-year (YOY) production through the entire life cycle. An increase in the number of adult fish is expected to increase genetic diversity of the splittail population. Discussions with agency biologists during the August 2013 workshops suggested that the only importance for splittail from tidal habitats is from intertidal areas, whereas subtidal habitat has no importance as a current constraint on the species. Because of the value of intertidal habitat to juvenile and adult splittail, and the potential importance of growth and survival in these life stages to sustaining high production following wet years, it was assumed with high certainty that intertidal habitat is an attribute of moderate importance for juvenile and adult life stages. Eggs and larvae were given low importance with low certainty as splittail do spawn in Suisun Marsh in low numbers (Meng and Matern 2001). During the August 2013 workshops with agency biologists, there was consensus regarding high certainty and moderate importance for juvenile and adult life stages; there was no importance suggested by agency biologists for eggs and larvae.

CM4 Tidal Natural Communities Restoration will result in large increases in surface areas of tidal wetland habitat in the late long-term, especially in the Cache Slough, Suisun Marsh, and South Delta ROAs. As described above in Section 5.5.1.1.1 for delta smelt, under the BDCP there would be approximately double the intertidal acreage in the late long-term (approximately 56,000 acres) in comparison with future conditions without the BDCP. The benefits of greater intertidal habitat availability to will be greatest to adult and juvenile splittail, but younger life stages could benefit as well. Cache Slough and Suisun Marsh are especially important habitat areas for splittail. Cache Slough receives most of the young splittail emigrating from the Yolo Bypass, resulting in heavy use while in migration, whereas Suisun Marsh is the most important rearing habitat for juvenile splittail and foraging habitat for adults (Appendix 5.E, Section 5.E.4.4.2.4, *Suitability of Restored Habitat for Covered Fish Species*). Cache Slough and Suisun Marsh are especially important habitat areas for splittail, so that restoration in these ROAs is expected to provide greater benefit to splittail than restoration in the South Delta ROA. Nonetheless, the increased habitat in the South Delta ROA is expected to increase habitat diversity, adding to the robustness and genetic diversity of the splittail population. Because of the large increases in adult and juvenile splittail tidal wetland habitat area and diversity expected to result from the BDCP, it is concluded with moderate certainty that the BDCP would result in a very high positive change for juvenile and adult splittail; a very high positive change was also concluded for larvae, but with low certainty because of most larvae remaining on the floodplains. Because use of tidal habitats for spawning is relatively low, it is concluded that the BDCP would result in a low positive change to this attribute with low certainty, for the egg life stage. During the August 2013 workshops, agency biologists considered a high positive change (with high certainty) to be appropriate for splittail larvae, juveniles, and adults; zero change was felt to be appropriate for eggs.

Channel Margin Habitat

Enhancement of channel margins (CM6) will increase the extent of higher value nearshore habitat in the Plan Area for Sacramento splittail, which will improve availability of rearing habitat for downstream migrating juveniles, and will provide spawning habitat in dry years

when inundated floodplain habitat is limited and thereby sustain the population through extended droughts.

Juvenile splittail use channel margin habitat during their downstream migrations from natal habitats, and the adults use this habitat during their spawning migrations. In dry years, larval splittail may use these habitats also as they are advected downstream from their spawning habitats (as indicated by collection in entrainment samples at the on-bank Freeport Regional Water Authority intake; ICF International 2012). An unknown fraction of the Sacramento River juveniles remain upstream to rear in off-channel habitats in the upper Sacramento River well upstream of the Plan Area (e.g., River Mile 205 near Glenn-Colusa Irrigation intake) and migrate to the Delta and Suisun Marsh the following year (Moyle et al. 2004; Feyrer et al. 2005). Channel margin habitat also is used for spawning and rearing, which may be important in dry years when inundated floodplain habitat is largely unavailable. Because channel margin habitat importance is poorly understood for all life stages of splittail, it was assumed with high certainty to be of low importance to all life stages; this assumption is in accordance with the opinion expressed by agency biologists during the August 2013 workshops, although some felt that low certainty in the low importance was warranted.

CM6 Channel Margin Enhancement is expected to enhance 20 linear miles of channel margin in the Plan Area. If 75% of the proposed 20 miles of CM6 channel margin enhancement occurred in important North Delta subregion channels such as the mainstem Sacramento River, Sutter/Steamboat Sloughs, and Miner Slough (see Figure 5.E.6-1, *Revetment within Channels of the Plan Area*, in Appendix 5.E, *Habitat Restoration*), then the enhancement would represent around 9% of the channel length in this subregion. The measure is directed at improving habitat conditions for covered fish species along Delta channel banks by improving channel geometry and restoring riparian habitat, tidal marsh, and mudflats along levees. Most of the locations planned for channel margin enhancements (Appendix 5.E, *Habitat Restoration,* Section 5.E.6.4, *Explanation of the Conservation Measure*) are migration corridors for emigrating YOY splittail that are currently leveed, and are often rip-rapped. Depending on the quality of the habitat provided by the channel margin enhancements, some emigrating larval and juvenile splittail could choose to rear in channel margin habitat. Splittail use freshwater channel margins (*CM6 Channel Margin Enhancement*) and backwater sloughs in the Sacramento and San Joaquin Rivers during dry years for spawning (Feyrer et al. 2005). If used for spawning, this habitat will add to the modest dry-year spawning benefit provided by *CM2 Yolo Bypass Fisheries Enhancement*, as noted above, further improving the ability of the splittail population to withstand extended periods of drought when minimum floodplain habitat is available. It is concluded with low certainty that the BDCP would result in a low positive change to the channel margin habitat attribute for all splittail life stages. During the August 2013 workshops, agency biologists felt that low or moderate positive change conclusions were warranted, with certainty ranging from low to high, depending on life stage.

Monitoring actions would inform assessments of the change in habitat value resulting from CM6. There may be some risk to young splittail associated with use of enhanced channel margin habitat by predatory fish species such as largemouth bass (HT Harvey & Associates with PRBO Conservation Science 2010); this risk would be assessed as part of a monitoring and adaptive management program in order to determine the specific site features that may need to be altered to reduce the risk.

Foodweb Effects

Restoration and enhancement of floodplain (CM2 and CM5), tidal (CM4), and channel margin (CM6) habitats may increase food for local consumption and export to open-estuary areas.

Little information exists regarding food-resource limitation of splittail. Reduction of *Neomysis*, a major prey item of juvenile and adult splittail, that resulted following the invasion of the estuary by *Potamocorbula* in the 1980s, may have caused reduced growth rate and fecundity of splittail (Moyle et al. 2004; Feyrer and Baxter 1998), but there is no evidence that splittail abundance was affected (Kimmerer 2002). Zooplankton, especially cladocerans, and insect larvae are the major prey of larvae and young juveniles rearing on inundated floodplains and channel margins (not including the Napa and Petaluma Rivers), although dominant prey items of importance varied by geographic area and conditions within habitats (Feyrer et al. 2007). Abundance of cladocerans in the Delta has greatly declined since the 1980s (Winder and Jassby 2011). The abundance of splittail larvae on the Cosumnes River floodplain has been correlated to blooms of zooplankton (Crain et al. 2004). The abundance of zooplankton (which includes mysids) was considered of moderate importance with moderate certainty for all life stages except eggs. It was assumed with moderate certainty that benthic and epibenthic prey abundance is an attribute of low importance for larval splittail, and moderate importance for juvenile and adult splittail, on the basis of consumption of benthic organisms such as *Potamocorbula*. It was assumed with moderate certainty that insect abundance is an attribute of low importance for larvae and of moderate importance for (older) juveniles, and low importance for adults. These assumptions generally represents agency biologist opinion from in the August 2013 workshops.

Increases in inundated floodplain habitat are expected to increase foodweb resources for larval and early juvenile splittail in particular. Detailed information on the requirements and expected availabilities of habitats of the food resource species is not available, so the changes resulting from the BDCP to zooplankton abundance and insect availability for splittail larvae and early juveniles are considered analogous to the effect on floodplain habitat. Juvenile and adult splittail may benefit from greater insect abundance in or adjacent to restored habitats (i.e., CM4, CM6, and CM7) or adjacent to restored or more frequently inundated floodplains (CM2, CM5).

Potential effects of the BDCP on the foodweb resources of Delta habitats other than the floodplains, including the tidal wetland and channel margin habitats inhabited by older juvenile and adult splittail, were analyzed with respect to the phytoplankton-based foodweb. Analysis of the potential increase in phytoplankton growth rate as a function of average habitat depth (Lopez et al. 2006) was used as an indication of potential phytoplankton productivity increases in the ROAs as a result of restoration actions (Appendix 5.E, *Habitat Restoration,* Section 5.E.4.4.2.5, *Food in the Delta and the Effect of the Conservation Measures on Food for Covered Fish Species*). This analysis suggests a considerable increase in potential primary productivity (Table 5.5.1-3 in Section 5.5.1, *Delta Smelt*), which may translate into increased zooplankton and mysids for juvenile and adult splittail in the ROAs, as well as export beyond the ROAs. As noted for other species, there is uncertainty in relation to potential consumption of enhanced plankton productivity from tidally restored areas by invasive clams within and outside the ROAs.

Considering the factors described above, it is concluded with moderate certainty that there will be a high positive change to benthic/epibenthic and insect prey abundance from the BDCP, for larvae, juvenile, and adult splittail. Reflecting the uncertainty in plankton consumption by invasive clams in restored tidal areas, it is concluded with low certainty that there would be a moderate positive change in zooplankton abundance for the larval, juvenile, and adult life stages. Agency biologist opinion during the August 2013 workshops suggested generally suggested that moderate to high or very high change conclusions were appropriate, with low moderate certainty that reflects the factors discussed above (e.g., clam consumption of productivity).

5.5.7.1.2 Reduced Entrainment

Overall entrainment of splittail will be lower under the BDCP, because north Delta diversion operations will reduce reliance on the south Delta export facilities, but this benefit would be limited because entrainment under existing conditions is of low importance to the splittail population.

Large numbers of YOY splittail are entrained at the SWP/CVP south Delta facilities in wet years when abundance of splittail is high; whereas entrainment numbers are much lower in dry years when abundance is lower. From 1980 to 2009, entrainment at the south Delta facilities ranged from 931 in 2007 (dry year) to 5.4 million in 2006 (wet year). Most of the entrained fish are juveniles, but adults and larvae also are entrained. Past studies have found no evidence that entrainment of splittail significantly affects population abundance (Sommer et al. 1997; Moyle et al. 2004). As a general reflection of agency biologist opinion from the August 2013 workshops, it was assumed with high certainty that entrainment at the south Delta export facilities is an attribute of low importance to larval, juvenile, and adult splittail; agency biologists thought that no importance may be warranted for adult splittail

As noted in the introduction to the splittail effects analysis, it is important to distinguish between total entrainment and the rate of entrainment (per capita entrainment) when evaluating the effect of the BDCP on entrainment of splittail. This distinction is reflected in the very different results obtained from two different modeling techniques that were used to estimate entrainment (represented by salvage) of splittail at the south Delta facilities (Appendix 5.B, *Entrainment*, Section 5.B.5.4.5, *Sacramento Splittail*). The results of the analysis using the per capita entrainment method indicate that the BDCP will result in a large reduction in splittail entrainment; whereas the results of the analysis using the days of Yolo Bypass inundation method indicate that the BDCP will increase entrainment, in terms of the number of splittail lost. The days of Yolo Bypass inundation method accounts for differences in splittail abundance (and by extension, salvage density) in analyzing the effect of the BDCP on entrainment, so as to account for the very large effect of abundance on total entrainment; the per capita entrainment method does not account for these differences. The days of inundation method uses days of Yolo Bypass inundation as a proxy for abundance, based on the observed correlation between days of inundation and salvage density (Appendix 5.B, Section 5.B.5.4.5.2, *Total Salvage Based on Yolo Bypass Inundation*). The estimates of entrainment are more directly related to exports when using the per capita entrainment method than when using the days of inundation method. As discussed in Appendix 5.B, Section 5.B.5.4.5, as a result of this difference, the per capita entrainment method more closely estimates per capita entrainment risk; whereas the days of inundation method more closely estimates total entrainment.

As shown by the results of the two methods for estimating entrainment (Appendix 5.B, Section 5.B.6.1.7.1, *Juvenile*), the BDCP was estimated to result in a substantial increase in total entrainment of juvenile splittail at the south Delta facilities, but the increase is entirely due to the predicted increase in YOY abundance resulting from increased floodplain habitat (Appendix 5.B, Section 5.B.6.1.7.1). The per capita rate of entrainment, which better represents entrainment as a proportion of the population, was estimated under the BDCP to be 48% lower for juvenile splittail and 53% lower for adults compared to existing conditions. The BDCP is expected to result in especially substantial reductions in wet year (per capita) entrainment losses, because diversions at the SWP/CVP facilities will be greatly reduced in wet years and little entrainment of splittail at the screened new north Delta intakes and other diversions is expected (Appendix 5.B, Section 5.B.6.2.4, *Sacramento Splittail (Larvae, Juvenile, and Adult)*). However, a reduction of entrainment in wet years is not expected to significantly affect population abundance, because production of the YOY in wet years is so high that even the large entrainment losses have little effect on total abundance, as demonstrated by the lack of correlation between splittail entrainment and population abundance (Sommer et al. 1997). A large reduction in dry year per capita entrainment, when YOY abundance is low, likely will benefit the population, but as noted, numbers entrained in dry years are low under existing conditions. However, reduced entrainment in wet years potentially will result in increased spawning stock, especially because restoration actions are expected to increase availability of rearing and foraging habitat for juveniles and adults, as previously discussed.

Based on these results, it is concluded with high certainty that the BDCP would result in a moderate positive change (i.e., moderately less entrainment) to south Delta entrainment for juvenile splittail and a low positive change for adult splittail. Splittail larvae are not salvaged, so their entrainment has not been quantified. It was assumed that entrainment levels for splittail larvae are low relative to their numbers in the floodplain and channel margin habitats where they are produced. It is concluded with moderate certainty that the BDCP would result in a low positive change to the south Delta entrainment attribute for splittail larvae. During the August 2013 workshops, agency biologists felt that the positive change in the South Delta entrainment attribute would be low for larvae, whereas for juveniles and adults, opinion was split between low and high change. An important point raised by the agency biologists was that much of the entrainment currently occurring may be of splittail originating in the San Joaquin River region, which is partly reflected in the relatively low importance of this attribute that was assumed above.

Entrainment from other existing sources within the Plan Area that are related to the BDCP, i.e., agricultural diversions and the North Bay Aqueduct, was not felt to be of any importance to splittail as a current constraint on population performance by agency biologists during the August 2013 workshops; consistent with this thinking and with available evidence for relatively low numbers entrained (Cook and Buffaloe 1998; http://www.dfg.ca.gov/delta/data/nba/), it therefore was assumed for this effects analysis that entrainment from these sources is of no importance to any splittail life stage. Although removal or screening of agricultural diversions (in association with habitat restoration and *CM21 Nonproject Diversions*; Appendix 5.B, Section 5.B.6.4.1.1, *Particle Tracking Modeling*) and the construction/operation of an alternative NBA intake on the Sacramento River would be expected to reduce splittail per-capita loss from these sources, it is concluded that there would not be an appreciable effect on the splittail population. This agrees with the 2009 DRERIP evaluation of the then-proposed BDCP measure (similar to the current *CM21 Nonproject Diversions*) to modify or eliminate agricultural diversions concluded that the effect of the measure generally would be, from a fish population–level perspective, of the lowest magnitude (score = 1) with the lowest certainty (score = 1) for most of the covered fish species, including splittail (Appendix 5.B, Section 5.B.6.4.3.1, *Delta Regional Ecosystem Restoration Implementation Plan Analysis of Nonproject Diversions*).

5.5.7.1.3 Reduced Interior Delta Entry during YOY Outmigration

The BDCP may improve survival of outmigrating YOY juveniles because of nonphysical barriers (CM16) that potentially inhibit YOY splittail from entering the interior Delta.

As described for winter-run Chinook salmon (Section 5.5.3.1.3), entry into the interior Delta results in reduced survival for juvenile salmonids migrating out of the mainstem Sacramento and San Joaquin Rivers. The effects on splittail have not been investigated, but presumably survival of YOY splittail is lower in the interior Delta than in the lower Sacramento River. It was assumed with low certainty that this attribute is of low importance for juvenile splittail; in contrast to salmonids, the majority of splittail juveniles would be leaving the Yolo Bypass having been spawned there and so would not have been subject to interior Delta entry at Georgiana Slough, for example. During the August 2013 workshops, agency biologists suggested (with high certainty) that this attribute is of no importance to splittail juveniles as there is no evidence to suggest that it is.

Under *CM16 Nonphysical Fish Barriers*, YOY splittail potentially would benefit from nonphysical barriers at important channel divergences leading to the interior Delta such as the Sacramento River at Georgiana Slough. The effects on splittail of the proposed nonphysical barriers (acoustic signal augmented by strobe lights and enclosed within a bubble curtain) are unknown, but based on the species water column position, hearing ability, and swimming ability (see Appendix 5.C, *Flows, Salinity, Turbidity, and Passage*, Section 5.C.5.3.9, *Nonphysical Barriers*), it is concluded with low certainty that CM16 would result in a low positive change to the interior Delta entry attribute for juvenile splittail (i.e., less entry into the interior Delta).

5.5.7.1.4 Enhanced Spring Instream Habitat in the Feather River

The BDCP will increase spring flows in the Feather River (CM1), which has the potential to enhance splittail channel margin habitat and result in greater availability of rearing habitat for YOY juveniles.

As noted elsewhere in this effects analysis, instream habitat within the Sacramento River upstream of the Plan Area would not be affected by the BDCP. In contrast, as described in more detail in the analysis of green and white sturgeon (Section 5.5.8.1.4, *Increased Recruitment Potential in the Feather River*), the BDCP would result in increased spring flows in the Feather River, which could increase channel margin habitat (California Department of Water Resources 2004) of potential importance to splittail. During the August 2013 workshops, agency biologists suggested with low certainty that instream habitat for splittail within the Feather River is of zero or low importance (reflecting potential use in drier years). Reflecting the latter view, it was assumed with low certainty for this effects analysis that instream habitat for all life stages has low importance. It is concluded with low certainty that the BDCP would result in a low positive change to this attribute for all life stages of splittail in the Feather River.

5.5.7.2 Adverse Effects

5.5.7.2.1 Exposure to Contaminants

Increased exposure of splittail to contaminants and *Microcystis* may occur following restoration, enhancement, and increased residence times under the BDCP; exposure to some

contaminants may decrease later in the BDCP term because of reduced agricultural production.

Contaminants that potentially affect the splittail population include methylmercury, pyrethroids, and selenium, but little is known about their effects under current conditions. Some aspects of splittail biology put this species at increased risk of exposure to contaminants, and other aspects put them at reduced risk. Aspects that increase risk include their relatively long lives, leading to greater bioaccumulation, and their benthic feeding habitats, which bring them into contact with potentially contaminated sediments and prey. On the other hand, all life stages of splittail feed at a relatively low trophic level, so biomagnification is likely not as important for splittail as for many other fish species. Major spawning and rearing areas for splittail, such as the Yolo Bypass and Cache Slough, occur in areas of high methylmercury concentrations. Spawning often occurs on inundated agricultural fields treated with pesticides (Teh et al. 2005). Selenium is found at high concentrations in *Potamocorbula* living in Suisun Bay and Suisun Marsh, where the clams are an important prey item of splittail, and has produced documented toxic effects in splittail (Stewart et al. 2004). Maternal transfer of selenium by spawning females adversely affects the embryo stage, which is especially susceptible to selenium toxicity. As previously noted, consumption of *Potamocorbula* has increased following invasion by the clam of the estuary and the concomitant decline of *Neomysis*, which was formerly a dominant prey of splittail (Moyle et al. 2004; Feyrer and Baxter 1998, Feyrer et al. 2003). Larvae on the Yolo Bypass are especially vulnerable to methylmercury because of high levels of mercury loading. Because larvae consume potentially contaminated prey organisms, they are more susceptible to methylmercury poisoning than the embryos (Alvarez et al. 2006). Henery et al. (2010) compared methylmercury in Chinook salmon confined in the Yolo Bypass with those from the Sacramento River and found that the fish that reared in the Yolo Bypass accumulated 3.2% more methylmercury than fish held in the nearby Sacramento River. However, only two of the 199 salmon sampled had tissue concentrations that exceeded the whole-body threshold level for potentially important sublethal effects. Reduced survival of splittail larvae on the Yolo Bypass as a result of contaminant exposure could result in reduced abundance of the splittail population and a lower spawning stock. A lower spawning stock potentially reduces genetic diversity and increases the vulnerability of the population to environmental stressors. For this effects analysis, it was assumed with moderate certainty that contaminants are an attribute of moderate importance for all life stages except juveniles, for which contaminants were assumed to have low importance. During the August 2013 workshops, agency biologists suggested that, because of maternal transfer, the importance of contaminants (focusing on selenium) may be best expressed in eggs and larvae; they suggested moderate importance of this attribute (with moderate certainty) for these two life stages. The current effects analysis assumes some importance throughout the life cycle, consistent with the analysis for green and white sturgeon presented below.

Restoration and enhancement under the BDCP, especially *CM4 Tidal Natural Communities Restoration* and *CM2 Yolo Bypass Fisheries Enhancement*, have the potential to increase exposure of splittail to contaminants. Restoration activities likely will mobilize contaminants, especially methylmercury, but any such effect should be localized, short-lived, and of low magnitude (Appendix 5.D, *Contaminants,* Section 5.D.0, *Summary*). Restoration and enhancement also could affect the average exposure of splittail to contaminants by altering the spatial distribution of the population. CM2 and CM4 are likely to increase the proportion of the splittail population using the Yolo Bypass and Cache Slough, both of which have relatively high levels of methylmercury in sediments, thereby increasing the average exposure of the population to this contaminant. *CM12 Methylmercury Management* will help minimize potential adverse effects. The BDCP is not expected to increase levels of selenium in splittail, because concentrations are not expected to increase in major foraging areas of adult splittail, such as Suisun Bay (Appendix 5.D, Section 5.D.5.2.2, *Selenium*). Analyses presented in Appendix 5.D suggest that there is a low potential for increased contaminant exposure from the BDCP. Over time, this effect may shift to become beneficial because of reduced contaminants from restoration of areas previously used for agriculture. However, it is highly uncertain and so it is concluded with low certainty that the BDCP would result in a low negative change in exposure to contaminants (i.e., increased exposure) for all life stages of splittail.

As noted for delta smelt (Section 5.5.1.2.3), the toxic blue-green alga, *Microcystis*, has been shown to have potentially negative effects on the aquatic foodweb of the Delta, principally in the south Delta subregion and the middle to upper portions of the West Delta subregion near locations such as Collinsville, Antioch, and Franks Tract (Lehman et al. 2010). Restoration actions (*CM4 Tidal Natural Communities Restoration*) included in the BDCP may facilitate blooms of *Microcystis* by increasing water residence time, thereby adversely affecting the food supply, particularly plankton, and increasing toxic exposure of covered fish species to microcystins. Young fish are likely more vulnerable than older fish because they feed on zooplankton and are more susceptible to toxins. *Microcystis* rarely occurs in the habitats where splittail larvae and young juveniles rear. Reflecting agency biologist opinion during the August 2013 workshops, for this effects analysis it is assumed with low certainty that *Microcystis* is an attribute of low importance for juvenile and adult splittail. *Microcystis* blooms occur primarily in the summer and fall, when water temperatures and residence times are generally highest. Most splittail occur primarily in Suisun Bay and Suisun Marsh in the summer and fall, where *Microcystis* is less prevalent than in the South Delta and West Delta subregions; however, some splittail are found throughout the Delta in all seasons. Thus, it is concluded with low certainty that the BDCP would result in a low negative change to the *Microcystis* attribute (i.e., increase in *Microcystis* blooms) for juvenile and adult splittail.

5.5.7.2.2 Increased Water Clarity

The BDCP north Delta intakes will reduce the quantity of sediment entering the Plan Area, possibly increasing water clarity in some areas and negatively affecting splittail, although the BDCP has the potential for mixed effects on water clarity overall in splittail habitat. Uncertainty would be reduced considerably with development of a suspended sediment simulation model.

Splittail typically inhabit shallow, turbid water (Moyle et al. 2004), but the importance of water clarity to splittail has not been studied. Given the general importance of water clarity for such ecological processes as predation, for this effects analysis it was assumed with moderate certainty that water clarity is an attribute of moderate importance to the motile splittail life stages (larvae, juveniles, and adults); this view was consistent with agency biologist thinking during the August 2013 workshops.

The BDCP has the potential to increase the water clarity in portions of the Plan Area, with a great deal of local variation (Appendix 5.C, Attachment 5C.D, *Water Clarity—Suspended Sediment Concentration and Turbidity*). As described in more detail for delta smelt in Section 5.5.1.2.1, the north Delta intakes proposed under *CM1 Water Facilities and Operation* were estimated to result in around 8 to 9% less sediment in the late long-term entering the Plan Area from the Sacramento River, the main source of sediment for the Delta and downstream subregions. In addition, sediment accretion in the ROAs would occur over time as part of the development of tidal marsh under *CM4 Tidal Natural Communities Restoration*. These two BDCP actions could limit sediment supply to downstream areas of importance to splittail, such as Suisun Bay and Suisun Marsh. As noted in Section 5.5.1.2.1 for delta smelt, Cloern et al. (2011) noted the uncertainty in future turbidity trends in the Plan Area: specifically, it is unclear whether a 40-year average decline in turbidity of 1.6% per year will continue at this rate. How the BDCP may affect water clarity in the late long-term is uncertain, and depends on a variety of interacting factors (Appendix 5.C, Attachment 5C.D); development of a suspended sediment model would allow better understanding of how the different factors may interact in the future. Because larval splittail tend to occupy floodplains or channel margins during higher flow times of the year, it is concluded with low certainty that there would be no change in water clarity for this life stage. It is concluded with low certainty that there would be a low negative change (i.e., greater water clarity) to the water clarity attribute for juvenile and adult splittail, reflecting occupation of downstream areas such as Suisun Bay and Suisun Marsh. Limited agency biologist comment during the August 2013 workshops suggested that a zero or low negative change would be appropriate for the juvenile life stage, reflecting occupation of the downstream areas previously mentioned; other life stages were not felt to be of as much relevance for consideration with respect to water clarity in these areas.

5.5.7.2.3 Entrainment and Impingement at North Delta Intakes

Entrainment of splittail through the screened new north Delta intakes would be limited to larval splittail and, as discussed in Appendix 5.B, Section 5.B.6.2.4.1, *Entrainment (Screening Effectiveness Analysis)*, it is expected that most of the splittail migrating through the portion of the Sacramento River where the intakes would be located would be greater than 22 mm, and would therefore be effectively excluded by the proposed intake screens. Impingement is also expected to have a only a minor effect on juvenile splittail because of the low approach velocities of the screens and the strong swimming ability of the fish (Appendix 5.B, Section 5.B.6.2.4.2, *Impingement and Screen Contact*). Direct screen contact potentially would result in injury, but the smooth surface of the screens is expected to minimize such injuries. Large numbers of larvae would likely be present at the intakes only following high flow events that flushed larvae from nursery habitats. Larval production is generally so high following high flow events that loss to entrainment or impingement probably would be of low consequence to the species. Reflecting agency biologist comments from the August 2013 workshops, it was assumed for this effects analysis that the north Delta entrainment/impingement attribute has low importance to larval and juvenile splittail, with low certainty for larvae and moderate certainty for juveniles.

It is concluded with moderate certainty that the north Delta intakes would result in a low negative change to the north Delta intakes entrainment/impingement attribute for larval and juvenile splittail. The only agency biologist comment received during the August 2013 workshops suggested a moderate negative change (with high certainty) for larvae. Monitoring and real-time operations can address the loss of juvenile and larval splittail to entrainment or impingement at the north Delta intakes.

5.5.7.2.4 Reduced Plan Area Flows

The BDCP will reduce flows in the Sacramento River downstream of the north Delta intakes (CM1), which may reduce survival of outmigrating YOY juveniles.

By analogy to outmigrating juvenile salmonids, it is assumed that survival of downstream migrating YOY splittail is positively related to river flow, although no studies have been done to specifically look at this. Greater river flows generally are associated with higher turbidity and shorter passage times to juvenile rearing areas (Suisun Marsh and Suisun Bay), which facilitates less contacts with predators. It was assumed with low certainty that this attribute has moderate importance to juvenile splittail and no importance to splittail larvae and adults with high certainty, which is consistent with agency biologist opinion during the August 2013 workshops. The BDCP is expected to result in reductions in Sacramento River flows downstream of the north Delta intakes during the May to July YOY outmigration period. Thus, it is concluded with moderate certainty that the BDCP would result in a low negative change to Plan Area flows for juvenile splittail.

5.5.7.2.5 Exposure to In-Water and Maintenance Activities

In-water construction and maintenance effects of the BDCP could affect splittail but will be minimized with *CM22 Avoidance and Minimization Measures* and other standard measures.

In-water construction activities at the proposed north Delta intakes (*CM1 Water Facilities and Operation*) will be limited to one construction season between June and October (Appendix 5.H, *Aquatic Construction and Maintenance Effects*). Generally, most splittail have emigrated well downstream of the construction area by this time (Appendix 2.A, *Covered Species Accounts*). Any splittail remaining in the area could experience adverse effects from underwater sound (pile driving), entrapment in enclosed areas (e.g., cofferdams), exposure to temporary water quality deterioration (e.g., suspended sediment and suspension of toxic materials), and accidental spills. Habitat will be temporarily and permanently affected by intake construction, although habitat at the intake sites is generally of low value (steep-sloping, revetted banks). Maintenance dredging may decrease water quality temporarily. Restoration actions associated with *CM4 Tidal Natural Communities Restoration, CM5 Seasonally Inundated Floodplain Restoration*, *CM6 Channel Margin Enhancement*, and *CM7 Riparian Natural Community Restoration* temporarily may cause reduced water quality in the immediate area of disturbance and could affect splittail, because the activities will occur within the species' main distribution. Breaching levees to create tidal habitat may reduce areas of channel margin, but there will be considerable gains of habitat caused by the breaching. In-water activities associated with *CM14 Stockton Deep Water Ship Channel Dissolved Oxygen Levels, CM15 Localized Reduction of Predatory Fish, CM16 Nonphysical Fish Barriers,* and *CM21 Nonproject Diversions* will have little to no effect on splittail because of the small scale of the work. Implementation of *CM22 Avoidance and Minimization Measures* will reduce the likelihood of adverse effects from in-water activities related to construction and maintenance on splittail. Therefore, it is concluded with high certainty that construction and maintenance associated with the BDCP represent a low negative effect on splittail.

5.5.7.3 Impact of Take on Species

The covered activities are expected to result in take of splittail from continued entrainment at the SWP/CVP south Delta facilities and as a result of construction activities. Construction and maintenance at the proposed north Delta intakes, restoration sites, conservation hatcheries, and nonphysical barriers may result in a number of adverse effects on splittail, including disturbance from in-water activity and hydrodynamic changes, physical injury from riprap/rock placement and noise and vibration, exposure to fuel or oil, and elevated turbidity levels (Appendix 5.H, *Aquatic Construction and Maintenance Effects*). These actions, however, will have temporary effects unlikely to adversely affect splittail on a population level, because the large majority of the population is well downstream of the area where the main in-water activities (construction of north Delta diversion facilities) will be located during the time of year the construction will occur. Avoidance and minimization measures are expected to further reduce or eliminate any such take (Appendix 5.H). Therefore, it is concluded with high certainty that take from these construction and enhancement activities will have a low negative impact.

Historically, levels of splittail take at the south Delta pumping facilities have been related to abundance. Entrainment has been high in wet years because of high production of young splittail on inundated floodplains, such as the Yolo Bypass. Once the north Delta intake facilities begin operating, take, as a proportion of the splittail population, is expected to decline substantially, because diversions at the south Delta facilities will be much reduced and entrainment at the north Delta intakes is expected to be low in comparison to the south Delta water diversions because of the state-of-the-art fish screen facilities. It is anticipated that decreases in entrainment at the south Delta export facilities, North Bay Aqueduct, Barker Slough Pumping Plant, and at numerous agricultural diversions that will be decommissioned under the BDCP will more than offset any entrainment and impingement at the proposed north Delta diversion facilities.

5.5.7.4 Net Effects

Figure 5.5.7-1 shows the relative population-level outcomes that are concluded to result from implementation of the BDCP, by attribute, for Sacramento splittail covered under the BDCP. The graph illustrates the effect of the BDCP, by considering the change to an attribute for each life stage in light of the importance of the attribute to that life stage. The positive effects of the BDCP are concluded to outweigh the negative effects, so that the net effect of the BDCP is expected to benefit Sacramento splittail. Most of the concluded effects are made with low or moderate certainty, whereas the main benefit of the BDCP (i.e., enhanced floodplain availability because of *CM2 Yolo Bypass Fisheries Enhancements*) is assessed to be of high certainty, as is less entrainment of juveniles and adults at the south Delta export facilities. Many effect conclusions are made with low certainty that reflect low certainty about the current importance of the attribute (e.g., the importance of habitat created by Feather River flows), low certainty about the magnitude of the change that BDCP may provide (e.g., positive changes to the habitat attribute of intertidal marsh to spawning and larval splittail under *CM4 Tidal Natural Communities Restoration*) or low certainty regarding both the importance and change to the attribute (e.g., for the effect of the BDCP on entry of juvenile splittail into the interior Delta).

Taken together, the covered activities are expected to have a positive effect on the abundance, productivity, and diversity of splittail populations and to reduce the risks to its survival. As described above, the variability in abundance of the splittail population stems from the strong effect of hydrologic variability on YOY production. Wet years with high river flow and extensive floodplain inundation produce large splittail year classes, while dry years produce much smaller year classes. The abundance of splittail populations is determined largely by the availability of inundated floodplain habitat, which is used for spawning and rearing of larvae and young juveniles. As a result of *CM2 Yolo Bypass Fisheries Enhancement*, the most important benefit to splittail will be to increase the frequency, duration, and surface area of inundated floodplain habitat on the Yolo Bypass (Appendix 5.C, *Flow, Passage, Salinity, and Turbidity,* Section 5.C.5.4.1.1, *Sacramento Splittail Habitat Area*), including in drier years. This benefit is expected to increase population abundance and reduce the risk to the population of an extended drought. CM2 is expected to result occasionally in sufficient inundation for modest splittail production during dry or critical years, which is not expected to occur under existing conditions. Such dry-year splittail production could further reduce the risk to the population of an extended drought. *CM4 Tidal Natural Communities Restoration* and *CM6 Channel Margin Enhancement* will increase availability of tidal wetland and channel margin habitat, respectively, and potentially increase the availability of dry-year spawning and rearing habitat (Appendix 5.E, *Habitat Restoration,* Section 5.E.65.2.4, *Sacramento Splittail*). However, the degree to which splittail spawn in such habitats in the Delta is uncertain, and the main result from south Delta floodplain restoration may be increased habitat diversity and ultimately in greater biological diversity of the population. These restoration measures may benefit splittail foodweb resources, thereby adding to the benefits of the increased habitat availability (Appendix 5.E, Section 5.E.4.4.2.5, *Food in the Delta and the Effect of the Conservation Measures on Food for Covered Fish Species*).

As indicated in Figure 5.5.7-1, there is potential for a high positive effect of intertidal habitat restoration on juvenile and adult splittail, for the proposed BDCP restoration of this habitat type represents a substantial increase over existing conditions. The moderate certainty reflects potential benefits of the BDCP being reduced if nonnative competitors and predators colonize these new or adjacent habitats in large numbers, but the BDCP includes conservation measures to reduce the potential adverse effects of IAV and predation in the ROAs (*CM13 Invasive Aquatic Vegetation Control and CM15 Localized Reduction of Predatory Fishes*). Additionally, monitoring and adaptive management will be used to minimize these adverse effects.

In addition to direct habitat benefits described above, the covered activities will greatly reduce per capita entrainment of splittail from reduced diversions at the south Delta SWP/CVP facilities. This reduction may not result in an appreciable change in overall abundance of splittail populations, as demonstrated by the lack of correlation between entrainment and abundance of splittail (Sommer et al. 1997; Moyle et al. 2004). However, reduced diversions potentially will result in an enlarged spawning stock, especially if restoration actions increase availability of rearing and foraging habitat for juveniles and adults. An enlarged spawning stock potentially will increase the population's genetic diversity.

Zooplankton community composition and illegal harvest are attributes considered to be of no importance to splittail life stages. Because it is not thought that early life stages of splittail are preferential in prey selection, (i.e., important prey items represent the most abundant prey items in differing habitats), and juveniles and adults eat mostly detritus, it was assumed with high certainty that zooplankton community composition is an attribute of no importance for larval, juvenile and adult splittail. *CM17 Illegal Harvest Reduction*, is not likely to have any effect on splittail because the measure is not likely to target splittail and the degree to which illegal harvest is currently occurring is unknown.

The BDCP is expected to result in a small increase in the existing stress on splittail from exposure to methylmercury, which could reduce abundance of the population and result in a lower spawning stock. Methylmercury is not believed to affect splittail at the population level (U.S. Fish and Wildlife Service 2010b), and the likelihood of adverse effects resulting from the BDCP is low. As described in Appendix 5.D, *Contaminants*, ammonium and copper, both of which can have direct toxic effects on fish as well as effects on the foodweb, are not expected to significantly change as a result of the BDCP. The BDCP is not expected to greatly affect DO levels (other than in some parts of Suisun Marsh as wetlands managed for waterfowl are restored into tidal habitats) and will have little effect on water temperatures, whereas splittail are tolerant of broad ranges of DO levels and water temperatures (Young and Cech 1996). Outside of the Yolo Bypass, passage barriers of most types are expected to have little effect on splittail, although information to confirm this is lacking. The late-winter and spring operations of the Suisun Marsh Salinity Control Gates overlap the period of adult splittail spawning migrations from Suisun Marsh, but the gates, which operate 10 to 20 days per year, are believed to delay fish migrations by a few days at most (Appendix 5.C, *Flow, Passage, Salinity, and Turbidity,* Section 5.C.5.3.10, *Suisun Marsh Salinity Control Structure*) and therefore are expected to have a negligible effect on the splittail population. Discussion of passage barriers on the Yolo Bypass is included in the section above on floodplain habitat.

The importance of predation to splittail is unclear, because almost nothing is known of predation rates. Nobriga and Feyrer (2007) found only three splittail in the stomachs of 1,172 predators in surveys in the Delta conducted March through October in 2001 and 2003, but this low rate may have resulted from low local abundance of splittail or habitat conditions that reduced splittail predation risk. During the August 2013 workshops, agency biologists suggested, with high certainty, that predation is not a current constraint of any importance to splittail. The BDCP may have several effects on predation. Restoration actions could affect predation on splittail, but the effect is highly uncertain. Changes in water operations under *CM1 Water Facilities and Operation* are expected to result in a lower proportion of the splittail population being entrained at the south Delta export facilities, which in turn will reduce exposure to predation, particularly in the Clifton Court Forebay (such losses are captured within the calculations of changes in entrainment loss discussed above). In contrast, the north Delta intakes potentially will result in added predation pressure. The striped bass bioenergetics model for predation on juvenile salmon was used, with modifications, to estimate effects on YOY splittail at the north Delta intakes. The model estimated a large number of splittail consumed by striped bass, but the level of predation relative to the size of the splittail population (the per capita rate of predation) is unknown, so the effect on the splittail population could not be determined. The BDCP will reduce flow in the lower Sacramento River below the new intakes during May through July, when most YOY splittail emigrate, which is expected to result in increased predation on the emigrating splittail. *CM2 Yolo Bypass Fisheries Enhancement* potentially will reduce the proportion of splittail subjected to predation at the north Delta intakes. Most of the splittail produced on the Yolo Bypass, the most important spawning habitat of splittail (Feyrer et al. 2006), migrate downstream via the Cache Slough area and enter the Sacramento River downstream of the north Delta intake locations. As a result, these fish will not be exposed to predators around the intake structures. Assuming CM2 results, as expected, in an increased proportion of the splittail population being produced on the Yolo Bypass, exposure to predation at the intake will be reduced. *CM15 Localized Reduction of Predatory Fishes* may reduce predation pressure at key locations such as during the south Delta salvage process (e.g., by predator capture, by increasing numbers of release sites) (Appendix 5.F, *Biological Stressors on Covered Fish,* Section 5.F.3.5, *CM15 Localized Reduction of Predatory Fishes*), at the north Delta intakes, around nonphysical barriers, and at the Fremont Weir.

In conclusion, the magnitude of benefits of the BDCP for Sacramento splittail at the population level cannot be quantified with certainty. Nonetheless, the overall net effect of the BDCP is expected to be positive, with the potential to increase the resiliency and abundance of Sacramento splittail relative to existing conditions. This overall conclusion is made with moderate certainty. The BDCP should provide for the conservation and management of the species in the Plan Area and may help it cope with expected climate change and the ongoing threats as they are perceived. As noted for other species in this effects analysis, the BDCP will not directly address the main effects of climate change (i.e., increased temperature) but, by expanding habitat, increasing habitat diversity, and increasing the number of productive habitat patches in the Delta, the BDCP may lead to a more robust Sacramento splittail population with the resiliency and diversity necessary to cope with a changing environment.

Therefore, the BDCP will minimize and mitigate impacts to the maximum extent practicable and provide for the conservation and management of the Sacramento splittail in the Plan Area.

Category	Appendix	Attributes	Definition	Eggs	Larvae	Juvenile	Adults
Food	E	Zooplankton community	Species composition of the zooplankton community and presence of suitable prey species	NA			
		Zooplankton abundance	The abundance of zooplankton	NA	Low	Moderate	Moderate
		Benthic & Epibenthic prey abundance	The abundance of epibenthic prey species such as amphipods	NA	Low	Moderate	Moderate
		Insect abundance	The abundance of insect prey	NA	Low	Moderate	Low
Entrainment & Impingement	B	North Delta Intakes	Potential entrainment/impingement from the proposed North Delta intakes	NA	Very Low -	Very Low -	
		South Delta Pumps	Pumping rate from the CVP/SWP south Delta export facilities and resulting entrainment	NA	Very Low	Low	Very Low
		North Bay Aqueduct	Entrainment from the SWP NBA facilities	NA			
		Ag Diversions	Entrainment from Agriculture Diversions	NA			
Migration & Movement	C	Plan Area Flows	Magnitude, timing, direction, and duration of flows during migratory periods throughout the Plan Area	NA		Low-	
		Interior Delta Entry	Entry of fish into the interior Delta from the mainstem Sacramento or San Joaquin Rivers through channels such as Georgiana Slough or Old River	NA		Very Low	
		Passage Barriers	Structures or conditions that potentially block upstream or downstream migration	NA			
Habitat	C, E	Inter-tidal habitat	Intertidal area from the mean low low water level to the extreme high water level that may support intertidal vegetation and form mudflats; dynamic elements of habitat such as appropriate salinity are considered on a species-specific basis	Very Low	Moderate	High	High
		Channel Margin	The extent of shallow water, low slope habitat that generally is characterized by structural complexity, native emergent vegetation and riparian shading cover	Very Low	Very Low	Very Low	Very Low
		Floodplains	The interface between upland topography and river hydrology during high flow events	High	High	High	High
		Riparian	Forest and scrub that occurs along the margins of river channels and within floodplains	NA	NA	NA	NA
		Sub-tidal habitat	Extent and location of sub-tidal area in the Plan Area, including the low salinity zone (LSZ); dynamic elements of habitat such as appropriate salinity are considered on a species-specific basis				
Sediment	C	Water clarity	Water clarity in the Plan Area as influenced by amount of suspended material within the water column	NA	0	Low-	Low-
Temperature	C	Temperature	Adverse effects of high temperatures within the Plan Area			0	
DO	C	Dissolved Oxygen	Adverse effects of low dissolved oxygen level within the Plan Area				
Toxins	D, F	Contaminants	Adverse effects of methylated mercury, selenium, pesticides and other pollutants	Low-	Low-	Very Low -	Low-
		Microcystis	The abundance of Microcystis aeruginosa blooms that are toxic to covered fish species and their food			Very Low -	Very Low -
Predation	F	Predation	The species-specific consumption of covered fish species by predatory fish (e.g., striped bass, Sacramento pikeminnow, centrarchid bass species, catfish, and inland silversides); note that the attribute aims to isolate predation effects that may not be captured by other attributes, e.g., at manmade structures such as the north Delta diversions				
		Illegal Harvest	Illegal harvest of covered fish species in the Plan Area	NA	NA		

Category	Appendix	Attributes	Definition	Eggs	Larvae	Juvenile	Adults
In-stream Habitat	C	Sacramento R. Habitat	Flows in the Sacramento River mainstem (below Keswick Dam to the Plan Area) that influence spawning, egg incubation, rearing, or holding habitat	0	0	0	0
		Feather R. Habitat	Flows in the Feather River (below Oroville Dam to the confluence with the Sacramento River) that influence spawning, egg incubation, rearing, or holding habitat	Very Low	Very Low	Very Low	Very Low
		American R. Habitat	Flows in the American River (below Nimbus Dam to the confluence with the Sacramento River) that influence spawning, egg incubation, rearing, or holding habitat				
Migration & Movement	C	Sacramento R. Migration Flows	Flows in the Sacramento River mainstem (below Keswick Dam to the Plan Area) that influence migration and movement				
		Feather R. Migration Flows	Flows in the Feather River (below Oroville Dam to the confluence with the Sacramento River) that influence migration and movement				
		American R. Migration Flows	Flows in the American River (below Nimbus Dam to the confluence with the Sacramento River) that influence migration and movement				
Temperature	C	Sacramento R. Temperature	Adverse effects of high water temperatures in the Sacramento River mainstem (below Keswick Dam to the Plan Area)				
		Feather R. Temperature	Adverse effects of high water temperatures in the Feather River (below Oroville Dam to the confluence with the Sacramento River)				
		American R. Temperature	Adverse effects of high water temperatures in the American River (below Nimbus Dam to the confluence with the Sacramento River)				

Certainty

(grey)	No effect conclusion made because attribute assumed not to have importance as a current constraint
NA	Life stage not present or not applicable
(green)	Low certainty
(light blue)	Moderate certainty
(blue)	High certainty
(purple)	Very high certainty

Figure 5.5.7-1. Effect of the Covered Activities on Sacramento Splittail

5.5.8 Green Sturgeon (Southern DPS) and White Sturgeon

Green sturgeon (southern DPS) (*Acipenser meditrostris*) and white sturgeon (*Acipenser transmontanus*) are long-lived species that use the San Francisco Estuary as a migration corridor, feeding area, and juvenile rearing area. The southern DPS green sturgeon is listed as threatened under ESA and is a California species of special concern. Both species have been observed throughout the Plan Area, including Suisun Bay and the Yolo Bypass. The abundance of white sturgeon in the Central Valley has declined from an estimated 114,000 adults in 1994 to 10,000 adults in 2005 (Bland 2006). CDFW estimated that green sturgeon abundance in the Bay-Delta estuary ranged from 175 to more than 8,000 adults between 1954 and 2001 with an annual average of 1,509 adults (California Department of Fish and Game 2002). White sturgeon spawn in the Sacramento, Feather, and San Joaquin Rivers, and possibly the Stanislaus River, during late winter and spring (February through May/June). Green sturgeon spawn in the Sacramento River and the Feather River from around March–July, depending on water temperature. White sturgeon spend the majority of their lives in brackish portions of the estuary in deep water, although a small number of individuals dwell in the ocean (Moyle 2002; Surface Water Resources, Inc. 2004; Welch et al. 2006). Green sturgeon adults spend extended periods of time within the ocean making long migrations as far north as southern Alaska and as far south as Ensenada, Mexico (Moyle 2002; Lindley 2008). Detailed species accounts of white and green sturgeon are presented in Appendix 2.A, *Covered Species Accounts*. As noted in those accounts, white sturgeon early life stages (eggs and larvae) have some potential to occur within the Plan Area, whereas green sturgeon eggs and larvae do not occur within the Plan Area. Environmental attributes that potentially affect white and green sturgeon and that may be affected by the BDCP are described in the sections below.

The following sections describe in detail the beneficial and adverse effects of the BDCP on white and green sturgeon, followed by a description of the overall net effects of the BDCP on each species.

5.5.8.1 Beneficial Effects

5.5.8.1.1 Reduced Illegal Harvest

Implementation of *CM2 Yolo Bypass Fisheries Enhancement* and *CM17 Illegal Harvest Reduction* are expected to reduce the illegal harvest of green and white sturgeon, substantially contributing to increased productivity and higher abundance.

Harvest of white sturgeon is thought to have a substantial adverse effect on the population (Beamesderfer et al. 1996), particularly through the illegal harvest of gravid females (Schwall pers. comm.). Likewise, illegal harvest is thought to have a substantial adverse effect on green sturgeon (Israel and Klimley 2008). Because of their longevity, late maturation and low populations, both white and green sturgeon are particularly susceptible to threats from overfishing (Musick 1999; Israel and Klimley 2008; Israel et al. 2009). There is no legal harvest of green sturgeon; however, evidence suggests that both white and green sturgeon are harvested illegally. For this effects analysis, it was assumed that illegal harvest is an attribute of very high importance to white sturgeon adults (with very high certainty) and green sturgeon adults (with high certainty, reflecting less being known of this species because of lower abundance); it was further assumed with moderate certainty that illegal harvest of juvenile white and green sturgeon is of high importance, reflecting the potential importance of the harvest of larger juveniles. The assumptions for adults reflected the views of agency biologists at the August 2013 workshops, and these biologists also noted the potential importance for larger juveniles.

None of the conservation measures would affect the legal harvest of white sturgeon, although legal harvest is already aggressively managed through angling regulations to maintain exploitation rates at acceptable levels. The BDCP includes *CM17 Illegal Harvest Reduction*, which will decrease poaching of white and green sturgeon and other covered fishes. The Implementation Office will provide funding to increase the enforcement of fishing regulations in the Plan Area and upstream tributaries in order to reduce illegal harvest of covered fish species. Funds will be provided to hire and equip 17 additional game wardens and five supervisory and administrative staff in support of the existing field wardens assigned to the Delta-Bay Enhanced Enforcement Project over the term of the BDCP; this represents nearly a tripling of the existing 10-warden squad.

It is concluded that there will be a very high positive change to the illegal harvest attribute (i.e., a very high reduction in illegal harvest), with very high certainty, for green and white sturgeon adults and juveniles. This conclusion directly reflects the opinion of agency biologists at the August 2013 workshop and is based on the detailed description of the expected benefits of *CM17 Illegal Harvest Reduction* by Roberts and Laughlin (2013). Following is a summary of the main points raised by Roberts and Laughlin (2013) in their analysis of the expected benefits of CM17 .

- Illegal harvest of large white and green sturgeon is adverse to these species because of the life-history characteristics of the species, their current status, and existing constraints on habitat.
    - Central Valley sturgeon are at the southern edge of their distribution, resulting in environmental conditions for successful spawning that are less frequent than in other areas, making the populations more prone to decline.
    - Spawning and rearing habitat in the Central Valley has been substantially degraded by development.
    - Individual sturgeon spawn only once every 2–9 years, making the conservation and recovery of mature individuals particularly important from a management perspective.
    - Abundance is very low relative to other harvested populations of fish: there are approximately 35,000 white sturgeon of legally harvestable size, less oversized individuals, and the catch rate of white sturgeon often outnumbers the catch rate of green sturgeon by around 100 times, suggesting green sturgeon to be much less abundant.
    - The predictable behavior and physiology of adult sturgeon makes them very straightforward to capture. Commercial harvest has thus been illegal for approximately 100 years and recreational harvest is increasingly restricted.
    - Illegal harvest reduces the resiliency of the species to natural and anthropogenic habitat disturbances.
- Additional wardens will allow substantial expansion of the spatial and temporal coverage by patrols.
    - Currently, enforcement efforts are limited to one team of 9 wardens working from Thursday to Sunday, 10 hours per day.
    - The existing uniformed patrol squad will double in number as a result of CM17 and will consist of 2 squads of 9 people each.

  - Expansion of the unit with additional wardens would allow seven-day-per-week, twelve-hour-per-day coverage over a greater spatial area, including areas not frequently patrolled at present (in particular upstream of the Plan Area).
- Compliance rates of sport fishers with harvest regulations are anticipated to increase with increased uniformed patrols.
  - The compliance rate of citizens contacted by DBEEP officers was around 90% over 2005–2012 (nearly 16,000 warnings or citations out of around 160,000 contacts); this is an increase from around 60% at the start of the DBEEP unit two decade earlier.
  - It is anticipated that the compliance rate with harvest regulations will increase as the public becomes aware of the increased patrols facilitated by the expansion of uniformed patrols proposed under CM17.
- Increased undercover efforts would reduce illegal harvest.
  - The DBEEP currently relies on a Special Operations Unit (SOU) to provide additional assistance with surveillance of the illegal commercialization of sturgeon in the Plan Area and upstream waterways—this effort focuses on sturgeon during the October–April period, and leaves the DBEEP short of staff for uniformed patrols; in addition, the SOU is generally unavailable at other times primarily because of abalone harvest violation investigations in coastal areas.
  - Establishment of a year-round undercover team of 8 wardens will allow the DBEEP to continue important efforts during times when the SOU is unavailable, particularly in relation to important areas such as south San Francisco Bay, which has high presence of sturgeon in summer and fall.
  - In addition, the undercover DBEEP team would be able to focus on party boats and illegal guide services targeting sturgeon and other species such as salmon.
- Increased education of the public would result from more frequent contacts.
  - A greater uniformed patrol presence would result in more opportunity to educate the public regarding fishing regulations, leading to increased compliance.
  - Increased contacts and interaction with the public may lead to greater participation of citizens in schemes such as CALTIP, which allows information on illegal activities to be reported to law enforcement authorities.

In addition to the main direct benefits to sturgeon from reduced illegal harvest noted above, it is also expected that the expanded DBEEP would provide increased patrols and assistance to local law enforcement to locate and remove illegal marijuana cultivation sites in the Plan Area, which are detrimental to waterways because of pollution from pesticides/fertilizers and other factors; this enhanced coverage in particular would focus on areas restored under the BDCP in order to assist in the maintenance of habitat quality.

In addition to the anticipated benefits of CM17, the BDCP is expected to provide passage of sturgeon at the Fremont Weir (*CM2 Yolo Bypass Fisheries Enhancement*), reducing stranding in the stilling basin, thus reducing the ease with which they can be illegally harvested from the area near the weir. Passage improvements are discussed further below.

5.5.8.1.2 Improved Passage

Implementation of *CM2 Yolo Bypass Fisheries Enhancement* is expected to improve passage for adult white and green sturgeon at Fremont Weir, which is a known major passage impediment to these species.

CM2 Yolo Bypass Fisheries Enhancement is expected to improve passage for white and green sturgeon. As described in Appendix 5.C, *Flow, Passage, Salinity, and Turbidity,* Section 5.C.5.3.12, *Fremont Weir Adult Fish Passage (CM2 Yolo Bypass Fisheries Enhancement)*, appreciable numbers of sturgeon may be stranded below Fremont Weir in the Yolo Bypass, which is of particular importance given low population sizes. Thomas et al. (2013) conducted a population viability analysis for green sturgeon and found that recurrent stranding—at both Fremont Weir, as well as Tisdale Weir in the Sutter Bypass—of the magnitude observed in the high-flow year of 2011 could, over 50 years, reduce adult female green sturgeon abundance by 33% compared to a baseline condition with no stranding. Their modeling results suggested that fish rescue of the type employed in 2011 could have led to 7% lower abundance after 50 years compared to a no-stranding baseline scenario, thereby improving existing conditions.

The passage barrier at Fremont Weir is assumed for this effects analysis to be of high importance for adult green and white sturgeon, with high certainty for green sturgeon (because of the modeling study by Thomas et al. 2013 noted above) and moderate certainty for white sturgeon because the population size is larger and there has been no explicit study of population-level effects of the stranding. Agency biologists at the August 2013 workshops felt that high importance (with moderate certainty) was warranted for green sturgeon adults, and that moderate or high importance was warranted for white sturgeon (with the moderate importance reflecting population size differences between green and white sturgeon). *CM2 Yolo Bypass Fisheries Enhancement* includes a number of actions to reduce fish passage impediments in the Yolo Bypass, including the addition of sturgeon ramps near the Fremont Weir (Appendix 5.C, *Flow, Passage, Salinity, and Turbidity,* Section 5.C.5.3.12). Improving fish passage at Fremont Weir is expected to reduce stranding and poaching of sturgeon in the stilling basin below the weir after water recedes. As noted for adult salmonids, improvements in Fremont Weir passage are concluded to be greater than any potential negative effects of CM2 that may arise if more adult fish enter the Yolo Bypass because of more flow coming down the bypass (see also DRERIP assessment of CM2; Appendix 5.C, Flow, Passage, Salinity, and Turbidity, Section 5.C.5.3.12.2, *DRERIP Evaluation of Fremont Weir and Yolo Bypass Inundation*). CM2 also includes fish rescue in addition to improved fish passage at Fremont Weir, which would benefit sturgeon prior to completion of the Fremont Weir passage enhancements.

It is concluded with moderate certainty that this conservation measure would result in a high positive change to the passage barriers attribute for green and white sturgeon adults. Agency biologists concurred with the high positive change, and felt that moderate or high certainty was warranted; this certainty reflected the commitment included in CM2 to rescue fish, rather than solely based on physical modifications of Fremont Weir with sturgeon ramps.

5.5.8.1.3 Restored Floodplain, Tidal, and Channel Margin Habitat

Tidal habitat restoration under *CM4 Tidal Natural Communities Restoration* will provide substantial benefits to green and white sturgeon by providing additional epibenthic and benthic food resources and rearing habitat. Further, sturgeon are expected to benefit from

the transfer of increased production in restored marshes to benthic mudflat prey species. *CM2 Yolo Bypass Fisheries Enhancement, CM5 Seasonally Inundated Floodplain Restoration, CM6 Channel Margin Enhancement, and CM7 Riparian Natural Community Restoration* may all provide small benefits, although with low certainty, to sturgeon in the form of food and habitat benefits.

Physical habitat alteration is pervasive among significant portions of the freshwater and estuarine ecosystem inhabited by green and white sturgeon in the Plan Area. Before 1850, 540 square miles of freshwater wetlands and 308 square miles of salt marshes were sustained in the region. Today only 48 square miles of these habitats remain (U.S. Geological Survey 1994). Tidal marshes and, in particular, brackish marshes, provide foraging resources for both juvenile and adult green and white sturgeon. When juvenile white sturgeon migrate from the river to the estuary, their diet shifts to larger benthic food items, although they remain opportunistic foragers. Seasonally abundant drifting and benthic invertebrates are major food items of white sturgeon in major rivers (Muir et al. 2000). In the Delta, mysid shrimp and amphipods (*Corophium*) were identified as the primary food items in juvenile (<39 cm) white sturgeon stomachs (Radtke 1966). As white sturgeon juveniles grow, they are presumed to become more piscivorous, consuming herring and their eggs (*Clupea harengus pallasi*), American shad (*Alosa sapidissima*), starry flounder (*Platichthys stellatus*), and goby (Radtke 1966, McKechnie and Fenner 1971).

Intertidal and subtidal habitat restoration under *CM4 Tidal Natural Communities Restoration* will increase the amount of freshwater and brackish marsh habitat that presumably supports the drift, epibenthic, and benthic foodwebs through the production of emergent vegetation, detritus, and phytoplankton. The increase in production will situationally move by hydraulics from dendritic channel networks to larger channels that juvenile and adult sturgeon use as migration pathways through the estuary and Plan Area, thus providing benefits to subtidal habitats as well. Kogut (2008) found that the overbite clam (*Potamocorbula amurensis*) is a major component of the white sturgeon diet. It is likely that *Potamacorbula* will invade and establish in parts of brackish marsh restoration areas, especially Suisun Marsh. This will provide additional food resources for green and white sturgeon, although it should be noted that Kogut (2008) also found that unopened clams were also able to pass through the digestive tract; Israel et al. (2009) speculated that this may lead to dietary dilution but also noted that no specific studies had been conducted to investigate this further since the invasion of *Potamocorbula*. The importance of subtidal habitat to white and green sturgeon for migration, feeding, and juvenile rearing should not be underestimated. The diversity of the prey of juvenile sturgeons may be an indication of competition with other riverine fish for drifting prey. If this is the case, there may be competition for food with other fish present in the Plan Area such as Sacramento suckers, striped bass, and salmonids, although there is little information about whether intra- or interspecific competition or predator-prey dynamics influence white sturgeon abundance, distribution, or growth (Muir et al. 1988, Parsley et al. 1989).

For this effects analysis, it was assumed that intertidal habitat for occupancy has low importance as a current constraint on green sturgeon juveniles and adults, and white sturgeon larvae, juveniles and adults, with moderate certainty for all of these life stages, with the exception of low certainty for larval white sturgeon. These assumptions generally reflected the majority of agency biologist opinion at the August 2013 workshops, with some suggesting that there was no importance to larval white sturgeon and others suggesting no importance of intertidal habitat to any life stage of either species. As noted above in the effects analyses of the smelts and salmonids, tidal habitat restoration under the BDCP appreciably increases the extent of this habitat type in the Plan Area. Tidal habitat restoration is expected to provide mudflat habitat used by sturgeon to access food. It is concluded with moderate certainty that there would be a high positive change to this habitat type for juvenile sturgeons, and a moderate positive change for adults and white sturgeon larvae (the latter with low certainty). During the August 2013 workshops, agency biologist opinion was diverse, and suggested change could range from low to high for juveniles and adults, with low certainty when given.

With respect to subtidal habitat, it was assumed that this habitat type is of moderate importance to juvenile sturgeons in the Plan Area (with high certainty), whereas it is assumed with moderate certainty that this habitat type is of low importance to adult sturgeons and larval white sturgeon. Agency biologists at the August 2013 workshops felt low importance for adults was warranted; most felt that low importance also was warranted for juveniles (and for larval white sturgeon), although some felt that moderate importance was warranted, and certainty, when expressed, was low or moderate. As previously described in the effects analyses for the smelts and salmonids, *CM4 Tidal Natural Communities Restoration* increases subtidal habitat extent in the Plan Area, although relatively less than intertidal habitat, because a considerable extent of subtidal habitat already exists in the Plan and the conservation strategy focuses restoration efforts on intertidal habitat. For the life stages noted above, it is concluded with moderate certainty that there would be a moderate positive change in subtidal habitat. Limited agency comment during the August 2013 workshops suggested a high positive change for white sturgeon life stages and a moderate positive change for green sturgeon adults to be warranted.

Although little is known about the use of channel margin habitat by white and green sturgeon, the DRERIP evaluations reported with low certainty that there may be some rearing benefit *CM6 Channel Margin Enhancement* (Appendix 5.E, Section 5.E.6.5.2.5, *Green Sturgeon and White Sturgeon*). Channel margin enhancement may increase the availability and quality of resting habitat for migrating adults by increasing channel margin complexity (e.g., woody material, emergent vegetation, low slope-low velocity areas) that provides refuge from high flows. However, the benefits of such increased resting habitat are uncertain because of a lack of research on this use of channel margin habitat by adult anadromous fishes. These same areas may increase foraging areas within the river margins for larval (white) and juvenile sturgeon species. Overhanging trees and scrub provide shade (cover), potentially decreasing the likelihood of predation from both aquatic and avian predators. *CM2 Yolo Bypass Fisheries Enhancement* and *CM5 Seasonally Inundated Floodplain Restoration* would increase the amount of floodplain habitat in the Plan Area appreciably. However, floodplains and channel margins as habitat for occupancy were assumed with low certainty to be of low importance to the larval and juvenile sturgeon life stages occupying the Plan Area; they were assumed unimportant to adults, again with low certainty. This generally reflected the low or zero importance noted as appropriate by agency biologists during the August 2013 workshops. (Riparian habitat was assumed part of floodplain and channel margin for the purposes of this assessment). It is concluded that there would be a low positive change to these habitats for occupancy by sturgeon life stages, with low certainty, as a result of *CM5 Seasonally Inundated Floodplain Restoration* and *CM6 Channel Margin Enhancement*; this was in accordance with most agency biologist sentiment from the August 2013 workshops.

More detailed discussion of the effects of the BDCP conservation measures on food for covered fish species is provided in Appendix 5.E, *Habitat Restoration*. As noted above, tidal habitat restoration may also produce and export food that may indirectly benefit sturgeon in the form of increased epibenthic organisms such as amphipods, shrimp, and benthic species such as bivalves, including the introduced clams, *Potamocorbula* and *Corbicula*. These benefits are likely to vary among ROAs because of differences in substrate types, salinity regimes, and available prey. It was assumed that benthic/epibenthic food has low importance (with low certainty) as a current constraint on the different life stages of sturgeons occupying the Plan Area. *CM5 Seasonally Inundated Floodplain Restoration* has the potential to provide a small benefit to sturgeon in the Plan Area in the form of habitat (discussed above) and food benefits, but also in the export of primary production that is linked to epibenthic and benthic foodwebs in other habitats (Appendix 5.E, Section 5.E.5). During the August 2013 workshops, agency biologists thought that low or moderate importance with low to high certainty was warranted for this attribute, with other factors such illegal harvest being of more importance. It is concluded with moderate certainty that restoration under CM4 would result in a high positive change in the epibenthic-benthic prey abundance attribute for sturgeon life stages in the Plan Area.

In addition to providing increased benthic and epibenthic production, *CM4* is anticipated to also increase the abundance of insects in the Plan Area through creation of tidal marsh habitat. Increases in insect abundance may also be a benefit of increased floodplain inundation and extent under *CM2 Yolo Bypass Fisheries Enhancements* and *CM5 Seasonally Inundated Floodplain Restoration*, as well as through *CM6 Channel Margin Enhancement* and *CM7 Riparian Natural Community Restoration*. It was assumed with low certainty that insect abundance is of low importance to juvenile green and white sturgeon and white sturgeon larvae; the conservation measures listed above were concluded to result in a high positive change to insect abundance (with high certainty). The assumptions of insect abundance importance were consistent with agency biologist opinion from the August 2013 workshops that suggested low or zero importance.

It was assumed with low certainty that zooplankton abundance (including prey items such as mysids) is of low importance as a current constraint to the juvenile and larval sturgeon life stages within the Plan Area, which was generally consistent with agency biologist thinking from the August 2013 workshops (some thought moderate importance for juveniles may be warranted). Following the rationale presented previously for other species, it was assumed that there would be a moderate positive change to zooplankton abundance in the Plan Area, but with low certainty because of factors previously discussed for species such as delta smelt, i.e., consumption of phytoplankton by nonnative clams and uncertainty regarding export of zooplankton outside of restored areas.

5.5.8.1.4 Increased Recruitment Potential in the Feather River

Green and white sturgeon recruitment potential is not expected to be affected by the BDCP in the Sacramento River but could appreciably increase in the Feather River. Delta outflows during spring months are expected to moderately decrease under the ESO and moderately increase under the HOS.

The reproductive success of white sturgeon, as judged by the year-class index of downstream trawl captures, is greatest in wet and above-normal water years when spring flows are high (Kohlhorst et al. 1991; Fish 2010), and may also be beneficial to green sturgeon. The mechanism behind the importance of higher flows is not known and may involve both upstream and downstream (Plan Area) factors. Although the mechanism is unknown, it is hypothesized that higher flows help disperse young sturgeon downstream, provide increased freshwater rearing habitat, increase spawning activity cued by higher upstream flows, increase nutrient loading into nursery areas, or increase downstream migration rate and survival through reduced exposure time to predators (U.S. Fish and Wildlife Service 1995; Israel pers. comm.). Higher spring flows also benefit incubating eggs (U.S. Fish and Wildlife Service 1995). Coutant (2004) put forth the hypothesis that large recruitment events only happen during years when high spring and early summer outflows occur. This hypothesis was subsequently tested and found to be supported on the Columbia River by van der

Leeuw et al. (2006). The USFWS Anadromous Fish Restoration Program (AFRP) working paper (U.S. Fish and Wildlife Service 1995) suggested that in wet and above-normal years, mean flows of at least 31,000 cfs in the Sacramento River at Verona and 17,700 cfs at Grimes during February through May, and mean Delta outflows during April through May of 25,000 cfs, are ideal for successful white sturgeon recruitment. Flows above these minima were identified as beneficial for adult migration, spawning habitat conditions, and downstream larval transport (U.S. Fish and Wildlife Service 1995). Note that regarding the benefit of increased Delta outflow, the paper states the following.

> It is not clear whether Delta outflow itself is important in affecting production or whether upstream flows in the Sacramento and San Joaquin rivers and their tributaries, for which Delta outflow is a surrogate, are the important limiting factors.

Further, these flow criteria were not included in the Final Restoration Plan for the AFRP (U.S. Fish and Wildlife Service 1997). Instead, the paper recommends the following.

> Identify and attempt to maintain adequate flows for white and green sturgeon from February to May for spawning, emigration, egg incubation and rearing, consistent with actions to protect Chinook salmon and steelhead and when hydrologic conditions are adequate to minimize adverse effects to water supply operations.

Therefore, when reasonableness was addressed in the development of the Final Restoration Plan, as required by CVPIA, these numeric flow criteria were removed (U.S. Fish and Wildlife Service 1997). Further, additional study is needed to identify adequate flows. Although the numeric flow thresholds included in the draft AFRP working paper were analyzed in the effects analysis, caution is required when drawing conclusions regarding flow effects on white sturgeon reproductive success, and the weight of evidence from a number of other analyses is also considered.

High flows during summer and fall may facilitate downstream transport and migration of young sturgeon, but the importance of such flows is poorly understood downstream (Israel and Klimley 2008; Israel et al. 2009). As noted by Fish (2010), white sturgeon year-class indices correlate with Delta outflows, which are currently correlated with Delta inflows, at various periods. As described above, it is unclear if year-class strength for white sturgeon is related solely to Delta outflow, Delta inflow, or both.

As described above, the effects analysis evaluated changes in flows at each of the locations identified in the AFRP white paper: Sacramento River at Grimes, Sacramento River at Verona, and Delta outflow. Sacramento River flow at Wilkins Slough was used as a surrogate for flow at Grimes. The AFRP draft white paper February through May flow thresholds in the Sacramento River at Wilkins Slough and Verona are not expected to be affected by the BDCP (Table 5.C.5.3-212 (Wilkins), Table 5.C.5.3-213 (Verona), Figure 5.C.5.3-164 (Wilkins), and Figure 5.C.5.3-165 (Verona), in Appendix 5.C, *Flow, Passage, Salinity, and Turbidity*,). Under ESO_LLT, the percentage of years with April and May Delta outflows above the AFRP draft white paper Delta outflow thresholds was 7 to 25% lower than under existing conditions or under EBC2_LLT, depending on water-year type (Table 5.5.8-1; Table 5.C.5.3-214 and Figures 5.C.5.3-166 to 5.C.5.3-171 in Appendix 5.C). These results indicate that while the lower spring outflow scenarios (ESO and LOS) would not affect upstream flows during the February to May period, they would cause a reduction in the frequency of exceedance of the 25,000-cfs Delta outflow draft white paper threshold in wet and above-normal years. Under HOS_LLT, in contrast, the outflow thresholds would be exceeded more frequently in April of wet and above-normal years than under existing or future conditions without the BDCP; whereas in May the exceedence frequency would be similar or slightly lower, resulting in an April–May average frequency of exceedance under HOS_LLT that is 17% higher in above-normal years than under EBC2 and EBC2_LLT (Table 5.5.8-1; Table 5.C.5.3-215 in Appendix 5.C). In wet years, the April–May average percentage exceedance of 25,000 cfs Delta outflow under HOS_LLT is similar to under EBC2_LLT and 12% lower than under EBC2 (Table 5.5.8-1).

Table 5.5.8-1. Percentage of Wet and Above Normal Water Years from CALSIM 1922–2003 Modeling in Which Delta Outflows Exceed 25,000 cfs in April, May, and April–May Average, for Existing Conditions and Future Scenarios[a]

Month	Water-Year Type	EBC2	EBC2_LLT	ESO_LLT	HOS_LLT
April	Wet	81	77	65	88
	Above normal	58	50	42	83
May	Wet	69	58	42	58
	Above normal	25	25	17	17
April–May Average	Wet	81	69	62	69
	Above normal	50	50	25	67

[a] For descriptions of scenarios, see Table 5.2-3.

The evaluation results using the two sets of draft white paper AFRP flow thresholds lead to differing conclusions regarding the effect of the BDCP on white sturgeon recruitment: there was little apparent effect of the BDCP during February–May (as assessed by the analyses in relation to Grimes [Wilkins Slough] and Verona flows), whereas examination of April–May Delta outflow suggests a somewhat negative flow effect of the ESO (and therefore LOS) scenario, and a positive flow effect of HOS. It is therefore important to consider the mechanisms by which the flows in each case may affect white sturgeon. Kohlhorst et al. (1991) and Fish (2010) found high correlations between white sturgeon year class strength and Delta outflow (which is also currently strongly correlated with Delta inflow), but correlations with south Delta exports were low (Kohlhorst et al. 1991). Fish (2010) examined a number of Delta outflow periods as possible indicators of white sturgeon recruitment, ranging from November to July, and with some months averaged together (i.e., late fall/winter, November–February, and spring/early summer, March–July). He found the strongest correlation for November–February and suggested that it may be because of these fall/winter flows providing stimuli for adult migration (attraction flows) and gonadal maturation. He also found nearly as strong correlations for April and July, with the correlation for March–July also being relatively strong.[10] Fish (2010) hypothesized that the correlations with Delta outflow in the spring/early summer primarily were due to combined beneficial effects of higher river flows for increased spawning stimuli; for increased survival of egg, larvae, and early juveniles; and for increased downstream transport of young sturgeon. He suggested that recruitment is a function of both spring and winter outflow, but that large year classes are dependent on high spring outflows in particular, because high spring outflow has always been followed by high recruitment whereas high winter outflow followed by low spring outflow did not produce high recruitment.

Fish's (2010) regression equations were used to illustrate the potential changes in white sturgeon recruitment success for BDCP scenarios in relation to existing and future conditions without the BDCP. For the November to February period, hypothesized by Fish (2010) to be a potential indicator of attraction flows for adults (and therefore of relevance to adults in the Plan Area), the average

[10] Note that Fish (2010) found appreciable correlations (>0.6) for most of the months that he analyzed.

estimated year class index under the BDCP LLT scenarios was around 10% larger than under existing conditions (EBC2) averaged across all years, with the differences between average indices by water-year type ranging from similar or slightly lower in below-normal and dry years, to higher in wetter years (Table 5.5.8-2 and Table 5.5.8-3). Compared to future conditions without the BDCP (EBC2_LLT), estimated average white sturgeon year class indices were similar or slightly lower under the BDCP, depending on water-year type (Table 5.5.8-2 and Table 5.5.8-3). For the March–July period, hypothesized by Fish (2010) to be a potential indicator of upstream spawning/rearing habitat and juvenile migration conditions, the average estimated year class index under the BDCP (ESO_LLT and LOS_LLT) was around 12% lower than under existing conditions (EBC2) averaged across all years, with the greatest differences in below-normal, above-normal, and wet years (Table 5.5.8-4 and Table 5.5.8-5). There was less of a difference under HOS_LLT, because it includes higher outflows during the spring period in wetter years. Average white sturgeon year class indices under ESO_LLT and LOS_LLT were 8 to 9% lower than under EBC2_LLT; whereas the HOS_LLT average index was similar or slightly lower than for EBC2_LLT (Table 5.5.8-4 and Table 5.5.8-5).

Because the March–July period highlighted by Fish (2010) is particularly relevant for upstream conditions such as spawning and early rearing, as well as migration of juveniles, the year class indices developed by Fish (2010: 81) were regressed against Sacramento River region Delta inflow (i.e., combined flow for Sacramento River at Freeport and Yolo Bypass at Delta, from DAYFLOW). In effect, this represents a different conceptual model: whereas a correlation with Delta outflows implies in-Delta flow conditions are of greatest importance, a correlation with Delta inflows implies upstream conditions are of more importance. This does not exclude the possibility that both may be important. The resulting regression had a similar fit ($r = 0.73$) as those calculated by Fish (2010), and was used as an additional indicator of upstream conditions and the potential effect on white sturgeon recruitment, by applying the regression to CALSIM data. This analysis generally resulted in little difference in estimated average recruitment between BDCP scenarios and existing or future conditions without the BDCP, averaged across water years (Table 5.5.8-6 and Table 5.5.8-7). The greatest differences between LLT scenarios was for below-normal years (11 to 14% greater under the BDCP scenarios than EBC2_LLT), whereas drier years had slightly lower (6–9%) average recruitment indices under the BDCP scenarios than under EBC2_LLT (Table 5.5.8-6 and Table 5.5.8-7).

Table 5.5.8-2. Mean Estimated[a] White Sturgeon Year Class Indices under Existing and Future Scenarios[b], Based on Mean November–February Delta Outflow

Water-Year Type	EBC2	EBC2_LLT	ESO_LLT	HOS_LLT	LOS_LLT
Wet	63.2	74.5	72.1	72.9	74.2
Above normal	24.8	27.5	25.7	25.7	26.5
Below normal	7.7	8.0	7.3	7.7	7.2
Dry	3.6	3.7	3.6	3.6	3.4
Critical	1.8	1.9	1.9	1.8	1.8
All	26.0	30.1	28.9	29.2	29.6

[a] Calculations were based on Fish (2010: 82, Figure 2).
[b] For descriptions of scenarios, see Table 5.2-3.

Table 5.5.8-3. Differences in Mean Estimated[a,b] White Sturgeon Year Class Indices (and Percentage Change) under BDCP Scenarios[c] compared to Existing Conditions and Future Conditions without the BDCP, Based on Mean November–February Delta Outflow

Water-Year Type	ESO_LLT vs. EBC2	ESO_LLT vs. EBC2_LLT	HOS_LLT vs. EBC2	HOS_LLT vs. EBC2_LLT	LOS_LLT vs. EBC2	LOS_LLT vs. EBC2_LLT
Wet	8.9 (14%)	-2.4 (-3%)	9.7 (15%)	-1.6 (-2%)	11.0 (17%)	-0.3 (0%)
Above normal	1.0 (4%)	-1.8 (-6%)	0.9 (4%)	-1.9 (-7%)	1.7 (7%)	-1.0 (-4%)
Below normal	-0.3 (-4%)	-0.6 (-8%)	0.0 (0%)	-0.3 (-4%)	-0.5 (-6%)	-0.8 (-10%)
Dry	0.0 (0%)	-0.1 (-3%)	0.0 (0%)	-0.1 (-3%)	-0.2 (-6%)	-0.3 (-9%)
Critical	0.1 (5%)	0.0 (2%)	0.0 (0%)	-0.1 (-3%)	0.0 (0%)	-0.1 (-3%)
All	2.9 (11%)	-1.2 (-4%)	3.2 (12%)	-0.9 (-3%)	3.6 (14%)	-0.5 (-2%)

[a] Calculations were based on Fish (2010: 82, Figure 2).
[b] Negative differences indicate lower indices under BDCP scenarios.
[c] For descriptions of scenarios, see Table 5.2-3.

Table 5.5.8-4. Mean Estimated[a] White Sturgeon Year Class Indices for Existing Conditions and Future Scenarios[b], Based on Mean March–July Delta Outflow

Water-Year Type	EBC2	EBC2_LLT	ESO_LLT	HOS_LLT	LOS_LLT
Wet	28.2	26.5	24.5	26.0	24.7
Above normal	9.8	10.1	8.8	9.9	8.6
Below normal	3.8	3.6	3.2	4.1	3.1
Dry	2.2	2.3	2.1	2.3	2.1
Critical	1.0	1.2	1.1	1.1	1.0
All	11.7	11.2	10.2	11.0	10.2

[a] Calculations were based on Fish (2010: 82, Figure 3).
[b] For descriptions of scenarios, see Table 5.2-3.

Table 5.5.8-5. Differences in Mean Estimated[a,b] White Sturgeon Year Class Indices (and Percentage Change) for Existing Conditions and Future Scenarios[c], Based on Mean March–July Delta Outflow

Water-Year Type	ESO_LLT vs. EBC2	ESO_LLT vs. EBC2_LLT	HOS_LLT vs. EBC2	HOS_LLT vs. EBC2_LLT	LOS_LLT vs. EBC2	LOS_LLT vs. EBC2_LLT
Wet	-3.8 (-13%)	-2.0 (-8%)	-2.3 (-8%)	-0.6 (-2%)	-3.6 (-13%)	-1.8 (-7%)
Above normal	-1.0 (-10%)	-1.3 (-13%)	0.1 (1%)	-0.2 (-2%)	-1.1 (-12%)	-1.4 (-14%)
Below normal	-0.6 (-15%)	-0.4 (-11%)	0.3 (7%)	0.4 (12%)	-0.7 (-18%)	-0.5 (-14%)
Dry	-0.1 (-3%)	-0.2 (-8%)	0.1 (6%)	0.0 (1%)	-0.1 (-7%)	-0.3 (-11%)
Critical	0.1 (7%)	-0.1 (-7%)	0.1 (9%)	-0.1 (-5%)	0.0 (3%)	-0.1 (-10%)
All	-1.4 (-12%)	-0.9 (-8%)	-0.6 (-5%)	-0.1 (-1%)	-1.4 (-12%)	-1.0 (-9%)

[a] Calculations were based on Fish (2010: 82, Figure 2).
[b] Negative differences indicate lower indices under BDCP scenarios.
[b] For descriptions of scenarios, see Table 5.2-3.

Table 5.5.8-6. Mean Estimated[a] White Sturgeon Year Class Indices for Existing Conditions and Future Scenarios[b], Based on Mean March–July Sacramento River Region Delta Inflow

Water-Year Type	EBC2	EBC2_LLT	ESO_LLT	HOS_LLT	LOS_LLT
Wet	24.8	23.2	23.7	23.9	24.3
Above normal	8.6	8.7	9.3	8.8	9.4
Below normal	3.3	3.0	3.4	3.4	3.4
Dry	2.2	2.2	2.2	2.0	2.2
Critical	1.0	1.0	0.9	0.9	0.9
All	10.3	9.8	10.1	10.0	10.3

[a] Calculations were made by ICF and used the regression below:
Log_{10}(Year Class Index) = 2.5184(log_{10}inflow) – 10.197, r^2 = 0.53, r = 0.73
Sacramento River region inflow = flow in Sacramento River at Freeport + Yolo Bypass at Delta (from DAYFLOW)
[b] For descriptions of scenarios, see Table 5.2-3.

Table 5.5.8-7. Differences in Mean Estimated[a,b] White Sturgeon Year Class Indices (and Percentage Change) for Existing Conditions and Future Scenarios[c], Based on Mean March–July Sacramento River Region Delta Inflow

Water-Year Type	ESO_LLT vs. EBC2	ESO_LLT vs. EBC2_LLT	HOS_LLT vs. EBC2	HOS_LLT vs. EBC2_LLT	LOS_LLT vs. EBC2	LOS_LLT vs. EBC2_LLT
Wet	-1.0 (-4%)	0.5 (2%)	-0.8 (-3%)	0.7 (3%)	-0.5 (-2%)	1.0 (4%)
Above normal	0.7 (8%)	0.6 (7%)	0.2 (3%)	0.2 (2%)	0.8 (9%)	0.7 (8%)
Below normal	0.1 (3%)	0.3 (11%)	0.1 (4%)	0.3 (11%)	0.2 (6%)	0.4 (14%)
Dry	0.0 (-2%)	0.0 (-1%)	-0.2 (-7%)	-0.2 (-7%)	0.0 (0%)	0.0 (0%)
Critical	-0.1 (-7%)	-0.1 (-7%)	-0.1 (-9%)	-0.1 (-9%)	-0.1 (-6%)	-0.1 (-6%)
All	-0.2 (-2%)	0.3 (3%)	-0.3 (-2%)	0.3 (3%)	0.0 (0%)	0.5 (5%)

[a] Calculations were based on Fish (2010: 82, Figure 2).
[b] Negative differences indicate lower indices under BDCP scenarios.
[c] For descriptions of scenarios, see Table 5.2-3.

Delta outflow is highly correlated with Delta inflow, particularly with inflows from the Sacramento River region (the majority of which is from the Sacramento and Feather Rivers). The BDCP is not expected to affect Sacramento River flows above the proposed NDD, whereas there would be appreciable changes in Feather River flows under all of the BDCP scenarios. Reliance solely upon evaluation of the changes in Delta outflow may not be fully representative of changes that would arise under the BDCP, as the mechanism is uncertain for the importance of flow for the two sturgeon species and how the change in the Delta inflow-outflow relationship may affect any correlations between year-class strength and Delta outflow. By analogy, another covered fish species, Sacramento splittail, has a statistically significant correlation with February–May X2, an indicator of Delta outflow (Kimmerer 2002; Kimmerer et al. 2009); for this species, it is less likely that Delta outflow is driving this correlation, rather than the greater floodplain inundation that occurs in wetter years and enhances reproductive output (Sommer et al. 1997). This need not mean that in-Delta conditions are not also important, but additional study under conditions in which CVP/SWP exports occur on the Sacramento River, is required to better understand how outflow is related to recruitment. It therefore currently is challenging to elucidate what may be important above-Delta, through-Delta flow, or above- and through-Delta mechanisms for the correlation between white sturgeon year class index and flow. The relationship of sturgeon recruitment success to Delta outflow, Delta inflow, and other measures will be part of the BDCP's research, monitoring, and adaptive management process, particularly with respect to differences related to outflow under the low-outflow and high-outflow scenarios that are considered as part of the spring outflow decision tree.

For this effects analysis, instream flow-related habitat for egg incubation is assumed to be of high importance as a current constraint on the green and white sturgeon populations, with high certainty, in the Sacramento River; the same importance is assigned to the Feather River, but with low certainty as a current population-level constraint because a relatively low proportion of the two species occurs in the Feather River. During the August 2013 workshops, agency biologists felt that high or critical importance was warranted for this attribute, with high or very high certainty, for the Sacramento River; for the Feather River, some felt that low certainty was warranted (because it appears that a low proportion of the population is found there, whereas others felt that same certainty as the Sacramento River was warranted. For adults in these rivers, it was assumed with moderate certainty that flow-related habitat has low importance as a constraint.

Flows in the Sacramento River during the green sturgeon spawning and egg incubation period (March through August) were generally similar between the BDCP and existing conditions, ranging from 8% lower to 12% higher. It is concluded with moderate certainty that the BDCP would result in low positive changes in flow-related habitat during the spawning and egg incubation periods for white sturgeon (February through June) and green sturgeon (March through June) in the Feather River (Section 5C.5.2.4.5 and 5C.5.2.4.4.6 in Appendix 5.C, *Flow, Passage, Salinity, and Turbidity*). Feather River flows under the ESO scenario are expected to be up to 51% higher on average than under existing conditions. Average flows under the HOS scenario are expected to be 39 to 82% higher than those under the ESO scenario during April and May, but are expected to be 29 to 31% lower than the ESO flows during June. However, June flows under both the HOS and ESO scenarios are expected to be higher than those under existing conditions. Overall, the BDCP provides increased spring flows in the Feather River, regardless of which Delta outflow scenario is applied.

For white sturgeon, larval migration flows were assumed to be of moderate importance, with moderate certainty in the Sacramento River and low certainty in the Feather River; this reflected agency biologist opinion from the August 2013 workshops. It is concluded with moderate certainty that there would be a moderate positive change to spring larval migration flows in the Feather River. For adult green sturgeon upstream migration in the Feather River, it is concluded that there would be a moderate positive change because of the overlap with the spring period noted above.

In summary, there would be little change in Sacramento River flows for the two sturgeons. Flows in the Feather River generally change positively for green sturgeon adult immigrants and early life stages of both species that overlap the spring period. Further investigation is needed to better understand the association of Delta outflow to sturgeon recruitment, and if needed, adaptive management would be used to make adjustments to the BDCP. Additional discussion of Plan Area flow effects is provided in the discussion of *Reduced Transport and Migration Flows* below.

5.5.8.1.5 Reduced Predation

Overall, the BDCP has the potential provide minor reductions in predation to green and white sturgeon although there is low certainty and predation is not thought to be a major stressor to either species.

Predation within the Plan Area is thought to be of low importance to the white and green sturgeon populations (Israel and Klimley 2008; Israel et al. 2009). For the most part, predation probably occurs upstream of the Plan Area when sturgeon are still in the egg and larval stages (Gadomski and Parsley 2005). Consequently, for this effects analysis it is assumed with low certainty that predation is an attribute of low importance to larval and juvenile life stages in the Plan Area.

The BDCP may have several effects on predation on sturgeon. Habitat restoration measures could affect predation, but the effect is highly uncertain. Changes in water operations under *CM1 Water Facilities and Operation* are expected to result in a lower proportion of the sturgeon population being entrained (larvae and juveniles) at the south Delta export facilities, which in turn will reduce exposure to predation, particularly in the Clifton Court Forebay (such losses are captured within the calculations of changes in entrainment loss discussed below), although very few sturgeon have been entrained historically. In contrast, the north Delta intakes could potentially result in some added predation pressure. Striped bass are expected to be the most important fish predator near the new intakes, but they are principally a pelagic predator and white and green sturgeon are benthic species, so any increase in predation on sturgeon at the intakes would likely be small. *CM15 Localized Reduction of Predatory Fishes*, although primarily focused on reducing predation risk for downstream-migrating juvenile salmonids, also has the potential to provide a small benefit to white and green sturgeon migrating through the Plan Area while these species are within vulnerable size ranges (larvae and small juveniles). Predation risk diminishes as sturgeon grow beyond the optimal prey size for piscivorous fish in the Delta. It is concluded with low certainty that the BDCP would result in a low positive change in the predation attribute for larval and juvenile white sturgeon and juvenile green sturgeon. This overall assessment of predation importance and potential change because of the BDCP is consistent with agency biologist sentiment expressed at the August 2013 workshops.

5.5.8.1.6 Reduced Entrainment

The BDCP will provide reductions in entrainment of sturgeon larvae and juveniles, although entrainment is not thought to be a major stressor to either species.

Entrainment of larval and juvenile sturgeon at the south Delta facilities is thought to be of less importance to the species as management of the fishery and the degradation of habitat (Moyle 2002; Israel and Klimley 2008; Israel et al. 2009). As such, it was assumed with low certainty that south Delta entrainment is an attribute of low importance for sturgeon larvae and juveniles; this was consistent with agency biologist comment during the August 2013 workshops (some felt that zero importance may be warranted). Entrainment of adults at the south Delta facilities does not generally occur and was not analyzed in this effects analysis. Juvenile sturgeon entrainment risk at south Delta pumps would be moderately reduced under the BDCP as a result of reductions in exports (Appendix 5.B, *Entrainment*, Section 5.B.6.1, *SWP/CVP South Delta Export Facilities (South Delta Subregion)*). The greatest reductions in entrainment of white sturgeon (58% annual average reduction) and green sturgeon (57% annual average reduction) will occur in wetter water years (wet and above-normal), although substantial relative reductions in entrainment (white, 26% annual average reduction; green, 37% annual average reduction) are predicted in drier water years (below-normal, dry, and critical) (Table 5.B.6-201 through Table 5.B.6-204 in Appendix 5.B). It is concluded with moderate certainty that the BDCP would result in a moderate overall positive change to the south Delta entrainment attribute (i.e., moderately less entrainment) for white sturgeon larvae and juveniles and green sturgeon juveniles. This again was consistent with general agency biologist thinking from the August 2013 workshops.

Entrainment of sturgeon in agricultural diversions is extremely rare under existing conditions (Israel and Klimley 2008; Israel et al. 2009). Therefore, it is assumed with low certainty that this is an attribute of low importance only to white sturgeon larvae. Thus, the small predicted reduction in the number of diversions due to changed land use under the BDCP are expected to have only a low benefit to sturgeon (Appendix 5.B, Section 5.B.6.4, *Agricultural Diversions (Cache Slough, North Delta, West Delta, East Delta, South Delta, and Suisun Marsh Subregions)*). In addition, according to the 2009 DRERIP evaluation, the elimination or modification of agricultural diversions under *CM21 Nonproject Diversions* would provide a low benefit with low certainty (Cavallo et al. 2009). Overall, it is concluded with low certainty that the BDCP would result in a low positive change in this attribute (i.e., a low reduction in entrainment in agricultural diversions) for white sturgeon larvae. Entrainment of green and white sturgeon at the North Bay Aqueduct Barker Slough pumping plant would not change due to BDCP because the effect of the North Bay Aqueduct on sturgeon under existing conditions is concluded to be unimportant because of the existing screens. During the August 2013 workshops, agency biologists also thought that agricultural diversions and the North Bay Aqueduct were of zero or low importance for sturgeons.

Entrainment or impingement at the new north Delta facilities is predicted to be unimportant to all life stages of sturgeon, except for a low importance (with low certainty) to any larval white sturgeon entering the Plan Area and accessing the Sacramento River near Hood (Appendix 5.B, *Entrainment*, Sections 5.B.6.2.5, *White Sturgeon (Egg/Embryo, Larvae, and Juvenile)*, and 5.B.6.2.6, *Green Sturgeon (Juvenile)*). It is concluded with low certainty that the BDCP would cause a very low amount of entrainment or impingement of white sturgeon larvae, at the north Delta intakes. This conclusion was consistent with the zero or low importance assumed to be appropriate by agency biologists during the August 2013 workshops. Entrainment and impingement of white sturgeon larvae would be minimized through the use of state-of-the-art fish screens and operational criteria. The benthic/epibenthic nature of white and green sturgeon adults and juveniles and existing laboratory studies suggests that there would be no effect of the north Delta intakes on these life stages (Appendix 5.B *Entrainment*, Sections 5.B.6.2.5.2 and 5.B.6.2.6.2, *Impingement and Screen Contact*). Monitoring of impingement and entrainment will inform future assessment of the effects of the north Delta intakes.

5.5.8.2 Adverse Effects

5.5.8.2.1 Exposure to Contaminants and *Microcystis*

The BDCP will result in a low negative change on exposure of sturgeon to contaminants following habitat restoration, although there is low certainty. Exposure to agriculture-related contaminants later in the BDCP term may decrease because of restoration of agricultural areas. There will be a low increase in the risk of exposure of juvenile and adult green and white sturgeon to *Microcystis* blooms under the BDCP due to their prolonged presence in the Plan Area.

Effects of toxic contaminants and *Microcystis* on white and green sturgeon populations in the Plan Area are also not well understood and may be important. At sufficient levels, some toxics cause deformation and mortality of eggs, embryos, and larvae (Kroll and Doroshov 1991), which may result from the accumulation of the toxics in adults (primarily maternal body burden), and their subsequent transfer to the eggs. Increases in metal levels in benthic food resources (Luoma and Presser 2000; Stewart et al. 2004) likely elevate concentrations in sturgeon tissue.

Contaminants that potentially affect white and green sturgeon populations include methylmercury, pyrethroids, and selenium, but little is known about the population effects under current conditions. Some aspects of sturgeon biology put these species at increased risk of exposure to contaminants and other aspects put them at reduced risk. Aspects that increase risk include their long lives, resulting in greater bioaccumulation, and their benthic feeding habitats, which bring them into contact with potentially contaminated sediments and prey. On the other hand, most stages of white and green sturgeon feed at a relatively low trophic level, so biomagnification may not be as important for sturgeon as for piscivorous fish, for example.

Selenium is found at high concentrations in *Potamocorbula* living in Suisun Bay and Suisun Marsh, where the clams are an important prey item of both species of sturgeon, and has resulted in documented toxic levels of selenium in the liver of white sturgeon (Stewart et al. 2004). Larvae have higher incidence of skeletal deformities and mortality associated with maternal transfer of selenium (Linville 2006). For the purposes of this effects analysis, it is assumed that contaminants have high importance for adult green and white sturgeon (with moderate certainty for white sturgeon, because of the published study by Stewart et al. (2004) noted above, and low certainty for green sturgeon because there has been no published study and the species tends to occupy the Plan Area for a shorter duration than white sturgeon), moderate importance for larval white sturgeon (with low certainty), and moderate importance (with moderate certainty) for juvenile white and green sturgeon (reflecting the relatively long time occupying the Plan Area by these life stages). Agency biologists felt that high importance was warranted for both species, possibly with slightly lower importance for green sturgeon because of less time occupying the Plan Area.

The BDCP is expected to increase selenium concentrations locally in the south Delta, but it is not expected to increase levels of selenium in sturgeon because concentrations are not expected to increase in major foraging areas of adult sturgeon, such as Suisun Bay (Appendix 5.D, *Contaminants*, Section 5.D.5.2.2, *Selenium*). Habitat restoration and enhancement measures of the BDCP, especially *CM4 Tidal Natural Communities Restoration*, have the potential to increase exposure of sturgeon to contaminants. Methylmercury production is expected to increase as a result of habitat restoration, potentially leading to increased accumulation in sturgeon tissue, although concentrations are not expected to rise enough to adversely affect the fish (Appendix 5.D, Section 5.D.4.1.2.2, *Restoration*).

CM12 Methylmercury Management will help minimize potential negative effects. Localized and short-term increases in pesticide (pyrethroids, organophosphate pesticides, and organochlorine pesticides) concentrations are predicted near ROAs, although these increases are not expected to result in increased effects on sturgeon because of their ephemeral and localized nature.

Analyses presented in Appendix 5.D, *Contaminants*, suggest that there is a low potential for increased contaminant exposure from the BDCP and there may be a beneficial effect in the late long-term because of reduced contaminants from restoration of areas previously used for agriculture. It is concluded with low certainty that the BDCP will result in a low negative change on exposure of sturgeon life stages in the Delta (larvae [white sturgeon only], juveniles, and adults), to contaminants. During the August 2013 workshops, agency biologists felt that a moderate negative change may be warranted because of greater San Joaquin River flows reaching areas where selenium could be bioaccumulated by *Potamocorbula*.

There is the potential for a low increase in the risk of exposure of green and white sturgeon juveniles and adults to *Microcystis* blooms under the BDCP although there is low certainty in this conclusion. *Microcystis* blooms may be exacerbated by water operations under the BDCP by increasing water residence times, and creating more slow-moving warmer areas in restored aquatic habitats (Appendix 5.F, *Biological Stressors on Covered Fish,* Section 5.F.8, *Microcystis*). Juvenile and adult sturgeon life stages, which may be present year-round, may be vulnerable to prolonged risk of exposure. However, the effects, if any, of *Microcystis* exposure on green and white sturgeon are currently unknown; therefore, the attribute is considered to be of low importance with low certainty to both species' juvenile and adult life stages. Agency biologists at the August 2013 workshops felt that zero or low importance, with low certainty was warranted for these life stages. Overall, the potential increase in *Microcystis* exposure is concluded to be a low negative change with low certainty to these life stages; agency biologists felt that the high mobility of sturgeon juveniles and adults would allow them to move away from adverse conditions caused by *Microcystis*, so that a zero or low negative change to this attribute would be warranted.

5.5.8.2.2 Reduced Transport and Migration Flows (Feather River and Plan Area)

The BDCP will have a low negative effect on transport flows for larval green sturgeon and migration flows for juvenile white and green sturgeon, although there is low certainty and high variability in flows during transport and migration periods.

After leaving upstream spawning areas, the larvae and young-of-year juveniles of white and green sturgeon continue to be transported or actively migrate downstream in the summer and early fall. Higher flows are hypothesized to facilitate such movement, helping the young reach suitable rearing habitat downstream (Israel and Klimley 2008; Israel et al. 2009). However, the importance and timing of the transport and migration flows are uncertain (Israel and Klimley 2008; Israel et al. 2009). Lab studies have shown the larval white sturgeon enter a swim up stage after hatching (Brannon et al. 1985), although this study was conducted on Columbia River individuals, which may differ in their behavior from Central Valley individuals (Kynard and Parker 2005). The amount of time spent in the water column is inversely related to water velocity. The swim-up behavior represents a dispersal mechanism to transport larval sturgeon to suitable rearing habitats. The factors that increase the time in the drift (slower current due to reduced discharge) or increases in predator visibility (increased visibility due to dams and flow regimes) would reduce survival (Hildebrand et al. 1999). Green sturgeon tend to be less mobile than white sturgeon. For this effects analysis, it was assumed with moderate and low certainty that migration and movement flows for green sturgeon larvae have low importance in the Sacramento and Feather Rivers, respectively; this reflects larval green sturgeon tending not to be as mobile as white sturgeon, as well as less certainty about the importance of the Feather River population (as also noted by agency biologists). Agency biologists at the August 2013 workshops felt that low or moderate importance with low or moderate certainty was warranted for larval migration and movement flows. It was assumed that juvenile migration flow is of high importance to both green and white sturgeon, with moderate certainty in the Sacramento River and low certainty in the Feather River for the reasons previously given. Agency biologists at the August 2013 workshops felt that moderate or high importance was appropriate, with moderate or high certainty for the Sacramento River and less certainty for the Feather River; note that some indicated the high importance was because of the year-class index correlation with flow that was previously discussed above.

Table 5.5.8-8 shows the ranges in the percent change in monthly flow (averaged over all year types) for comparisons between the ESO, HOS, and LOS scenarios versus EBC2 in the early and late long-terms for white sturgeon juvenile migration (June through September), green sturgeon larval transport (August through October), and green sturgeon juvenile migration (August through June). The comparisons are provided for the Feather River at Thermalito, the Sacramento River at Verona, and the Sacramento River at Wilkins Slough. The white sturgeon larval transport period is not included, because the white sturgeon larvae move downstream in the spring and are affected by the spring flows discussed above in Section 5.5.1.1.4. Under the BDCP, higher releases from Oroville are made in the spring, increasing Feather River spring flows, as described above in Section 5.5.8.1.4, *Increased Reproductive Success*. The summer flows are reduced to ensure that there are no changes in end of September storage to protect the cold water pool. Early fall releases are reduced under the LOS relative to EBC2, due the LOS assumes no Fall X2 requirement. As such, average instream flows during some months of the three periods identified above (June–September, August–October, August–June) are expected to substantially decline in the Feather River at Thermalito and moderately decline in the Sacramento River at Verona under the BDCP, especially for the LOS scenario (Appendix 5.C, *Flow, Passage, Salinity, and Turbidity,* Section 5.C.5.3.3, *High Outflow and Low Outflow Scenarios*). Note that the migration periods for the juvenile sturgeon also include spring months (June for white sturgeon, April–June from green sturgeon), which generally result in large maximum increased flows for their migration periods (Table 5.5.8-1). The changes in Sacramento River flow at Wilkins Slough, which is not affected by Feather River flows, are generally expected to be small.

Table 5.5.8-8. Difference in Range of Average Monthly Flows in the Sacramento River at Wilkins Slough and Verona and the Feather River at Thermalito under Six Future Scenarios[a] Compared to Existing Conditions

Period	Range	Change under Future Scenarios[a] Compared to EBC2					
		ESO_ELT	HOS_ELT	LOS_ELT	ESO_LLT	HOS_LLT	LOS_LLT
Feather River, Thermalito							
Jun–Sept	Min	-20.84%	-35.95%	-64.87%	-19.29%	-39.71%	-63.96%
	Max	51.33%	3.98%	56.27%	47.96%	5.24%	44.32%
Aug–Oct	Min	-20.84%	-35.95%	-64.87%	-19.29%	-39.71%	-63.96%
	Max	9.58%	-3.96%	11.68%	9.43%	1.27%	12.38%
Aug–Jun	Min	-20.84%	-35.95%	-64.87%	-19.29%	-39.71%	-63.96%
	Max	51.33%	86.95%	56.27%	47.96%	92.02%	44.32%

Period	Range	Change under Future Scenarios[a] Compared to EBC2					
		ESO_ELT	HOS_ELT	LOS_ELT	ESO_LLT	HOS_LLT	LOS_LLT
Sacramento River, Verona							
Jun–Sept	Min	-10.80%	-14.70%	-32.00%	-12.50%	-18.00%	-34.50%
	Max	16.50%	-0.20%	17.60%	19.00%	-0.20%	18.00%
Aug–Oct	Min	-10.80%	-13.60%	-32.00%	-12.50%	-16.50%	-34.50%
	Max	0.80%	-0.30%	3.90%	-0.30%	-1.00%	1.40%
Aug–Jun	Min	-10.80%	-13.60%	-32.00%	-12.50%	-16.50%	-34.50%
	Max	16.50%	13.90%	17.60%	19.00%	14.20%	18.00%
Sacramento River, Wilkins Slough							
Jun–Sept	Min	-6.41%	-2.93%	-19.96%	-7.93%	-3.58%	-26.26%
	Max	7.41%	5.43%	7.03%	12.30%	6.61%	12.39%
Aug–Oct	Min	-6.41%	-2.93%	-19.96%	-7.93%	-0.47%	-26.26%
	Max	-2.14%	5.43%	1.61%	2.44%	6.61%	-2.01%
Aug–Jun	Min	-12.66%	-11.90%	-19.96%	-12.21%	-10.57%	-26.26%
	Max	7.41%	5.43%	7.03%	12.30%	6.61%	12.39%

[a] For descriptions of scenarios, see Table 5.2-3.

As indicated above, the importance and timing of the transport and migration flows for both species of sturgeon are uncertain. In considering flow stressors for juvenile sturgeon, the DRERIP conceptual models for white and green sturgeon assigned scores of 2 ("low") for importance and predictability and a score of 1 ("little or no") for understanding (Israel and Klimley 2008; Israel et al. 2009). DRERIP provides no separate evaluation for green sturgeon larval transport flows. The DRERIP conceptual models resulted in high scores for effects of flow on white sturgeon "feeding larvae", but the transport period is April through June, when flows are generally high for BDCP (ESO_ELT and ESO_LLT), and therefore, as described in the previous section, the BDCP is considered to have a positive effect on these larvae. The BDCP is concluded with moderate certainty to result in a moderate negative change to migration flows for green sturgeon larvae and a low negative change for juvenile green sturgeon in the Feather River, and a low negative change for white sturgeon juveniles in the Feather River. Further study is needed to determine the roles and relative importance of transport flows in movement and migration of early life stages, including any specific hydrologic or hydraulic thresholds to better understand and manage possible effects. Similar changes were also assumed for flow-related habitat for these life stages in the Feather River.

As with upstream areas, the certainty regarding the importance of migration and movement Plan Area flows (e.g., for attraction of adults and downstream movement of juveniles) is low. As noted by Fish (2010) and described above, Delta outflow correlates with white sturgeon year class index, with plausible mechanisms including attraction of adults (during late fall/winter, i.e., November–February) and downstream movement of early life stages in spring. For the purposes of this effects analysis, it was assumed with low certainty that Plan Area flows for migration and movement of green and white sturgeon has high importance. This uncertainty was reflected in agency biologist opinion from the August 2013 workshops: some felt critical importance was warranted (with low or moderate certainty) for the adult life stage (reflecting attraction flows), whereas others felt that adult flows were of moderate importance with moderate certainty (as adults migrate upstream in most years, regardless of flow); some biologists thought that there should be high importance for white sturgeon larvae and juveniles (with high certainty), whereas others did not assign any importance to the larval or juvenile life stages.

As described above in Section 5.5.8.1.4, *Increased Recruitment Potential in the Feather River*, Fish (2010) suggested that the correlation between white sturgeon year-class index and November–February Delta outflow may be because of improved adult attraction flows. As shown in Table 5.5.8-2 and Table 5.5.8-3, these indices are similar or slightly lower under BDCP scenarios compared to future conditions without the BDCP (EBC2_LLT). Average Sacramento River flows below the north Delta intakes are also lower under the BDCP scenarios compared to EBC2_LLT (Table 5.5.8-9) in most months, and therefore also generally would be lower for migrating adult green sturgeon (winter/spring), larval (spring) and juvenile (summer/fall) white sturgeon, and juvenile green sturgeon (summer/fall/winter/spring).

Table 5.5.8-9. Average Monthly Flows in the Sacramento River below the North Delta Diversions under Existing Conditions and Future Scenarios, and Differences between Average Monthly Flows, By Water-Year Type

Month	Water-Year Type	Flows					Differences in Average Flows		
		EBC2	EBC2_LLT	ESO_LLT	HOS_LLT	LOS_LLT	NAA_LLT vs. ESO_LLT	EBC2_LLT vs. HOS_LLT	EBC2_LLT vs. LOS_LLT
JAN	W	50,599	52,878	43,883	43,431	44,637	-8994 (-17%)	-9446 (-17.9%)	-8241 (-15.6%)
	AN	38,350	40,484	33,047	32,999	34,572	-7438 (-18.4%)	-7486 (-18.5%)	-5912 (-14.6%)
	BN	22,883	22,653	18,431	18,786	18,739	-4221 (-18.6%)	-3866 (-17.1%)	-3914 (-17.3%)
	D	17,222	17,451	14,939	14,662	15,344	-2512 (-14.4%)	-2789 (-16%)	-2107 (-12.1%)
	C	14,527	15,073	13,966	12,682	14,139	-1107 (-7.3%)	-2391 (-15.9%)	-934 (-6.2%)
	AVG	31,469	32,595	27,220	26,882	27,849	-5374 (-16.5%)	-5713 (-17.5%)	-4746 (-14.6%)
FEB	W	56,778	59,847	49,932	49,815	50,234	-9915 (-16.6%)	-10032 (-16.8%)	-9613 (-16.1%)
	AN	44,745	47,786	39,397	39,450	40,095	-8390 (-17.6%)	-8336 (-17.4%)	-7691 (-16.1%)
	BN	30,829	31,592	25,437	26,096	25,892	-6155 (-19.5%)	-5497 (-17.4%)	-5700 (-18%)
	D	21,218	21,107	17,751	17,765	17,651	-3356 (-15.9%)	-3342 (-15.8%)	-3456 (-16.4%)
	C	14,829	14,291	12,979	13,098	12,995	-1311 (-9.2%)	-1193 (-8.3%)	-1296 (-9.1%)
	AVG	36,642	38,087	31,736	31,840	31,992	-6351 (-16.7%)	-6247 (-16.4%)	-6095 (-16%)
MAR	W	49,379	50,993	40,299	41,904	40,575	-10694 (-21%)	-9089 (-17.8%)	-10418 (-20.4%)
	AN	43,809	45,088	35,162	35,541	36,077	-9926 (-22%)	-9547 (-21.2%)	-9011 (-20%)
	BN	23,300	22,915	16,710	18,484	16,891	-6205 (-27.1%)	-4431 (-19.3%)	-6023 (-26.3%)
	D	20,409	20,650	16,213	16,956	16,418	-4437 (-21.5%)	-3694 (-17.9%)	-4232 (-20.5%)
	C	13,113	13,137	11,961	11,884	12,081	-1176 (-9%)	-1253 (-9.5%)	-1056 (-8%)
	AVG	32,445	33,134	26,086	27,105	26,401	-7049 (-21.3%)	-6030 (-18.2%)	-6734 (-20.3%)
APR	W	37,941	37,543	28,339	32,440	28,525	-9205 (-24.5%)	-5103 (-13.6%)	-9019 (-24%)
	AN	26,006	24,931	17,897	23,219	17,833	-7035 (-28.2%)	-1712 (-6.9%)	-7098 (-28.5%)
	BN	17,445	17,128	14,235	18,304	14,230	-2893 (-16.9%)	1176 (6.9%)	-2898 (-16.9%)
	D	13,040	12,904	11,826	12,022	11,925	-1078 (-8.4%)	-882 (-6.8%)	-978 (-7.6%)
	C	10,198	10,365	9,808	9,686	9,893	-557 (-5.4%)	-679 (-6.6%)	-472 (-4.6%)
	AVG	23,169	22,826	18,066	20,865	18,149	-4760 (-20.9%)	-1961 (-8.6%)	-4677 (-20.5%)

Month	Water-Year Type	Flows					Differences in Average Flows		
		EBC2	EBC2_LLT	ESO_LLT	HOS_LLT	LOS_LLT	NAA_LLT vs. ESO_LLT	EBC2_LLT vs. HOS_LLT	EBC2_LLT vs. LOS_LLT
MAY	W	31,699	24,500	18,652	22,238	18,675	-5848 (-23.9%)	-2263 (-9.2%)	-5825 (-23.8%)
	AN	20,708	18,657	15,722	18,057	15,550	-2935 (-15.7%)	-599 (-3.2%)	-3106 (-16.7%)
	BN	13,851	12,394	12,134	12,955	12,064	-261 (-2.1%)	561 (4.5%)	-331 (-2.7%)
	D	10,714	11,427	11,633	11,240	11,686	206 (1.8%)	-187 (-1.6%)	259 (2.3%)
	C	7,631	8,011	7,608	7,575	7,645	-403 (-5%)	-436 (-5.4%)	-366 (-4.6%)
	AVG	18,915	16,295	13,953	15,481	13,941	-2342 (-14.4%)	-814 (-5%)	-2355 (-14.5%)
JUN	W	23,671	18,603	15,070	13,371	14,999	-3533 (-19%)	-5233 (-28.1%)	-3604 (-19.4%)
	AN	16,451	16,051	14,041	11,894	13,982	-2010 (-12.5%)	-4158 (-25.9%)	-2069 (-12.9%)
	BN	13,420	13,898	13,247	13,020	13,415	-651 (-4.7%)	-878 (-6.3%)	-482 (-3.5%)
	D	12,367	12,656	12,087	11,528	12,119	-568 (-4.5%)	-1128 (-8.9%)	-536 (-4.2%)
	C	9,880	10,123	9,403	9,151	9,435	-719 (-7.1%)	-972 (-9.6%)	-687 (-6.8%)
	AVG	16,365	14,880	13,124	12,072	13,134	-1756 (-11.8%)	-2807 (-18.9%)	-1746 (-11.7%)
JUL	W	19,889	21,425	18,173	16,275	17,886	-3252 (-15.2%)	-5150 (-24%)	-3539 (-16.5%)
	AN	21,881	22,727	20,291	16,332	20,243	-2436 (-10.7%)	-6396 (-28.1%)	-2485 (-10.9%)
	BN	21,258	20,513	17,266	16,143	16,670	-3247 (-15.8%)	-4369 (-21.3%)	-3843 (-18.7%)
	D	19,076	18,957	13,429	13,557	14,341	-5528 (-29.2%)	-5400 (-28.5%)	-4616 (-24.3%)
	C	14,178	13,767	10,410	10,630	10,060	-3357 (-24.4%)	-3136 (-22.8%)	-3707 (-26.9%)
	AVG	19,400	19,797	16,151	14,838	16,100	-3647 (-18.4%)	-4959 (-25.1%)	-3698 (-18.7%)
AUG	W	15,911	16,064	10,427	10,041	9,874	-5636 (-35.1%)	-6023 (-37.5%)	-6190 (-38.5%)
	AN	16,389	17,491	12,175	11,215	12,203	-5316 (-30.4%)	-6276 (-35.9%)	-5288 (-30.2%)
	BN	15,763	16,232	12,274	12,675	11,902	-3958 (-24.4%)	-3557 (-21.9%)	-4330 (-26.7%)
	D	15,862	14,351	10,582	12,117	10,855	-3769 (-26.3%)	-2234 (-15.6%)	-3496 (-24.4%)
	C	9,901	8,996	8,382	8,994	8,727	-614 (-6.8%)	-2 (0%)	-269 (-3%)
	AVG	15,066	14,891	10,733	10,965	10,609	-4158 (-27.9%)	-3926 (-26.4%)	-4283 (-28.8%)

Month	Water-Year Type	Flows					Differences in Average Flows		
		EBC2	EBC2_LLT	ESO_LLT	HOS_LLT	LOS_LLT	NAA_LLT vs. ESO_LLT	EBC2_LLT vs. HOS_LLT	EBC2_LLT vs. LOS_LLT
SEP	W	27,571	27,212	19,827	19,710	8,137	-7385 (-27.1%)	-7502 (-27.6%)	-19075 (-70.1%)
	AN	20,549	21,006	13,210	13,146	8,939	-7796 (-37.1%)	-7860 (-37.4%)	-12067 (-57.4%)
	BN	12,340	12,306	8,515	8,982	8,041	-3791 (-30.8%)	-3324 (-27%)	-4265 (-34.7%)
	D	11,149	8,620	8,861	9,937	9,148	241 (2.8%)	1316 (15.3%)	528 (6.1%)
	C	8,059	7,292	8,580	9,106	8,693	1287 (17.7%)	1814 (24.9%)	1400 (19.2%)
	AVG	17,483	16,763	12,874	13,221	8,541	-3888 (-23.2%)	-3542 (-21.1%)	-8222 (-49%)
OCT	W	12,903	13,277	10,166	10,117	10,243	-3112 (-23.4%)	-3160 (-23.8%)	-3034 (-22.9%)
	AN	10,436	11,864	10,291	10,625	10,574	-1572 (-13.3%)	-1239 (-10.4%)	-1289 (-10.9%)
	BN	11,052	12,124	10,197	9,340	10,494	-1927 (-15.9%)	-2784 (-23%)	-1629 (-13.4%)
	D	9,898	10,487	9,011	8,880	9,364	-1476 (-14.1%)	-1606 (-15.3%)	-1122 (-10.7%)
	C	9,537	9,964	9,452	9,606	10,018	-512 (-5.1%)	-358 (-3.6%)	54 (0.5%)
	AVG	11,074	11,776	9,831	9,712	10,108	-1945 (-16.5%)	-2064 (-17.5%)	-1668 (-14.2%)
NOV	W	20,772	19,285	14,622	14,557	13,472	-4663 (-24.2%)	-4728 (-24.5%)	-5813 (-30.1%)
	AN	16,856	15,925	11,531	11,685	10,283	-4394 (-27.6%)	-4240 (-26.6%)	-5642 (-35.4%)
	BN	13,721	13,037	9,467	9,586	8,404	-3570 (-27.4%)	-3450 (-26.5%)	-4633 (-35.5%)
	D	12,685	11,914	9,467	9,345	8,795	-2448 (-20.5%)	-2569 (-21.6%)	-3119 (-26.2%)
	C	9,824	9,295	8,209	8,320	7,654	-1086 (-11.7%)	-975 (-10.5%)	-1641 (-17.7%)
	AVG	15,618	14,647	11,219	11,231	10,262	-3427 (-23.4%)	-3415 (-23.3%)	-4385 (-29.9%)
DEC	W	37,465	37,022	31,257	31,752	32,758	-5766 (-15.6%)	-5270 (-14.2%)	-4265 (-11.5%)
	AN	22,241	22,629	20,348	19,748	20,699	-2280 (-10.1%)	-2881 (-12.7%)	-1929 (-8.5%)
	BN	16,935	16,692	15,155	14,902	15,969	-1537 (-9.2%)	-1791 (-10.7%)	-724 (-4.3%)
	D	15,511	15,159	13,977	13,537	14,196	-1182 (-7.8%)	-1621 (-10.7%)	-963 (-6.4%)
	C	11,289	10,632	11,005	10,300	11,263	372 (3.5%)	-332 (-3.1%)	630 (5.9%)
	AVG	23,082	22,784	20,154	19,981	20,906	-2629 (-11.5%)	-2803 (-12.3%)	-1877 (-8.2%)
Note: Negative values indicate lower average flows under the BDCP scenarios compared to existing conditions or future conditions without the BDCP.									

Given that most green and white sturgeon occupying the Plan Area are likely to be from the Sacramento River region, it is concluded with moderate certainty that there would be a low negative change to Plan Area flows because of diversions at the north Delta intakes, for juvenile and adult green sturgeon; and for larval, juvenile, and adult white sturgeon. During the August 2013 workshops, in which agency biologists assessed the potential change in relation to High-Outflow scenario flows, it was felt that a low positive change would be warranted for all of the above life stages of both species. This was because of the focus on the spring outflow period. However, as noted above, flows on the Sacramento River below the north Delta intakes, the main migratory pathway, would not be greater under all scenarios, and in fact generally would be lower; therefore it is felt that a low negative change is warranted. As noted above in Section 5.5.8.1.4, *Increased Recruitment Potential in the Feather River*, there is appreciable uncertainty in the mechanisms involved in Plan Area (and other) flows for migration and movement, which would be investigated during BDCP implementation monitoring and research.

5.5.8.2.3 Negative Feather River Temperature Effects on Green Sturgeon During Summer/Fall Months

Higher water temperatures on the Feather River may negatively affect larval green sturgeon in the Feather River, although lower spring temperatures may benefit eggs and early larvae.

On the Sacramento River, it is concluded that there would be no biologically meaningful changes in temperature conditions between the BDCP scenarios and future conditions without the BDCP (EBC2_LLT) for any life stage of white sturgeon (Appendix 5.C, *Flow, Passage, Salinity, and Turbidity*, Section 5.C.5.2.1.6) or green sturgeon (Appendix 5.C, Section 5.C.5.2.1.7) as operations would not greatly differ.

On the Feather River, in contrast, there is the potential for appreciable change in the Feather River as a result of operational differences between the BDCP scenarios and future conditions without the BDCP (EBC2_LLT). The importance of temperature as a current constraint on green and white sturgeon in the Feather River received relatively little comment during the August 2013 workshops with agency biologists. The comments that were received suggested that there may be low importance with moderate certainty for larval green sturgeon, and zero importance for juveniles and adults of both white and green sturgeon. For this effects analysis, it was assumed that there is low importance of temperature on the Feather River, with moderate certainty, for all life stages of green and white sturgeon.

For white sturgeon, temperature modeling for the Feather River for eggs/embryos and adults during the spawning period (February–June), larvae (February–June), and juvenile rearing (year-round) suggests no biologically meaningful differences in water temperature between the BDCP in the late long-term and late long-term conditions without the BDCP (Appendix 5.C, Section 5.C.5.2.4.5); therefore, it is concluded with moderate certainty that there would be no change in the Feather River water temperature attribute. Agency biologists at the August 2013 workshops suggested that moderate and low positive change would be appropriate for eggs and larvae, respectively, whereas they suggested a low negative would be warranted for juveniles because of overlap with the summer period.

For green sturgeon, temperature modeling for the Feather River for eggs/embryos and adults during the spawning period (February–June), suggests little difference in average water temperature between the BDCP LLT scenarios (ESO, LOS, HOS) and EBC2_LLT; further examination of exceedance of a 64°F spawning/egg incubation/larval rearing threshold suggests that there would be a moderate positive change during May through June, corresponding to the egg/embryo period (Appendix 5.C, Section 5.C.5.2.4.6). For larvae (April–August), there was little difference in average temperature between the BDCP LLT scenarios and EBC2_LLT. Examination of the 64°F larval threshold temperature during larval rearing (May–September) showed differences by month: during the early months of this period, the frequency of exceedance of the threshold under the BDCP LLT scenarios generally was less than EBC2_LLT in May and June; similar to EBC2_LLT in July/August; and greater than EBC2_LLT in August/September. As noted in Appendix 5.C, Section 5.C.5.2.4.6, a potential outcome of this shift from warm temperatures earlier and cool temperatures later during the May to September period under EBC2_LLT to cooler temperatures earlier and warmer temperatures later under the BDCP scenarios is that eggs and larvae may survive better under the BDCP scenarios and be able to grow to a larger size, allowing them to become more temperature-tolerant or move to areas of cooler water when warmer conditions occur later in the summer/fall. Therefore, cooler temperatures earlier in the period may provide a benefit that outweighs negative effects of increased temperatures later in the period. Additional monitoring and research is needed to better understand these effects.

Regardless, all current applicable regulatory standards for the Feather River in the NMFS (2009a) BiOp would be met under the BDCP scenarios at the same frequency as are being met under existing conditions. Therefore, regardless of these results, these scenarios would be protective of green sturgeon as defined by NMFS (2009a). For juvenile green sturgeon rearing (August–March), there was little difference in water temperature between the BDCP LLT scenarios and EBC2_LLT (Appendix 5.C, Section 5.C.5.2.4.6). It is concluded with moderate certainty that there would be low positive changes to temperature for green sturgeon eggs and adults on the Feather River, a low negative change for larvae (conservatively reflecting the later months of the threshold exceedance analysis described above), and no change for juveniles. During the August 2013 workshops, agency biologists suggested a low positive change for eggs (little difference in temperature for spring), a moderate negative change for larvae (because of higher temperatures in July and August), little to no change for juveniles because of their tolerance, and a low negative change for adults that remain in the river during the summer.

5.5.8.2.4 Exposure to In-Water Construction and Maintenance Activities

In-water construction and maintenance effects of the BDCP could affect white and green sturgeon, but will be minimized with *CM22 Avoidance and Minimization Measures* and other measures.

In-water construction activities at the proposed north Delta intakes (*CM1 Water Facilities and Operation*) will be limited to one construction season between June to October (Appendix 5.H, *Aquatic Construction and Maintenance Effects*). White and green sturgeon juveniles could be present in the construction area during this period (Appendix 2.A, *Covered Species Accounts*) and could experience adverse effects from underwater sound (pile driving), entrapment in enclosed areas (e.g., cofferdams), exposure to temporary water quality deterioration (e.g., suspended sediment and suspension of toxic materials), and accidental spills. Habitat will be temporarily and permanently affected by intake construction, although habitat at the intake sites is generally of low value (steep-sloping, revetted banks). Maintenance dredging may decrease water quality temporarily. Habitat restoration activities associated with *CM4 Tidal Natural Communities Restoration, CM5 Seasonally Inundated Floodplain Restoration*, *CM6 Channel Margin Enhancement*, and *CM7 Riparian Natural*

Community Restoration may temporarily cause reduced water quality in the immediate area of disturbance and could affect sturgeon because the activities will occur within the species' main distributions. Breaching levees to create tidal habitat may reduce areas of channel margin, but there will be considerable gains of habitat caused by the breaching. In-water activities associated with *CM14 Stockton Deep Water Ship Channel Dissolved Oxygen Levels, CM15 Localized Reduction of Predatory Fish, CM16 Nonphysical Fish Barriers,* and *CM21 Nonproject Diversions* will have little to no effect on sturgeon because of the small scale of the work. Implementation of *CM22 Avoidance and Minimization Measures* will reduce the likelihood of adverse effects from in-water activities related to construction and maintenance on sturgeon. Therefore, construction and maintenance activities associated with the BDCP are expected to have a minor adverse effect on both sturgeon species.

5.5.8.3 Impact of Take on Species

The covered activities are expected to result in take of white and green sturgeon from continued entrainment at the SWP/CVP south Delta facilities and as a result of construction activities. As described in the previous section, although construction and maintenance activities have the potential to increase take of sturgeon, the effects will be temporary and avoidance and minimization measures should further reduce or eliminate any such take (Appendix 5.H, *Aquatic Construction and Maintenance Effects*). Historical entrainment estimates of juvenile white and green sturgeon is based on salvage. Salvage during water years 1996 through 2008 ranged from 12 to 805 white sturgeon and 0 to 252 green sturgeon (California Department of Fish and Game unpublished data). As previously described, the BDCP has the potential to substantially reduce average annual salvage by approximately 25 to 60% depending on water-year type, based on less south Delta export pumping. The Adaptive Management Team's management of operations and adaptive management coupled with monitoring should allow further reductions of take at the export facilities. If white and green sturgeon respond to covered activities as predicted, resulting in small net increases in the abundance of their populations, the total number of juveniles entrained at the south Delta facilities could increase, but the per capita entrainment rate would still be lower than under existing conditions. Take at north Delta diversion facilities is predicted to be negligible because of the size of white and green sturgeon at the time they would be near the facilities, the very small area of influence of the diversions due to the high sweeping to approach velocity ratio, and the efficiency of the fish screens.

5.5.8.4 Net Effects

Figure 5.5.8-1 and Figure 5.5.8-2 depict the qualitative relative effects, by attribute, on green sturgeon and white sturgeon, respectively, resulting from implementation of the BDCP.

Category	Appendix	Attributes	Definition	Egg	Larvae	Juvenile	Adults
Food	E	Zooplankton community	Species composition of the zooplankton community and presence of suitable prey species	NA	NA		
		Zooplankton abundance	The abundance of zooplankton	NA	NA	Low	
		Benthic & Epibenthic prey abundance	The abundance of epibenthic prey species such as amphipods	NA	NA	Low	Low
		Insect abundance	The abundance of insect prey	NA	NA	Low	
Entrainment & Impingement	B	North Delta Intakes	Potential entrainment/impingement from the proposed North Delta intakes	NA	NA		
		South Delta Pumps	Pumping rate from the CVP/SWP south Delta export facilities and resulting entrainment	NA	NA	Low	
		North Bay Aqueduct	Entrainment from the SWP NBA facilities	NA	NA		
		Ag Diversions	Entrainment from Agriculture Diversions	NA	NA		
Migration & Movement	C	Plan Area Flows	Magnitude, timing, direction, and duration of flows during migratory periods throughout the Plan Area	NA	NA	Low-	Low-
		Interior Delta Entry	Entry of fish into the interior Delta from the mainstem Sacramento or San Joaquin Rivers through channels such as Georgiana Slough or Old River	NA	NA	Zero	NA
		Passage Barriers	Structures or conditions that potentially block upstream or downstream migration	NA	NA		High
Habitat	C, E	Inter-tidal habitat	Intertidal area from the mean low low water level to the extreme high water level that may support intertidal vegetation and form mudflats; dynamic elements of habitat such as appropriate salinity are considered on a species-specific basis	NA	NA	Low	Low
		Channel Margin	The extent of shallow water, low slope habitat that generally is characterized by structural complexity, native emergent vegetation and riparian shading cover	NA	NA	Very Low	
		Floodplains	The interface between upland topography and river hydrology during high flow events	NA	NA	Very Low	
		Riparian	Forest and scrub that occurs along the margins of river channels and within floodplains	NA	NA	NA	NA
		Sub-tidal habitat	Extent and location of sub-tidal area in the Plan Area, including the low salinity zone (LSZ); dynamic elements of habitat such as appropriate salinity are considered on a species-specific basis	NA	NA	Moderate	Low
Sediment	C	Water clarity	Water clarity in the Plan Area as influenced by amount of suspended material within the water column	NA	NA		
Temperature	C	Temperature	Adverse effects of high temperatures within the Plan Area	NA	NA		
DO	C	Dissolved Oxygen	Adverse effects of low dissolved oxygen level within the Plan Area	NA	NA		
Toxins	D, F	Contaminants	Adverse effects of methylated mercury, selenium, pesticides and other pollutants	NA	NA	Low-	Low-
		Microcystis	The abundance of Microcystis aeruginosa blooms that are toxic to covered fish species and their food	NA	NA	Very Low-	Very Low-
Predation	F	Predation	The species-specific consumption of covered fish species by predatory fish (e.g., striped bass, Sacramento pikeminnow, centrarchid bass species, catfish, and inland silversides); note that the attribute aims to isolate predation effects that may not be captured by other attributes, e.g., at manmade structures such as the north Delta diversions	NA	NA	Very Low	
		Illegal Harvest	Illegal harvest of covered fish species in the Plan Area	NA	NA	High	Very High

Category	Appendix	Attributes	Definition	Egg	Larvae	Juvenile	Adults
In-stream Habitat	C	Sacramento R. Habitat	Flows in the Sacramento River mainstem (below Keswick Dam to the Plan Area) that influence spawning, egg incubation, rearing, or holding habitat	Zero	Zero	Zero	Zero
		Feather R. Habitat	Flows in the Feather River (below Oroville Dam to the confluence with the Sacramento River) that influence spawning, egg incubation, rearing, or holding habitat	Low	Zero	Low-	Very Low
		American R. Habitat	Flows in the American River (below Nimbus Dam to the confluence with the Sacramento River) that influence spawning, egg incubation, rearing, or holding habitat	NA	NA	NA	NA
Migration & Movement	C	Sacramento R. Migration Flows	Flows in the Sacramento River mainstem (below Keswick Dam to the Plan Area) that influence migration and movement	NA	Zero	Zero	Zero
		Feather R. Migration Flows	Flows in the Feather River (below Oroville Dam to the confluence with the Sacramento River) that influence migration and movement	NA	Low-	Low-	Moderate
		American R. Migration Flows	Flows in the American River (below Nimbus Dam to the confluence with the Sacramento River) that influence migration and movement	NA	NA	NA	NA
Temperature	C	Sacramento R. Temperature	Adverse effects of high water temperatures in the Sacramento River mainstem (below Keswick Dam to the Plan Area)	Zero	Zero	Zero	Zero
		Feather R. Temperature	Adverse effects of high water temperatures in the Feather River (below Oroville Dam to the confluence with the Sacramento River)	Very Low	Very Low-	Zero	Very Low
		American R. Temperature	Adverse effects of high water temperatures in the American River (below Nimbus Dam to the confluence with the Sacramento River)	NA	NA	NA	NA

Certainty

- No effect conclusion made because attribute assumed not to have importance as a current constraint
- NA — Life stage not present or not applicable
- Low certainty
- Moderate certainty
- High certainty
- Very high certainty

Figure 5.5.8-1. Effect of the Covered Activities on Green Sturgeon

Category	Appendix	Attributes	Definition	Egg	Larvae	Juvenile	Adults
Food	E	Zooplankton community	Species composition of the zooplankton community and presence of suitable prey species				
		Zooplankton abundance	The abundance of zooplankton		Low	Low	
		Benthic & Epibenthic prey abundance	The abundance of epibenthic prey species such as amphipods		Low	Low	Low
		Insect abundance	The abundance of insect prey		Low	Low	
Entrainment & Impingement	B	North Delta Intakes	Potential entrainment/impingement from the proposed North Delta intakes		Very Low-		
		South Delta Pumps	Pumping rate from the CVP/SWP south Delta export facilities and resulting entrainment		Low	Low	
		North Bay Aqueduct	Entrainment from the SWP NBA facilities				
		Ag Diversions	Entrainment from Agriculture Diversions		Very Low		
Migration & Movement	C	Plan Area Flows	Magnitude, timing, direction, and duration of flows during migratory periods throughout the Plan Area		Low-	Low-	Low-
		Interior Delta Entry	Entry of fish into the interior Delta from the mainstem Sacramento or San Joaquin Rivers through channels such as Georgiana Slough or Old River		Zero	Zero	NA
		Passage Barriers	Structures or conditions that potentially block upstream or downstream migration				High
Habitat	C, E	Inter-tidal habitat	Intertidal area from the mean low low water level to the extreme high water level that may support intertidal vegetation and form mudflats; dynamic elements of habitat such as appropriate salinity are considered on a species-specific basis		Low	Low	Low
		Channel Margin	The extent of shallow water, low slope habitat that generally is characterized by structural complexity, native emergent vegetation and riparian shading cover		Very Low	Very Low	
		Floodplains	The interface between upland topography and river hydrology during high flow events			Very Low	
		Riparian	Forest and scrub that occurs along the margins of river channels and within floodplains	NA	NA	NA	NA
		Sub-tidal habitat	Extent and location of sub-tidal area in the Plan Area, including the low salinity zone (LSZ); dynamic elements of habitat such as appropriate salinity are considered on a species-specific basis		Low	Moderate	Low
Sediment	C	Water clarity	Water clarity in the Plan Area as influenced by amount of suspended material within the water column		Zero		
Temperature	C	Temperature	Adverse effects of high temperatures within the Plan Area				
DO	C	Dissolved Oxygen	Adverse effects of low dissolved oxygen level within the Plan Area				
Toxins	D, F	Contaminants	Adverse effects of methylated mercury, selenium, pesticides and other pollutants		Low-	Low-	Low-
		Microcystis	The abundance of Microcystis aeruginosa blooms that are toxic to covered fish species and their food			Very Low-	Very Low-
Predation	F	Predation	The species-specific consumption of covered fish species by predatory fish (e.g., striped bass, Sacramento pikeminnow, centrarchid bass species, catfish, and inland silversides); note that the attribute aims to isolate predation effects that may not be captured by other attributes, e.g., at manmade structures such as the north Delta diversions		Very Low	Very Low	
		Illegal Harvest	Illegal harvest of covered fish species in the Plan Area			High	Very High

Category	Appendix	Attributes	Definition	Egg	Larvae	Juvenile	Adults
In-stream Habitat	C	Sacramento R. Habitat	Flows in the Sacramento River mainstem (below Keswick Dam to the Plan Area) that influence spawning, egg incubation, rearing, or holding habitat	Zero	Zero	Zero	Zero
		Feather R. Habitat	Flows in the Feather River (below Oroville Dam to the confluence with the Sacramento River) that influence spawning, egg incubation, rearing, or holding habitat	Low	Zero	Low-	Zero
		American R. Habitat	Flows in the American River (below Nimbus Dam to the confluence with the Sacramento River) that influence spawning, egg incubation, rearing, or holding habitat	NA	NA	NA	NA
Migration & Movement	C	Sacramento R. Migration Flows	Flows in the Sacramento River mainstem (below Keswick Dam to the Plan Area) that influence migration and movement	NA	Zero	Zero	Zero
		Feather R. Migration Flows	Flows in the Feather River (below Oroville Dam to the confluence with the Sacramento River) that influence migration and movement	NA	Moderate	Low-	Zero
		American R. Migration Flows	Flows in the American River (below Nimbus Dam to the confluence with the Sacramento River) that influence migration and movement	NA	NA	NA	NA
Temperature	C	Sacramento R. Temperature	Adverse effects of high water temperatures in the Sacramento River mainstem (below Keswick Dam to the Plan Area)	Zero	Zero	Zero	Zero
		Feather R. Temperature	Adverse effects of high water temperatures in the Feather River (below Oroville Dam to the confluence with the Sacramento River)	Zero	Zero	Zero	Zero
		American R. Temperature	Adverse effects of high water temperatures in the American River (below Nimbus Dam to the confluence with the Sacramento River)	NA	NA	NA	NA

Certainty

- No effect conclusion made because attribute assumed not to have importance as a current constraint
- NA — Life stage not present or not applicable
- Low certainty
- Moderate certainty
- High certainty
- Very high certainty

Figure 5.5.8-2. Effect of the Covered Activities on White Sturgeon

White and green sturgeon face a number of stressors that may limit their abundance in the Central Valley. The BDCP is expected to affect some of these attributes, but not others. The primary positive effects of the BDCP on the covered sturgeon species are anticipated to be reduced illegal harvest as a result of CM17 (both within the Plan Area and in other areas, upstream and downstream), and improved passage (principally at Fremont Weir) as a result of CM2 (including fish rescue as necessary). Together, these two conservation measures are expected, with moderate to high certainty, to have a high or very high positive effect on green and white sturgeon. Also beneficial, but less certain and of lower effect magnitude, are increased suitable habitat, greater food production, and reduced entrainment at the south Delta export facilities; these improvements are within the Plan Area and therefore of most importance to rearing juveniles.

One area of high uncertainty is the extent to which spring flows throughout the upstream habitats and Delta affect year class strength. As described above, it is unclear if year-class strength for white sturgeon is related solely to Delta outflow, Delta inflow, or both. The BDCP is expected to have little effect on upper Sacramento River flows for the sturgeons, but is anticipated to moderately improve spawning and egg incubation conditions in the Feather River, as well as to increase white sturgeon larval migration flows from that tributary. However, only a relatively small proportion of the green and white sturgeon populations are believed to occupy the Feather River, with most being distributed in the Sacramento River during freshwater stages of the life cycle. None of the BDCP flow scenarios affect the Sacramento River at Grimes or Sacramento River at Verona thresholds included in the AFRP draft white paper. The ESO scenario would moderately reduce the percentage of years that the AFRP draft white paper February through May Delta outflow thresholds for white sturgeon recruitment are satisfied, while the HOS scenario would increase the percentage of years that the thresholds are met. The effects of Delta outflow on white sturgeon are poorly understood in terms of the mechanisms involved and how they are related to upstream flow conditions. As noted above in the analysis based on the Fish (2010) regressions, there may be importance of winter/early spring flows on adult attraction, and high flows in spring/early summer may result in better early-life-stage migration. Higher flows in upstream portions of the rivers may improve spawning success in spring/early summer. The relationship between outflow and white sturgeon recruitment may be affected by changes in flow management that will result from implementation of *CM1 Water Facilities and Operation*, i.e., although upstream criteria may be met, diversion at the north Delta intakes would reduce the amount of Delta outflow for a given amount of inflow. Further investigation is needed to better understand how flows in different reaches of the Sacramento River and Delta outflow affect year class strength for white and green sturgeon. The decision-tree process will be used to improve understanding of how spring outflows relate to sturgeon year class strength.

Upstream flows are not predicted to change under the BDCP, except in the Feather River, which would have increased spring flows and decreased summer temperatures driven by reduced summer flows under all BDCP scenarios, with the HOS causing the greatest increase in summer temperatures. As noted above, greater spring flows in the Feather River could enhance green sturgeon early life stage survival and facilitate better survival and accelerated growth before conditions deteriorate subsequently in the summer/early fall months; improved early growth may allow better avoidance of poorer conditions later in the year, if individuals grow more.

There are a number of attributes that may be of importance as current constraints to green and white sturgeon but that would not be expected to change under the BDCP. Water temperature is considered important and potentially limiting for all life stages of white sturgeon (Israel et al. 2009) and green sturgeon (Israel and Klimley 2008), but as described in Appendix 5.C, *Flow, Passage, Salinity, and Turbidity*, the BDCP is not expected to affect water temperatures in the Plan Area (although water temperatures are anticipated to increase as a result of climate change). The BDCP may increase water clarity in portions of the Plan Area, with a great deal of local variation (Appendix 5.C, Attachment 5C.D, *Water Clarity—Suspended Sediment Concentration and Turbidity*), but the importance of this attribute to white and green sturgeon is poorly understood. Discussions during the August 2013 workshops with agency biologists suggested that water clarity may be unimportant to most life stages of green and white sturgeon in the Plan Area, but that there could be low importance to white sturgeon larvae (equating to potential predation risk); there was low certainty from all biologists regarding the importance of water clarity. Regarding change in water clarity because of the BDCP, it is concluded with low certainty that there would not be a change in water clarity for white sturgeon larvae; some agency biologists thought that there might be a low negative change (with low certainty), i.e., an slight increase in water clarity, because of sediment removal by the north Delta intakes and accretion in the ROAs (see further discussion in delta smelt effects analysis). Such an effect would depend on the spatial distribution of white sturgeon larvae and if they are inhabiting areas where less sediment is available for resuspension at low-flow times of the year because of the BDCP. The BDCP is expected to have negligible effects on dissolved oxygen concentrations in the Plan Area (Appendix 5.C, *Flow, Passage, Salinity, and Turbidity*, Section 5.C.5.4.3, *Dissolved Oxygen*), other than improvement of dissolved oxygen conditions in the Stockton Deepwater Ship Channel as a result of CM14. Although not analyzed in depth here, under *CM14 Stockton Deep Water Ship Channel Dissolved Oxygen Levels,* the BDCP will increase DO concentrations and improve the habitat conditions for any sturgeon occurring in the Stockton Deep Water Ship Channel during months in which dissolved oxygen is low (Appendix 5.C, Section 5.C.5.3.11, *Passage Improvements at the Stockton Deep Water Ship Channel*). The continued and potentially expanded use of oxygen aerators under the BDCP is expected to reduce the number of DO violations, potentially allow greater movement of any sturgeon (in particular white sturgeon juveniles) found in this area. Although there is potential for the BDCP to lessen entry into the interior Delta for migrating juvenile salmonids through the implementation of *CM16 Nonphysical Fish Barriers*, this measure is expected to have negligible effects on guiding larval and juvenile sturgeon away from the interior Delta because of sturgeon water column position and poor hearing ability (Appendix 5.C, Section 5.C.5.3.9, *Nonphysical Barriers*).

As a result of the changed operations in the Feather River, the BDCP is expected to have small negative effects on instream transport and migration flows during larval and juvenile periods for white and green sturgeon and juvenile period for white sturgeon in the Sacramento and Feather Rivers (no flow changes are expected in the San Joaquin River).The BDCP is not expected to increase effects of contaminants on The BDCP is predicted to have no effect on adult attraction flows for either species of sturgeon in any river.

It is concluded that the positive effects of the BDCP outweigh the negative effects and that the BDCP would provide for the conservation and management of both green and white sturgeon through improvements in attributes linked to the viable population parameters discussed for salmonids, i.e., capacity (abundance), life-history productivity, life history diversity, and spatial structure. Attributes related to these parameters would be positively change in the Plan Area, with some improvements in upstream habitats as well. Capacity (abundance) would be enhanced because of improved food resources and extent of habitat in the Plan Area. Life history productivity primarily would be enhanced because of reduction in illegal harvest, improvement of passage at Fremont Weir, reduced South Delta entrainment, and improved abundance of prey items; as noted there may be some negative effects of reduced Plan Area flows and less water flow in the Feather River during summer/fall. Life history diversity may be increased by increases in different Plan Area habitat types from the various restoration-related conservation measures, while there may be a low negative effect from less Sacramento River flow below the north Delta intakes. Should Feather River flow improvements during spring lead to greater sturgeon recruitment from that tributary, spatial structure of the white and green sturgeon populations would be enhanced.

The decision-tree process will be used to improve understanding of how spring outflows relate to sturgeon year class strength. The magnitudes of many of the anticipated beneficial and adverse effects of the BDCP on sturgeon are highly uncertain for both species. Monitoring and adaptive management will provide the opportunity to address this uncertainty and alter covered activities to maximize long-term benefits.

Therefore, the BDCP will minimize and mitigate impacts to the maximum extent practicable and provide for the conservation and management of the green and white sturgeon in the Sacramento River region of the Plan Area.

5.5.9 Pacific and River Lamprey

Because very little is known about river lamprey (*Lampetra ayresii*), much of this discussion uses information about Pacific lamprey (*Entosphenus tridentatus*). Where known, differences are noted. Pacific lamprey spend the majority of their 9-to 12-year lifespan upstream: 5 to 7 years as eggs and rearing ammocoetes and up to 1 year as prespawn adults (Moyle 2002). River lamprey spend 3 to 5 years of their 6- to 7-year lifespan upstream (Moyle 2002). The remainder of their lifespan is spent in the ocean, except during the periods when they migrate upstream to spawn and downstream toward the ocean after rearing upstream. Pacific and river lamprey life history and status are discussed more thoroughly in Appendix 2.A, *Covered Species Accounts*.

A number of attributes (stressors) have been identified that affect upstream life stages of both species, but the certainty of their importance as stressors is low. The upstream life stages include spawning adults, eggs, ammocoetes (which spend multiple years rearing upstream), and outmigrating ammocoetes and macropthalmia. Passage barriers include dams, culverts, water diversions, and tidal gates (Klamath-Siskiyou Wildlands Center et al. 2003; Luzier et al. 2009). Adult lamprey have difficulty passing over ladders designed for passage of other species (Kostow 2002). Outmigrating ammocoetes and macropthalmia (juveniles) may have difficulty in traditional spill gates because they migrate in deeper water than salmonids (Moursund et al. 2003). Based on existing literature, passage barriers are predicted to be of moderate importance to lamprey. Redd dewatering and ammocoete stranding as a result of rapid changes instream flows (Streif 2007; Luzier et al. 2009) are predicted to be of high importance. Dredging associated with channel or screen irrigation maintenance or mining (Luzier et al. 2009) is predicted to be of moderate importance. Chemical poisoning and contaminants in the upstream silty substrate inhabited by ammocoetes (Kostow 2002; Haas and Ichikawa 2007; Bettaso and Goodman 2008) are predicted to be of low importance. Elevated water temperatures (higher than 22°C) lead to significant egg and ammocoete deformation and mortality (Meeuwig et al. 2005). This stressor is predicted to be of high importance. Harvest of ammocoetes and adults for food and commercial uses has not been well studied but could affect a large proportion of the population (Luzier et al. 2009; Moyle et al. 2010). There are currently no regulations on the harvest of lamprey in California (69 FR 77158). This stressor is expected to be of moderate importance.

For this effects analysis, macropthalmia were classified as all emigrating lamprey from upstream to the ocean. Pacific and river lamprey macropthalmia migrate downstream during winter and spring, likely in association with high flow events (Moyle 2002). Downstream transport flows are a major driver of outmigrating macropthalmia (Luzier et al. 2009). This stressor was assumed with low certainty to be of moderate importance. The duration of time that macropthalmia spend in the Delta is thought to be extremely short (less than 1 month), indicating that exposure to in-Delta stressors is small relative to stressors over the course of their life cycle. Such in-Delta stressors that may be affected by the BDCP include predation associated with structures, particularly the new north Delta intakes; entrainment at the proposed north Delta intakes and south Delta pumps, and at agricultural diversions; and passage barriers, including the Stockton Deep Water Ship Channel and Fremont Weir. These in-Delta stressors are predicted to be of low importance, with low certainty, because the time migrating macropthalmia spend in the Delta is short as described above.

Although there are no data on the amount of time that adults from the Central Valley spend in the ocean, individuals from British Columbia spend 3 to 4 years in the ocean (Moyle 2002). River lamprey adults are thought to spend 3 to 4 months in the ocean (Moyle 2002). There are three primary stressors on adult lamprey: ocean conditions, passage impediments, and upstream attraction flows. The most important stressor is likely ocean conditions, which may affect host and prey populations (Luzier et al. 2009), although there is low certainty in this assertion. Because the covered activities will not affect Pacific or river lamprey downstream of Suisun Marsh or in the Pacific Ocean, the adult life stages will be affected by the BDCP only during the upstream migration period and the prespawning and spawning periods.

Specific to Central Valley populations of Pacific lamprey, Goodman and Reid (2012) identified five main attributes (stressors/threats) of importance to Sacramento and San Joaquin subregion populations: passage; dewatering and streamflow management; stream and floodplain degradation; water quality; and predation. In summarizing their assessment for the Sacramento subregion populations (which was essentially the same as for the San Joaquin subregion populations), Goodman and Reid (2012: 81) noted:

> Beyond the historical elimination of much of the lamprey habitat in the Sacramento by impassable dams, the primary threats to currently occupied HUCs were smaller passage constraints and dewatering or flow management. A major uncertainty is the effects of the large water diversions at the Tracy Pumping Facility and Clifton Forebay Diversion Facility in the lower San Joaquin delta, which potentially impact passage for large numbers of downstream migrating juveniles from the Sacramento drainages. Assessment of entrainment and passage effects at these facilities is currently underway and is dependent on screening efficiency, diversion timing, flow management in the complicated Central Valley water system, and downstream migration timing for juvenile lampreys. A second uncertainty is the threat represented by striped bass in the lower river reaches that serve as major migratory corridors for both adults and outmigrating juveniles.

During the agency biologist workshops of August 2013 that discussed species attribute importance and change under the BDCP, it was clear that little was known about Pacific and river lamprey attributes of importance within the Plan Area and any conclusions would be reached with low certainty. Agency biologists noted that the main attributes of importance probably are upstream of the Plan Area, within the species' natal streams; this is because ammocoetes rear within the substrate for several years and thus likely are exposed to a wide variety of environmental conditions, including stressful temperatures. For this reason, the attribute ranking process used for other covered fish species was not adopted for Pacific and river lamprey. Instead, the potential effects are discussed below, recognizing the low certainty in most of the evaluation. It is anticipated that research and monitoring efforts conducted during the BDCP implementation would aim to elucidate attributes of importance to Pacific and river lamprey within and outside of the Plan Area. The knowledge gained from such research and monitoring would then be used to adaptively manage aspects of the BDCP that could potentially affect the two lamprey species.

In relation to upstream effects on Pacific and river lamprey, it is anticipated there would be no biologically meaningful changes to lamprey adult attraction flows under the BDCP in any river examined (See the following tables in Appendix 5.C, *Flow, Passage, Salinity, and Turbidity,* by river—Sacramento River: Table 5.C.5.3-206 and Table 5.C.5.3-207; Feather River: Table 5.C.5.3-223 and Table 5.C.5.3-224; American River: Table 5.C.5.3-227 and Table 5.C.5.3-228; Stanislaus River: 5.C.5.3-229 and Table 5.C.5.3-230; San Joaquin River:Table 5.C.5.3-9 and Table 5.C.5.3-10). Flows under BDCP operations are predicted to generally be similar, with some small increases and decreases depending on river and month. Overall, there will be no net adverse effects of the BDCP on river lamprey adult attraction flows, although there is low certainty in this conclusion due to a lack of understanding of the effect of flows on adult lamprey migration success.

There will be no major effects to redd dewatering risk of Pacific or river lamprey. There will be small to moderate reductions (up to 14% lower) in the dewatering risk of Pacific and river lamprey redds in the Sacramento River due to the BDCP (Table 5.C.5.2 91, *Dewatering Risk of Pacific Lamprey Redd Cohorts under EBC and ESO Scenarios*, and Table 5.C.5.2-92, *Differences between EBC and ESO Scenarios in Dewatering Risk of Pacific Lamprey Redd Cohorts*, in Appendix 5.C). However, redd dewatering risk in the Trinity, American, and Stanislaus Rivers is not predicted to be affected by the BDCP (less than 5% difference). Redd dewatering risk in the Feather River is predicted to increase moderately (11% greater) for Pacific lamprey with the BDCP, but would be similar for river lamprey. The proportions of the overall Pacific lamprey populations found in the Feather River are not known such that the effect of increased redd dewatering risk in the Feather River on the overall population is unknown. The modeled effects of climate change are nearly always larger than the effects of the BDCP.

Effects of the BDCP on Pacific and river lamprey ammocoete stranding risk are predicted to be variable among and within upstream rivers such that, overall, there will be no effect on stranding risk. There would be no effect or beneficial effects of the BDCP on Pacific lamprey ammocoete stranding risk in the Sacramento River (Table 5.C.5.2-95, *Differences between EBC and ESO Scenarios in the Number of Pacific Lamprey Ammocoete Cohorts Exposed to Month-over-Month Flow Reductions, Sacramento River at Keswick*, Table 5.C.5.2-97 [upstream of Red Bluff], and Figure 5.C.5.2-78 [at Keswick], Figure 5.C.5.2-80 [upstream of Red Bluff], in Appendix 5.C), Trinity River (Table 5.C.5.2-107 [below Lewiston Dam] and Figure 5.C.5.2-82), Feather River (Table 5.C.5.2-178 [at Thermalito Afterbay] and Figure 5.C.5.2-135), and Stanislaus River (Table 5.C.5.2-286, and Figure 5.C.5.2-195). There would also generally be low positive effects (i.e., very minor beneficial effects) on Pacific lamprey ammocoete stranding risk in the American River, although there would be small to moderate increases in exposure to stranding under some flow reductions analyzed (Table 5.C.5.2-251 [at Nimbus Dam], Table 5.C.5.2-253 [at Sacramento River confluence], Figure 5.C.5.2-165 [at Nimbus Dam], and Figure 5.C.5.2-167 [at Sacramento River confluence]).

There would very low positive effects of the BDCP on river lamprey ammocoete stranding in the Sacramento River (Table 5.C.5.2-96, Table 5.C.5.2-98, Figure 5.C.5.2-79, and Figure 5.C.5.2-81), Trinity River (Table 5.C.5.2-108 and Figure 5.C.5.2-83), Feather River (Table 5.C.5.2-209, Table 5.C.5.2-211), and Stanislaus River (Table 5.C.5.2-287, and Figure 5.C.5.2-196). There would also generally be low positive effects on river lamprey ammocoete stranding risk in the American River, although there would be small to moderate increases in exposure to stranding under some flow reductions analyzed (Table 5.C.5.2-252, Table 5.C.5.2-254, Figure 5.C.5.2-166, and Figure 5.C.5.2-168). Overall, there is expected to be no net effect of the BDCP on stranding of Pacific or river lamprey ammocoetes in upstream rivers.

The effect of the BDCP on Pacific and river lamprey spawner, egg, and ammocoete exposure to elevated water temperature will be negligible in all rivers because water temperatures will change very little due to BDCP operations (Appendix 5.C, *Flow, Passage, Salinity, and Turbidity*: Sacramento River: Section 5.C.5.2.1.8; Trinity River: Section 5.C.5.2.2.1; Feather River: Section 5.C.5.2.4.7; American River: Section 5.C.5.2.5.4; Stanislaus River: Section 5.C.5.2.7.4). Modeling results of future changes in upstream water temperatures predicted that climate change would be the primary, and in many cases, only driver of changes in upstream water temperatures. Where changes in BDCP water temperatures were modeled, they were negligible compared to the changes predicted from climate change.

Taken together, results indicate that flow- and water temperature-related effects of the BDCP on Pacific and river lamprey spawning, egg incubation, and ammocoete rearing habitat in upstream parts of the BDCP study area generally will be very low, and there is little certainty in this assessment.

5.5.9.1 Beneficial Effects

5.5.9.1.1 Reduced Entrainment

The BDCP will provide a moderate reduction in entrainment of Pacific and river lamprey, primarily at the south Delta export facilities, but possibly also associated with implementation of *CM21 Nonproject Diversions*.

The importance of entrainment of lamprey in the south Delta export facilities is unknown; as noted above, it was one of few attributes explicitly mentioned in the summary of threats to Central Valley Pacific lamprey by Goodman and Reid (2012), who noted the effects were uncertain. The BDCP is expected to reduce Pacific and river lamprey entrainment at south Delta export facilities by around 40% on average (Table 5.B.6-218, *Estimated Mean Monthly and Annual Entrainment Index (Number of Fish as Expanded Salvage with 95% Confidence Interval [CI]) of Lamprey for Six Model Scenarios at the SWP and CVP Salvage Facilities for All Water Years*, Table 5.B.6-219, *Mean Difference in Estimated Average Monthly Lamprey Entrainment Index (Number of Fish and Percent Difference) between Model Scenarios at CVP and SWP Salvage Facilities Combined*, and Figure 5.B.6-40, *Historical Mean Monthly Lamprey Salvage (Fish per Thousand Acre-Feet with 95% Confidence Interval [CI]) at CVP and SWP Salvage Facilities for All Water Years*, in Appendix 5.B, *Entrainment*) because of reduced exports at these facilities. The BDCP may also reduce entrainment at agricultural diversions due to implementation of *CM21 Nonproject Diversions* and changed land use associated with habitat restoration conservation measures that would eliminate the need for multiple diversions in restoration locations, although the importance of entrainment at these diversions to lamprey is thought to be low with low certainty. Based on recent monitoring at the nearby Freeport intake facility (ICF International 2012), there will be a low risk of entrainment of ammocoete-sized (20–46 mm) lamprey at north Delta diversions with low certainty (Appendix 5.B, *Entrainment*, Section 5.B.6.2.7.1, *Entrainment (Screening Effectiveness Analysis)*). Macropthalmia will generally be too large to be entrained due on screen size design, although there will be a low risk of screen impingement with low certainty (Appendix 5.B, Section 5.B.6.2.7.2, *Impingement and Screen Contact*).

5.5.9.1.2 Improved Macropthalmia Emigration Flows in Upstream Areas

The BDCP will provide small improvements to Pacific and river lamprey macropthalmia emigration conditions with low certainty by increasing flows during the macropthalmia period in several rivers.

The importance of downstream migration flows by Pacific and river lamprey macropthalmia is thought to be moderate to lamprey, although certainty in this assertion is low due to a lack of understanding of the effect of migration flows on the species. Lamprey macropthalmia have weak swimming ability and rely upon sufficient flows to emigrate downstream (Luzier et al. 2009). There will be small to moderate beneficial effects of the BDCP on downstream emigration flows for Pacific and river lamprey macropthalmia during April in the Feather River (up to 14% greater; Table 5.C.5.3-223 and Table 5.C.5.3-224, in Appendix 5.C, *Flow, Passage, Salinity, and Turbidity,*) and during May in the Sacramento River (up to 12% greater; Table 5.C.5.3-206 and Table 5.C.5.3-207), Feather River (up to 23% greater; Table 5.C.5.3-223 and Table 5.C.5.3-224), and American River (up to 24% greater; Table 5.C.5.3-227 and Table 5.C.5.3-228). There will be no biologically meaningful effects to flows during other months within the emigration period in these rivers or throughout the entire migration period in the San Joaquin River (Table 5.C.5.3-9 and Table 5.C.5.3-10) and Stanislaus River (Table 5.C.5.3-229 and Table 5.C.5.3-230).

Overall, there may be small benefits to Pacific and river lamprey macropthalmia emigration due to small to moderate increases in upstream flows in the Sacramento, Feather, and American Rivers. There is low certainty in this conclusion.

5.5.9.1.3 Improved Adult Attraction Flows for Pacific Lamprey

The BDCP will provide small improvements to Pacific lamprey adult attraction conditions with low certainty by increasing flows during the adult attraction period in several rivers.

The importance of upstream attraction flows to Pacific and river lamprey adults is thought to be low, although certainty in this assertion is low due to a lack of understanding of the effect of flows on adult lamprey migration success. There is mixed evidence and low certainty that olfactory cues drive patterns in upstream lamprey migration and spawning site fidelity to specific streams and rivers (Hatch and Whiteaker 2009). Low site fidelity is further supported by the low genetic diversity of Pacific lamprey from British Columbia to California (Goodman 2005).

There will be small to moderate beneficial effects of the BDCP on Pacific lamprey adult attraction flows in multiple months during the January through June adult migration period in the Sacramento, Feather, and American Rivers (Appendix 5.C, *Flow, Passage, Salinity, and Turbidity,* Table 5.C.5.3-206, Table 5.C.5.3-207, Table 5.C.5.3-223, Table 5.C.5.3-224, Table 5.C.5.3-227, and Table 5.C.5.3-228). There will be no biologically meaningful effects on attraction flows throughout the entire Pacific lamprey migration period in the San Joaquin River (Appendix 5.C, Table 5.C.5.3-9 and Table 5.C.5.3-10) and Stanislaus River (Appendix 5.C, Table 5.C.5.3-229 and Table 5.C.5.3-230).

As discussed above, aside from a few isolated increases and decreases in flows, there will be no biologically meaningful effects on river lamprey adult attraction flows in any river examined throughout the river lamprey adult migration period (September through November).

Because the new north Delta export facilities will reduce the need to export from the south Delta, a greater proportion of water in the West Delta subregion will be made up by water from the San Joaquin River, which will increase substantially during the January through June adult Pacific lamprey migration period (24 to 122% increase, on average depending on month) (Appendix 5.C, Figure 5.C.5.3-159 and Table 5.C.5.3-201), and September through November adult river lamprey migration period (373 to 1,077% increase, on average, depending on month) (Appendix 5.C, Figure 5.C.5.3-160 and Table 5.C.5.3-202), potentially improving attraction flows of adult lamprey toward the San Joaquin River.

Overall, effects may be low to moderately positive for Pacific lamprey adults and negligible for river lamprey adults in upstream rivers and there would be increases in the San Joaquin River attraction flows in the Plan Area. These changes may be of some benefit to lampreys, but this is not known with certainty.

5.5.9.1.4 Reduced Impediments to Passage

Implementation of *CM2 Yolo Bypass Fisheries Enhancement* and *CM14 Stockton Deep Water Ship Channel Dissolved Oxygen Levels* will provide moderate improvements to Pacific and river lamprey macropthalmia and adult passage by reducing impediments to passage.

Passage impediments, including the Stockton Deep Water Ship Channel and Fremont Weir, may be of importance to Pacific and river lamprey macropthalmia and adults, although there is low certainty in this assertion because of lack of evidence. Passage of Pacific and river lamprey macropthalmia and adults through the Stockton Deep Water Ship Channel is expected to improve because of aeration technology (ICF International 2010) under *CM14 Stockton Deep Water Ship Channel Dissolved Oxygen Levels*, which will largely eliminate the DO sag in the channel. Fremont Weir fish ladders that use existing lamprey passage technology from the lower Columbia River (e.g., Moser et al. 2002) and the newest available information (e.g., Daigle et al. 2005; Magie et al. 2007; Moser and Mesa 2009; Moser et al. 2011) are expected to allow efficient passage of lamprey adults from the Yolo Bypass to the Sacramento River under *CM2 Yolo Bypass Fisheries Enhancement*. Additional sculpting of the Yolo Bypass landscape under this conservation measure is expected to further reduce stranding risk for lamprey macropthalmia and adults on the floodplain.

Overall, Pacific and river lamprey macropthalmia and adult passage is expected to be improved as a result of BDCP conservation measures, although there is low certainty in this conclusion because Fremont Weir fish ladders have not yet been designed to benefit lamprey.

5.5.9.1.5 Improved Tidal Habit and Channel Margin Conditions for Ammocoete Rearing

Implementation of CM4 Tidal Natural Communities Restoration and CM6 Channel Margin Enhancement will provide small improvements to Pacific and river lamprey ammocoete rearing conditions by providing additional shallow subtidal substrate.

Any Pacific and river lamprey ammocoetes entering the Plan Area may receive small benefits from habitat restoration associated with CM4 *Tidal Natural Communities Restoration* and CM6 *Channel Margin Enhancement*. These conservation measures would increase the area of inundated non-revetted substrate in the Plan Area into which ammocoetes can bury, potentially providing increased suitable habitat in the Plan Area. Monitoring suggests that ammocoetes do occur in the substrates in the Plan Area, although these may just be a relatively small proportion of individuals that otherwise would rear upstream and may be washed downstream during high flows; it is uncertain whether the Plan Area actually functions as a beneficial rearing area.

5.5.9.2 Adverse Effects

5.5.9.2.1 Reduced Attraction and Migration Flows For Sacramento River Region Lampreys

Less river flow below the North Delta intakes may negatively affect migrating Pacific and River lamprey macropthalmia from the Sacramento River region.

Diversions at the proposed north Delta intakes would reduce Sacramento River flow below the intakes and may be of importance, particularly in the less tidally influenced reaches of the Plan Area.

There is uncertainty regarding the importance of Plan Area flows for lamprey macropthalmia (as with many other aspects of the species' ecology within the Plan Area), although by analogy with other species such as salmonids, these flows may be of importance in reducing travel time/distance and therefore limiting predation loss. During the river lamprey and Pacific lamprey downstream migration period (December–May), the difference in average Sacramento River flows at Rio Vista by water-year type ranged from around 4 to 5% less in December and January of dry and critical years, up to around 25% in May of wet years (Table 5.C.5.3-188, *Differences between EBC and ESO Scenarios in Mean Monthly Flows (cfs) in Sacramento River at Rio Vista*, in Appendix 5.C, *Flow, Passage, Salinity, and Turbidity*). This may be a low negative effect to migration of Pacific and lamprey macropthalmia. Adoption of the BDCP high-outflow scenario would result in smaller differences during the spring months: flow under HOS_LLT was a maximum of 13% lower than under EBC2_LLT when comparing differences between water year averages, and as much as 17% higher (in April of below-normal years; Appendix 5.C, Table 5.C.5.3 236). Note that caution is required when considering the significance of (net) flow changes at Rio Vista (a very tidally influenced area; see Appendix 5.C, Section 5.C.5.3.13.1.11, *Context for Monthly Average Flow Changes in Tidally Influenced Areas of the Plan Area (Delta Region)*); nevertheless, this area does provide an indication of reduced flow in the Sacramento River.

As illustrated Table 5.C.5.3-202, in Appendix 5.C, the average percentage composition of water at Collinsville made up by Sacramento River water (i.e., a proxy for attraction flows/olfactory cues) during the river lamprey September–November adult upstream migration period, as modeled with DSM2 fingerprinting, was marginally lower (approximately 2 to 4%) under ESO_LLT than under EBC2_LLT because of the north Delta intakes. Such a small change does not seem likely to appreciably affect adult lamprey migration, although this is uncertain. For the Pacific lamprey January–June migration period, the average percentage composition of water at Collinsville made up by Sacramento River water under ESO_LLT was around 11 to 13% lower than under EBC2_LLT in March–June, and 2 to 7% in January–February (Table 5.C.5.3-201 in Appendix 5.C). It is not known whether such a change would be of significance to Pacific and river lamprey upstream migration, but it is possible.

5.5.9.2.2 Increased Contaminant Exposure

Exposure to contaminants by Pacific and river lamprey ammocoete, macropthalmia, and adult life stages will increase slightly under BDCP although there is low certainty in this conclusion.

There will be small increases in the exposure of Pacific and river lamprey ammocoete, macropthalmia, and adult life stages in the Plan Area to mercury, pesticides, selenium, and copper due to BDCP (Appendix 5.D, C*ontaminants*). The largest effect would be to ammocoetes, which likely spend the greatest amount of time in the Plan Area. Even so, the increase in exposure is expected to be small. There is low certainty in these conclusions due to a lack of knowledge of the effects of contaminants on lamprey.

5.5.9.3 Impact of Take on Species

The SWP/CVP export facilities are expected to continue to take Pacific and river lamprey individuals at south Delta export facilities. Annual historical (water years 1996 to 2008) take of Pacific and river lamprey combined ranged from 8 to 1,704 individuals at the SWP facility and 168 to 13,230 individuals at the CVP facility. Although there are no population estimates available to determine whether this represents a large proportion of the population, it is unlikely given the relatively large number of individuals caught in trawls that sample only a very small proportion of the water column for a short period of time. Trawls between 1995 and 2010 captured an average of approximately 250 individuals per year, which represent 2 to 15% of the salvage at combined SWP/CVP combined. This suggests that take has a negligible effect on the overall populations of Pacific and river lamprey because trawls operate for a short period of time in a small portion of the river. Further, the BDCP is expected to reduce take at the south Delta by around 40% based on reductions in south Delta exports.

Take at the north Delta diversion facilities from entrainment is predicted to be low because of the size at which lamprey emigrate (average length = 127 mm) relative to the 1.75-mm vertical wedgewire screen aperture width; however, small ammocoetes entering the Plan Area and encountering the intakes would have potential for entrainment.

Take associated with construction of the north Delta intakes is expected to be minimal because avoidance and minimization measures (e.g., work windows, spill prevention) will eliminate nearly all take and the proportion of the year that lamprey would be present in and near areas of construction would small because they are thought to use the Delta primarily as a migration corridor.

5.5.9.4 Net Effects

Knowledge of the relative effects of different stressors on Pacific lamprey is very limited, and even less is known about river lamprey. Because of the amount of time spent upstream by Pacific and river lamprey, upstream stressors will affect upstream individuals for a longer duration than oceanic and Plan Area stressors. Likewise, stressors affecting adults in the ocean are likely to have prolonged effects on individuals relative to Plan Area stressors. However, the population-level effect of a stressor on an individual adult is much larger than the population-level effect of a stressor on an individual egg or ammocoete because an individual adult has a higher reproductive value than younger life stages. In addition, Moyle et al. (2010) indicate that climate change is an important stressor to the species because of its predicted effect on increased water temperature and alteration of flows.

The analysis of threats to Sacramento and San Joaquin subregion Pacific lamprey by Goodman and Reid (2012) suggested (with considerable uncertainty) that manipulation of flow in the lower Sacramento by the south Delta export facilities may have substantial effects on orientation of migrating lampreys (adults and juveniles). The reduced reliance on the south Delta export facilities under CM1 operations, coupled with screened north Delta intakes, generally would be expected to benefit lampreys during migratory periods, although there is the potential for negative effects of less flow below the north Delta intakes in less tidally influenced areas. As also suggested by Goodman and Reid (2012), predation of lamprey by striped bass may be important within the Plan Area, but this is not known with any certainty. Although *CM15 Localized Reduction of Predatory Fishes* primarily is intended to benefit downstream migrating juvenile salmonids, it may also benefit downstream migrating lamprey macropthalmia because the timing of migration overlaps with that of salmonids. As noted for juvenile salmonids, near-field and far-field effects of the north Delta intakes could lead to greater predation in and downstream of the reach of the Sacramento River near Hood. Improvement in habitat may provide less suitable habitat for predatory fish in the Plan Area, e.g., from *CM2 Yolo Bypass Fisheries Enhancement, CM4 Tidal Natural Communities Restoration, CM5 Seasonally Inundated Floodplain Restoration, CM6 Channel Margin Enhancement,* and

CM13 Invasive Aquatic Vegetation Control. Additional measures such as Fremont Weir passage improvements also could benefit Pacific and river lamprey.

There is high uncertainty regarding the effects of the BDCP on Pacific and river lamprey because of a deficiency of scientific knowledge of lamprey biology and ecology in the Plan Area. It is tentatively concluded that the BDCP has the potential to provide an overall benefit to both Pacific and river lamprey through improvements in Plan Area conditions. There may also be small net positive effects on Pacific and river lamprey macropthalmia and adults and negligible effects on Pacific and river lamprey eggs and ammocoetes. Overall, benefits of the BDCP will be similar in magnitude for Pacific and river lamprey, although benefits to Pacific lamprey would be somewhat greater than those to river lamprey because of improved flows during the downstream adult Pacific lamprey migration period. If monitoring during BDCP implementation indicates methods to improve conservation, conservation measures will be adaptively managed to improve conditions for both species of lamprey to the extent practicable. The effects of climate change on upstream flows and water temperatures are expected to be mostly adverse and will likely offset some of the predicted benefits of the BDCP.

Therefore, the BDCP will minimize and mitigate impacts to the maximum extent practicable and provide for the conservation and management of the Pacific and river lamprey in the Sacramento River region of the Plan Area.

5.6 Effects on Covered Wildlife and Plant Species

This section provides the results of the effects analysis for covered wildlife and plant species. Section 5.2.8, *Effects Analysis for Wildlife and Plant*, describes the methods used for this analysis. The maximum allowable habitat loss for each species is provided in Table 5.6-1 and Table 5.6-2. The periodic effects related to Yolo Bypass and floodplain inundation are presented in Table 5.6-3 and Table 5.6-4. The indirect effects related to disturbance adjacent to covered activities are quantified in Table 5.6-5 and Table 5.6-6. The net effects on modeled habitat for each species are quantified in Table 5.6-7 and Table 5.6-8. Table 5.6-9 summarizes the covered plant occurrences to be affected and conserved through covered activities, including conservation measures. These tables are located in Section 5.6.32, *Covered Species Tables.*

Table 5.6-10 and Table 5.6-11 show the acres of affected habitat for greater sandhill crane and Swainson's hawk, respectively.

Appendix 5.A.1, *Climate Change Implications for Natural Communities and Terrestrial Species*, summarizes the effects of climate change in California and the Plan Area that are relevant to covered wildlife and plant species. Appendix 5.D, *Contaminants*, analyses the effects of contaminants on covered species. Appendix 5.J, *Effects on Natural Communities, Wildlife, and Plants*, Attachment 5J.A, *Construction-Related Nitrogen Deposition on BDCP Natural Communities*, describes the potential effects of construction-related nitrogen deposition on plant communities. Appendix 5.J, Attachment 5J.C, *Analysis of Potential Bird Collisions at Proposed BDCP Powerlines*, describes effects on covered bird species potentially resulting from collisions with the proposed powerlines.

5.6.1 Riparian Brush Rabbit

This section describes the adverse, beneficial, and net effects of the covered activities, including conservation measures, on the riparian brush rabbit. The methods used to assess these effects are described in Section 5.2.8, *Effects Analysis for Wildlife and Plants,* and Table 5.J.1, *Quantitative Effects Analysis Methods and Assumptions*, in Appendix 5.J, *Effects on Natural Communities, Wildlife, and Plants*. The habitat model used to assess effects for the riparian brush rabbit includes 38 vegetation associations in the valley/foothill riparian natural community and adjacent grasslands. The vegetation associations were selected based on a review of understory and overstory composition from Hickson and Keeler-Wolf (2007) and species habitat requirements. Further details regarding the habitat model, including assumptions on which the model is based, are provided in Appendix 2.A, *Covered Species Accounts.* Factors considered in assessing the value of adversely affected habitat for the riparian brush rabbit, to the extent information was available, included size and degree of isolation of habitat patches, proximity to recorded species occurrences, and adjacency to conservation lands.

5.6.1.1 Adverse Effects

5.6.1.1.1 Permanent Habitat Loss, Conversion, and Fragmentation

Covered activities will result in the permanent loss of up to 65 acres[1] of riparian habitat (2% of riparian habitat in the Plan Area) and 168 acres of associated grassland habitat (5% of grassland habitat in the Plan Area) for the riparian brush rabbit (Table 5.6-1). Covered activities resulting in permanent habitat loss include water conveyance facilities construction, tidal natural communities restoration, and floodplain restoration. The effects are described below for each covered activity.

Water Conveyance Facility Construction

This activity will result in the permanent loss of approximately 3 acres of riparian habitat and 124 acres of associated grassland habitat for the riparian brush rabbit (Table 5.6-1) in Conservation Zone 8. There will be no permanent habitat loss of riparian brush rabbit habitat as a result of transmission line installation. The riparian habitat that will be removed is of low value for the riparian brush rabbit: it consists of several small, isolated patches surrounded by cultivated lands northeast of Clifton Court Forebay. The associated grasslands are also of low value for the species: they consist of long, linear strips that abut riparian habitat, but extend several miles from the riparian habitat and therefore provide few if any opportunities for adjacent cover. Trapping efforts conducted for the riparian brush rabbit in this area were negative (Appendix 3.E, *Conservation Principles for the Riparian Brush Rabbit and Riparian Woodrat*).

Tidal Natural Communities Restoration

This activity will result in the permanent removal of approximately 19 acres of riparian habitat and 18 acres of associated grassland habitat for the riparian brush rabbit (Table 5.6-1) in the South Delta ROA in Conservation Zone 7. The riparian habitat that will be removed consists of relatively small and isolated patches along canals and irrigation ditches surrounded by cultivated lands in the Union Island and Roberts Island areas, and several small patches along the San Joaquin River. The habitat that will be removed is not adjacent to any existing conservation lands, and is several miles north and northeast of the northernmost riparian brush rabbit record located northeast of Paradise Cut (Williams et al. 2002). Although the final footprint for tidal natural communities restoration will differ from the hypothetical footprint, compliance monitoring will be implemented to ensure that acreage limits are not exceeded. In addition, *AMM25 Riparian Woodrat and Riparian Brush Rabbit*, described in Appendix 3.C, *Avoidance and Minimization Measures*, requires that tidal natural communities restoration avoid removal of any habitat occupied by the riparian brush rabbit.

Floodplain Restoration

Levee construction associated with this activity will result in the permanent removal of approximately 43 acres of riparian habitat and 26 acres of associated grassland habitat for the riparian brush rabbit (Table 5.6-1) in Conservation Zone 7. The value of this habitat for the riparian brush rabbit is high: although it consists of small patches and narrow bands of riparian vegetation, these areas are in proximity to, or contiguous with, habitat with recorded occurrences of riparian

[1] Habitat or natural community loss acreage estimates are based on hypothetical footprints and models rather than detailed project-level design and represent the maximum allowed under the permit. Actual losses will be tracked through compliance monitoring to ensure that they do not exceed estimates.

brush rabbits. The hypothetical footprint for levee construction overlaps with one occurrence record for the riparian brush rabbit, south of the Interstate 5/Interstate 205 interchange.

Although the final floodplain restoration design will differ from the hypothetical footprint used for this effects analysis, restoration of the river floodplain in Conservation Zone 7 will be targeted in the general area of the riparian brush rabbit population. Through monitoring and adaptive management described in Chapter 3, Section 3.6, *Adaptive Management and Monitoring Program*, and AMM25 (Appendix 3.C), the Implementation Office will ensure that riparian brush rabbit habitat permanently removed does not exceed the maximum allowable habitat loss for this species.

5.6.1.1.2 Periodic Inundation

Floodplain restoration is the only covered activity expected to result in periodic inundation of riparian brush rabbit habitat.

Floodplain Restoration

This activity will periodically inundate approximately 264 acres of riparian habitat (9% of riparian habitat in the Plan Area) and 423 acres of associated grassland habitat (14% of associated grassland habitat in the Plan Area) for the riparian brush rabbit. The area between existing levees will be breached and the newly constructed setback levees will be inundated through seasonal flooding. The potentially inundated areas consist of high-value habitat for the species: although they consist of small patches and narrow bands of riparian vegetation, many of these areas are in proximity to, or contiguous with, habitat with recorded occurrences of riparian brush rabbits. The restored floodplain will include a range of elevations from low-lying areas that flood frequently (i.e., every 1 to 2 years) to high-elevation areas that flood infrequently (i.e., every 10 years or more).

Seasonal flooding in restored floodplains can result in injury or mortality of individuals if riparian brush rabbits occupy these areas and cannot escape flood waters. One recorded occurrence of riparian brush rabbits (Williams et al. 2002), just west of Stewart Road in Mossdale, is in the area that will be seasonally flooded based on the hypothetical restoration footprint.

The adverse effects of periodic inundation on the riparian brush rabbit will be minimized through construction and maintenance of flood refugia to allow riparian brush rabbits to escape inundation, as described under Section 5.6.1.2, *Beneficial Effects*.

5.6.1.1.3 Construction-Related Effects

Permanent effects of construction are described above in Section 5.6.1.1.1, *Permanent Habitat Loss, Conversion, and Fragmentation*. Other construction-related effects on the riparian brush rabbit include short- and long-term temporary habitat loss as a result of grading and ground disturbance, construction-related injury or mortality, and indirect noise and visual disturbance to habitat in the vicinity of construction. Effects on the species are described below for each effect category. Effects are described collectively for all covered activities, and are also described for specific covered activities to the extent that this information is pertinent for assessing the value of affected habitat or the specific nature of the effect.

Temporary Habitat Loss

Grading and ground disturbance associated with water conveyance facility construction, Yolo Bypass fisheries enhancement, and floodplain restoration levee construction will temporarily remove approximately 35 acres of riparian habitat (1 % of riparian habitat in the Plan Area) and 74 acres of associated grassland habitat (2% of associated grassland habitat in the Plan Area) for the riparian brush rabbit. Conveyance facility construction will temporarily remove up to 1 acre of riparian habitat and 54 acres of modeled grassland habitat for the riparian brush rabbit in Conservation Zones 6 and 8, adjacent to and north of Clifton Court Forebay: this is low-value habitat for the species based on its fragmented nature and the low likelihood that the species is present in this area. Some of the temporarily removed grassland habitat is associated with installation of a temporary transmission line. Although grassland restoration following construction may not return the area to its original topography, this is not expected to affect the riparian brush rabbit because the species is not likely to be present in the area of effect based on a lack of occurrences in Conservation Zone 8 and recent negative survey results (Appendix 3.E, *Conservation Principles for the Riparian Brush Rabbit and Riparian Woodrat*). Based on the hypothetical floodplain restoration footprint, the construction of setback levees to restore seasonally inundated floodplain is expected to temporarily remove up to 35 acres of modeled riparian habitat that is of high value based on habitat patch size and proximity to recorded occurrences in Conservation Zone 7, and 20 acres of adjacent grassland habitat.

Temporarily disturbed areas will be restored as riparian and grassland habitat within 1 year following completion of construction activities. Although the effects are considered temporary, several years may be required for ecological succession to occur and for restored riparian habitat to functionally replace habitat that has been affected. Most of the riparian vegetation within the species' range in the Plan Area is early- to midsuccessional, and this species prefers riparian scrub that is early successional; therefore, the replaced riparian vegetation is expected to meet habitat requirements for the riparian brush rabbit within the first few years after the initial restoration activities are complete.

Construction-Related Injury or Mortality

Water conveyance facility construction is not likely to result in injury or mortality of individual riparian brush rabbits because the species is not likely to be present in the areas that will be affected by this activity, based on live trapping results (Appendix 3.E, *Conservation Principles for the Riparian Brush Rabbit and Riparian Woodrat*). Tidal natural communities restoration will not result in injury or mortality of the riparian brush rabbit because, under AMM25, tidal natural communities restoration projects will be designed to avoid occupied riparian brush rabbit habitat (Appendix 3.C). Activities associated with construction of setback levees for floodplain restoration could result in injury or mortality of riparian brush rabbits: however, preconstruction surveys, construction monitoring, and other measures in AMM25 will be implemented to avoid and minimize injury or mortality of this species during construction, as described in Appendix 3.C. If occupied habitat cannot be avoided, mortality will be avoided through implementation of a trapping and relocation program. The program will be developed in coordination with USFWS, and relocation will be to sites approved by USFWS prior to construction activities.

Indirect Construction-Related Effects

Noise and visual disturbance adjacent to construction activities could indirectly affect the use of 101 acres of modeled riparian brush rabbit riparian habitat (3% of riparian habitat in the Plan Area) and 316 acres of associated grassland habitat (10% of riparian habitat in the Plan Area) (Table 5.6-5). These construction activities will include water conveyance (including transmission line) construction, tidal natural communities restoration construction, and construction of setback levees.

Water conveyance facility construction will potentially affect 5 acres of adjacent riparian habitat and 191 acres of associated grassland habitat. This construction will occur in Conservation Zone 8, and while suitable habitat exists in this area for the species, surveys by the Endangered Species Recovery Program (Figure 2.A.12-2, *Riparian Brush Rabbit Habitat Model and Recorded Occurrences*, Appendix 2.A, *Covered Species Accounts*) did not indicate the species is present in this area. Therefore, the potential for adverse noise and visual effects from water conveyance facility construction will be minimal. Tidal natural communities restoration construction will potentially affect 51 acres of adjacent riparian habitat and 51 acres of associated grassland habitat for this species. However, adverse effects on the species are unlikely, because, under AMM25, tidal natural communities restoration projects will be sited to avoid areas occupied by the riparian brush rabbit (Appendix 3.C). The activity most likely to result in noise and visual disturbance to the riparian brush rabbit is the construction of setback levees for floodplain restoration, which will take place in Conservation Zone 7, where the species is known to occur. Floodplain restoration will potentially indirectly affect 74 acres of riparian habitat and 45 acres of grassland habitat. These adverse effects will be minimized through AMM25, described in Appendix 3.C.

The use of mechanical equipment during construction might cause the accidental release of petroleum or other contaminants that will affect the riparian brush rabbit in adjacent habitat, if the species is present. The potential for this adverse effect will be avoided and minimized through best management practices (BMPs) under *AMM2 Construction Best Management Practices and Monitoring*, described in Appendix 3.C.

5.6.1.1.4 Effects of Ongoing Activities

Facilities Operation and Maintenance

Facilities operation and maintenance activities are not expected to adversely affect the riparian brush rabbit. This species is not expected to occur in the vicinity of proposed facilities.

Habitat Enhancement and Management

Enhancement and management actions in riparian brush rabbit habitat within the reserve system may include invasive plant removal, planting and maintaining vegetation to improve and sustain habitat characteristics for the species, and creating and maintaining flood refugia. Injury or mortality of the riparian brush rabbit will be avoided by implementation of *AMM25 Riparian Woodrat and Riparian Brush Rabbit*, described in Appendix 3.C. Although these activities may result in harassment of riparian brush rabbits through noise and visual disturbance, adverse effects will be minimal, if any.

Recreation

Passive recreation in the reserve system, where that recreation is compatible with the biological goals and objectives, could result in disturbance of individual riparian brush rabbits foraging in the ecotone between riparian and adjacent open habitats. However, *AMM37 Recreation* (Appendix 3.C) limits trail development adjacent to riparian corridors within the range of the riparian brush rabbit. With this minimization measure in place, recreation-related effects on the riparian brush rabbit are expected to be minimal.

5.6.1.1.5 Impact of Take on Species

Populations of the riparian brush rabbit are known to have occurred historically in riparian forests along the San Joaquin and Stanislaus Rivers and some tributaries to the San Joaquin River (U.S. Fish and Wildlife Service 1998). One population estimate within this historical range was approximately 110,000 individuals (U.S. Fish and Wildlife Service 1998). As a result of habitat loss and fragmentation, the species has since been reduced to populations in only two areas: an approximately 258-acre patch in Caswell Memorial State Park on the Stanislaus River, immediately southwest of the Plan Area; and several small, isolated or semi-isolated patches totaling approximately 270 acres along Paradise Cut and Tom Paine Slough and channel of the San Joaquin River in the south Delta, within the Plan Area. The Plan Area consists of a large proportion of the species' total range (Appendix 2.A, *Covered Species Accounts*). Conservation within the Plan Area is therefore important to the long-term survival and conservation of this species.

There are 6,011 acres of modeled riparian brush rabbit habitat in the Plan Area, consisting of 2,909 acres of riparian habitat and 3,103 acres of associated grassland habitat. Covered activities will result in permanent loss of 65 acres of riparian and 168 acres of grassland modeled habitat for the riparian brush rabbit, and additional temporary and potential indirect and ongoing management-related effects on modeled habitat as described above. Many of these effects will be in areas that are not likely to be occupied by the species (Conservation Zone 8) or will result from tidal natural communities restoration that will be designed to avoid occupied habitat. Periodic flooding is not expected to adversely affect the species because flood refugia will be constructed and maintained to allow riparian brush rabbits to escape flood waters. Effects most likely to result in take of the riparian brush rabbit are permanent habitat removal (65 acres of riparian and 168 acres of associated grassland habitat) and temporary habitat removal (35 acres of riparian and 74 acres of associated grassland habitat) as a result of levee construction for floodplain restoration.

Based on the rarity and narrow range of this species, and the large proportion of the species' range in the Plan Area, take resulting from covered activities has the potential to adversely affect the long-term survival and conservation of the species. However, beneficial effects on the species, described below, are expected to offset potential adverse effects of habitat loss and contribute to the long-term conservation of the riparian brush rabbit in the Plan Area.

5.6.1.2 Beneficial Effects

The Plan requires that at least 800 acres of early- to midsuccessional riparian natural community to be conserved in Conservation Zone 7, in areas that are adjacent to or that facilitate connectivity with existing occupied or potentially occupied habitat (Objective RBR1.2). This will consist of 200 acres of protected habitat (Objective RBR1.1) and 600 acres of restored habitat. The 800 acres to be conserved will consist of early successional riparian vegetation suitable for riparian brush rabbit. The conserved habitat will also be part of a larger, more contiguous, and less patchy area of protected and restored riparian natural community than what currently exists in Conservation Zone 7 and will be contiguous with existing modeled riparian brush rabbit habitat. Riparian restoration and protection will focus on connectivity along riparian systems within the Plan Area (linkages #5, 6, and 7, Figure 3.2-16, *Landscape Linkages*, in Chapter 3), and with existing riparian conservation lands south of the Plan Area (linkage #4, Figure 3.2-16). The Plan further requires that the 200 acres of protected riparian habitat (Objective RBR1.4) and 300 acres of the restored riparian habitat (Objective RBR1.3) meet more specific ecological requirements of riparian brush rabbit, including large patches of dense riparian brush; ecotonal edges that transition from brush species to grasses and forbs, scaffolding plants to support vines that grow above flood levels; a tree canopy that is open, if present; and high-ground refugia from flooding. In protected riparian areas that are occupied by riparian brush rabbit, nonnative predators that are known to prey on riparian brush rabbit will be monitored and controlled (Objective RBR1.5).

If riparian brush rabbits do not occupy riparian habitat areas protected and restored specifically for this species, the Endangered Species Recovery Program's captive breeding program (Williams et al. 2002) may be used as a source of individuals to be introduced into protected and restored riparian brush rabbit habitat in the Plan Area (see *CM11 Natural Communities Enhancement and Management*). Once used, the captive breeding program is not the responsibility of the Implementation Office to maintain.

In addition to restoration and protection of riparian habitat for the riparian brush rabbit, the Implementation Office will protect, and, if necessary, create or restore grasslands adjacent to suitable riparian vegetation in areas outside the floodplain levees (Objective RBR1.6). These grasslands are expected to provide additional foraging opportunities for the riparian brush rabbit and upland refugia during flood events. Assuming the restored and protected grassland natural community will provide riparian brush rabbit grassland habitat proportional to the amount of modeled grassland habitat in this natural community in the Plan Area (4% of the grassland natural community in the Plan Area is modeled riparian brush rabbit grassland habitat adjacent to riparian areas), the restoration of 2,000 acres of grassland natural community (*CM8 Grassland Natural Community Restoration*) will provide an estimated 79 acres of restored riparian brush rabbit grassland habitat that is comparable to or of higher value than existing modeled grassland habitat (Table 5.6-7). Based on the same assumption, the protection of 8,000 acres of grassland natural community (*CM3 Natural Communities Protection and Restoration*) will provide an estimated 317 acres of habitat that is comparable to or of higher value than existing modeled habitat for riparian brush rabbit (Table 5.6-7). However, the actual acreage of grassland to be restored or protected for riparian brush rabbit will depend on site-specific needs adjacent to restored and protected riparian habitat (see *CM3 Natural Communities Protection and Restoration* for details). Grasslands on the landward side of levees adjacent to restored floodplain will be restored or protected as needed to provide flood refugia and foraging habitat for riparian brush rabbit (Objective RBR1.6).

In addition to grasslands protected and restored outside the levees for riparian brush rabbit, as needed, the floodplains will transition from areas that flood frequently (i.e., every 1 to 2 years) to areas that flood infrequently (i.e., every 10 years or more) (Objective L1.5); these infrequently flooded areas will provide refuge for the riparian brush rabbit during most years. The Implementation Office will also create and maintain mounds, levee sections, or other high areas in restored and protected riparian areas (Objective RBR1.4) that are designed specifically to provide flood refugia for the riparian brush rabbit (Appendix 3.E, *Conservation Principles for the Riparian Brush Rabbit and Riparian Woodrat*). Additionally, nonnative predators that are known to prey on riparian brush rabbit (e.g., feral dogs and cats) will be monitored in protected and restored riparian areas that are occupied by riparian brush rabbit (Objective RBR1.5), and controlled as needed (*CM11 Natural Communities Enhancement and Management*).

5.6.1.3 Net Effects

Including both the habitat loss described in Section 5.6.1.1, *Adverse Effects*, and the riparian habitat restoration and protection described in Section 5.6.1.2, *Beneficial Effects*, the BDCP will result in an estimated net increase of 735 acres (25%) of total riparian habitat and an estimated net increase of 999 acres (729%) of protected riparian habitat for the riparian brush rabbit (Table 5.6-7). Similarly, the BDCP will result in an estimated net decrease of 89 acres (3%) in total adjacent grassland habitat and an estimated net increase of 290 acres (74%) in total protected adjacent grassland habitat for riparian brush rabbit.

Restored and protected habitat will have values greater than the modeled habitat currently present in the Plan Area. The 65 acres of riparian habitat and 168 acres of adjacent grassland habitat that will be lost as a result of covered activities includes areas in Conservation Zones 6 and 8 that are fragmented and isolated, and where Endangered Species Recovery Program surveys contracted by DWR (Figure 2A.12-2, *Riparian Brush Rabbit Habitat Model and Recorded Occurrences*, in Appendix 2.A, *Covered Species Accounts*) did not indicate species presence in this area; as well as some areas in Conservation Zone 7 that provide high-value habitat for the species, where the species is potentially present based on recorded occurrences in the vicinity. The 800 acres of maintained riparian habitat (Objective RBR1.2) will provide the riparian brush rabbit with large, contiguous habitat areas in Conservation Zone 7, and will either be occupied or contiguous with occupied habitat, in areas that facilitate connectivity between occupied and other suitable habitat, facilitate species dispersal and genetic interchange between populations, and contribute to population expansion and species conservation. Restoration and protection of adjacent grasslands and creation and maintenance of upland refugia are expected to protect the species from loss of individuals that could otherwise result from seasonal flooding in restored floodplains. All near-term loss of riparian brush rabbit habitat will result from water conveyance facility construction, which will occur in an area in Conservation Zone 8 consisting of fragmented habitat with no recorded species occurrences, as described above. Furthermore, all riparian protection will occur during the near-term period, to offset early riparian losses. Habitat loss in Conservation Zone 7, in areas known or likely to be occupied, will occur during the early long-term and late long-term periods. Riparian restoration will be phased to minimize temporal habitat loss (Table 6-3, *Compliance Schedule for Rough Proportionality Measurements*, in Chapter 6, *Plan Implementation*).

Overall, the BDCP will provide a substantial net benefit to the riparian brush rabbit through the increase in available habitat and habitat in protected status. These protected areas will be managed and monitored (both habitat and populations) to support the species. Therefore, the BDCP will minimize and mitigate impacts, to the maximum extent practicable, and provide for the conservation and management of the riparian brush rabbit in the Plan Area.

5.6.2 Riparian Woodrat

This section describes the adverse, beneficial, and net effects of the covered activities, including conservation measures, on the riparian woodrat. The methods used to assess these effects are described in Section 5.2.8, *Effects Analysis for Wildlife and Plants,* and Table 5.J.1, *Quantitative Effects Analysis Methods and Assumptions*, in Appendix 5.J, *Effects on Natural Communities, Wildlife, and Plants*. The habitat model used to assess effects for the riparian woodrat consists of selected plant alliances from the valley/foothill riparian natural community, geographically constrained to the south Delta portion of the Plan Area (Conservation Zone 7), south of State Route 4 and Old River Pipeline along the Stanislaus, San Joaquin, Old, and Middle Rivers. Valley/foothill riparian areas along smaller drainages (Paradise Cut, Tom Paine Slough), and some larger streams in the northern portion of Conservation Zone 7 were excluded from the riparian woodrat habitat model due to a lack of trees or riparian corridors that were too narrow. Further details regarding the habitat model, including assumptions on which the model is based, are provided in Appendix 2.A, *Covered Species Accounts.* Factors considered in assessing the value of affected habitat for the riparian woodrat, to the extent that information is available, include habitat patch size and connectivity.

5.6.2.1 Adverse Effects

5.6.2.1.1 Permanent Habitat Loss, Conversion, and Fragmentation

Covered activities will result in the permanent loss of up to 51 acres[2] of habitat (2% of the habitat in the Plan Area) for the riparian woodrat (Table 5.6-1). Covered activities resulting in adverse effects on the riparian woodrat include tidal natural communities restoration and seasonally inundated floodplain restoration. Seasonally inundated floodplain restoration is expected to result in the majority (41 acres; 80%) of the permanent habitat loss.

Tidal Natural Communities Restoration

This activity will result in the permanent removal of approximately 10 acres of riparian woodrat habitat in the South Delta ROA for the riparian woodrat (Table 5.6-1). This habitat is of low value, consisting of a small, isolated patch surrounded by cultivated lands, and the species has a relatively low likelihood of being present in these areas based on the low habitat value and lack of known occurrences in this and surrounding areas. *AMM25 Riparian Woodrat and Riparian Brush Rabbit*, described in Appendix 3.C, *Avoidance and Minimization Measures*, requires that tidal natural communities restoration avoid removal of any habitat occupied by the riparian woodrat as determined by presence/absence surveys.

Floodplain Restoration

Levee construction associated with floodplain restoration will result in the permanent removal of approximately 41 acres of riparian woodrat habitat in Conservation Zone 7 (Table 5.6-1). The value of this habitat for the riparian woodrat is moderate. Although the habitat consists of small patches and narrow bands of riparian vegetation and no riparian woodrats have been detected in Conservation Zone 7, the riparian patches are in proximity to each other along the San Joaquin River. There are two species occurrences immediately south of Conservation Zone 7, one of which is less than 1.5 mile from the southernmost patch of riparian habitat potentially affected by levee construction.

The final floodplain restoration design will differ from the hypothetical footprint used for this effects analysis. However, through monitoring and adaptive management described in Chapter 3, Section 3.6, *Adaptive Management and Monitoring Program*, and AMM25 (Appendix 3.C), the Implementation Office will ensure that riparian woodrat habitat permanently removed does not exceed the amount estimated based on the hypothetical footprint. Habitat loss is expected to be lower than 41 acres because sites will be selected and restoration designed to minimize effects on the riparian woodrat.

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[2] Habitat or natural community loss acreage estimates are based on hypothetical footprints and models rather than detailed project-level design and represent the maximum allowed under the permit. Actual losses will be tracked through compliance monitoring to ensure that they do not exceed estimates.

5.6.2.1.2 Periodic Inundation

Seasonal flooding as a result of floodplain restoration is the only covered activity expected to result in periodic inundation of riparian woodrat habitat.

Floodplain Restoration

Floodplain restoration will result in periodic inundation of up to 203 acres of riparian woodrat habitat (9% of the riparian woodrat habitat in the Plan Area). The area between existing levees will be breached and the newly constructed setback levees will be inundated through seasonal flooding. The potentially inundated areas consist of habitat of moderate value for the species. Although the habitat consists of small patches and narrow bands of riparian vegetation and no riparian woodrats have been detected in Conservation Zone 7, the riparian patches are in proximity to each other along the San Joaquin River and there are two species occurrences immediately south of Conservation Zone 7, one of which is less than 1 mile from the southernmost patch of riparian habitat potentially affected by levee construction. The restored floodplains will transition from areas that flood frequently (i.e., every 1 to 2 years) to areas that flood infrequently (i.e., every 10 years or more).

Seasonal flooding in restored floodplains can result in injury or mortality of individuals if riparian woodrats occupy these areas and cannot escape flood waters. The adverse effects of periodic inundation on the riparian woodrat will be minimized through construction and maintenance of flood refugia to allow riparian woodrats to escape inundation, as described under Section 5.6.2.2, *Beneficial Effects*.

5.6.2.1.3 Construction-Related Effects

Permanent effects of construction are described above in Section 5.6.2.1.1, *Permanent Habitat Loss, Conversion, and Fragmentation*. Other construction-related effects on the riparian woodrat include temporary habitat loss as a result of grading and ground disturbance, construction-related injury or mortality, and indirect effects, outside the project footprint, including noise and visual disturbance. Effects on the species are described below for each effect category. Effects are described collectively for all covered activities, and are also described for specific covered activities to the extent that this information is pertinent for assessing the value of affected habitat or the specific nature of the effect.

Temporary Habitat Loss

Levee construction will temporarily remove approximately 33 acres of riparian woodrat habitat (1.5% of total habitat in the Plan Area). Temporarily disturbed areas will be restored as riparian habitat within 1 year following completion of construction and management activities. Although the effects are considered temporary, the replaced riparian vegetation will likely take over a decade to develop suitable oak overstory for the species. As described in AMM25 (Appendix 3.C), floodplain restoration projects in Conservation Zone 7 will be designed to minimize the removal of mature oaks in areas providing suitable habitat for the riparian woodrat.

Construction-Related Injury or Mortality

Tidal natural communities restoration will not result in injury or mortality of riparian woodrat, because, under AMM26, tidal natural communities restoration projects will be designed to avoid occupied riparian woodrat habitat (Appendix 3.C). Activities associated with construction of setback levees for floodplain restoration could result in injury or mortality of riparian woodrats; however, preconstruction surveys, construction monitoring, and other measures will be implemented under

AMM25 to avoid and minimize injury or mortality of this species during construction, as described in Appendix 3.C. If occupied riparian woodrat habitat cannot be avoided, mortality will be avoided through implementation of a trapping and relocation program. The program will be developed in coordination with USFWS, and trapped individual will be relocated to a site approved by USFWS prior to construction activities.

Indirect Construction-Related Effects

Noise and visual disturbance adjacent to construction activities could indirectly affect the use of 81 acres of modeled habitat for the riparian woodrat (4% of its habitat in the Plan Area) (Table 5.6-5). These effects are related to construction activities associated with tidal natural communities restoration construction and construction of setback levees. Construction associated with tidal natural communities restoration will indirectly affect 18 acres of modeled habitat for this species: however, adverse effects on the species are unlikely, because, under AMM25, tidal natural communities restoration projects will be sited to avoid areas occupied by riparian woodrats (Appendix 3.C). The activity most likely to result in noise and visual disturbance to riparian woodrats is the construction of setback levees, where 63 acres of indirect effects are anticipated. These adverse effects will be minimized through the implementation of AMM25.

5.6.2.1.4 Effects of Ongoing Activities

The only ongoing effects on the riparian woodrat are those potentially resulting from habitat enhancement and management activities.

Enhancement and management actions in riparian woodrat habitat within the reserve system may include invasive plant removal, planting and maintaining vegetation to improve and sustain habitat characteristics for the species, and creating and maintaining flood refugia. Injury or mortality of the riparian woodrat will be avoided with implementation of AMM25, described in Appendix 3.C. Although these activities may result in harassment of riparian woodrats through noise and visual disturbance, adverse effects will be minimal, if any.

5.6.2.1.5 Impact of Take on Species

There are three extant CNDDB riparian woodrat occurrences in the species' range, none of which are in the Plan Area. The current known range of the species is confined to a small area in northern San Joaquin County immediately south of the Plan Area, with the nearest known extant CNDDB occurrence approximately 1.5 to 2 miles to the southeast of Conservation Zone 7, in Caswell State Park. An additional extant population might occur just outside the Plan Area, near Vernalis along the San Joaquin River, although there have been no sightings of the species at this location since the 1970s (Williams and Kilburn 1992). Based on the proximity of these occurrences, the riparian woodrat potentially occurs in suitable habitat in the Plan Area, in Conservation Zone 7, or could occupy this area in the future.

Full implementation of the BDCP will result in permanent loss of up to 51 acres (2% of the habitat in the Plan Area), temporary loss of 33 acres (less than 2% of the habitat in the Plan Area), and periodic inundation of up to 203 acres (9% of the habitat in the Plan Area) of habitat for the riparian woodrat. Take of riparian woodrats resulting from BDCP implementation is not expected to adversely affect the long-term survival and conservation of this species for the following reasons.

- There are no riparian woodrat occurrences in the Plan Area.

- The habitat that will be removed consists of small patches that are of moderate value for the species.
- The habitat that will be removed permanently is a small proportion of the total habitat in the Plan Area (2%).
- Avoidance and minimization measures will be implemented to avoid injury or mortality of riparian woodrats, and to minimize loss of occupied habitat.
- Floodplain restoration will be designed to provide flood refugia so that flooding will not adversely affect any riparian woodrats that occupy restored floodplains.

5.6.2.2 Beneficial Effects

The Plan requires 300 acres of riparian habitat that meets the ecological requirements of the riparian woodrat (e.g., dense willow understory and oak overstory) and that is adjacent to or facilitates connectivity with existing occupied or potentially occupied habitat to be restored in Conservation Zone 7 (Objective RW1.1). The conserved habitat will also be part of a larger, more contiguous, and less patchy area of protected and restored riparian natural community than what currently exists in Conservation Zone 7 and will be contiguous with existing modeled riparian woodrat habitat. Riparian restoration and protection will focus on connectivity along riparian systems within the Plan Area (linkages #5, 6, and 7, Figure 3.2-16, *Landscape Linkages*, in Chapter 3), and with preserved riparian lands south of the Plan Area (linkage #4, Figure 3.2-16). Additionally, assuming the protected riparian natural community will provide riparian woodrat habitat proportional to the amount of modeled habitat in this natural community in the Plan Area (12% of the riparian natural community in the Plan Area is modeled riparian woodrat habitat), the protection of 750 acres of riparian natural community (*CM3 Natural Communities Protection and Restoration*) will provide an estimated 90 acres of protected riparian woodrat habitat that is comparable to or of higher value than existing modeled grassland habitat (Table 5.6-7). All riparian protection will occur during the near-term period, to offset early riparian losses.

The Implementation Office will also create and maintain mounds, levee sections, or other high areas in restored and protected riparian areas (Objective RW1.2) that are designed specifically to provide flood refugia for the riparian woodrat (Appendix 3.E, *Conservation Principles for the Riparian Brush Rabbit and Riparian Woodrat*). In addition, the restored floodplains will transition from areas that flood frequently (i.e., every 1 to 2 years) to areas that flood infrequently (i.e., every 10 years or more) (Objective L1.5); these infrequently flooded areas will provide refuge for the riparian woodrat during most years.

5.6.2.3 Net Effects

Including both the habitat loss described in Section 5.6.2.1, *Adverse Effects*, and the riparian habitat restoration and protection described in Section 5.6.2.2, *Beneficial Effects*, the BDCP will result in an estimated net increase of 249 acres (11%) in total riparian woodrat habitat and an estimated net increase of 390 acres (390%) in protected riparian habitat for the riparian woodrat (Table 5.6-7). The habitat that will be lost as a result of covered activities is of low to moderate value, consisting of small patches, some of which are isolated and surrounded by cultivated lands, and others that are in proximity to other riparian patches along the San Joaquin River. Habitat potentially removed in the southernmost portion of Conservation Zone 7 as a result of floodplain restoration is of higher value for the riparian woodrat because it is closer to riparian woodrat occurrences to the south. The habitat that will be restored will be high-value habitat that will be managed specifically to maintain suitable habitat components for the riparian woodrat. All riparian protection will occur during the near-term period, while habitat loss will occur during the early long-term and late long-term periods. Riparian restoration will be phased to minimize temporal habitat loss (Table 6-3, *Compliance Schedule for Rough Proportionality Measurements*, Chapter 6, *Plan Implementation*). Although there are no records of occurrences of the riparian woodrat in the Plan Area, habitat restoration in Conservation Zone 7, in the vicinity of occurrences south of the Plan Area, will increase opportunities for northward expansion of the species into the Plan Area.

Overall, the BDCP will provide a substantial net benefit to the riparian woodrat through the net increase in available habitat, and a net increase of habitat in protected status. These protected areas will be managed and monitored to support the species. Therefore, the BDCP will minimize and mitigate impacts, to the maximum extent practicable, and provide for the conservation and management of the riparian woodrat in the Plan Area.

5.6.3 Salt Marsh Harvest Mouse

This section describes the adverse, beneficial, and net effects of the covered activities, including conservation measures, on the salt marsh harvest mouse. The methods used to assess these effects are described in Section 5.2.8, *Effects Analysis for Wildlife and Plants*, and Table 5.J.1, *Quantitative Effects Analysis Methods and Assumptions*, in Appendix 5.J, *Effects on Natural Communities, Wildlife, and Plants*. The habitat model used to assess effects for the salt marsh harvest mouse includes six habitat types.

- Primary tidal marsh habitat.
- Secondary tidal marsh habitat (low marsh).
- Secondary upland habitat adjacent to tidal marsh habitat.
- Primary habitat in managed wetlands.
- Secondary habitat within managed wetlands (dominated by plants characteristic of low marsh).
- Upland habitats in managed wetland boundaries.

The tidal and managed wetland habitats are differentiated because of differences in long-term conservation values: managed wetlands are at high risk of catastrophic flooding and have lower long-term conservation value than tidal wetlands. The model includes habitat with a minimum patch size of 1 acre that is within Suisun Marsh and the portion of the Delta between Chipps Island and the western edge of Sherman Island (but not including Sherman Island; see Appendix 2.A, *Covered Species Accounts*). The model for upland habitat includes grasslands within 150 feet of tidal wetland edges in the modeled area, and upland vegetation within managed wetland diked areas. Further details regarding the habitat model, including assumptions on which the model is based, are provided in Appendix 2.A. Factors considered in assessing the value of affected habitat for the salt marsh harvest mouse, to the extent that information is available, include suitability of vegetation, habitat sustainability, and habitat contiguity.

5.6.3.1 Adverse Effects

5.6.3.1.1 Permanent Habitat Loss, Conversion, and Fragmentation

Covered activities will result in the permanent loss or conversion of up to 6,968 acres[3] of primary and secondary habitat (20% of the 35,588 acres of habitat in the Plan Area) for the salt marsh harvest mouse (Table 5.6-1). The only covered activity resulting in adverse effects on this species is tidal natural communities restoration, described below.

Tidal Natural Communities Restoration

Based on the hypothetical tidal restoration scenario described in Appendix 3.B, *BDCP Tidal Habitat Evolution Assessment*, tidal restoration will result in the inundation or construction loss or conversion of an estimated 6,968 acres of salt marsh harvest mouse habitat. Virtually all of the loss will be of managed wetlands that will be converted to tidal habitat. There is no loss of primary tidal wetland habitat, only conversion from primary to secondary low marsh (67 acres) as these areas experience a greater level of tidal flooding as a result of tidal restoration.

Tidal natural communities restoration throughout the Plan Area will all occur by year 40 in roughly even amounts for every 5-year period until year 40 (Chapter 6, *Plan Implementation*), with early restoration efforts focusing on restoration of areas most likely to support middle and high marsh. Initial adverse effects on the salt marsh harvest mouse and other tidal marsh covered species will be minimized through site selection and careful phasing of tidal marsh restoration in Suisun Marsh to ensure that sufficient and suitable habitat is available adjacent to tidal restoration areas so that salt marsh harvest mice are able to find refuge near restoration sites, and able to recolonize restored sites (*CM4 Tidal Natural Communities Restoration*).

5.6.3.1.2 Periodic Inundation

No periodic inundation effects on the salt marsh harvest mouse will occur as a result of covered activities.

5.6.3.1.3 Construction-Related Effects

Construction is not expected to result in loss of salt marsh harvest mouse habitat other than that described in in Section 5.6.3.1.1, *Permanent Habitat Loss, Conversion, and Fragmentation.* All staging and other temporary construction-related work areas for tidal natural communities restoration will either be on areas that do not provide habitat for the species (i.e., already disturbed sites) or will be within the footprint of permanently affected areas described above.

Construction-Related Injury or Mortality

The operation of equipment for construction could result in injury or mortality of salt marsh harvest mice, if present. However, under *AMM26 Salt Marsh Harvest Mouse and Suisun Shrew*, described in Appendix 3.C, *Avoidance and Minimization Measures,* nonmechanized equipment will be used to remove vegetation in salt marsh harvest mouse habitat. Restrictions on the use of mechanized equipment, biological construction monitoring, and other measures will be implemented to ensure

[3] Habitat or natural community loss acreage estimates are based on hypothetical footprints and models rather than detailed project-level design and represent the maximum allowed under the permit. Actual losses will be tracked through compliance monitoring to ensure that they do not exceed estimates.

that salt marsh harvest mice occupying the construction area will be able to leave and escape to suitable adjacent habitat. Any vegetation removed will be done under supervision of a CDFW- and USFWS-approved biological monitor familiar with salt marsh harvest mouse. Temporary exclusion fences will be installed to ensure that mice do not reenter work areas during construction.

Petroleum or other contaminant spills from construction equipment, drilling operations, or other activities could also affect salt marsh harvest mice, if present, and their habitat. Implementation of *AMM5 Spill Prevention, Containment, and Countermeasure Plan* and *AMM32 Hazardous Material Management* (Appendix 3.C) will minimize the potential for this effect.

Indirect Construction-Related Effects

Noise and visual disturbance outside the project footprint but within 100 feet of construction activities could temporarily affect the use of 429 acres (1.2%) of modeled salt marsh harvest mouse habitat (Table 5.6-5).

5.6.3.1.4 Effects of Ongoing Activities

Facilities Operation and Maintenance

Ongoing operation and maintenance activities are not expected to result in adverse effects on the salt marsh harvest mouse. Ongoing water operations are expected to change salinity levels but this is expected to have a beneficial effect on the salt marsh harvest mouse, as described below in Section 5.6.3.2, *Beneficial Effects*.

Habitat Enhancement and Management

Habitat enhancement and management activities in salt marsh harvest mouse habitat could result in temporary habitat disturbance or removal, and noise and disturbance related effects to adjacent habitat, but adverse effects, if any, are expected to be minimal. Vegetation manipulation for managed wetland management may include planting, herbicide treatment, flooding, burning, discing, and mowing. Injury or mortality of the salt marsh harvest mouse as a result of these activities will be avoided with implementation of *AMM26 Salt Marsh Harvest Mouse and Suisun Shrew* (Appendix 3.C). Discing will be limited to no more than 20% of the managed wetlands at any given time, to minimize effects on salt marsh harvest mouse (*CM11 Natural Communities Enhancement and Management*). Vegetation will be removed under supervision of a CDFW- and USFWS-approved biological monitor familiar with salt marsh harvest mouse. Management activities to minimize adverse effects and maximize beneficial effects on salt marsh harvest mouse in managed wetlands are described in CM11. Beneficial effects of managed wetland management on salt marsh harvest mouse are described in Section 5.6.3.2, *Beneficial Effects.*

Management of the 5,000 acres of managed wetlands to be protected for waterfowl and shorebirds is not expected to result in adverse effects on the salt marsh harvest mouse. Management actions that will improve wetland quality and diversity on managed wetlands include control and eradication of invasive plants; maintenance of a diversity of vegetation types and elevations, including upland areas to provide flood refugia; water management and leaching to reduce salinity; and enhancement of water management infrastructure (improvements to enhance drainage capacity, levee maintenance). These management actions will potentially benefit the salt marsh harvest mouse. The 5,000 acres of protected managed wetlands will be monitored and adaptively managed to ensure that management actions are implemented to avoid adverse effects on the salt marsh harvest mouse.

Recreation

Passive recreation in the reserve system, where that recreation is compatible with the biological goals and objectives, could result in disturbance of salt marsh harvest mice using habitat in the vicinity of trails. However, this species is primarily nocturnal, so day use is expected to have minimal effects on the species. Additionally, *AMM37 Recreation* (Appendix 3.C) limits trail placement to existing levees and requires enforcement of leash laws (excluding hunting activities). With recreation restrictions in place, as required under AMM37, recreation is not expected to have adverse effects on salt marsh harvest mouse.

5.6.3.1.5 Other Indirect Effects

Mercury

Covered activities have the potential to increase exposure to mercury in covered species that feed in aquatic environments. Exposure to methylmercury is known to affect mammals and thus could adversely affect the salt marsh harvest mouse. The operational impacts of new flows under the BDCP were analyzed using a DSM-2-based model to assess potential effects on mercury concentration and bioavailablity. Subsequently, a regression model was used to estimate fish-tissue concentrations in striped bass under these future operational conditions. Results indicated that changes in total mercury levels in water and fish tissues under future conditions with the BDCP were insignificant (Appendix 5.D, *Contaminants*, Attachment 5D.A, *Bioaccumulation Model Development for Mercury Concentrations in Fish,* Tables 5.D.A-1, 5.D.A-2, 5.D.A-3, and 5.D.A-4).

Marsh and floodplain restoration may also increase exposure to methylmercury. Mercury is transformed into the more bioavailable form of methylmercury in aquatic systems, especially areas subjected to regular wetting and drying such as tidal marshes and floodplains. Thus, restoration activities that create newly inundated areas could increase the bioavailability of mercury. Increased methylmercury associated with natural community and floodplain restoration may indirectly affect the salt marsh harvest mouse, via uptake in lower trophic levels (Appendix 5.D, *Contaminants*). In general, the highest methylation rates are associated with high tidal marshes that experience intermittent wetting and drying and associated anoxic conditions (Alpers et al. 2008). The potential mobilization or creation of methylmercury in the Plan Area varies with site-specific conditions and will need to be assessed at the project level. The *Suisun Marsh Habitat Management, Preservation, and Restoration Plan* (Suisun Marsh Plan) (Bureau of Reclamation et al. 2010) anticipates that tidal wetlands restored under the plan will generate less methylmercury than the existing managed wetlands. Along with minimization and mitigation measures and adaptive management and monitoring, *CM12 Methylmercury Management* is expected to reduce the amount of methylmercury resulting from the restoration of natural communities and floodplains. Currently, it is unknown if or how much of the sediment-derived methylmercury enters the food chain or what tissue concentrations are harmful to the salt marsh harvest mouse.

5.6.3.1.6 Impact of Take on Species

The salt marsh harvest mouse is endemic to the salt marshes of San Francisco, San Pablo, and Suisun Bays. The species today potentially occupies an area representing 15% of the habitat it historically occupied in this area (Dedrick 1989). Suisun Marsh, in the Plan Area, includes roughly 20% of the range-wide distribution of the salt marsh harvest mouse and is identified as a recovery unit in the *Draft Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California* (Draft Tidal Marsh Recovery Plan) (U.S. Fish and Wildlife Service 2010a). The Plan Area is therefore important to the long-term survival and conservation of the salt marsh harvest mouse.

Tidal natural communities restoration will result in the permanent loss or conversion of up to 20% of the salt marsh harvest mouse habitat in the Plan Area (6,968 acres). This temporal habitat loss has the potential to adversely affect the salt marsh harvest mouse population in Suisun Marsh. However, this temporal loss will be minimized by phasing efforts over time, allowing habitat and populations to recover at one restoration site before moving to the next. This will ensure that short-term population loss is small and incremental, and local population sources are preserved for recolonizing restored areas. Monitoring and the application of any adaptive management measures as needed, as described in Appendix 3.D, *Monitoring and Research Actions*, will ensure maintenance of salt marsh harvest mouse populations.

The Draft Tidal Marsh Recovery Plan describes a recurrent dilemma: the species often occupies diked wetlands, an anthropogenic habitat (U.S. Fish and Wildlife Service 2010a). Tidal marsh restoration is often accomplished by breaching levees and converting diked nontidal marsh currently occupied by salt marsh harvest mice to tidal wetlands, their historical condition. Conversion of these subsided areas requires sedimentation and accretion over time to restore marsh plains, resulting in a prolonged period (sometimes a decade or more) in which resident mice populations are displaced by uninhabitable aquatic areas (U.S. Fish and Wildlife Service 2010a). Despite these temporary adverse effects, the Draft Tidal Marsh Recovery Plan and Suisun Marsh Plan advocate strongly restoring tidal wetlands by converting managed wetlands. These plans are based on the premise that managed wetlands are at high risk of loss of salt marsh harvest mouse habitat from a variety of factors, including flooding from levee failure and cessation of active management (which is often necessary to maintain habitat values in managed wetlands). Therefore, the temporary effects under the BDCP are consistent with those deemed acceptable in the Draft Tidal Marsh Recovery Plan and the Suisun Marsh Plan. These temporary effects will be offset as described in Section 5.6.3.2, *Beneficial Effects*.

Take of the salt marsh harvest mouse through tidal natural communities restoration activities implemented by the BDCP has the potential to adversely affect the survival and conservation of the salt marsh harvest mouse. The removal of up to 20% of the species' habitat in the Plan Area may diminish the salt marsh harvest mouse population in the Plan Area and result in reduced genetic diversity, thereby putting the local population at risk of local extirpation due to random environmental fluctuations or catastrophic events. This effect is expected to be greatest if large amounts of habitat are removed at one time in Suisun Marsh and are not effectively restored for many years, and if there are no adjacent lands with salt marsh harvest mouse populations to recolonize restored areas. However, as described in Section 5.6.3.2, *Beneficial Effects*, below, measures will be implemented to ensure that the salt marsh harvest mouse population in the Plan Area is not adversely affected in this manner, and that the long-term benefits of tidal natural communities restoration outweigh the short-term adverse effects of these actions.

5.6.3.2 Beneficial Effects

Tidal restoration in Suisun Marsh is expected to increase the extent, quality, and connectivity of habitat for salt marsh harvest mouse. The Implementation Office will restore at least 6,000 acres of tidal brackish emergent wetland natural community in Suisun Marsh that will be distributed among three zones—the Western Suisun/Hill Slough Marsh Complex, the Suisun Slough/Cutoff Slough Marsh Complex, and the Nurse Slough/Denverton Marsh Complex (Objective TBEWNC1.1). These 6,000 acres are expected to provide primary and secondary habitat for salt marsh harvest mouse. Of the 6,000 acres, at least 1,500 acres will consist of primary middle and high marsh habitat in 150-acre or greater patches that provide viable habitat areas for the salt marsh harvest mouse habitat consistent with the Draft Tidal Marsh Recovery Plan (U.S. Fish and Wildlife Service 2010a). The Implementation Office will also protect and enhance at least 1,500 acres of managed wetlands in the Grizzly Island Marsh Complex to provide suitable habitat for the salt marsh harvest mouse consistent with the Draft Tidal Marsh Recovery Plan (U.S. Fish and Wildlife Service 2010a). The Plan stipulates that the 1,500 acres of restored middle and high marsh habitat will meet salt marsh harvest mouse population capture efficiency targets described in the Final Tidal Marsh Recovery Plan (U.S. Fish and Wildlife Service in prep.) (Objective SMHM1.1). The Plan also stipulates that salt marsh harvest mouse populations in the 1,500 acres of managed wetlands will increase above the current baseline (Objective SMHM1.2). These population objectives are expected to be met through restoration, enhancement, and management actions described in *CM4 Tidal Natural Communities Restoration* and *CM11 Natural Communities Enhancement and Management*.

Upland transitional areas will be protected adjacent to restored tidal lands to accommodate sea level rise. Within the transitional uplands, a 200-foot-wide swath adjacent to tidally restored areas will be maintained as upland habitat for salt marsh harvest mouse and other tidal brackish emergent wetland species (*CM4 Tidal Natural Communities Restoration*). Additionally, grasslands will be protected to provide at least 200 feet of grasslands adjacent to tidal brackish emergent wetlands beyond the sea level rise accommodation. Both the 200-foot-wide swath within the transitional uplands and the 200-foot-wide swath beyond sea level rise accommodation will be managed to provide upland cover and flood refugia for the salt marsh harvest mouse.

In order to ensure that temporal loss as a result of tidal natural communities restoration does not adversely affect the salt marsh harvest mouse population, restoration in Suisun Marsh will be carefully phased over time to offset adverse effects of restoration as it occurs, ensure that short-term population loss is relatively small and incremental, and maintain local source populations to recolonize newly restored areas (*CM4 Tidal Natural Communities Restoration*). The salt marsh harvest mouse habitat and population will be monitored during the phasing process and adaptive management will be applied to ensure maintenance of Suisun Marsh populations as described in Appendix 3.D, *Monitoring and Research Actions*.

Water salinity in Suisun Marsh is generally expected to increase as a result of water operations and operations of salinity control gates to mimic a more natural water flow. This will likely encourage the establishment of tidal wetland plant communities tolerant of more saline environments, such as pickleweed (*Salicornia pacifica*), which should be favorable to the salt marsh harvest mouse because of the importance of pickleweed as both food and cover. However, the degree to which salinity changes in all tidal channels and sloughs in and around Suisun Marsh is highly variable, and the salt marsh harvest mouse response to these changes may be variable as well.

5.6.3.3 Net Effects

Including both the habitat loss described in Section 5.6.3.1, *Adverse Effects*, and the habitat restoration and protection described in Section 5.6.3.2, *Beneficial Effects*, the BDCP will result in an estimated net decrease of 922 acres (3%) in total salt marsh harvest mouse habitat and an estimated net increase of 634 acres (2%) in salt marsh harvest mouse habitat on conservation lands (Table 5.6-7).

It is expected that the 6,000 acres of restored tidal brackish marsh habitat will provide greater long-term conservation value for the salt marsh harvest mouse than the high-risk managed wetland habitat that will be lost, consistent with the Draft Tidal Marsh Recovery Plan. In addition, part of the conservation strategy is to conserve (protect and enhance) 1,500 acres of managed wetland on the Grizzly Island Marsh Complex specifically for this species. The habitat that will be restored and protected will consist of large blocks of contiguous tidal brackish emergent wetland that have a large proportion of pickleweed-dominated vegetation suitable for the species. This will provide greater habitat connectivity and greater habitat value and quantity, which is expected to accommodate larger populations and to therefore increase population resilience to random environmental events and climate change. The managed wetland habitat that will be converted to tidal brackish emergent wetland habitat is not a sustainable habitat type because of the potential for catastrophic flooding associated with subsided lands, known levee instability, and sea level rise, in addition to the intensive management required of these lands (U.S. Fish and Wildlife Service 2010b).

Although tidal natural communities restoration will remove occupied habitat and displace existing salt marsh harvest mice from the restored areas over the short term, at least 1,500 acres of these areas will be converted to high-value primary habitat that will provide lasting, long-term benefits to the species. The effects of temporal loss on the population will be minimized through monitoring and phasing to mitigate loss as it occurs and to protect adjacent source populations for subsequent recolonization into newly restored areas. Additional opportunities to benefit this species will also be sought throughout the restoration process.

Overall, the BDCP will provide a long-term net benefit to the salt marsh harvest mouse through the increase in available high-value and sustainable habitat in large, connected blocks, and management and enhancement of this habitat specifically to benefit the salt marsh harvest mouse. These protected areas will be managed and monitored to support the species, and adaptive management will be implemented as needed to ensure restoration goals are met (Chapter 3, Section 3.6, *Adaptive Management and Monitoring Program*). Therefore, the BDCP will minimize and mitigate impacts, to the maximum extent practicable, and provide for the conservation and management of the salt marsh harvest mouse in the Plan Area.

5.6.4 San Joaquin Kit Fox

This section describes the adverse, beneficial, and net effects of the covered activities, including conservation measures, on the San Joaquin kit fox. The methods used to assess these effects are described in Section 5.2.8, *Effects Analysis for Wildlife and Plants,* and Table 5.J.1, *Quantitative Effects Analysis Methods and Assumptions*, in Appendix 5.J, *Effects on Natural Communities, Wildlife, and Plants*. The habitat model used to assess effects for the San Joaquin kit fox includes grasslands and vernal pool complex in the area south and west of State Route 4 from Antioch to Old River and in the vicinity of Clifton Court Forebay, as described further in Appendix 2.A, *Covered Species Accounts.* Factors considered in assessing the value of affected habitat for the San Joaquin kit fox, to the extent that information is available, include size and connectivity of habitat patches.

5.6.4.1 Adverse Effects

5.6.4.1.1 Permanent Habitat Loss, Conversion, and Fragmentation

Covered activities will result in the permanent loss of up to 214 acres of habitat (4% of the habitat in the Plan Area) for the San Joaquin kit fox (Table 5.6-1). The majority of these impacts (97%) are from water conveyance facility construction.

Water Conveyance Facility Construction

This activity will result in the permanent removal of 207 acres of modeled kit fox habitat in Conservation Zone 8, immediately south of Clifton Court Forebay. This habitat is of low value as it is composed of fragmented patches of grassland surrounded by cultivated lands. Habitat connectivity is important for the species because of its long-distance movements. The San Joaquin kit fox habitat that will be lost is located between two large canals leading from the forebay. These canals already greatly restrict movement for kit foxes in the region, so the additional impact is not expected to sever or further degrade an existing movement route for the species.

An estimated 52 of the 207 acres of San Joaquin kit fox habitat will be lost due to placement of reusable tunnel material. The material will likely be moved to other sites for use in levee build-up and restoration, and the affected area will likely be restored. While this effect is categorized as permanent, because there is no assurance that the material will eventually be moved, the effect will likely be temporary. Furthermore, the amount of storage area needed for reusable tunnel material is flexible, and the footprint used in the effects analysis is based on a worst-case scenario; the actual area to be affected by reusable tunnel material storage will likely be less than the estimated acreage.

Recreation

Based on the recreation assumptions described in Chapter 4, *Covered Activities and Associated Federal Actions*, an estimated 7.5 acres of San Joaquin kit fox habitat will be removed as a result of constructing trails and associated recreational facilities. *AMM24 San Joaquin Kit Fox* will be implemented to ensure that kit fox dens are avoided, as described in Appendix 3.C, *Avoidance and Minimization Measures*.

5.6.4.1.2 Periodic Inundation

No periodic inundation effects on the San Joaquin kit fox will occur as a result of covered activities.

5.6.4.1.3 Construction-Related Effects

Permanent effects of construction are described above in the Section 5.6.4.1.1, *Permanent Habitat Loss, Conversion, and Fragmentation*. Other construction-related effects on the San Joaquin kit fox include temporary habitat loss from establishment and use of borrow and spoil areas, construction-related injury or mortality, and temporary, construction-related indirect effects. Effects on the species are described below for each effect category. Effects are described collectively for all covered activities, and are also described for specific covered activities to the extent that this information is pertinent for assessing the value of affected habitat or specific nature of the effect.

Temporary Habitat Loss

Establishment and use of borrow and spoil areas associated with water facility construction will result in the removal of approximately 103 acres of habitat for this species in Conservation Zone 8 (Table 5.6-1). Although these borrow and spoil areas will be restored to preproject conditions within a year following construction, they may not be restored to their original topography. This habitat, in the vicinity of Clifton Court Forebay, is of low value as it is composed of fragmented patches of grassland surrounded by cultivated lands.

Construction-Related Injury or Mortality

During construction activities, construction equipment could result in the injury or mortality of San Joaquin kit foxes if individuals are present; however, no injury or mortality of the kit fox is expected to occur because foxes are not likely to be present in the Plan Area, and if present, will likely avoid the increased activity and noise related to the construction activities. Preconstruction surveys will be conducted and if kit fox dens are found, AMM24 will be implemented to ensure that injury or mortality is avoided, as described in Appendix 3.C.

Indirect Construction-Related Effects

Noise and visual disturbances outside the project footprint but within 250 feet of construction activities could temporarily affect the use of 182 acres (3%) of modeled San Joaquin kit fox habitat (Table 5.6-5). Given the remote likelihood of active kit fox dens in the vicinity of the conveyance facility, the potential for this effect is small and will further be minimized with the implementation of seasonal no-disturbance buffers around occupied dens, if any, and other measures as described in AMM24 (Appendix 3.C).

5.6.4.1.4 Effects of Ongoing Activities

The only ongoing covered activities expected to affect the San Joaquin kit fox are those associated with habitat enhancement and management, and recreational activities.

Habitat Enhancement and Management

A variety of habitat management actions to be implemented to enhance wildlife values on conservation lands may result in localized ground disturbances that could temporarily remove small amounts of San Joaquin kit fox habitat in Conservation Zone 8. Ground-disturbing activities such as removal of nonnative vegetation and road and other infrastructure maintenance activities are expected to have minor effects on available kit fox habitat. Management activities could result in the injury or mortality of San Joaquin kit foxes if individuals are present in work sites or if dens occur in the vicinity of habitat management work sites. Noise and visual disturbances could also affect San Joaquin kit fox use of the surrounding habitat. These effects are expected to be minor, and will be minimized with implementation of the worker awareness training, monitoring, avoidance of active kit fox dens, and BMPs described in Appendix 3.C.

Recreation

Passive recreation in the reserve system, where that recreation is compatible with the biological goals and objectives, could result in disturbance of San Joaquin kit foxes at their den site. Natal and pupping dens would be particularly vulnerable to human disturbance. Additionally, disease could be transmitted from domestic dogs that enter the reserve system with recreational users. However, *AMM37 Recreation* (Appendix 3.C) prohibits construction of new trails within 250 feet of active kit fox dens. Existing trails will be closed within 250 feet of active natal/pupping dens until young have vacated, and within 50 feet of other active dens. No dogs will be allowed on reserve units with active kit fox populations. Rodent control will be prohibited even on grazed or equestrian-access areas with kit fox populations. With these restrictions, recreation-related effects on San Joaquin kit fox are expected to be minimal.

5.6.4.1.5 Impact of Take on Species

The southwestern portion of the Plan Area (Conservation Zone 8) overlaps with the northernmost extent of the San Joaquin kit fox's range-wide distribution. The San Joaquin kit fox was originally found throughout most of the San Joaquin Valley in Central California, but is now found only on the edges of the San Joaquin Valley from southern Kern County up to Alameda, Contra Costa, and San Joaquin Counties on the west and up to Stanislaus County on the east, and a few populations exist in the valley floor. When the San Joaquin kit fox was added to the endangered species list in 1967, there were no known extant occurrences in San Joaquin County or northward. In the 1970s, however, surveys revealed that the range of the kit fox extended northward beyond Tracy to Contra Costa County (Jensen 1972; Clark et al. 2002). Relatively few San Joaquin kit foxes have been found in the northern portion of their range within the last few decades, despite a number of surveys (Hall 1983; California Department of Fish and Game 1983; Bell 1994; Smith et al. 2006; Clark et al. 2007).

The northern range of the San Joaquin kit fox (including the Plan Area) was most likely marginal habitat historically and has been further degraded due to development pressures, habitat loss, and fragmentation (Clark et al. 2007). CNDDB (California Department of Fish and Wildlife 2013a) reports eight occurrences of San Joaquin kit foxes along the extreme western edge of the Plan Area within Conservation Zone 8, south of Brentwood. However, Clark et al. (2007) provide evidence that a number of CNDDB occurrences in the northern portion of the species' range may be coyote pups misidentified as kit foxes. Smith et al. (2006) suggest that the northern range may possibly be a population sink for the San Joaquin kit fox.

The loss of 163 acres of kit fox habitat in Conservation Zone 8 is not expected to adversely affect the long-term survival and conservation of the San Joaquin kit fox for the following reasons.

- The affected habitats are composed of naturalized grassland in a highly disturbed or modified setting.
- Potentially suitable habitat areas to be lost are located in the northernmost extent of the species' range, in an area where kit foxes seldom occur, and which has marginal value for the long-term survival and conservation of the species.
- The loss of suitable habitat south of Clifton Court Forebay would not sever or degrade an existing movement route because it occurs between two existing aqueducts that already restrict movement of the species.
- The proportion of the species' range to be affected is small in comparison to the species' range-wide distribution.

5.6.4.2 Beneficial Effects

With full implementation of the BDCP, at least 1,000 acres of grassland will be protected in Conservation Zone 8, where the San Joaquin kit fox is most likely to occur if present in the Plan Area.

Additionally, a portion of the 2,000 acres of grassland restoration will likely occur in Conservation Zone 8. Assuming the restored grasslands will provide suitable San Joaquin kit fox habitat proportional to the amount of modeled habitat in this natural community in the Plan Area (6.8% of the grasslands in the Plan Area consist of modeled San Joaquin kit fox habitat), an estimated 132 acres of restored grasslands will be suitable for the species (6.6% of 2,000 acres). Because kit fox home ranges are large (ranging from around 1 to 12 square miles; see Appendix 2.A, *Covered Species Accounts*), habitat connectivity is key to the conservation of the species. Grasslands will be acquired for protection in locations that provide connectivity to existing protected breeding habitats in Conservation Zone 8 and to other adjoining kit fox habitat within and adjacent to the Plan Area. Connectivity to occupied habitat adjacent to the Plan Area will help ensure the movement of kit foxes, if present, to larger habitat patches outside of the Plan Area in Contra Costa County (Linkage #2, Figure 3.2-16). Grassland protection will focus in particular on acquiring the largest remaining contiguous patches of unprotected grassland habitat, which are located south of State Route 4 in Conservation Zone 8 (Appendix 2.A). This area connects to over 620 acres of existing habitat that was protected under the East Contra Costa County HCP/NCCP. Grasslands in Conservation Zone 8 will also be managed and enhanced to increase prey availability and to increase mammal burrows, which could benefit the San Joaquin kit fox by increasing potential den sites, which are a limiting factor for the kit fox in the northern portion of its range. These management and enhancement actions are expected to benefit the San Joaquin kit fox by increasing the habitat value of the protected and restoration grasslands.

5.6.4.3 Net Effects

Including both the habitat loss described in Section 5.6.4.1, *Adverse Effects*, and the habitat restoration and protection described in Section 5.6.4.2, *Beneficial Effects*, full implementation of the BDCP will result in an estimated decrease of 82 acres (2%) of habitat for the San Joaquin kit fox and an estimated net increase of 1,016 acres (95%) of San Joaquin kit fox habitat in conservation lands. The modeled habitat that will be lost as a result of covered activities consists of small, fragmented patches that are surrounded by cultivated lands and that are unlikely to be used by this species. The grasslands that will be protected and restored and that provide suitable habitat for the San Joaquin kit fox will consist of large, interconnected areas in Conservation Zone 8 that will connect with protected San Joaquin kit fox habitat to the west in the East Contra Costa County HCP/ NCCP Plan Area. Connectivity to occupied habitat adjacent to the Plan Area will help ensure that kit foxes, if present, are able to move between the Plan Area and larger habitat patches outside of the Plan Area in Contra Costa County.

Overall, the BDCP will provide a substantial net benefit to the San Joaquin kit fox, if the species occurs in the Plan Area, through the increase in habitat in protected status, and management and monitoring of habitat to support the species. Therefore, the BDCP will minimize and mitigate impacts, to the maximum extent practicable, and provide for the conservation and management of the San Joaquin kit fox in the Plan Area.

5.6.5 Suisun Shrew

This section describes the adverse, beneficial, and net effects of the covered activities, including conservation measures, on the Suisun shrew. The methods used to assess these effects are described in Section 5.2.8, *Effects Analysis for Wildlife and Plants,* and Table 5.J.1, *Quantitative Effects Analysis Methods and Assumptions*, in Appendix 5.J, *Effects on Natural Communities, Wildlife, and Plants*. The habitat model for the Suisun shrew identifies primary habitat (minimum 1-acre mapping unit) in the Plan Area as all pickleweed-dominated natural seasonal wetlands and certain bulrush and cattail-dominated tidal brackish emergent wetlands located in Suisun Marsh only. Managed wetlands have been excluded from the model and low marsh habitat is secondary. Secondary habitats generally provide only a few ecological functions such as foraging (low marsh) or extreme high tide refuge (upland transition zones), while primary habitats provide multiple functions, including breeding, effective predator cover, and forage. Further details regarding the habitat model, including assumptions on which the model is based, are provided in Appendix 2.A, *Covered Species Accounts*. Factors considered in assessing the value of affected habitat for the Suisun shrew, to the extent that information is available, include habitat patch size, connectivity, and proximity to recorded occurrences of the species.

5.6.5.1 Adverse Effects

5.6.5.1.1 Permanent Habitat Loss, Conversion, and Fragmentation

Covered activities will result in the permanent loss or conversion of up to 387 acres[4] of habitat (5% of the habitat in the Plan Area) for the Suisun shrew (Table 5.6-1). The only covered activities that will adversely affect this species are those associated with tidal natural communities restoration, as described below.

Tidal Natural Communities Restoration

The tidal marsh restoration is expected to result in the permanent loss of 60 acres (2%) of primary and 318 acres (7%) of secondary Suisun shrew habitat, and the conversion of 24 acres of secondary habitat to primary habitat. Although the actual tidal natural communities restoration effects are likely to differ from the hypothetical footprint used to estimate losses, the Implementation Office will not exceed these upper limits of habitat loss or conversion for the Suisun shrew. Tidal marsh restoration is expected to result in the permanent loss of 60 acres of primary habitat.

5.6.5.1.2 Periodic Inundation

No periodic inundation effects on the Suisun shrew will occur as a result of covered activities.

5.6.5.1.3 Construction-Related Effects

Construction is not expected to result in loss of Suisun shrew habitat other than that described in Section 5.6.5.1.1, *Permanent Habitat Loss, Conversion, and Fragmentation*. All staging and other temporary construction-related work areas for tidal natural communities restoration will either be in areas that do not provide habitat for the species (i.e., already disturbed sites) or will be within the footprint of permanently affected areas described above. Construction-related injury or mortality and indirect effects of construction are described below.

[4] Habitat or natural community loss acreage estimates are based on hypothetical footprints and models rather than detailed project-level design and represent the maximum allowed under the permit. Actual losses will be tracked through compliance monitoring to ensure that they do not exceed estimates.

Construction-Related Injury or Mortality

Operation of construction equipment could result in injury or mortality of Suisun shrews. Risk will be greatest during extreme high tides when shrews may move to higher and drier lands where they might come in contact with upland construction activities. Disturbance, injury, or mortality to Suisun shrews will be avoided or minimized with implementation of *AMM26 Salt Marsh Harvest Mouse and Suisun Shrew* (Appendix 3.C). AMM26 includes passive removal of shrews in the proximity of construction activity by removing shrew cover habitat within 100 feet of construction using nonmechanized hand tools. Vegetation will be removed under the supervision of a CDFW- and USFWS-approved biological monitor familiar with Suisun shrew. Further, construction will be avoided during extreme high-tide events when upland encounters with shrews are highest.

Indirect Construction-Related Effects

Noise and visual disturbance outside of the project footprint but within 100 feet of construction activities could temporarily affect the use of 167 acres of Suisun shrew habitat adjacent to these activities (Table 5.6-5). This disturbance will be minimized by implementing the BMPs described under *AMM2 Construction Best Management Practices and Monitoring* (Appendix 3.C).

5.6.5.1.4 Effects of Ongoing Activities

The only ongoing covered activities expected to affect the Suisun shrew are those associated with habitat enhancement and management, and recreation.

Habitat Enhancement and Management

Activities associated with natural communities enhancement and management that are intended to maintain and improve habitat functions in the protected habitats for the Suisun shrew and other covered species, such as ground disturbance or removal of nonnative vegetation, could result in local adverse habitat effects, injury, or mortality of Suisun shrews, and temporary noise and disturbance effects if individuals are present in work sites over the term of the BDCP. These potential effects are currently not quantifiable but will be minimized with implementation of AMM26, described in Appendix 3.C.

Recreation

Passive recreation in the reserve system, where that recreation is compatible with the biological goals and objectives, could result in disturbance of Suisun shrews using habitat in the vicinity of trails. However, *AMM37 Recreation*, described in Appendix 3.C, limits trail placement to existing levees and requires that leash laws be enforced (excluding hunting activities). With recreation restrictions in place, as required under AMM37, recreation-related effects on salt marsh harvest mouse are expected to be minimal.

5.6.5.1.5 Other Indirect Effects

Mercury

Covered activities have the potential to increase exposure to mercury in covered species that feed in aquatic environments. Exposure to methylmercury is known to affect mammals and could adversely affect the Suisun shrew. The operational impacts of new flows under *CM1 Water Facilities and Operation* were analyzed using a DSM-2-based model to assess potential effects on mercury concentration and bioavailablity. Subsequently, a regression model was used to estimate fish-tissue concentrations in striped bass under these future operational conditions. Results indicated that changes in total mercury levels in water and fish tissues under future conditions with the BDCP were insignificant (Appendix 5.D, *Contaminants*, Attachment 5D.A, *Bioaccumulation Model Development for Mercury Concentrations in Fish,* Tables 5.D.A-1, 5.D.A-2, 5.D.A-3, and 5.D.A-4).

Marsh restoration also has the potential to increase exposure to methylmercury. Mercury is transformed into the more bioavailable form of methylmercury in aquatic systems, especially areas subjected to regular wetting and drying such as tidal marshes and flood plains. Thus, restoration activities that create newly inundated areas could increase bioavailability of mercury. Increased methylmercury associated with natural community and floodplain restoration may indirectly affect the Suisun shrew, via uptake in lower trophic levels (Appendix 5.D). In general, the highest methylation rates are associated with high tidal marshes that experience intermittent wetting and drying and associated anoxic conditions (Alpers et al. 2008). The potential mobilization or creation of methylmercury in the Plan Area varies with site-specific conditions and will need to be assessed at the project level. The Suisun Marsh Plan (Bureau of Reclamation et al. 2010) anticipates that tidal wetlands restored under the plan will generate less methylmercury than the existing managed wetlands. Along with minimization and mitigation measures and adaptive management and monitoring, *CM12 Methylmercury Management* is expected to reduce the amount of methylmercury resulting from the restoration of natural communities and floodplains.

For short-lived small mammals such as shrews, which live approximately 16 months, mercury bioaccumulation is generally not of concern because the species feeds low on the food chain and generally does not live long enough to bioaccumulate toxic concentrations of mercury except when they occur in highly toxic sites. Toxic concentrations of methylmercury have been found in the kidneys of shrews that inhabit contaminated sites and forage on earthworms and other prey that live within contaminated sediments (Talmage and Walton 1993; Hinton and Veiga 2002). Hays (1990) found Suisun shrews to eat mostly isopods and amphipods, two aquatic prey types less likely to harbor methylmercury concentrations compared to a benthic organism (e.g., polychaetes). Therefore, the indirect effects of potential increases to mercury exposure on the Suisun shrew are expected to be negligible.

5.6.5.1.6 Impact of Take on the Species

The Suisun shrew is endemic to the tidal marshes of Suisun Bay. Approximately half of the range of this subspecies of ornate shrew occurs in Suisun Marsh, reflecting the importance of the Plan Area to the subspecies. There are 15 CNDDB/DHCCP occurrences through the species' range, of which five extant occurrences are in the Plan Area (33%). The hypothetical footprint for covered activities overlaps with three of these occurrences, all within Suisun Marsh in areas subject to tidal habitat restoration.

Based on modeled habitat for the Suisun shrew, the Plan Area supports 7,515 acres of suitable habitat, of which 3,128 acres (42%) is primary middle or high tidal marsh habitat and the remaining secondary low marsh or upland refugia habitat. Of the total habitat, up to 401 acres of modeled habitat (5%) will be affected by tidal natural communities restoration. This loss of Suisun shrew habitat is not expected to adversely affect the long-term survival and conservation of the species for the following reasons.

- The amount of habitat to be restored (6,006 acres) greatly exceeds the amount habitat permanently lost (401 acres).

- Habitat removal will be sequenced with tidal habitat restoration to minimize adverse effects on habitat abundance.

5.6.5.2 Beneficial Effects

The Implementation Office is expected to restore or create at least 6,000 acres of tidal brackish emergent wetland natural community in Conservation Zone 11 (*CM4 Tidal Natural Communities Restoration*). Tidal wetlands will be restored as a mosaic of large, interconnected, and biologically diverse patches that support a natural gradient extending from subtidal to the upland fringe. The habitat and ecosystem functions of tidal brackish emergent wetland will be maintained and enhanced over the term of the BDCP (*CM11 Natural Communities Enhancement and Management*). At least 1,500 acres of the restored tidal brackish emergent wetland will meet the primary habitat requirements of the Suisun shrew, including middle and high marsh vegetation with dense, tall stands of pickleweed cover. Nonnative predators will be reduced to help maintain species abundance (CM11). Restoration will be sequenced and oriented in a manner that minimizes any temporary, initial loss of habitat and habitat fragmentation. These restoration activities will improve habitat conditions for the Suisun shrew and enhance the long-term viability of this species in the Plan Area.

Upland transitional areas will be protected adjacent to restored tidal lands to accommodate sea level rise. Within the transitional uplands, a 200-foot-wide swath adjacent to tidally restored areas will be maintained as upland habitat for Suisun shrew and other tidal brackish emergent wetland species (*CM4 Tidal Natural Communities Restoration*). Additionally, grasslands will be protected to provide at least 200 feet of grasslands adjacent to tidal brackish emergent wetlands beyond the sea level rise accommodation. Both the 200-foot-wide swath within the transitional uplands and the 200-foot-wide swath beyond sea level rise accommodation will be managed to provide upland cover and flood refugia for the Suisun shrew.

Water operations associated with covered activities intended to mimic more natural patterns of water flow are expected to increase salinity in Suisun Marsh. Salinity changes in the tidal channels and sloughs are expected to be highly variable. Consequently, these effects cannot be reasonably differentiated from tidal habitat restoration effects. Still, these elevated salinity levels will likely encourage the establishment of tidal brackish communities that were historically abundant in Suisun Marsh, and especially important species such as pickleweed, an outcome expected to benefit the Suisun shrew.

5.6.5.3 Net Effects

Including both the habitat loss described in Section 5.6.5.1, *Adverse Effects*, and the habitat restoration and protection described in Section 5.6.5.2, *Beneficial Effects*, implementation of the BDCP will result in an estimated net increase of at least 1,440 acres (46%) in primary habitat and 4,164 acres (95%) of secondary habitat for the Suisun shrew, and an estimated net increase of at least 1,441 acres of primary habitat (48%) and 4,410 acres (102%) of secondary habitat in conservation lands (Table 5.6-7). The potential take of Suisun shrews as a result of permanent and temporary habitat loss and indirect effects is not expected to adversely affect the long-term survival or conservation of this species. Avoidance and minimization measure described in Appendix 3.C, *Avoidance and Minimization Measures*, will be implemented to specifically protect Suisun shrews from disturbance and avoid injury or mortality. Tidal habitat restoration actions will primarily affect managed wetlands that provide low-value habitat for the Suisun shrew, and restoration will be phased to ensure that the local shrew population is not adversely affected. Much of the restored tidal brackish emergent wetland will meet the primary habitat requirements of the Suisun shrew, including middle and high marsh vegetation with dense, tall stands of pickleweed cover. Habitat management and enhancement, and reduction of nonnative predators as needed, will further benefit the species.

Overall, the BDCP will provide a substantial net benefit to the Suisun shrew through the increase in primary habitat. These areas will be managed and monitored to support the species. Therefore, the BDCP will minimize and mitigate impacts, to the maximum extent practicable, and provide for the conservation and management of the Suisun shrew in the Plan Area.

5.6.6 California Black Rail

This section describes the adverse, beneficial, and net effects of the covered activities, including conservation measures, on the California black rail. The methods used to assess these effects are described in Section 5.2.8, *Effects Analysis for Wildlife and Plants*, and Table 5.J.1, *Quantitative Effects Analysis Methods and Assumptions*, in Appendix 5.J, *Effects on Natural Communities, Wildlife, and Plants*. The modeled primary habitat for this species includes tidal brackish emergent wetland and tidal freshwater emergent wetland in Suisun Marsh and the Delta west of Sherman Island, and instream islands and White Slough Wildlife Area in the central Delta.

This species occurs primarily in middle and high brackish marsh, and on instream islands of the central Delta that supports both emergent marsh and riparian uplands. Low marsh, managed wetlands, and the upland fringe is considered secondary habitat (Appendix 2.A, *Covered Species Accounts*). Secondary habitats generally provide only a few ecological functions such as foraging (low marsh) or extreme high-tide refuge (upland transition zones), or support lower densities of California black rails (managed wetlands). Managed wetlands that are intensively managed (e.g., by mowing and discing) for waterfowl generally provide only marginal habitat for this species, while less intensively managed shallow-water areas may provide more suitable habitat. Primary habitats provide multiple functions, including breeding, effective predator cover, and forage. Further details regarding the habitat model, including assumptions on which the model is based, are provided in Appendix 2.A. Factors considered in assessing the value of affected habitat for the California black rail, to the extent that information is available, include habitat patch size, connectivity, and proximity to recorded occurrences of the species.

5.6.6.1 Adverse Effects

5.6.6.1.1 Permanent Habitat Loss, Conversion, and Fragmentation

Covered activities will result in the permanent loss or conversion of up to 3,127 acres[5] of habitat (12% of the habitat in the Plan Area) for the California black rail (Table 5.6-1). The covered activities that will adversely affect this species are those associated with bypass improvements and tidal natural communities restoration as described below.

[5] Habitat or natural community loss acreage estimates are based on hypothetical footprints and models rather than detailed project-level design and represent the maximum allowed under the permit. Actual losses will be tracked through compliance monitoring to ensure that they do not exceed estimates.

Fremont Weir/Yolo Bypass Improvements

This activity will result in the permanent removal of approximately 5 acres (less than 1%) of primary habitat for the California black rail (Table 5.6-1). All of this loss occurs within Conservation Zone 2.

Tidal Natural Communities Restoration

Tidal natural communities restoration is expected to result in the loss or conversion of an estimated 3,044 acres of secondary and 79 acres of primary California black rail habitat. Although the actual tidal natural communities restoration effects are likely to differ from the hypothetical footprint used to estimate losses, the Implementation Office will not exceed these upper limits of habitat loss or conversion for the California black rail.

California black rail modeled habitat will be affected by tidal marsh restoration in various ways. Some California black rail modeled habitat will be permanently lost such that it no longer serves as habitat, while other modeled habitat will change value through conversion from one habitat type to another. Without grading, adding fill, or implementing other mechanisms to raise elevations of subsided lands in Suisun Marsh, an estimated 2,363 acres of secondary habitat will be converted to subtidal habitats, resulting in a permanent loss of habitat for the species. In addition, 71 acres of middle and high marsh, which is primary habitat for the species, will be converted to low marsh, or secondary habitat, due to increased water elevations. The conversion of primary to secondary habitat for the species is represented as take because the conversion may meet the definition of *harm* under the ESA. However, the affected areas will remain suitable habitat for California black rails, albeit it a lower value. An estimated 16 acres of upland habitat will be converted to middle or high marsh, which represents a conversion from secondary to primary habitat for the species. To minimize temporal effects on the California black rail population, the tidal natural communities restoration will be phased over a 40-year period to ensure recovery of some areas before initiating restoration actions in other areas.

5.6.6.1.2 Periodic Inundation

Flooding of Fremont Weir/Yolo Bypass Inundation

Flooding of Yolo Bypass will not result in the periodic inundation of modeled habitat for the California black rail. There are no records for California black rails in the Yolo Bypass, although the extent to which this area has been surveyed for California black rails is unknown and the species is not conspicuous. Therefore, the species is potentially present in the Yolo Bypass. If periodic inundation were to occur it would not result in permanent habitat loss and should not prevent use of the bypass by future rail populations.

Floodplain Restoration

Floodplain restoration is expected to affect 6 acres of modeled secondary habitat (less than 1% of all secondary habitat in the Plan Area) for California black rails (Table 5.6-3). The floodplains will transition from areas that flood frequently (i.e., every 1 to 2 years) to areas that flood infrequently (i.e., every 10 years or more). Flooding could adversely affect black rails if no adjacent uplands are available for refuge from flood events. However, the 6 acres of modeled secondary habitat that would be affected consist of a small, isolated patch that is not associated with primary habitat, and is located in the south Delta where there are no recorded of occurrences of California black rail. The potential for California black rails to occur in this secondary habitat is low, and effects on the species will be minimal, if any.

5.6.6.1.3 Construction-Related Effects

Direct and permanent effects of construction are described above in Section 5.6.6.1.1, *Permanent Habitat Loss, Conversion, and Fragmentation*. Additional construction-related effects on the California black rail include temporary habitat loss, potential injury or mortality, and indirect noise and visual disturbance effects. Effects on the species are described below for each effect category. Effects are described collectively for all covered activities, and are also described for specific covered activities to the extent that this information is pertinent for assessing the value of affected habitat or the specific nature of the effect.

Temporary Habitat Loss

Construction of pipeline and tunnel facilities will result in temporary loss of approximately 18 acres of primary habitat (less than 1% of all primary habitat in the Plan Area) for the California black rail (Table 5.6-1). The temporary loss from water conveyance facility construction will take place in Conservation Zones 5 and 6. There are no recorded occurrences of black rail in the locations that are expected be temporarily affected.

Construction-Related Injury or Mortality

Operation of construction equipment, or contamination from petroleum or other chemical spills, could result in injury or mortality of California black rails. Risk will be greatest to eggs and nestlings susceptible to land-clearing activities, nest abandonment, or increased exposure to the elements or to predators. Injury to adults and fledged juveniles is less likely as these individuals are expected to avoid contact with construction equipment. Injury or mortality will be avoided by establishing 500-foot no-disturbance buffers during the breeding season, as described in *AMM19 California Clapper Rail and California Black Rail* (Appendix 3.C, *Avoidance and Minimization Measures*).

Indirect Construction-Related Effects

There are 495 acres of primary habitat and 431 acres of secondary habitat (4% of all existing habitat in the Plan Area) near proposed construction areas that could be indirectly affected by construction activities within 500 feet of habitat. Indirect effects associated with construction include noise, dust, and visual disturbance caused by grading, filling, contouring, and other ground-disturbing operations outside the project footprint but within 500 feet of the construction edge. Construction noise above background noise levels (greater than 50 dBA) is expected to extend 500 to 5,250 feet from the edge of construction activity (Table 4, *Estimated Impacts on the Delta Wintering Population of Greater Sandhill Cranes from Collisions with Proposed BDCP Power Lines*, in Appendix 5.J, Attachment 5J.D, *Indirect Effects of the Construction of the BDCP Conveyance Facility on Sandhill Crane*), although there is no available data to determine the extent to which these noise levels could affect California black rail. If construction occurs during the nesting season, indirect effects could result in the loss or abandonment of nests, and mortality of any eggs and/or nestlings. However, most of the estimated indirect effects (364 acres of primary and 428 acres of secondary habitat) are quantified from the edge of the tidal restoration footprint. Much of the construction-related work is expected to be well inside the restoration footprint (particularly when restoration involves levee breaching and no cut or fill). Therefore, indirect effects are expected to be considerably lower than the estimated amount. Furthermore, as described in AMM19, preconstruction surveys of potential breeding habitat will be conducted within 500 feet of project activities, and a 500-foot no-disturbance buffer will be established around any territorial call-centers during the breeding season, or construction will be avoided altogether in potentially indirectly affected areas if breeding territories cannot be accurately delimited.

5.6.6.1.4 Effects of Ongoing Activities

Transmission Lines

New transmission lines will increase the risk for bird- transmission line strikes, which could result in injury or mortality of the California black rail. Black rails in general have been known to suffer mortality from transmission line collision, likely associated with transit between foraging areas and/or migration (Eddleman et al 1994). Due to their wing shape and body size, rails have low to moderate flight maneuverability (Rayner 1988 and Bevanger 1998), increasing susceptibility to collision mortality. However, there are relatively few records of California black rail collisions with overhead wires. Several factors contribute to the relatively low collision susceptibility in this subspecies. Most important among these are daytime site fidelity and a lack of long-distance night migration, considered a principal factor contributing to collision mortality in the species (Eddleman et al. 1994). California black rail movements in the Plan Area are likely short, seasonal, and at low altitudes, typically less than 16 feet (5 meters) (Eddleman et al 1994). While the species may have low- to-moderate flight maneuverability, the bird's behavior (e.g., sedentary, nonmigratory, ground-nesting and foraging, solitary, no flocking, secretive) reduces potential exposure to overheard wires and vulnerability to collision mortality (Appendix 5.J, Attachment 5J.C, *Analysis of Potential Bird Collisions at Proposed BDCP Powerlines*). Transmission line poles and towers also provide perching substrate for raptors, which could result in increased predation pressure on local black rails. This is expected to have few adverse effects on the black rail population, if any.

Habitat Enhancement and Management

Activities associated with natural communities enhancement and management that are intended to maintain and improve habitat functions in habitats for the California black rail and other covered species, such as ground disturbance or removal of nonnative vegetation, could result in local adverse habitat effects, injury, or mortality of California black rails, and temporary noise and disturbance effects if individuals are present in work sites over the term of the BDCP. These potential effects are currently not quantifiable. However, only 1 acre of primary habitat and 2 acres of secondary habitat are expected to be impacted. These impacts, but will be minimized with implementation of the avoidance and minimization measures described in Appendix 3.C.

Management of the 5,000 acres of managed wetlands to be protected for waterfowl and shorebirds is not expected to result in overall adverse effects on the California black rail. Management actions that will improve wetland quality and diversity on managed wetlands include control and eradication of invasive plants; maintenance of a diversity of vegetation types and elevations, including upland areas to provide flood refugia; water management and leaching to reduce salinity; and enhancement of water management infrastructure (improvements to enhance drainage capacity, levee maintenance). These management actions will potentially benefit the California black rail. The 5,000 acres of protected managed wetlands will be monitored and adaptively managed to ensure that management options are implemented to avoid adverse effects on the California black rail.

Recreation

Passive recreation in the reserve system, where that recreation is compatible with the biological goals and objectives, could result in disturbance by humans and dogs of California black rails using habitat in the vicinity of trails. Nests could be disturbed during construction and ongoing use of trails and other amenities. Due to placement of trails, passive recreation on established trails is expected to result in limited disturbance. Hunting may result in disturbance, but this is baseline condition in managed wetlands. *AMM37 Recreation* (Appendix 3.C) limits trail placement to existing levees and requires that leash laws be enforced (excluding hunting activities). Construction of recreational amenities in and near suitable habitat will be limited to outside the breeding season. With recreation restrictions in place, as required under AMM37, recreation-related effects on California black rail are expected to be minimal.

5.6.6.1.5 Other Indirect Effects

Mercury

Covered activities have the potential to increase exposure to mercury in covered species that feed in aquatic environments, including the California black rail. The operational impacts of new flows under *CM1 Water Facilities and Operation* were analyzed using a DSM-2-based model to assess potential effects on mercury concentration and bioavailablity resulting from new flows. Subsequently, a regression model was used to estimate fish-tissue concentrations in striped bass under these future conditions. Results indicated that changes in total mercury levels in water and fish tissues under future conditions with the BDCP were insignificant (Appendix 5.D, *Contaminants,* Attachment 5D.A, *Bioaccumulation Model Development for Mercury Concentrations in Fish*, Tables 5.D.A-1, 5.D.A-2, 5.D.A-3, and 5.D.A-4).

Marsh and floodplain restoration has the potential to increase exposure to methylmercury. Mercury is transformed into the more bioavailable form of methylmercury in aquatic systems, especially areas subjected to regular wetting and drying such as tidal marshes and flood plains. Thus, restoration activities that create newly inundated areas could increase bioavailability of mercury. Increased methylmercury associated with natural community and floodplain restoration may indirectly affect the California black rail, via uptake in lower tropic levels (Appendix 5.D). In general, the highest methylation rates are associated with high tidal marshes that experience intermittent wetting and drying and associated anoxic conditions (Alpers et al. 2008). The potential mobilization or creation of methylmercury in the Plan Area varies with site-specific conditions and will need to be assessed at the project level. The Suisun Marsh Plan (Bureau of Reclamation et al. 2010) anticipates that tidal wetlands restored under the plan will generate less methylmercury than the existing managed wetlands. Along with minimization and mitigation measures and adaptive management and monitoring, *CM12 Methylmercury Management* is expected to reduce the amount of methylmercury resulting from the restoration of natural communities and floodplains.

Concentrations of methylmercury known to cause reproductive effects in birds have been found in blood and feather samples of San Francisco Bay black rails (Tsao et al. 2009). Because they forage directly in contaminated sediments, California black rails may be especially prone to methylmercury contamination. While restoration of marshlands might increase methylation of mercury, the Suisun Marsh Plan (Bureau of Reclamation et al. 2010) anticipates that the restored tidal wetlands will generate less methylmercury than existing managed wetlands (more flushing will prevent anaerobic environments), possibly reducing the overall risk. Currently, it is unknown how much of the sediment-derived methylmercury enters the food chain in Suisun Marsh or what tissue concentrations are actually harmful to the California black rail. Site-specific restoration plans that address the creation and mobilization of mercury, as well as monitoring and adaptive management as described in CM12 will reduce the effects of methylmercury on California black rails.

5.6.6.1.6 Impact of Take on the Species

The range of the California black rail extends throughout portions of California and Arizona, with populations in the Delta, San Francisco Bay, Central Valley, and southern California (Salton Sea and lower Colorado River). The Plan Area represents about 20% of the range-wide distribution of the black rail in California. There are 232 CNDDB occurrences through the species' range, of which 40 extant occurrences (17%) are in the Plan Area. The hypothetical footprint for covered activities overlaps with seven of these occurrences, all in Suisun Marsh in areas subject to tidal habitat restoration.

Based on modeled habitat for the California black rail, the Plan Area supports 25,382 acres of suitable habitat, most (85%) of which is managed wetland of lower value (23,458 acres). Of this, up to 3,122 acres of modeled habitat (12%) will be affected by tidal natural communities restoration. Some of the inundation effects may be construed as a long-term temporary loss as the inundated areas will eventually restore to marsh conditions favored by this bird. These losses of California black rail habitat are not expected to adversely affect the long-term survival and conservation of the species because most of the permanently removed habitat is managed wetland that provides marginal-value habitat for the species.

Habitat removal will be sequenced with tidal habitat restoration to minimize adverse effects on habitat abundance. *AMM19 California Clapper Rail and California Black Rail*, described in Appendix 3.C, will be implemented to avoid and minimize take of black rails.

5.6.6.2 Beneficial Effects

The Plan requires restoration of at least 6,000 acres of tidal brackish emergent wetland in Suisun Marsh (Objective TBEWNC1.1), and that at least 1,500 of the 6,000 acres be high and middle marsh (Objective TBEWNC1.2). The 1,500 acres of high and middle marsh are expected to provide primary habitat for California black rail, while the remainder of the restored tidal brackish emergent wetland is expected to provide secondary habitat. Additionally, the Plan requires that at least 1,700 acres of the restored tidal freshwater emergent wetland provide suitable habitat for California black rail (Objective CBR1.1). Assuming the restored tidal freshwater emergent wetland will provide California black rail secondary habitat proportional to the amount of modeled habitat in this natural community in the Plan Area (32% of the tidal freshwater emergent wetland provides modeled secondary habitat for California black rail), then restoration of 24,000 acres of tidal freshwater emergent wetland will provide an estimated 7,580 acres of secondary habitat for this species. Additionally, assuming that two-thirds of the nontidal marsh restoration will consist of nontidal freshwater emergent wetland, and that restored nontidal freshwater emergent wetlands will provide California black rail habitat proportional to the amount of modeled habitat in this natural community in the Plan Area (47% of the nontidal freshwater emergent wetland natural community in the Plan Area is modeled primary California black rail habitat, and 4% is modeled secondary habitat), the restoration of 1,200 acres of nontidal marsh will provide an estimated 379 acres of primary habitat and 35 acres of secondary habitat for California black rail. With all types of restoration, an estimated 3,579 acres of primary habitat and 12,115 acres of secondary habitat will be restored for California black rail.

In addition to habitat restoration (*CM4 Tidal Natural Communities Restoration*), natural communities protection (*CM3 Natural Communities Protection and Restoration*) will benefit California black rail. Assuming the protected managed wetlands will provide California black rail habitat proportional to the amount of modeled habitat in this natural community in the Plan Area (approximately 18% of the managed wetland natural community in the Plan Area is modeled California black rail habitat), the protection of 1,500 acres of managed wetlands for salt marsh harvest mouse will provide an estimated 275 acres of protected California black rail habitat that is comparable to or of higher value than existing modeled habitat (Table 5.6-7).

Tidal wetlands will be restored as a mosaic of large, interconnected, and biologically diverse patches that support a natural gradient extending from subtidal to the upland fringe. The habitat and ecosystem functions of tidal wetlands will be maintained and enhanced over the term of the BDCP. Much of the restored tidal brackish marsh will meet the primary habitat requirements of the California black rail, including development of middle- and high-marsh vegetation with dense, tall stands of pickleweed (*Salicornia pacifica*) and bulrush cover in Suisun Marsh. Tidal brackish emergent wetland restoration will be sequenced and oriented in a manner that minimizes any temporary, initial loss of habitat and habitat fragmentation. Additionally, at least 1,700 acres of the restored tidal freshwater marsh will provide high-value habitat for the species, consisting of shallowly inundated emergent vegetation at the upper edge of the marsh with adjacent riparian or other shrubs that will provide upland refugia, and other moist-soil perennial vegetation. Nonnative predators will be controlled as needed to reduce nest predation and help maintain species abundance (*CM11 Natural Communities Enhancement and Management*). These measures will improve habitat conditions for the California black rail and enhance the long-term viability of this species in the Plan Area.

Water operations associated with covered activities intended to mimic more natural patterns of water flow are expected to increase salinity in Suisun Marsh. Salinity changes in the tidal channels and sloughs are expected to be highly variable. Consequently, these effects cannot be reasonably differentiated from tidal habitat restoration effects. Still, these elevated salinity levels will likely encourage the establishment of tidal brackish communities that were historically abundant in Suisun Marsh, and especially important species such as pickleweed, an outcome expected to benefit the California black rail.

5.6.6.3 Net Effects

Including both the habitat loss described in Section 5.6.6.1, *Adverse Effects*, and the habitat restoration described in Section 5.6.6.2, *Beneficial Effects*, the BDCP will result in an estimated net increase of 3,496 acres (47%) in primary habitat and an estimated net increase of 9,072 acres (51%) in secondary habitat for the California black rail (Table 5.6-7). BDCP will result in an estimated net increase of 3,502 acres (76%) of protected primary habitat and an estimated increase of 9,426 acres (56%) of protected secondary habitat in the Plan Area. The take of the California black rail as a result of permanent and temporary habitat loss and other direct and indirect effects is not expected to result in an adverse effect on the long-term survival and conservation of this species. AMM19 will be implemented to specifically protect black rail nest sites and avoid injury or mortality to adults, nestlings, and eggs (Appendix 3.C). Tidal habitat restoration actions will primarily remove managed wetlands that provide habitat of lower value for the California black rail, while the restored and protected habitat will consist of large, interconnected areas of high-value habitat.

Overall, the BDCP will provide a substantial net benefit to the California black rail through the increase in amount and protection of primary and secondary habitat. These areas will be managed and monitored to support the species. Therefore, the BDCP will minimize and mitigate impacts, to the maximum extent practicable, and provide for the conservation and management of the California black rail in the Plan Area.

5.6.7 California Clapper Rail

This section describes the adverse, beneficial, and net effects of the covered activities, including conservation measures, on the California clapper rail. The methods used to assess these effects are described in Section 5.2.8, *Effects Analysis for Wildlife and Plants*, and Table 5.J.1, *Quantitative Effects Analysis Methods and Assumptions*, in Appendix 5.J, *Effects on Natural Communities, Wildlife, and Plants.* California clapper rail habitat includes mostly high and middle marsh habitat with select emergent wetland plant alliances described in Appendix 2.A, *Covered Species Accounts*. Secondary habitats generally provide only a few ecological functions such as foraging (low marsh) or high-tide refuge (upland transition zones), while primary habitats provide multiple functions including breeding, effective predator cover, and forage. Further details regarding the habitat model, including assumptions on which the model is based, are provided in Appendix 2.A. Factors considered in assessing the value of affected habitat for the California clapper rail, to the extent that information is available, include habitat patch size, connectivity, and proximity to recorded occurrences of the species.

5.6.7.1 Adverse Effects

5.6.7.1.1 Permanent Loss, Conversion, and Fragmentation

Covered activities will result in the permanent loss or conversion of up to 77 acres[6] of habitat (less than 1% of the habitat in the Plan Area) for the California clapper rail (Table 5.6-1). Covered activities that will adversely affect modeled California clapper rail habitat only include tidal natural communities restoration actions. Construction of the water conveyance facility will have no effect on this species.

Tidal Natural Communities Restoration

The tidal marsh restoration action is expected to result in the conversion and permanent loss of 35 acres of California clapper rail primary and secondary habitat in the Plan Area. Based on the hypothetical tidal restoration footprint, an estimated 27 acres of primary habitat will convert to secondary low marsh habitat and 8 acres of secondary habitat will convert to middle or high marsh. However, the actual tidal restoration effects are likely to differ from the hypothetical footprint used to estimate losses. To provide flexibility in implementation of tidal restoration projects, the take limit for secondary habitat is set higher than the amount of loss estimated under the hypothetical footprint. Up to 50 acres of secondary California clapper rail habitat may be removed through

[6] Habitat or natural community loss acreage estimates are based on hypothetical footprints and models and anticipated take levels rather than detailed project-level design and represent the maximum allowed under the permit. Actual losses will be tracked through compliance monitoring to ensure that they do not exceed estimates.

covered activities. Overall, covered activities will have little adverse effect on California clapper rail habitat.

5.6.7.1.2 Periodic Inundation

Yolo Bypass Operations

Appendix 5.J, *Effects on Natural Communities, Wildlife, and Plants,* provides the method used to estimate periodic inundation effects in the Yolo Bypass. Based on this method, periodic inundation could affect California clapper rails occupying areas up to 9 acres of habitat during a notch flow[7] of 6,000 cfs (B) (Table 5.6-3). However, project-associated inundation of areas that would not otherwise have been inundated is expected to occur in no more than 30% of all years, since Fremont Weir is expected to overtop the remaining estimated 70% of all years, and during those years notch operations will not typically affect the maximum extent of inundation. In more than half of all years under existing conditions, an area greater than the project-related inundation area already inundates in the bypass.

Floodplain Restoration

No periodic effects on the California clapper rail will occur as a result of periodic inundation associated with floodplain restoration.

5.6.7.1.3 Construction-Related Effects

Construction is not expected to result in loss of California clapper rail habitat other than that described in in Section 5.6.7.1.1, *Permanent Habitat Loss, Conversion, and Fragmentation.* All staging and other temporary construction-related work areas for tidal natural communities restoration will either be on areas that do not provide habitat for the species (i.e., already disturbed sites) or will be within the footprint of permanently affected areas described above. Construction-related effects on individuals and indirect effects are described below.

Construction-Related Injury or Mortality

Operation of construction equipment could result in injury or mortality of California clapper rails. Risk will be greatest to eggs and nestlings susceptible to land clearing activities, nest abandonment, or increased exposure to the elements or to predators. Injury to adults and fledged juveniles is less likely as these individuals are expected to avoid contact with construction equipment. However, under AMM19, activities will not occur within 500 feet of nest sites during the breeding season, as described in Appendix 3.C, *Avoidance and Minimization Measures*.

Indirect Construction-Related Effects

Construction activities related to tidal restoration are expected to result in temporary, indirect effects on 542 acres of California clapper rail habitat adjacent to these activities. Tidal natural communities restoration construction activities include grading, filling, contouring, and other ground-disturbing operations, with the potential to cause noise, dust, and visual disturbance. Indirect effects include those outside the project footprint but up to 600 feet from the construction edge. Construction noise above background noise levels (greater than 50 dBA) is expected to extend

[7] Flows through the notch at Fremont Weir.

500 to 5,250 feet from the edge of construction activity (Table 4, *Estimated Impacts on the Delta Wintering Population of Greater Sandhill Cranes from Collisions with Proposed BDCP Power Lines,* Appendix 5.J, Attachment 5J.D, *Indirect Effects of the Construction of the BDCP Conveyance Facility on Sandhill Crane*). There are no available data to determine the extent to which these noise levels could affect California clapper rail. If construction occurs during the nesting season, indirect effects could result in the loss or abandonment of nests, and mortality of any eggs and/or nestlings. However, 97% (524 acres) of the habitat indirectly affected is secondary low marsh rarely used by this species for nesting. Under AMM19 (Appendix 3.C), preconstruction surveys of potential breeding habitat will be conducted within 500 feet of project construction activities, and a 500-foot no-disturbance buffer will be established around the territorial call centers during the breeding season, or construction during the breeding season will be avoided altogether if breeding territories cannot be accurately delimited.

5.6.7.1.4 Effects of Ongoing Activities

Transmission Lines

New transmission lines will increase the risk for bird- transmission line strikes, which could result in injury or mortality of the California clapper rail. The California clapper rail is nonmigratory; however, some seasonal movements occur, probably in response to seasonal hydrologic changes and their effect on habitat availability and quality. Home range and territory of the California clapper rail is not known, but in locations outside of California, clapper rail territory ranges from 0.3 acres to 8 acres (0.1 to 3.2 hectares) (Rush et al. 2012). The location of the current population and suitable habitat for the species make collision with transmission lines highly unlikely (Appendix 5.J, Attachment 5J.C, *Analysis of Potential Bird Collisions at Proposed BDCP Powerlines*).

Habitat Enhancement and Management

Activities associated with natural communities enhancement and management may include ground disturbance or removal of nonnative vegetation, which could result in local adverse habitat effects, injury, or mortality of California clapper rails, and temporary noise and disturbance effects if individuals are present in work sites over the term of the BDCP. These potential effects are currently not quantifiable, but will be minimized with implementation AMM19, described in Appendix 3.C.

Recreation

Passive recreation in the reserve system, where that recreation is compatible with the biological goals and objectives, could result in disturbance by humans and dogs of California clapper rails using habitat in the vicinity of trails. Nests could be disturbed during construction and ongoing use of trails and other amenities. Due to placement of trails, passive recreation on established trails is expected to result in limited disturbance. Hunting may result in disturbance, but this is baseline condition in managed wetlands. *AMM37 Recreation*, described in Appendix 3.C, limits trail placement to existing levees and requires that leash laws be enforced (excluding hunting activities). Construction of recreational amenities in and near suitable habitat will be limited to outside the breeding season. With recreation restrictions in place, as required under AMM37, recreation-related effects on the California clapper rail are expected to be minimal.

5.6.7.1.5 Other Indirect Effects

Mercury

Covered activities have the potential to increase exposure to mercury in covered species that feed in aquatic environments, including the California clapper rail. The operational impacts of new flows under *CM1 Water Facilities and Operation* were analyzed using a DSM-2-based model to assess potential effects on mercury concentration and bioavailablity resulting from new flows. Subsequently, a regression model was used to estimate fish-tissue concentrations in striped bass under these future conditions. Results indicated that changes in total mercury levels in water and fish tissues under future conditions with the BDCP were insignificant (Appendix 5.D, *Contaminants*, Attachment 5D.A, *Bioaccumulation Model Development for Mercury Concentrations in Fish,* Tables 5.D.A-1, 5.D.A-2, 5.D.A-3, and 5.D.A-4).

Marsh and floodplain restoration also has the potential to increase exposure to methylmercury. Mercury is transformed into the more bioavailable form of methylmercury in aquatic systems, especially areas subjected to regular wetting and drying such as tidal marshes and flood plains. Thus, restoration activities that create newly inundated areas could increase bioavailability of mercury. Increased methylmercury associated with natural community and floodplain restoration may indirectly affect the California clapper rail because they forage directly in contaminated sediments (Appendix 5.D, *Contaminants*). Concentrations of methylmercury known to be toxic to bird embryos have been found in the eggs of San Francisco Bay clapper rails (Schwarzbach and Adelsbach 2003). In general, the highest methylation rates are associated with high tidal marshes that experience intermittent wetting and drying and associated anoxic conditions (Alpers et al. 2008). Currently, it is unknown how much of the sediment-derived methylmercury enters the food chain in Suisun Marsh or what tissue concentrations are actually harmful to the California clapper rail. The potential mobilization or creation of methylmercury in the Plan Area varies with site-specific conditions and will need to be assessed at the project level. The Suisun Marsh Plan (Bureau of Reclamation et al. 2010) anticipates that tidal wetlands restored under the plan will generate less methylmercury than the existing managed wetlands. Along with minimization and mitigation measures and adaptive management and monitoring, *CM12 Methylmercury Management* is expected to reduce the amount of methylmercury resulting from the restoration of natural communities and floodplains.

5.6.7.1.6 Impact of Take on the Species

The current distribution of the California clapper rail is limited to San Francisco Bay, San Pablo Bay, Suisun Bay, and tidal marshes associated with estuarine sloughs draining into these bays. The range of this subspecies of clapper rail barely extends into the Plan Area (Suisun Marsh), and the species may use the Plan Area only sporadically and in low densities. For example, surveys conducted annually from 2002 to 2007 in Suisun Marsh found up to eight birds and as few as no birds each year (California Department of Fish and Wildlife 2013b). In the Plan Area, the clapper rail occupies suitable habitat in the extreme western Delta and the Suisun Marsh. There are 88 CNDDB and DHCCP extant occurrences of the California clapper rail through the species' range, of which 13 (15%) occur in the Plan Area. The hypothetical footprint for covered activities overlaps with two of these occurrences, all in Suisun Marsh in areas subject to tidal habitat restoration.

Based on modeled habitat for the California clapper rail, the Plan Area supports 6,716 acres of suitable habitat. Of this, none will be permanently removed. Only 77 acres, or 1% of the total clapper rail habitat in the Plan Area, will be converted to a higher or lower habitat value. These losses of California clapper rail habitat are not expected to adversely affect the long-term survival and conservation of the species for the following reasons.

- The Plan Area represents the edge and a small portion of the species' range, in which its population occurs at low densities.
- There is no permanent habitat loss.
- Tidal habitat inundated will be sequenced with tidal habitat restoration to minimize adverse temporal and spatial effects on habitat abundance.

5.6.7.2 Beneficial Effects

The Plan requires restoration of at least 6,000 acres of tidal brackish emergent wetland in Suisun Marsh (Objective TBEWNC1.1) and that at least 1,500 of the 6,000 acres be high and middle marsh (Objective TBEWNC1.2). The 1,500 acres of high and middle marsh are expected to provide primary habitat for California clapper rail, while the remainder of the restored tidal brackish emergent wetland is expected to provide secondary habitat.

The 6,000 acres of tidal brackish emergent wetlands will be restored as a mosaic of large, interconnected, and biologically diverse patches that support a natural gradient extending from subtidal to the upland fringe. The habitat and ecosystem functions of tidal brackish emergent wetland will be maintained and enhanced for native species over the term of the BDCP. Much of the restored tidal brackish emergent wetland will meet the primary habitat requirements of the California clapper rail, including development of middle- and high-marsh vegetation with dense, tall stands of pickleweed cover. Nonnative predators will be controlled as needed to reduce nest predation and help maintain species abundance (*CM11 Natural Communities Enhancement and Management*). Restoration will be sequenced and spaced in a manner that minimizes any temporary, initial loss of habitat and habitat fragmentation. These measures will improve habitat conditions for the California clapper rail and enhance the long-term viability of this species in the Plan Area (primarily by converting unsuitable managed wetlands to suitable tidal brackish marsh).

Water operations associated with covered activities intended to mimic more natural patterns of water flow are expected to increase salinity in Suisun Marsh. Salinity changes in the tidal channels and sloughs are expected to be highly variable. Consequently, these effects cannot be reasonably differentiated from tidal natural communities restoration effects. Still, these elevated salinity levels will likely encourage the establishment of tidal brackish communities that were historically abundant in Suisun Marsh, and especially important species such as pickleweed, an outcome expected to benefit the California clapper rail.

5.6.7.3 Net Effects

Including both the habitat loss described in Section 5.6.7.1, *Adverse Effects*, and the riparian habitat restoration and protection described in Section 5.6.7.2, *Beneficial Effects*, the BDCP will result in an estimated net increase of 5,965 acres (89%) of habitat for California clapper rails, and an estimated net increase of at least 5,968 acres (98%) of California clapper rail habitat in conservation lands (Table 5.6-7). The take of California clapper rails as a result of permanent and temporary habitat loss and other direct and indirect effects is not expected to result in an adverse effect on the long-term survival and conservation of this species. California clapper rail avoidance and minimization measures (Appendix 3.C, *Avoidance and Minimization Measures*) will be implemented to specifically protect clapper rail nest sites and avoid injury or mortality to adults, nestlings, and eggs.

Overall, the BDCP will provide a substantial net benefit to the California clapper rail through the increase in primary habitat. These areas will be managed and monitored to support the species. Therefore, the BDCP will minimize and mitigate impacts, to the maximum extent practicable, and provide for the conservation and management of the California clapper rail in the Plan Area.

5.6.8 Greater Sandhill Crane

This section describes the adverse, beneficial, and net effects of the covered activities, including conservation measures, on the greater sandhill crane. The general methods used to assess these effects are described in Section 5.2.8, *Effects Analysis for Wildlife and Plants*, and Table 5.J.1, *Quantitative Effects Analysis Methods and Assumptions*, in Appendix 5.J, *Effects on Natural Communities, Wildlife, and Plants*. The habitat model used to assess effects to the species includes vegetation and land cover types associated with greater sandhill crane winter roosting and foraging habitat. Further details regarding the habitat model, including assumptions on which the model is based, are provided in Appendix 2.A, *Covered Species Accounts.* Factors considered in assessing the value of affected habitat for the greater sandhill crane include the relative habitat value of specific crop or land cover types in the crane's winter use area and proximity to known roosting sites.

Greater sandhill cranes in the Plan Area are almost entirely dependent on privately owned cultivated lands for foraging. Supporting a matrix of crop types that provide suitable foraging habitat and maintaining compatible agricultural practices, while sustaining and increasing the extent of other essential habitat elements such as night roosting habitat, will promote the species in the Plan Area over the long term. The habitat model for the greater sandhill crane includes "roosting and foraging" as well as "foraging" habitat, in the Plan Area. This includes certain agricultural types, specific grassland types, irrigated pastures and hays, and many managed seasonal wetland types. Roosting and foraging habitat includes known, traditional roost sites that also provide foraging habitat (Appendix 2.A). Foraging habitat supports foraging activity but does not include traditional roost sites. Further detail is provided in Appendix 2.A.

5.6.8.1 Adverse Effects

5.6.8.1.1 Permanent Habitat Loss, Conversion and Fragmentation

Based on the current conveyance facility footprint and hypothetical restoration footprints, covered activities would result in the permanent loss, conversion, or fragmentation of up to 7,136 acres[8] of modeled greater sandhill crane habitat (4% of its habitat in the Plan Area), including an estimated 71 acres of temporary roosting and foraging habitat and 7,065 acres of foraging habitat. There would be no loss of permanent roosting habitat as a result of BDCP. As explained in *Water Conveyance Facility Construction*, below, these impact estimates represent a worst-case scenario; the actual acreage of habitat loss for this species is expected to be less. *AMM6 Disposal and Reuse of Spoils, Reusable Tunnel Material, and Dredged Material* and *AMM30 Transmission Line Design and Alignment Guidelines*, described in Appendix 3.C, *Avoidance and Minimization Measures*, require that

[8] Habitat or natural community loss acreage estimates are based on hypothetical footprints and models rather than detailed project-level design and represent the maximum allowed under the permit. Actual losses will be tracked through compliance monitoring to ensure that they do not exceed estimates.

the final conveyance facility and transmission line footprints avoid loss of greater sandhill crane roosting habitat during the winter when cranes are present. With the implementation of these avoidance and minimization measures, the total maximum loss of temporary roosting and foraging habitat would be 41 acres, and the total maximum loss of foraging habitat would be 7,107 acres.

Table 5.6-10 provides the breakdown of foraging habitat loss by habitat value class. Covered activities resulting in adverse effects on the greater sandhill crane include conveyance facility construction, tidal and nontidal natural communities restoration, and grassland restoration. Habitat loss, conversion, and fragmentation resulting from each of these activities are described below.

Table 5.6-10. Total Amount of Greater Sandhill Crane Habitat Lost from Covered Activities

Foraging Habitat Value Class[a]	Cultivated Land Crops and Other Cover Types	Acres Affected[b] (% of Total Impact)
Very High	Corn, rice	2,663 (37%)
High	Alfalfa and alfalfa mixtures, mixed pasture, native pasture, wheat, other pasture, irrigated pasture, managed wetlands, native vegetation[c]	1,901 (26%)
Medium	Grain and hay crops, miscellaneous grain and hay, mixed grain and hay, nonirrigated mixed grain and hay, other grain crops, miscellaneous grasses, grassland, alkali seasonal wetlands, vernal pool complex	1,499 (21%)
Low	Other irrigated crops, idle cropland, blueberries, asparagus, clover, cropped within the last 3 years, grain sorghum, green beans, miscellaneous truck, miscellaneous field, new lands being prepped for crop production, nonirrigated mixed pasture, nonirrigated native pasture, onions, garlic, peppers, potatoes, safflower, sudan, sugar beets, tomatoes (processing), melons squash and cucumbers all types, artichokes, beans (dry)	1,188 (16%)
Totals		**7,250**

[a] See Appendix 2.A, *Covered Species Accounts*, for description of foraging habitat values.
[b] Total includes permanent, permanent – reusable tunnel material, and temporary borrow and spoil effects.
[c] Native vegetation is a land use designation within the California Department of Water Resources (2007) crop type dataset. For the purposes of incorporating native vegetation classes into the correct species models, and, when applicable, assigning habitat foraging values, the management of these lands most resembles that of native pasture, an irrigated pasture type.

Water Conveyance Facility Construction

The water conveyance facility and associated features as designed would result in the permanent removal of approximately 2,728 acres of greater sandhill crane habitat, including 29 acres of temporary roosting and foraging habitat and 2,699 acres of foraging habitat (Table 5.6-1). The temporary roosting and foraging habitat that would be permanently lost is located on Zacharias Island; the loss is a result of installation of a transmission line and associated access road. However, *AMM20 Greater Sandhill Crane* (Appendix 3.C) requires that the final transmission line alignment be designed to avoid crane roost sites; therefore, there will be no loss of crane temporary roosting and foraging habitat as a result of water conveyance facility construction once the facility is fully designed.

An estimated 2,347 acres (85%) of the affected foraging habitat would be lost due to placement of reusable tunnel material. The material will likely be moved to other sites for use in levee build-up and restoration, and the affected area will likely be restored. While this effect is categorized as a permanent impact, because there is no assurance that the material will eventually be moved, the effect will likely be temporary. Furthermore, the amount of storage area needed for reusable tunnel material is flexible (dependent on storage pile height and other factors), and the footprint used in the effects analysis is based on a worst-case scenario; the actual area to be affected by reusable tunnel material storage will likely be less than the estimated acreage. Additionally, AMM6 requires that the area used for reusable tunnel material storage be minimized in crane foraging habitat and that these areas completely avoid crane roost sites.

An estimated 1,283 of the 2,699 acres (47%) of the foraging habitat to be permanently lost as a result of conveyance facility construction would be at Staten Island, which is among the most significant crane use areas in the Delta (Littlefield and Ivey 2000). However, 1,257 acres (97%) of this loss would be a result of reusable tunnel material storage, and as described above, AMM6 requires this acreage to be minimized in crane foraging habitat. AMM6 also specifically requires that reusable tunnel material storage on Staten Island be sized and located in coordination with greater sandhill crane experts, USFWS, and CDFW, to reduce effects on greater sandhill crane.

Tidal Natural Communities Restoration

Based on the hypothetical tidal restoration footprint, this activity will result in the permanent conversion of an estimated 2,754 acres of greater sandhill crane habitat, including 2,713 acres of foraging habitat and 41 acres of roosting and foraging habitat. This loss will occur in the Cosumnes-Mokelumne River and West Delta ROAs (Table 5.6-1).

Effects in the Cosumnes/Mokelumne ROA associated with tidal wetland restoration activities occur in low-value cultivated lands that are restored to become tidal wetlands. To be conservative, these effects are counted as a permanent loss of sandhill crane habitat. However, tidal wetland restoration may in some cases provide habitat value for cranes.

Fragmentation of habitat is expected to be minimal because the majority of the affected acres are outside of the core occupied portion of the winter use area (based on modeled roosting and foraging habitat shown in Figure 2.A.-2, *Greater Sandhill Crane Habitat Model and Recorded Occurrences*, in Appendix 2.A, *Covered Species Accounts*) and because most effects are associated with tidal restoration. In Conservation Zone 5, loss of modeled habitat will occur along the western edge of the crane winter use area and therefore will not result in fragmentation of traditional crane habitats. In Conservation Zone 4, tidal wetland restoration may occur between the high crane use areas of the central Delta and the Cosumnes River Preserve. However, conversion to tidal wetlands in this area will not prohibit crane movement or reduce use of these important crane use areas.

Nontidal Marsh Natural Communities Restoration

This activity will result in the permanent conversion of an estimated 1,350 acres of modeled foraging habitat for the greater sandhill crane (roosting and foraging habitat is not affected) (Table 5.6-1). This is an estimated 1% of the modeled foraging-only habitat in the Plan Area. This activity includes effects from nontidal marsh restoration for the giant garter snake. The restored nontidal marsh is expected to continue to provide roosting and foraging habitat for the greater sandhill crane. However, a portion of the restored nontidal marsh is expected to be unsuitable for the crane as it will consist of open water that lacks emergent vegetation and is too deep to provide roosting or foraging habitat for this species.

Grassland Natural Communities Restoration

This activity will result in the permanent conversion of an estimated 300 acres of modeled foraging habitat for the greater sandhill crane (roosting and foraging will not be affected) (Table 5.6-1). This is less than 1% of the modeled foraging habitat for the greater sandhill crane in the Plan Area. The restored grasslands are expected to continue to provide value as foraging habitat for the crane.

5.6.8.1.2 Periodic Inundation

No periodic inundation effects on the greater sandhill crane will occur as a result of covered activities, since these activities are expected to occur outside modeled habitat areas for the species.

5.6.8.1.3 Construction-Related Effects

Direct and permanent effects of construction are described above in the Section 5.6.8.1.1, *Permanent Habitat Loss, Conversion, and Fragmentation*. Additional construction-related effects on the greater sandhill crane include temporary effects from water conveyance facilities construction and establishment of borrow and spoils sites, as well as indirect construction-related effects. Effects on the species are described below for each effect category. Effects are described collectively for all covered activities and are also described for specific covered activities to the extent that this information is pertinent for assessing the value of affected habitat or specific nature of the effect.

Temporary Habitat Loss

Covered activities are expected to temporarily remove 985 acres of modeled habitat (less than 1% of this habitat in the Plan Area). Nearly all the affected habitat is cultivated land. This includes 24 acres of roosting and foraging habitat (16 acres of which is temporary roosting habitat), and 778 acres of foraging habitat. Of the 985 acres, establishment and use of borrow and spoil areas associated with construction of water facilities will result in temporary removal of approximately 183 acres of modeled greater sandhill crane winter foraging habitat (Table 5.6-1). Although this habitat will be restored within 1 year following construction, it will not necessarily be restored to its original topography and areas that were originally cultivated lands may be restored as grasslands.

Indirect Construction-Related Effects

Construction-related noise and visual disturbances outside the project footprint are indirect effects that could temporarily affect the use of 11,554 acres (6%) of modeled greater sandhill crane habitat in the Plan Area (Table 5.6-5), assuming that all habitat within 1,300 feet of construction activities is indirectly affected. These construction activities include water conveyance facilities construction and tidal restoration activities.

A detailed analysis of potential indirect effects of conveyance facility construction on greater sandhill crane is provided in Appendix 5.J, Attachment 5J.D, *Indirect Effects of the Construction of the BDCP Conveyance Facility on Sandhill Crane*. The analysis addresses potential noise effects on cranes, and concludes that as much as 9,646 acres (5%) of crane habitat in the Plan Area would potentially be affected by noise above baseline level (50 to 60 dBA), including 1,085 acres of temporary crane roosting habitat, 548 acres of permanent crane roosting habitat, and 8,013 acres of crane foraging habitat. The analysis was conducted based on the assumption that there was direct line-of-sight from sandhill crane habitat areas to the construction site, and therefore is a worst-case estimate of effects. In many areas, existing levees and other structures will partially or completely block the line-of-sight to cranes and will function as effective noise barriers, substantially reducing noise transmission. Data is lacking to assess the effects that these increased noise levels will have on sandhill crane behavior.

Appendix 5.J, Attachment 5J.D, also addresses lighting effects on the species. Construction of each intake structure, dewatering near intakes, pumping plants, and certain pipeline construction areas would occur day and night, requiring bright lighting. Little data is available on the effects of artificial lighting on roosting birds. Direct light from automobile headlights has been observed to cause roosting cranes to flush, and it is thought that they may avoid roosting in areas where lighting is bright (Ivey pers. comm. [B]). However, roost site fidelity may cause cranes to still use a brightly lit site. If the birds do use a brightly lit roosting site, they may be vulnerable to sleep-wake cycle shifts and reproductive cycle shifts. Potential risks include a reduction in the cranes' quality of nocturnal rest, and effects on their sense of photo-period, which might cause them to shift their physiology towards earlier migration and breeding (Ivey pers. comm.). Such effects could reduce cranes' overall fitness and reproductive success, which could in turn have population-level impacts. A change in photo-period interpretation may also cause cranes to fly out earlier from roost sites to forage; this could increase their risk of transmission line collisions, if they leave roosts before dawn (Ivey pers. comm.).

Nighttime construction could also result in headlights flashing into roost sites when construction vehicles are turning onto or off of construction access routes. Proposed surge towers would require the use of safety lights that would alert low-flying aircraft to the presence of these structures because of their height. Such safety lighting could also disturb cranes.

These effects will be minimized through implementation of AMM20 (Appendix 3.C), which requires setback buffers from crane use areas during construction; installation of noise and visual barriers between construction areas and crane habitat; seasonal and timing restrictions; avoiding use of lighting in the highest use areas for cranes; shielding lights; directing lights away from crane habitat; establishing buffers between construction and crane roost sites; and creating high-value roosting and foraging habitat to attract cranes into areas away from construction disturbance. With these measures in place, indirect effects of construction activities are not expected to reduce the greater sandhill crane population in the Plan Area.

AMM20 requires that both direct and indirect effects on greater sandhill cranes on Staten Island be minimized to the extent practicable and that surrounding habitat on Staten Island, outside the area of potential indirect effects, be enhanced to achieve a performance standard of no net loss of crane use on Staten Island (see AMM20 for a definition of crane use and how it will be measured).

5.6.8.1.4 Effects of Ongoing Activities

Operation and Maintenance

Operations and maintenance activities within 1,300 feet of construction could permanently, indirectly affect 8 acres of modeled greater sandhill crane habitat (Table 5.6-5). Maintenance of the aboveground water conveyance facilities could result in ongoing but periodic postconstruction noise and visual disturbances that could affect greater sandhill crane use of surrounding habitat. These effects may include periodic vehicle use along the conveyance corridor, and inspection and maintenance of above-ground facilities. These potential effects will be minimized with implementation of AMM20, described in Appendix 3.C.

Transmission Lines

Greater sandhill cranes are known to be susceptible to collision with overhead wires, including electrical distribution lines (Avian Power Line Interaction Committee 1994; Brown and Drewien 1995; Manville 2005). Both permanent and temporary electrical transmission lines will be constructed to supply construction and operational power to BDCP facilities. Typically, higher-voltage (230-kilovolt) lines vary in height from 90 to 110 feet, while “sub” transmission (69-kilovolt) lines vary from 50 to 70 feet (Avian Power Line Interaction Committee 2006). Temporary lines will be removed after construction of the water conveyance facilities, within 10 years.

To further investigate the risk of collision, a variety of morphological and behavioral risk factors to were analyzed to assess the relative susceptibility of covered bird species with overhead wire collision (Appendix 5.J, Attachment 5J.C, *Analysis of Potential Bird Collisions at Proposed BDCP Powerlines*). Based on this analysis, several aspects of the species’ behavior and morphology make greater sandhill cranes particularly susceptible to collisions with overhead wires. Most importantly, flight altitudes during daytime movements are within the range of heights for the proposed lines (50 to 110 feet [15 to 33.5 meters]). This increases collision potential. Because most crane movement occurs within 2 miles (3.2 kilometers) of their primary roost, the proximity of the current proposed alignment is a key issue in evaluating collision risk for cranes. Several known roosting sites are less than 2 miles (3.2 kilometers) from the current proposed alignment and are known to intersect with traditional flight patterns (Appendix 5.J, Attachment 5J.C, *Analysis of Potential Bird Collisions at Proposed BDCP*). Delta wintering cranes are also regularly exposed to dense fog and are known to fly in the fog. This increases their transmission line collision mortality risk.

To quantify potential transmission line-collision mortality from the proposed lines, a collision risk map was developed for greater sandhill crane (Appendix 5.J, Attachment 5J.C). Risk factors derived from this map were used in conjunction with estimates of transmission line crossings and collision mortality from Brown and Drewien (1995). Using assumptions of crane mortality rates developed for similar situations in Colorado (Brown and Drewien 1995), it is estimated for unmarked lines that there is a potential for an estimated 16 deaths per year from the permanent lines and 122 deaths per year from the temporary lines.

Marking transmission lines with devices that make the lines more visible to birds has been shown to dramatically reduce the incidence of bird mortality, including for sandhill cranes. Brown and Drewien (1995) estimated that marking devices in the Central Valley would reduce crane mortality by 66%. Using this assumption, by incorporating line-marking devices into the designs the annual mortality rate is estimated to decrease to 6 deaths per year for the permanent lines and 42 deaths per year for the temporary lines.

Additional measures will be implemented, consistent with AMM20 (Appendix 3.C) to achieve no net increase in bird-strike risk for greater sandhill cranes in the Plan Area. This will be achieved by implementing any combination of the following.

- Site new transmission lines in lower bird-strike risk zones.
- Remove, relocate or underground existing lines.
- Install flight diverters on existing lines in the Greater Sandhill Crane Winter Use Area.

- For areas outside of the Stone Lakes National Wildlife Refuge project boundary[9], shift locations of flooded areas that provide crane roosts to lower risk areas.

This is expected to reduce existing mortality and thus fully offset the overall population effects of new transmission lines.

With these AMMs and the proposed mitigation, there is expected to be no net adverse effect on crane survival. There may be a positive effect on crane survival, because the bird flight diverters on existing lines and the undergrounded lines (if used) will remain in place after the temporary powerline (used for construction) is removed, thereby reducing mortality risk to cranes to a level below the baseline.

Recreation

Passive recreation in the reserve system, where that recreation is compatible with the biological goals and objectives, could result in disturbance of roost sites in the vicinity of trails. *AMM37 Recreation*, described in Appendix 3.C, limits construction of trails adjacent to crane use areas to spring and summer (outside the winter season when cranes are present). No hunting will be allowed at sites with temporary or permanent crane roost sites. Where feasible, no fall or winter hunting will be allowed on adjacent fields. Recreation on sites with crane roosts will be limited to public roadways and overlook areas, and no pets will be allowed onsite. With implementation of these measures, recreation-related effects on the greater sandhill crane are expected to be minimal.

5.6.8.1.5 Other Indirect Effects

Mercury

Covered activities have the potential to increase exposure to mercury in covered species that feed in aquatic environments, including the greater sandhill crane. The operational impacts of new flows under *CM1 Water Facilities and Operation* were analyzed using a DSM-2-based model to assess potential effects on mercury concentration and bioavailablity resulting from new flows. Subsequently, a regression model was used to estimate fish-tissue concentrations in striped bass under these future conditions. Results indicated that changes in total mercury levels in water and fish tissues under future conditions with the BDCP were insignificant (Appendix 5.D, Attachment 5D.A, *Bioaccumulation Model Development for Mercury Concentrations in Fish*, Tables 5.D.A-1, 5.D.A-2, 5.D.A-3, and 5.D.A-4).

Marsh and floodplain restoration also has the potential to increase exposure to methylmercury. Mercury is transformed into the more bioavailable form of methylmercury in aquatic systems, especially areas subjected to regular wetting and drying such as tidal marshes and flood plains. Thus, restoration activities that create newly inundated areas could increase bioavailability of mercury. Increased methylmercury associated with natural community and floodplain restoration may indirectly affect the greater sandhill crane via uptake in lower tropic levels (Appendix 5.D, *Contaminants*). In general, the highest methylation rates are associated with high tidal marshes that experience intermittent wetting and drying and associated anoxic conditions (Alpers et al. 2008). The potential mobilization or creation of methylmercury in the Plan Area varies with site-specific conditions and will need to be assessed at the project level. The Suisun Marsh Plan (Bureau of

[9] The project boundary delineates the area surrounding the existing refuge for which the refuge has authority to acquire land or easements.

Reclamation et al. 2010) anticipates that tidal wetlands restored under the plan will generate less methylmercury than the existing managed wetlands. Along with minimization and mitigation measures and adaptive management and monitoring, *CM12 Methylmercury Management* is expected to reduce the amount of methylmercury resulting from the restoration of natural communities and floodplains.

The potential indirect effects of increased mercury exposure are likely low for the greater sandhill crane for the following reasons.

- Greater sandhill cranes occur in the Plan Area only during the nonbreeding winter months.
- In the Plan Area, cranes forage primarily on cultivated crops.
- Cranes will likely have limited use of restored tidal wetlands compared to seasonal managed wetlands.

5.6.8.1.6 Impact of Take on Species

The Central Valley population of greater sandhill cranes breeds from British Columbia to northern California and winters in the Central Valley. A portion of the Plan Area (the greater sandhill crane winter use area) is one of two important greater sandhill crane winter use areas in the Central Valley, the other being the Butte Basin. In the Plan Area, the winter use area includes lands in Conservation Zones 3, 4, 5, and 6, which includes the central Delta and northern Delta east of the Stockton Deep Water Ship Channel and incorporates nearly all of the lands traditionally used by wintering greater sandhill cranes in the Delta.

The estimated total population of greater sandhill cranes is 62,600 (Littlefield and Ivey 2000). Although there is no recent population estimate for the Central Valley population of greater sandhill cranes, the most recent counts of summering cranes in California, Oregon and Washington total approximately 4,200 (Ivey and Herziger 2000, 2001), and a recent estimate of the summering cranes in interior British Columbia total an additional 4,000 (Breault pers. comm.), giving a total population estimate of 8,200 for the west coast of North America.

Covered activities are expected to permanently remove up to 7,136 acres of modeled habitat for greater sandhill crane representing 4% of the total habitat in the Plan Area, including 71 (less than 1%) of its modeled temporary roosting and foraging habitat. While cultivated lands will be affected, this and other adverse habitat effects resulting in take are not expected to adversely affect the species' long-term survival and conservation because the affected areas represent a small proportion of habitat in the Plan Area impacts are quantified in areas that will be converted to usable habitat for the crane, and much of the affected habitat has relatively low value.

As described in Appendix 5.J, Attachment 5J.C, *Analysis of Potential Bird Collisions at Proposed BDCP Powerlines*, without mitigation the proposed BDCP transmission lines could have an adverse effect on the Central Valley greater sandhill crane population. For unmarked lines, the alignment has the potential to cause declines in the Central Valley population that exceed the rate of population increase (1.4%), which could reduce population growth and inhibit the conservation of the species. For the Delta wintering population alone, the alignment results in a projected population decrease at both marked and unmarked lines. Minimization and mitigation described above will offset this ongoing impact and result in no net adverse change to regional mortality risk from transmission lines.

5.6.8.2 Beneficial Effects

The Plan requires protection of 7,300 acres of high- to very high-value habitat for greater sandhill crane, with at least 80% maintained in very high-value types in any given year (Objective GSHC1.1). The Plan requires creation of additional high-value greater sandhill crane winter foraging habitat by enhancing 10% of the habitat protected under Objective GSHC1.1 through acquiring low-value habitat or nonhabitat areas and converting them to high- or very high-value habitat (Objective GSHC1.2). The Plan also requires creation of 500 acres of wetlands providing high-value roosting and foraging habitat for greater sandhill crane (Objectives GSHC1.3 and GSHC1.4), and creation of an additional 95 acres of foraging habitat consisting of flooded agricultural fields that will be sited with consideration of the location of roosting habitat loss and that will be in place prior to roosting habitat loss (Objective GSHC1.5). As part of the 500 acres of created wetlands, 180 acres of wetland roosting habitat will be created in association with uplands at a 2:1 ratio of uplands to wetlands, providing buffers around created wetlands: these wetlands will consist of two sites between the Cosumnes Preserve and Stone Lakes National Wildlife Refuge to provide habitat connectivity in this area (linkage #10, Figure 3.2-16, *Landscape Linkages*, in Chapter 3). Finally, some portion of the freshwater tidal wetland natural community that is created will provide foraging, loafing, or roosting value to the greater sandhill crane and may facilitate the expansion of the greater sandhill cranes into currently unoccupied areas, particularly in Conservation Zone 7.

5.6.8.3 Net Effects

Implementation of the BDCP will result in a net permanent gain of modeled roosting and foraging habitat in the Plan Area of 533 acres. Creation of roosting habitat will offset losses of this essential habitat element and facilitate use of other modeled foraging habitat. Implementation of the BDCP will result in an estimated net decrease of 7,248 acres (4%) of foraging habitat for the greater sandhill crane. This impact would occur throughout most of the Delta and gradually over 40 years as tidal natural communities restoration occurs, ensuring that impacts are not concentrated geographically or in any one season. Most foraging habitat in the Plan Area is unoccupied in any given year, suggesting that the amount of foraging habitat is not limiting the population. The amount of foraging habitat to be permanently removed will be reduced further by reducing the footprint of reusable tunnel material storage areas in crane habitat prior to construction and restoring these areas after the material is relocated to other areas.

The extent of crane habitat in the Plan Area is declining as suitable crops are being converted to unsuitable crops (e.g., orchards, vineyards, row crops) or other land uses. The BDCP will help to arrest that decline by increasing protected habitat in the Plan Area by 10% (4,174 acres) (Table 5.6-7). The BDCP will maintain the conserved foraging habitat as high to very high value habitat for the crane, with at least 80% maintained as very high value habitat.

In addition to effects on the location and quality of modeled habitat, the proposed transmission lines have the potential to cause mortality through collision strike. However, adverse effects are reduced by an estimated 65% through installation of bird flight diverters on all new lines. Additional measures will be implemented, as described in AMM20, to reduce and offset bird-strike risk for cranes in the Plan Area. The net effect will be no net change of mortality risk to cranes from transmission line collision, and potentially a slight net reduction in mortality risk once the temporary transmission lines are removed.

The net effect of covered activities on the greater sandhill crane is expected to be beneficial for the following reasons.

- A large proportion of the crane use area, while modeled as suitable crane habitat, is unoccupied by cranes in any given year. Therefore, the amount of foraging habitat in the Plan Area is not considered limiting to the local population.
- A small proportion (4%) of the total available modeled crane habitat will be permanently removed.
- The amount of habitat to be permanently removed will be further reduced by reducing the footprint of reusable tunnel material storage areas in crane habitat, and restoring these areas after the material is relocated to other areas.
- The BDCP will maintain a standard of no net loss of crane use on Staten Island resulting from BDCP-related construction activity by minimizing the direct and indirect effect footprints and enhancing crane habitat on Staten Island.
- The agricultural habitat value that will be permanently lost will be replaced in equal proportion by protecting and enhancing other agricultural habitat and maintaining its high value for cranes.
- At least 80% of all protected greater sandhill crane habitat will be maintained each year in land cover types of the highest value with the remainder in land cover types of moderate to high value.
- Because agricultural habitat values change over time based largely on economically driven agricultural practices, protecting crane habitat will enhance the stability of agricultural habitat values in the crane use area.
- The creation and management of 595 acres of crane roosting habitat will increase the extent of roosting habitat in the crane use area and facilitate use of surrounding lands that may be currently unoccupied or underused due to the lack of proximity to roost sites.
- Marking all new transmission lines with bird flight diverters and implementing additional measures to reduce bird-strike risk, as described in AMM20, will result in no net increase in mortality risk for cranes from collisions with transmission lines in the region, ensuring no adverse population level effects.
- Indirect effects on greater sandhill crane from construction activities will be reduced through project design improvements; creating high-value roosting and foraging habitat to attract cranes into areas away from construction activities; restricting the season and timing of activities near roost sites were feasible; shielding lights and directing lighting away from habitat; and installing noise and visual barriers between construction activities and crane habitat.

Overall, the BDCP will provide a net benefit to the greater sandhill crane through the increase in available roosting habitat, the maintenance of existing or enhanced foraging habitat as well as an increase in extent of habitat in protected status. These protected areas will be managed and monitored to support the species. Collision mortality will be offset by implementation of minimization and mitigation measures with an expected no net loss of cranes due to bird strikes. Therefore, the BDCP will minimize and mitigate impacts, to the maximum extent practicable, and provide for the conservation and management of the greater sandhill crane in the Plan Area.

5.6.9 Least Bell's Vireo

This section describes the adverse, beneficial, and net effects of the covered activities, including conservation measures, on the least Bell's vireo. The methods used to assess these effects are described in Section 5.2.8, *Effects Analysis for Wildlife and Plant Species*. The habitat model for the least Bell's vireo identifies suitable nesting and migratory habitat as those plant alliances from the valley/foothill riparian modeled habitat that contain a dense shrub component, including all willow-dominated alliances. Although the species may use adjacent nonriparian scrub habitats for foraging or dispersal, nonriparian portions of the Plan Area are primarily in agricultural use and thus unsuitable for the least Bell's vireo. Therefore, the habitat model is restricted to riparian vegetation. Further details regarding the habitat model, including assumptions on which the model is based, are provided in Appendix 2.A, *Covered Species Accounts.* Factors considered in assessing the value of affected habitat for the least Bell's vireo, to the extent that information is available, include location in relation to species occurrences and existing conservation lands (Types 1 and 2)[10], and habitat patch size and configuration.

5.6.9.1 Adverse Effects

5.6.9.1.1 Permanent Habitat Loss, Conversion, and Fragmentation

Covered activities will result in the permanent loss of up to 685 acres[11] of habitat (5% of the habitat in the Plan Area) for the least Bell's vireo (Table 5.6-1). Covered activities resulting in adverse effects on the least Bell's vireo include water conveyance facility construction, tidal natural communities restoration, Fremont Weir/Yolo Bypass improvements, and floodplain restoration. A majority (80%) of the permanent loss is from tidal communities restoration.

Water Conveyance Facility Construction

Construction of all conveyance facilities including transmission lines will result in the permanent removal of an estimated 29 acres of least Bell's vireo habitat (less than 1% of habitat in the Plan Area) (Table 5.6-1). This habitat is of low value for the species: it consists of small patches scattered through Conservation Zones 3, 4, 5, 6, and 8, most of which are narrow strips along irrigation and drainage channels. The least Bell's vireo does not likely nest in habitat along the conveyance facility alignment: the alignment was surveyed by DWR biologists in 2009, 2010, and 2011 and although the surveys were not conducted specifically for least Bell's vireo, they occurred during the nesting season when this species is easily detected by its song, if present.

An estimated 18 of the 29 acres will be lost due to placement of reusable tunnel material. The material will likely be moved to other sites for use in levee build-up and restoration, and the affected area will likely be restored. While this effect is categorized as permanent, because there is no assurance that the material will eventually be moved, the effect will likely be temporary. Furthermore, the amount of storage area needed for reusable tunnel material is flexible (dependent upon storage pile height and other factors), and the footprint used in the effects analysis is based on

[10] See Chapter 3, Section 3.2.4.2.2, *Existing Conservation Lands*, for definitions of conservation land types.

[11] Habitat or natural community loss acreage estimates are based on hypothetical footprints and models rather than detailed project-level design and represent the maximum allowed under the permit. Actual losses will be tracked through compliance monitoring to ensure that they do not exceed estimates.

a worst-case scenario; the actual area to be affected by reusable tunnel material storage will likely be less than the estimated acreage.

Fremont Weir/Yolo Bypass Improvements

This activity will result in the permanent removal of an estimated 83 acres of least Bell's vireo habitat (Table 5.6-1) in Conservation Zone 2 (less than 1% of habitat in the Plan Area). Most of the habitat to be lost is of low to moderate value; although it is located in and near existing conservation lands (Type 1), the modeled habitat to be affected in the vicinity of Fremont Weir includes grasslands with scattered small patches of willows and other riparian vegetation rather than contiguous riparian vegetation, and there are no least Bell's vireo occurrences near the Fremont Weir.

Tidal Natural Communities Restoration

This activity will result in the permanent removal of an estimated 545 acres of least Bell's vireo habitat (4% of habitat in the Plan Area) in the Suisun, Cache Slough, Cosumnes/Mokelumne, West Delta, and South Delta ROAs (Table 5.6-1). The largest habitat loss (65%) is in Conservation Zone 2 in Cache Slough ROA. This area is considered of moderate to high value, because it includes relatively large habitat patches in or adjacent to conservation lands. The remainder of the habitat that will potentially be lost to tidal natural communities restoration is scattered in Conservation Zones 1, 4, 7, 8, and 11 and is of low to moderate value, mostly in relatively small patches and narrow strips along drainage channels and surrounded by cultivated lands.

Floodplain Restoration

Levee construction associated with floodplain restoration will result in the permanent removal of an estimated 28 acres of least Bell's vireo habitat in Conservation Zone 6 (less than 1% of habitat in the Plan Area) (Table 5.6-1). This habitat is of moderate to high value: although it consists primarily of small patches, these patches are in proximity to other habitat along the San Joaquin River, some of the patches are adjacent to existing conservation lands (Type 1 and Type 2), and some of the patches are within several miles of a breeding occurrence for least Bell's vireo south of the Plan Area.

5.6.9.1.2 Periodic Inundation

Yolo Bypass Operations

Appendix 5.J, *Effects on Natural Communities, Wildlife, and Plants,* provides the method used to estimate periodic inundation effects in the Yolo Bypass. Based on this method, periodic inundation could affect least Bell's vireos occupying areas ranging from an estimated 62 acres of habitat during a notch flow of 1,000 cfs to an estimated 85 acres during a notch flow of 4,000 cfs (Table 5.6-3). However, project-associated inundation of areas that would not otherwise have been inundated is expected to occur in no more than 30% of all years, since Fremont Weir is expected to overtop the remaining estimated 70% of all years, and during those years notch operations will not typically affect the maximum extent of inundation. In more than half of all years under existing conditions, an area greater than the project-related inundation area already inundates in the bypass. Therefore, habitat conditions in the bypass are not expected to change substantially as a result of Yolo Bypass operations and effects on the least Bell's vireo, if any, are expected to be minimal.

Floodplain Restoration

This activity will periodically inundate an estimated 148 acres of least Bell's vireo habitat (less than 1% of the habitat in the Plan Area). The floodplains will transition from areas that flood frequently (i.e., every 1 to 2 years) to areas that flood infrequently (i.e., every 10 years or more). Periodic inundation as a result of Yolo Bypass operations and floodplain restoration is not expected to adversely affect the least Bell's vireo because flooding is unlikely to occur during the breeding season when the vireo could be present, and the potential effects of inundation on existing riparian vegetation are expected to be minimal. While frequent flooding in the lower elevation portions of the floodplain may result in scouring of riparian vegetation, this is expected to have a beneficial rather than an adverse effect on the species (Section 5.6.9.2, *Beneficial Effects*).

5.6.9.1.3 Construction-Related Effects

Direct and permanent effects of construction are described above in Section 5.6.9.1.1, *Permanent Habitat Loss, Conversion, and Fragmentation*. Additional construction-related effects on the least Bell's vireo include long-term temporary habitat loss, potential construction-related injury or mortality, and indirect noise and visual disturbance. Effects on the species are described below for each effect category. Effects are described collectively for all covered activities, and are also described for specific covered activities to the extent that this information is pertinent for assessing the value of affected habitat or specific nature of the effect.

Temporary Habitat Loss

Construction-related effects will temporarily remove 131 acres of habitat for the least Bell's vireo (1% of the habitat in the Plan Area) (Table 5.6-1). Temporarily removed areas will be restored as riparian habitat within 1 year following completion of construction activities. Although the effects are considered temporary, 5 years to several decades may be required for ecological succession to occur and for restored riparian habitat to functionally replace habitat that has been affected. However, restored riparian vegetation can have the habitat structure to support breeding vireos within 3 to 5 years, particularly if the restored vegetation is adjacent to established riparian areas (Kus 2002). Furthermore, most of the riparian vegetation to be temporarily removed in the Plan Area is early- to midsuccessional; therefore, the replaced riparian vegetation is expected to have structural components comparable to the temporarily removed vegetation within the first 5 to 10 years after the initial restoration activities are complete.

Construction-Related Injury or Mortality

Although least Bell's vireo nesting has not been confirmed in the Plan Area, recent occurrences in the Yolo Bypass and south of the Plan Area at the San Joaquin River National Wildlife Refuge suggest that the reestablishment of a breeding population is a possibility over the duration of the BDCP. If the least Bell's vireo nests where covered activities are to occur, equipment operation for construction activities could result in injury or mortality of individuals. Risk will be greatest to eggs and nestlings that could be injured or killed through crushing by heavy equipment, nest abandonment, or increased exposure to the elements or to predators. Injury to adults and fledged juveniles is unlikely, as these individuals are expected to avoid contact with construction equipment. Under AMM22, injury or mortality to nesting least Bell's vireos will be avoided through preconstruction surveys and establishment of a 500-foot no-disturbance buffers around active nests, as described in Appendix 3.C, *Avoidance and Minimization Measures*.

Indirect Construction-Related Effects

Noise and visual disturbance outside the project footprint but within 500 feet of construction activities are indirect effects that could temporarily affect the use of 1,188 acres (8%) of modeled least Bell's vireo habitat (Table 5.6-5). Construction noise above background noise levels (greater than 50 dBA) is expected to extend 500 to 5,250 feet from the edge of construction activity (Table 4, *Estimated Impacts on the Delta Wintering Population of Greater Sandhill Cranes from Collisions with Proposed BDCP Power Lines*, in Appendix 5.J, Attachment 5J.D, *Indirect Effects of the Construction of the BDCP Conveyance Facility on Sandhill Crane*). There are no available data to determine the extent to which these noise levels could affect least Bell's vireo. As described above, there are no nesting records for this species in the Plan Area but recent sightings indicate that the species may become established in the Plan Area during Plan implementation. Under AMM22, indirect noise and visual effects on nesting vireos, if found, will be minimized by establishing 500-foot no-disturbance buffers around active nests.

5.6.9.1.4 Other Indirect Effects

Mercury

Covered activities have the potential to increase exposure to mercury in covered species that feed in aquatic environments, including the least Bell's vireo. The operational impacts of new flows under *CM1 Water Facilities and Operation* were analyzed using a DSM-2-based model to assess potential effects on mercury concentration and bioavailablity resulting from new flows. Subsequently, a regression model was used to estimate fish-tissue concentrations in striped bass under these future conditions. Results indicated that changes in total mercury levels in water and fish tissues under future conditions with the BDCP were insignificant (Appendix 5.D, *Contaminants*, Attachment 5.D.A, *Bioaccumulation Model Development for Mercury Concentrations in Fish,* Tables 5.D.A-1, 5.D.A-2, 5.D.A-3, and 5.D.A-4).

Marsh and floodplain restoration also has the potential to increase exposure to methylmercury. Mercury is transformed into the more bioavailable form of methylmercury in aquatic systems, especially areas subjected to regular wetting and drying such as tidal marshes and flood plains. Thus, restoration activities that create newly inundated areas could increase bioavailability of mercury. Increased methylmercury associated with natural community and floodplain restoration may indirectly affect the least Bell's vireo should the species begin to nest in Yolo Bypass over the duration of the BDCP (Appendix 5.D, *Contaminants*). In general, the highest methylation rates are associated with high tidal marshes that experience intermittent wetting and drying and associated anoxic conditions (Alpers et al. 2008). The potential mobilization or creation of methylmercury in the Plan Area varies with site-specific conditions and will need to be assessed at the project level. The Suisun Marsh Plan (Bureau of Reclamation et al. 2010) anticipates that tidal wetlands restored under the plan will generate less methylmercury than the existing managed wetlands. Along with minimization and mitigation measures and adaptive management and monitoring, *CM12 Methylmercury Management* is expected to reduce the amount of methylmercury resulting from the restoration of natural communities and floodplains.

5.6.9.1.5 Effects of Ongoing Activities

Ongoing activities potentially adversely affecting least Bell's vireo include operation and maintenance activities, and habitat enhancement and management.

Transmission Lines

New transmission lines will increase the risk for bird- transmission line strikes, which could result in injury or mortality of the least Bell's vireo. The potential for this risk, however, is considered minimal based on the bird's likely low abundance near the proposed transmission line corridors, as well as factors assessed in the bird strike vulnerability analysis (Appendix 5.J, Attachment 5J.C, *Analysis of Potential Bird Collisions at Proposed BDCP Powerlines*) including wing morphology, flight altitude and timing, foraging behavior, and social behavior. Transmission line poles and towers also provide perching substrate for raptors, which could result in increased predation pressure on local least Bell's vireos. This is expected to have few adverse effects on the species' population, if any.

Operation and Maintenance

Activities associated with operation and maintenance activities that could affect least Bell's vireo habitat include transmission line and substation maintenance, excavation to repair pipeline, and levee maintenance, These activities could result in local, temporary adverse habitat effects, injury or mortality of vireos, and temporary noise and disturbance effects if individuals are present in or near work sites over the term of the BDCP. Vegetation clearing in Yolo Bypass to improve flood conveyance may temporarily adversely affect least Bell's vireo habitat: however, vegetation is already regularly removed from the bypass to improve flood conveyance, and no occupied nesting habitat will be removed during the nesting season. Maintenance effects will be avoided and minimized with implementation of AMM22 (Appendix 3.C).

Habitat Enhancement and Management

Activities associated with natural communities enhancement and management in protected least Bell's vireo habitat, such as ground disturbance or herbicide use to control nonnative vegetation, could result in local adverse habitat effects, injury or mortality of vireos, and temporary noise and disturbance effects if individuals are present in work sites over the term of the BDCP. These effects will be avoided and minimized with implementation of *AMM2 Construction Best Management Practices and Monitoring* (Appendix 3.C).

Recreation

Passive recreation in the reserve system, where that recreation is compatible with the biological goals and objectives, could result in disturbance of least Bell's vireos using habitat in the vicinity of trails. Nests could be disturbed during construction and ongoing use of trails and other amenities. Due to placement of trails, passive recreation on established trails is expected to result in limited disturbance. *AMM37 Recreation* (Appendix 3.C) limits trail construction to outside the breeding season for nesting birds. The number and length of trails that parallel the edge of the riparian forest will be limited unless located sufficiently away from those communities to minimize disturbance and allow use of open habitats by edge-dependent species. When adjacent to riparian communities, trails will be on the top of a levee or behind the top of bank except where topographic, resource management, or other constraints or management objectives make this infeasible or undesirable. With implementation of these measures, recreation-related effects on least Bell's vireo are expected to be minimal.

5.6.9.1.6 Impact of Take on Species

The least Bell's vireo's historical breeding distribution in California once extended from coastal southern California through the San Joaquin and Sacramento Valleys as far north as Tehama County near Red Bluff. The Sacramento and San Joaquin Valleys were considered the center of the species' historical breeding range, supporting 60 to 80% of the historical population (51 FR 16474). Coinciding with widespread loss of riparian vegetation throughout California (Katibah 1984), Grinnell and Miller (1944) began to detect population declines in the Sacramento and San Joaquin Valley region. Surveys conducted in the late 1970s (Goldwasser et al. 1980) detected no least Bell's vireos in the Sacramento and San Joaquin Valleys, and the species was considered extirpated from the region. In 1986, the estimated the statewide least Bell's vireo population was approximately 300 pairs (51 FR 16474), and the population was confined to southern California. By 1998, the population had increased to an estimated 2,000 pairs after extensive cowbird trapping efforts (Kus 2002), but the population was confined to southern California. Recent occurrences, however, have suggested a range expansion to the northern extent of the species' historical breeding range, including nest sites reported from the San Joaquin River National Wildlife Refuge adjacent to the Plan Area to the south (Howell et al. 2010) and recent (2010 and 2011) observations of two singing least Bell's vireo males in the southern portion of the Yolo Bypass Wildlife Area (California Department of Fish and Wildlife 2013c). This recent occurrence in the Plan Area represents one of 236 CNDDB occurrences throughout the state. The hypothetical footprint for covered activities does not overlap with this occurrence. No confirmation of breeding by vireo has been documented in the Plan Area since the 1970s.

Based on modeled habitat for the least Bell's vireo, the Plan Area supports 14,528 acres of potentially suitable nesting and migratory habitat. Of this, up to 685 acres of suitable habitat (5% of such habitat in the Plan Area) will be permanently removed, and up to 131 acres of suitable habitat (1% of such habitat in the Plan Area) will be temporarily removed. An estimated 62 to 85 acres of nesting and migratory habitat in the Yolo Bypass will be flooded more frequently as a consequence of the operation of the Fremont Weir, and an estimated 148 acres of habitat is expected to be periodically inundated as a result of floodplain restoration, but this periodic flooding is not expected to affect the least Bell's vireo because flooding is unlikely to occur during the breeding season when vireos could be present, and adverse changes to riparian vegetation from flooding is unlikely. Construction-related activities will avoid direct injury or mortality or indirect noise or visual effects through implementation of AMM22 (Appendix 3.C).

Take of the least Bell's vireo resulting from permanent and temporary habitat loss and other direct and indirect effects is not expected to adversely affect the long-term survival and conservation of the species for the following reasons.

- Vireo occurrence is expected to be uncommon in the Plan Area.
- The nesting and migratory habitat to be lost is small relative to the amount of habitat in the Plan Area and the species range throughout California.
- Most of the permanently removed habitat consists of relatively small, fragmented riparian stands that provide low-value habitat for the vireo.

5.6.9.2 Beneficial Effects

Within the restored riparian natural community, the Implementation Office will maintain at least 1,000 acres of the valley/foothill riparian natural community as early- to midsuccessional vegetation with dense shrubby understory on restored seasonally inundated floodplain. Fluvial disturbance in restored floodplains is expected to help maintain this early- to midsuccessional vegetation. Riparian systems subject to natural erosional and depositional processes provide conditions conducive to the establishment of dense willow stands preferred by vireos for nesting. These restoration actions will improve habitat conditions and increase the likelihood for breeding by least Bell's vireos in the Plan Area. Additionally, assuming the protected riparian natural community will provide suitable least Bell's vireo habitat proportional to the amount of modeled habitat that currently exists in this natural community in the Plan Area (approximately 82% of the riparian natural community in the Plan Area consists of modeled least Bell's vireo habitat), the protection of 750 acres of riparian natural community (*CM3 Natural Communities Protection and Restoration*) will provide an estimated 593 acres of protected habitat for this species (Table 5.6-7). Riparian restoration will focus along riparian systems within the Plan Area (linkages #5, 6, and 7, Figure 3.2-16, Landscape Linkages, in Chapter 3), and on connectivity with preserved riparian lands south of the Plan Area (linkage #4, Figure 3.2-16).

Invasive plants such giant reed and tamarisk that diminish structural diversity and potentially render habitat unsuitable for the least Bell's vireo will be controlled, and this is expected to maintain and enhance vireo habitat. If a least Bell's vireo population becomes established in the Plan Area and the Implementation Office determines through population monitoring that the population is declining as a result of cowbird parasitism, a cowbird control program will be implemented to maintain the vireo population in the Plan Area (*CM11 Natural Communities Enhancement and Management*).

5.6.9.3 Net Effects

Including both the habitat loss described in Section 5.6.9.1, *Adverse Effects*, and the riparian habitat restoration and protection described in Section 5.6.9.2, *Beneficial Effects*, the BDCP will result in an estimated net increase of at least 314 acres (2%) of high-value habitat for the least Bell's vireo and an estimated net increase of at least 1,054 acres (21%) of least Bell's vireo habitat in conservation lands (Table 5.6-7). This assumes that only 1,000 acres of the 5,000 acres of restoration (that portion to be maintained as early- to midsuccessional vegetation) will support least Bell's vireo; some portion of the additional 4,000 acres of restored riparian is also expected to provide habitat for this species.

The habitat that will be lost as a result of covered activities is of low to moderate value, consisting primarily of relatively small, isolated patches and narrow strips of riparian vegetation in a cultivated landscape. The restored and protected habitat will consist of large, contiguous areas, at least 1,000 acres of which will be managed to sustain appropriate vegetation structural requirements for the species. Increasing the size and connectivity of the reserve system by acquiring lands adjacent to and between existing conservation lands will protect least Bell's vireo by reducing the risks of habitat fragmentation and adverse effects from adjacent lands uses. Restoration, protection, and management of least Bell's vireo habitat in the Plan Area will increase opportunities for a breeding population of least Bell's vireos to become reestablished in this portion of its historical range.

Overall, the BDCP will provide a substantial net benefit to the least Bell's vireo through the net increase in available habitat and habitat in protected status. These protected areas will be managed and monitored to support the species. Therefore, the BDCP will minimize and mitigate impacts, to the maximum extent practicable, and provide for the conservation and management of the least Bell's vireo in the Plan Area.

5.6.10 Suisun Song Sparrow

This section describes the adverse, beneficial, and net effects of the covered activities, including conservation measures, on the Suisun song sparrow. The methods used to assess these effects are described in Section 5.2.8, *Effects Analysis for Wildlife and Plant Species*. Suisun song sparrow primary breeding is high and middle brackish marsh, although they do use managed wetlands. See Appendix 2.A, *Covered Species Accounts*, for more specific detail on habitat. Secondary habitats generally provide only a few ecological functions such as foraging (low marsh and managed wetlands) or extreme high-tide refuge (upland transition zones), while primary habitats provide multiple functions, including breeding, effective predator cover, and forage. Further details regarding the habitat model, including assumptions on which the model is based, are provided in Appendix 2.A. Factors considered in assessing the value of affected habitat for the Suisun song sparrow, to the extent that information is available, include habitat patch size, connectivity, and proximity to recorded occurrences of the species.

5.6.10.1 Adverse Effects

5.6.10.1.1 Permanent Habitat Loss, Conversion, and Fragmentation

Covered activities will result in the permanent loss or conversion of up to 3,688 acres[12] of primary and secondary habitat (13% of the habitat in the Plan Area) for the Suisun song sparrow (Table 5.6-1). The majority of the effects (98%) will be on habitat of moderate value in managed wetlands that will be converted to tidal marsh. The only covered activities that will adversely affect this species are activities associated with tidal habitat restoration in Conservation Zone 11.

Tidal Natural Communities Restoration

Tidal natural communities restoration is expected to result in the permanent loss of 3,688 acres of Suisun song sparrow habitat, which includes the conversion of 55 acres of primary habitat to secondary low marsh, and the conversion of 123 acres of secondary habitat to primary middle or high marsh. All of the 3,633 acres of permanent loss is habitat of lower value that will convert to intertidal or subtidal habitat due to subsidence that has occurred in the restoration area. Less than 2% of the primary Suisun song sparrow habitat in the Plan Area will be affected, but it will not be a permanent loss, only a conversion to foraging habitat. Although the actual tidal natural communities restoration effects are likely to differ from the hypothetical footprint used to estimate losses, the Implementation Office will not exceed these upper limits of habitat loss or conversion for the Suisun song sparrow.

5.6.10.1.2 Periodic Inundation

No periodic inundation effects on the Suisun song sparrow will occur as a result of covered activities, because activities that would result in periodic inundation will not be implemented in Suisun Marsh, where the species occurs.

[12] Habitat or natural community loss acreage estimates are based on hypothetical footprints and models rather than detailed project-level design and represent the maximum allowed under the permit. Actual losses will be tracked through compliance monitoring to ensure that they do not exceed estimates.

5.6.10.1.3 Construction-Related Effects

Construction is not expected to result in loss of the Suisun song sparrow other than that described in in Section 5.6.10.1.1, *Permanent Habitat Loss, Conversion, and Fragmentation*. All staging and other temporary construction-related work areas for tidal natural communities restoration will either be in areas that do not provide habitat for the species (i.e., already disturbed sites) or will be within the footprint of permanently affected areas described above. Construction-related injury and mortality as well as indirect effects are described below.

Construction-Related Injury or Mortality

Operation of construction equipment could result in injury or mortality of Suisun song sparrows. Risk will be greatest to eggs and nestlings susceptible to land clearing activities, nest abandonment, or increased exposure to the elements or to predators. Injury to adults and fledged juveniles is less likely as these individuals are expected to avoid contact with construction equipment. However, establishment under AMM22 of a 250-foot no-disturbance buffer around nest sites during construction is expected to minimize the potential for injury or mortality of the Suisun song sparrow (Appendix 3.C, *Avoidance and Minimization Measures*).

Indirect Construction-Related Effects

Construction activities related to tidal natural communities restoration are expected to result in temporary, indirect effects on 871 acres of Suisun song sparrow habitat (287 acres of primary habitat) adjacent to these activities. These construction activities include grading, filling, contouring, and other ground-disturbing operations, with the potential to cause noise, dust, and visual disturbance outside the project footprint, up to 500 feet from the construction edge. Construction noise above background noise levels (greater than 50 dBA) is expected to extend 500 to 5,250 feet from the edge of construction activity (Table 4, *Estimated Impacts on the Delta Wintering Population of Greater Sandhill Cranes from Collisions with Proposed BDCP Power Lines*, Appendix 5.J, Attachment 5J.D, *Indirect Effects of the Construction of the BDCP Conveyance Facility on Sandhill Crane*). There are no available data to determine the extent to which these noise levels could affect Suisun song sparrow. If construction occurs during the nesting season, these indirect effects could result in the loss or abandonment of nests, and mortality of any eggs and/or nestlings. However, preconstruction surveys will be conducted and if an active nest site is present within 250 feet of construction activity, a 250-foot no-disturbance buffer will be established around the nest site during the breeding season, as described further in AMM22.

5.6.10.1.4 Effects of Ongoing Activities

Transmission Lines

New transmission lines will increase the risk for bird- transmission line strikes, which could result in injury or mortality of the Suisun song sparrow. The range of the Suisun song sparrow extends eastward into the Plan Area to approximately Kimball Island. During the breeding season, the Suisun song sparrow occupies small territories (approximately 0.1 acre [0.04 hectares] in optimal habitat), usually adjacent to the territories of other Suisun song sparrows in a single linear arrangement along the edges of sloughs and bays. During the fall and winter, adults and young may range up to 600 feet (183 meters) from the territory and occupy adjacent seasonal marshes or grasslands, while continuing to occupy the same general area and return to the same breeding territory each year (Marshall 1948; Walton 1975). In consideration of this behavior, known occurrences of Suisun song sparrows are not likely to intersect with the proposed transmission lines (Appendix 5.J, Attachment 5J.C, *Analysis of Potential Bird Collisions at Proposed BDCP Powerlines*).

Habitat Enhancement and Management

Activities associated with natural communities enhancement and management in protected habitats, such as ground disturbance or removal of nonnative vegetation, could result in local adverse habitat effects, injury or mortality of Suisun song sparrows, and temporary noise and disturbance effects if individuals are present in work sites over the term of the BDCP. These potential effects are currently not quantifiable, but will be minimized with implementation AMM22.

Management of the 5,000 acres of managed wetlands to be protected for waterfowl and shorebirds is not expected to result in overall adverse effects on the Suisun song sparrow. Management actions that will improve wetland quality and diversity on managed wetlands include control and eradication of invasive plants; maintenance of a diversity of vegetation types and elevations, including upland areas to provide flood refugia; water management and leaching to reduce salinity; and enhancement of water management infrastructure (improvements to enhance drainage capacity, levee maintenance). These management actions will potentially benefit the Suisun song sparrow. The 5,000 acres of protected managed wetlands will be monitored and adaptively managed to ensure that management options are implemented to avoid adverse effects on the Suisun song sparrow.

Recreation

Passive recreation in the reserve system, where that recreation is compatible with the biological goals and objectives, could result in disturbance of Suisun song sparrows using habitat in the vicinity of trails. Nests could be disturbed during construction and ongoing use of trails and other amenities. Due to placement of trails, passive recreation on established trails is expected to result in limited disturbance. Hunting may result in disturbance, but this is baseline condition in managed wetlands. *AMM37 Recreation* (Appendix 3.C) limits trail placement to existing levees and requires that leash laws be enforced (excluding hunting activities). Construction of recreational amenities in and near suitable habitat will be limited to outside the breeding season. With recreation restrictions in place, as required under AMM37, recreation-related effects on Suisun song sparrow are expected to be minimal.

5.6.10.1.5 Other Indirect Effects

Mercury

Covered activities have the potential to increase exposure to mercury in covered species that feed in aquatic environments, including the Suisun song sparrow. The operational impacts of new flows under *CM1 Water Facilities and Operation* were analyzed using a DSM-2-based model to assess potential effects on mercury concentration and bioavailablity resulting from new flows. Subsequently, a regression model was used to estimate fish-tissue concentrations in striped bass under these future conditions. Results indicated that changes in total mercury levels in water and fish tissues under future conditions with the BDCP were insignificant (Appendix 5.D, Attachment 5.D.A, *Bioaccumulation Model Development for Mercury Concentrations in Fish,* Tables 5.D.A-1, 5.D.A-2, 5.D.A-3, and 5.D.A-4).

Marsh and floodplain restoration also has the potential to increase exposure to methylmercury. Mercury is transformed into the more bioavailable form of methylmercury in aquatic systems, especially areas subjected to regular wetting and drying such as tidal marshes and flood plains. Thus, restoration activities that create newly inundated areas could increase bioavailability of mercury. Increased methylmercury associated with natural community and floodplain restoration may indirectly affect the Suisun song sparrow, which feeds on aquatic snails, amphipods, and insects (Grenier 2004). (Appendix 5.D, *Contaminants*). In general, the highest methylation rates are associated with high tidal marshes that experience intermittent wetting and drying and associated anoxic conditions (Alpers et al. 2008). Robinson et al. (2011) found toxic levels of methylmercury levels in song sparrow populations from southern San Francisco Bay, although populations near Suisun Marsh (i.e., San Pablo and Simas Creeks) were much lower. The potential mobilization or creation of methylmercury in the Plan Area varies with site-specific conditions and will need to be assessed at the project level. The Suisun Marsh Plan (Bureau of Reclamation et al. 2010) anticipates that tidal wetlands restored under the plan will generate less methylmercury than the existing managed wetlands. Along with minimization and mitigation measures and adaptive management and monitoring, *CM12 Methylmercury Management* is expected to reduce the amount of methylmercury resulting from the restoration of natural communities and floodplains.

5.6.10.1.6 Impact of Take on the Species

The Suisun song sparrow is a subspecies of song sparrow that is endemic to the tidal marshes of Suisun Bay. In the Plan Area, it occupies suitable habitat in the extreme western Delta and the Suisun Marsh. There are 37 CNDDB/DHCCP occurrences through the species' range, of which 23 extant occurrences (62%) are in the Plan area. The hypothetical footprint for covered activities overlaps with five of these occurrences, all in Suisun Marsh in areas subject to tidal habitat restoration.

Based on modeled habitat for the Suisun song sparrow, the Plan area supports 27,707 acres of suitable habitat, most (87%) of which is low-value managed wetland (23,986 acres). Of this, up to 3,590 acres of modeled habitat (13%) will be affected by tidal natural communities restoration. None of the permanent loss will be of primary habitat. The 55 acres of primary habitat that will be converted to low-value low marsh represents less than 1% of the song sparrow habitat in the Plan area. These losses of Suisun song sparrow habitat are not expected to adversely affect the long-term survival and conservation of the species for the following reasons.

- Most of the permanently removed habitat is managed wetland that provides habitat of marginal value for the species.
- Habitat removal will be sequenced with tidal habitat restoration to minimize adverse effects on habitat and the Suisun song sparrow population.

5.6.10.2 Beneficial Effects

The Plan requires restoration of at least 6,000 acres of tidal brackish emergent wetland in Suisun Marsh (Objective TBEWNC1.1) and that at least 1,500 of the 6,000 acres be high and middle marsh (Objective TBEWNC1.2). The 1,500 acres of high and middle marsh are expected to provide primary habitat for Suisun song sparrow, while the remainder of the restored tidal brackish emergent wetland is expected to provide secondary habitat. Additionally, assuming the protected managed wetland natural community will provide suitable Suisun song sparrow habitat proportional to the amount of modeled habitat that currently exists in this natural community in the Plan Area (approximately 26% of the managed wetlands in the Plan Area consist of modeled Suisun song sparrow habitat), implementation of the BDCP will protect an estimated 384 acres of secondary Suisun song sparrow habitat (Table 5.6-7).

Tidal wetlands will be restored as a mosaic of large, interconnected, and biologically diverse patches that support a natural gradient extending from subtidal to the upland fringe. Larger and more interconnected patches of suitable habitat are expected to reduce the effects of habitat fragmentation that exist in Suisun Marsh. This, in turn, is expected to allow increases in the populations of native species, including the Suisun song sparrow. The habitat and ecosystem functions of tidal brackish emergent wetland will be maintained and enhanced for native species over the term of the BDCP. Much of the restored tidal brackish emergent wetland will meet the primary habitat requirements of the Suisun song sparrow, including development of middle- and high-marsh vegetation. Nonnative predators will be controlled as needed to reduce nest predation and help maintain species abundance (*CM11 Natural Communities Enhancement and Management*). Tidal habitat restoration actions will primarily affect managed wetlands that provide low-value habitat for the Suisun song sparrow. At Grizzly Island, where unrestored managed wetland will remain, enhancement of 1,500 acres of salt marsh harvest mouse habitat (CM11) will also benefit the Suisun song sparrow, given the similarity in the use of that habitat by the two species. Restoration will also be sequenced (over 40 years) and oriented in a manner that minimizes any temporary, initial loss and fragmentation of habitat. These measures will improve habitat conditions for the Suisun song sparrow and enhance the long-term viability of this species in the Plan Area.

Water operations associated with covered activities intended to mimic more natural patterns of water flow are expected to increase salinity in Suisun Marsh. Salinity changes in the tidal channels and sloughs are expected to be highly variable. Consequently, these effects cannot be reasonably differentiated from tidal habitat restoration effects. Still, these elevated salinity levels will likely encourage the establishment of tidal brackish communities that were historically abundant in Suisun Marsh, and especially important species such as pickleweed, an outcome expected to benefit the Suisun song sparrow.

5.6.10.3 Net Effects

Including both the habitat loss described in Section 5.6.2.10, *Adverse Effects*, and the riparian habitat restoration and protection described in Section 5.6.10.2, *Beneficial Effects*, the BDCP will result in an estimated net increase of 2,410 acres (9%) of habitat for Suisun song sparrows and an estimated net increase of at least 2,794 acres (11%) of Suisun song sparrow habitat in conservation lands (Table 5.6-7).

The potential take of Suisun song sparrows in the form of noise and visual disturbance associated with covered activities is not expected to adversely affect the long-term survival and conservation of this species. Suisun song sparrow avoidance and minimization measures, as described in Appendix 3.C, *Avoidance and Minimization Measures,* will be implemented to specifically protect song sparrow nest sites and avoid injury or mortality to adults, nestlings, and eggs. Managed wetland management and protection conservation measures (*CM11 Natural Communities Enhancement and Management*) will also contribute to offsetting Suisun song sparrow losses by enhancing 1,500 acres of salt marsh harvest mouse habitat (also used by Suisun song sparrows) in the Grizzly Island complex. Collectively, these actions will offset the effects of covered activities and further contribute to the long-term survival and conservation of the Suisun song sparrow.

Overall, the BDCP will provide a substantial net benefit to the Suisun song sparrow through the increase in high-value primary habitat. These areas will be managed and monitored to support the species. Therefore, the BDCP will minimize and mitigate impacts, to the maximum extent practicable, and provide for the conservation and management of the Suisun song sparrow in the Plan Area.

5.6.11 Swainson's Hawk

This section describes the adverse, beneficial, and net effects of the covered activities, including conservation measures, on the Swainson's hawk. The methods used to assess these effects are described in Section 5.2.8, *Effects Analysis for Wildlife and Plants*, and Table 5.J.1, *Quantitative Effects Analysis Methods and Assumptions*, in Appendix 5.J, *Effects on Natural Communities, Wildlife, and Plants*, and more specific assessment methods are described below. The habitat model for the Swainson's hawk includes vegetation and land cover types associated with Swainson's hawk nesting and foraging habitat. Further details regarding the habitat model, including assumptions on which the model is based, are provided in Appendix 2.A, *Covered Species Accounts.*

Factors considered in assessing the value of affected Swainson's hawk habitat, to the extent that information is available, include the relative habitat value of different vegetation and land cover types used as foraging habitat based on structural characteristics and crop management that relate to prey accessibility and availability.

In addition to the quantitative analysis of habitat loss described above, the loss of habitat was also qualitatively reviewed with regard to the geographic location of habitat removed relative to the Swainson's hawk nesting distribution and the effects of possible habitat fragmentation. Because the species is wide-ranging, the loss of large patches of cultivated land foraging habitat as a result of tidal wetland restoration is likely to affect the viability of some local nesting territories. This qualitative analysis also recognizes that the final design for covered activities will likely differ somewhat from hypothetical footprints.

5.6.11.1 Adverse Effects

5.6.11.1.1 Permanent Habitat Loss, Conversion and Fragmentation

Covered activities will result in the permanent removal or conversion of up to 53,275 acres[13] of habitat (11% of the habitat in the Plan Area) for the Swainson's hawk (Table 5.6-11). This total includes loss of nesting habitat (430 acres) and loss of foraging habitat (52,845 acres). Table 5.6-11 provides a breakdown of foraging habitat loss by habitat value class. Covered activities resulting in adverse effects on the Swainson's hawk include water conveyance facility construction, Fremont Weir/Yolo Bypass improvements, tidal natural communities restoration, floodplain restoration, nontidal marsh restoration, riparian restoration, grassland restoration, and conservation hatcheries facilities. Most (71%) of this loss will result from tidal natural communities restoration.

[13] Habitat or natural community loss acreage estimates are based on hypothetical footprints and models rather than detailed project-level design and represent the maximum allowed under the permit. Actual losses will be tracked through compliance monitoring to ensure that they do not exceed estimates.

Table 5.6-11. Total Acres of Swainson's Hawk Habitat Permanently Affected

Foraging Habitat Value Class[a]	Agricultural Crops and Other Cover Types	Acres Affected[b] (% of Total Impact)
Very high	Alfalfa hay	661 (1%)
Moderate	Irrigated pasture, other hay crops, tomatoes, sugar beets, grain crops (wheat, barley, oats)	38,425 (73%)
Low	Other irrigated field and truck/berry crops	5,997 (11%)
Very low	Safflower, sunflower, corn, grain sorghum	7,945 (15%)
Totals		**53,028**

[a] See Appendix 2.A, *Covered Species Accounts*, for a description of habitat values
[b] Total includes permanent, permanent – reusable tunnel material, and temporary borrow and spoil effects.

Historically, Swainson's hawks foraged in grasslands and other open habitats of the Plan Area, and nested in vast areas of riparian forests and oak woodlands. Diking, levee construction, channelization, agricultural conversion, urbanization, and other activities have substantially altered and fragmented their historical habitat. With substantial conversion of the native landscape to support farming operations, Swainson's hawks have shifted their nesting and foraging to include those agricultural lands that provide low, open vegetation for hunting rodent prey, and nearby remnant trees suitable for nesting. Restoration activities such as grading, filling, contouring, and other ground-disturbing operations may result in permanent habitat loss that further fragments nesting and foraging habitat. This could reduce functions provided by Swainson's hawk habitat until restoration is achieved, a process that could take several years (e.g., grassland foraging areas) to decades (e.g., valley/foothill riparian nesting habitat) to achieve.

The Swainson's hawk is a highly mobile species that ranges over a broad area while foraging. Home ranges are significantly larger than for most other buteos and foraging Swainson's hawks adjust their foraging ranges seasonally and annually to changes in land use patterns and crop dynamics (Estep 1989; Babcock 1995). Depending on the availability of nesting habitat, the nesting distribution of the Swainson's hawk can also be quite broad across a diverse agricultural landscape. The Plan Area is no exception. While fewer nests are documented within the Central Delta due to fewer available nest trees and a somewhat less suitable foraging landscape, the nesting distribution includes all portions of the Plan Area.

Effects on Swainson's hawks are also expected to occur over a fairly broad area. The majority of effects on Swainson's hawk will occur through the conversion of cultivated land to tidal wetlands in Conservation Zones 1, 2, 3, 4, 5, 6, and 7.

Because the species is highly mobile and wide-ranging, and the effects on nesting and foraging habitat will occur over a large proportion of the Plan Area, habitat fragmentation is not expected to reduce the use of remaining cultivated lands or preclude access to surrounding lands. In this regard, fragmentation will not isolate subpopulations or individual nest sites or result in a barrier to movement. However, the conversion of cultivated lands to tidal wetlands over fairly broad areas in the tidal restoration footprints could result in the removal or abandonment of nesting territories that occur in or near the restoration areas. Depending on the extent and value of remaining habitat, this could reduce the local nesting population. There are 32 documented Swainson's hawk CNDDB occurrences that overlap with the hypothetical impact footprint, suggesting that numerous nest sites could be directly affected by restoration activities.

Swainson's hawk permanent habitat loss and conversion are described below for each covered activity.

Water Conveyance Facility Construction

This activity will result in the permanent removal of approximately 4,353 acres of habitat for the Swainson's hawk in Conservation Zones 3, 4, 5, 6, 7, and 8 (Table 5.6-1). This total represents a loss of 4,335 acres of foraging habitat and 18 acres of nesting habitat for the Swainson's hawk. Effects on foraging habitat occur primarily on cultivated land, in an area with numerous Swainson's hawk occurrences.

An estimated 3,245 of the 4,353 acres will be lost due to placement of reusable tunnel material. The material will likely be moved to other sites for use in levee build-up and restoration, and the affected area will likely be restored. While this effect is categorized as permanent, because there is no assurance that the material will eventually be moved, the effect will likely be temporary. Furthermore, the amount of storage area needed for reusable tunnel material is flexible, and the footprint used in the effects analysis is based on a worst-case scenario; the actual area to be affected by reusable tunnel material storage will likely be less than the estimated acreage.

Fremont Weir/Yolo Bypass Improvements

This activity will result in the permanent removal of an estimated 1,075 acres of habitat in Conservation Zones 2 and 3 for the Swainson's hawk (Table 5.6-1). This represents a loss of 996 acres of foraging habitat and 79 acres of nesting habitat for the Swainson's hawk.

Tidal Natural Communities Restoration

Based on the hypothetical tidal restoration footprint, this activity will result in the permanent removal or conversion of an estimated 37,654 acres of habitat in the Yolo Bypass, Cache Slough, Suisun Marsh, West Delta, Cosumnes/Mokelumne, and South Delta ROAs for the Swainson's hawk (Table 5.6-1). This total represents a loss of 37,359 acres of foraging habitat and 295 acres of nesting habitat for the Swainson's hawk.

Floodplain Restoration

Levee construction associated with floodplain restoration will result in the permanent removal of an estimated 1,857 acres of habitat in Conservation Zone 7 for the Swainson's hawk (Table 5.6-1). This total represents a loss of 1,820 acres of foraging habitat and 38 acres of nesting habitat for the Swainson's hawk.

Riparian Restoration

This activity will result in the permanent removal of an estimated 4,962 acres of Swainson's hawk habitat, all of which is modeled as foraging habitat (Table 5.6-1). However, 3,991 acres of this will be a conversion from foraging to nesting habitat rather than a total habitat loss.

Nontidal Marsh Restoration

Based on nontidal marsh restoration objectives in the giant garter snake conservation strategy, this activity will result in the permanent removal of an estimated 1,440 acres of habitat in the Conservation Zones 2, 4, and 5 for the Swainson's hawk (Table 5.6-1).

Grassland Restoration

This activity will result in the permanent removal of an estimated 1,849 acres of cultivated lands providing Swainson's hawk habitat, all of which is modeled foraging habitat (Table 5.6-1). However, the restored grassland will continue to provide foraging habitat value for the species, therefore this is a conversion from one foraging habitat type to another, rather than loss of foraging habitat.

Conservation Hatcheries Facilities

Based on a preliminary design footprint, this activity will result in the permanent removal of an estimated 35 acres of cultivated natural community in Conservation Zone 1 for the Swainson's hawk (Table 5.6-1).

Recreation

Based on the recreation assumptions described in Chapter 4, *Covered Activities and Associated Federal Actions*, an estimated 50 acres of Swainson's hawk habitat will be removed as a result of constructing trails and associated recreational facilities. *AMM37 Recreation* (Appendix 3.C, *Avoidance and Minimization Measures*) will be implemented to ensure that construction of new trails and recreational amenities is limited to outside the nesting season within 600 feet of potential nest trees as described in AMM37. Indirect effects of recreational activities are described below, in Section 5.6.11.1.4, *Effects of Ongoing Activities*.

5.6.11.1.2 Periodic Inundation

Fremont Weir/Yolo Bypass Improvements

Appendix 5.J, *Effects on Natural Communities, Wildlife, and Plants,* provides the method used to estimate periodic inundation effects in the Yolo Bypass. Based on this method, periodic inundation could affect Swainson's hawks occupying areas ranging from an estimated 3,082 acres of habitat during a notch flow of 1,000 cfs to an estimated 6,705 acres during a notch flow of 4,000 cfs. The inundation could affect Swainson's hawks in 3,025 to 6,635 acres of foraging habitat and 41 to 70 acres of nesting habitat (Table 5.6-3). However, project-associated inundation of areas that would not otherwise have been inundated is expected to occur in no more than 30% of all years, since Fremont Weir is expected to overtop the remaining estimated 70% of all years, and during those years notch operations will not typically affect the maximum extent of inundation. In more than half of all years under existing conditions, an area greater than the project-related inundation area already inundates in the bypass. Therefore, habitat conditions in the bypass are not expected to change substantially as a result of Yolo Bypass operations. Increased duration of inundation during years of Fremont Weir operation, however, may delay the period for which foraging habitat is available to Swainson's hawks by up to several weeks.

Floodplain Restoration

This activity will periodically inundate an estimated 8,008 acres of modeled Swainson's hawk foraging and 189 acres of nesting habitat (Table 5.6-1). Floodplain restoration is expected to restore a more natural flood regime and sustain riparian vegetation types that support regeneration of Swainson's hawk nesting habitat. The restored floodplains will transition from areas that flood frequently (i.e., every 1 to 2 years) to areas that flood infrequently (i.e., every 10 years or more).

Foraging habitat that is inundated after Swainson's hawks arrive in the Central Valley in mid-March could result in a periodic loss of available foraging habitat due to the reduction in available prey. Inundated habitats are expected to recover following draw-down and provide suitable foraging conditions until the following inundation period. Thus, this is considered a periodic and short term effect that is unlikely to affect Swainson's hawk distribution and abundance, or foraging use of the Plan Area.

5.6.11.1.3 Construction-Related Effects

Direct and permanent effects of construction are described above in Section 5.6.11.1.1, *Permanent Habitat Loss, Conversion, and Fragmentation*. Construction-related effects on the Swainson's hawk include short-term temporary effects from water conveyance facility construction and levee construction associated with Yolo Bypass improvements and floodplain restoration, and long-term temporary effects from establishment of borrow and spoils sites. Construction-related injury or mortality as well as indirect effects are also described. Effects on the species are described below for each effect category. Effects are described collectively for all covered activities, and are also described for specific covered activities to the extent that this information is pertinent for assessing the value of affected habitat or specific nature of the effect.

Temporary Habitat Loss

Covered activities are expected to temporarily remove 2,765 acres from the Plan Area (Table 5.6-1), representing less than 1% of the modeled Swainson's hawk habitat in the Plan Area. Most of the affected modeled habitat is cultivated land. Temporary losses will result from water conveyance facility construction (18 acres of nesting habitat and 1,113 acres of foraging habitat) in Conservation Zones 3 through 8, Yolo Bypass fisheries enhancements (54 acres of nesting habitat and 504 acres of foraging habitat) in Conservation Zones 2 and 3, and construction of floodplain restoration levees (31 acres of nesting habitat and 1,036 acres foraging habitat) in Conservation Zone 7. Establishment and use of borrow and spoil areas associated with water facility construction will result in the temporary removal of approximately 183 acres of modeled Swainson's hawk foraging habitat in Conservation Zones 4, 5, and 8 (Table 5.6-1).

Temporarily removed areas will be restored to their previous habitat condition within 1 year following completion of construction and management activities. It is expected that restored habitats will achieve conditions favored by Swainson's hawks for foraging and nesting within several years (e.g., grassland and agricultural areas) to decades (e.g., valley/foothill riparian habitat) following disturbance. Most temporary effects resulting from covered activities will affect agricultural and grassland habitats that can be restored relatively quickly to suitable foraging habitat. However, restored riparian habitat will likely require decades before trees attain sufficient size and structure adequate for nesting by Swainson's hawks. Borrow and spoil areas may not be restored to their original topography, and areas that were originally cultivated lands may be restored as grasslands, but the restored areas are expected to provide foraging habitat value for the Swainson's hawk.

Although this habitat will be restored to preproject conditions within the permit term, the timeframe for restoration is unknown.

Construction-Related Injury or Mortality

Operation of construction equipment could result in injury or mortality of Swainson's hawk eggs or nestlings, which are susceptible to land-clearing activities, nest abandonment, or increased exposure to the elements or to predators. Injury to adults and fledged juveniles is less likely as these individuals are expected to avoid contact with construction equipment. With implementation of *AMM18 Swainson's Hawk and White-Tailed Kite* (Appendix 3.C), injury or mortality will be avoided by establishing a 600-foot-radius no-disturbance buffer around each active Swainson's hawk nest site. No entry of any kind related to a BDCP construction activity will be allowed in the buffer while a nest site is occupied by Swainson's hawk during the breeding season.

Indirect Construction-Related Effects

Construction-related noise and visual disturbances outside the project footprint but within 600 feet of construction activities are indirect effects that could temporarily affect the use of 21,262 acres (5% of total modeled habitat in the Plan Area) of modeled Swainson's hawk habitat (Table 5.6-5). These construction activities will include water conveyance construction, tidal restoration activities, floodplain restoration, and Fremont Weir/Yolo Bypass Enhancements. Construction noise above background noise levels (greater than 50 dBA) is expected to extend 500 to 5,250 feet from the edge of construction activity (Table 4, *Estimated Impacts on the Delta Wintering Population of Greater Sandhill Cranes from Collisions with Proposed BDCP Power Lines*, in Appendix 5.J, Attachment 5J.D, *Indirect Effects of the Construction of the BDCP Conveyance Facility on Sandhill Crane*). There are no available data to determine the extent to which these noise levels could affect Swainson's hawk.

Swainson's hawks are seasonally abundant across much of the Plan Area wherever adequate nest trees occur in a cultivated landscape that supports suitable foraging habitat. There is a potential for noise and visual disturbances associated with covered activities to temporarily displace Swainson's hawks and temporarily reduce the use of suitable habitat adjacent to construction areas. Assuming effects up to 0.25 mile from the edge of construction to nest sites and up to 600 feet for foraging birds, noise and visual disturbances could temporarily affect the use of up to 888 acres of nesting habitat for the Swainson's hawk (Table 5.6-5). These adverse effects will be minimized with the implementation of AMM18.

5.6.11.1.4 Effects of Ongoing Activities

Transmission Lines

New transmission lines will increase the risk for bird- transmission line strikes, which could result in injury or mortality of Swainson's hawks. This species is expected to be at low risk of bird strike mortality based on factors assessed in the bird strike vulnerability analysis (Appendix 5.J, Attachment 5J.C, *Analysis of Potential Bird Collisions at Proposed BDCP Powerlines*) including wing morphology, flight altitude and timing, foraging behavior, and social behavior. The Swainson's hawk has long, narrow, tapered wings and a body size that allows for efficient soaring flight and highly developed aerial maneuverability, along with highly developed eyesight, and fair-weather flight behavior. The species, therefore, has a low relative risk for transmission line collision mortality. The existing network of transmission lines in the Plan Area currently poses this risk for the Swainson's hawk, and any incremental risk associated with the new transmission line corridors (up to approximately 9.3 miles in the Plan Area) is expected to be low. Mortality associated with transmission line collision is not anticipated to affect the Plan Area population of Swainson's hawks.

Facilities Operation and Maintenance

Maintenance of the above-ground water conveyance facilities could result in ongoing but periodic postconstruction noise and visual disturbances that could affect Swainson's hawk use of surrounding habitat. These effects may include periodic vehicle use along the conveyance corridor, and inspection and maintenance of above-ground facilities. These potential effects will be minimized with implementation of AMM18.

Habitat Enhancement and Management

Activities associated with habitat enhancement and management intended to maintain and improve habitat functions in protected habitats could result in localized effects on Swainson's hawk habitat, and temporary noise and disturbance effects over the term of the BDCP. If active nests are located near work sites, disturbance could reduce reproductive success or result in nest failure or abandonment. These effects will be minimized with the implementation of AMM18. Over the term of the BDCP, these habitat enhancement and management effects are expected to result in a net benefit because these actions will improve habitat functions for Swainson's hawks and other covered species.

Management of the 5,000 acres of managed wetlands to be protected for waterfowl and shorebirds is not expected to result in overall adverse effects on the Swainson's hawk. Management actions that will improve wetland quality and diversity on managed wetlands include control and eradication of invasive plants and maintenance of a diversity of vegetation types and elevations, including upland areas. These management actions will potentially benefit the Swainson's hawk. The 5,000 acres of protected managed wetlands will be monitored and adaptively managed to ensure that management options are implemented to avoid adverse effects on the Swainson's hawk.

Recreation

Passive recreation in the reserve system, where that recreation is compatible with the biological goals and objectives, could result in disturbance of Swainson's hawks nesting in the vicinity of trails. *AMM37 Recreation* (Appendix 3.C) limits trail construction to outside the breeding season within 600 feet of potential nest trees, and requires trail closure within 600 feet of active nests. The number and length of trails that parallel the edge of the riparian forest will be limited unless located sufficiently away from those communities to minimize disturbance and allow use of open habitats by edge-dependent species. When adjacent to riparian communities, trails will be on the top of a levee or behind the top of bank except where topographic, resource management, or other constraints or management objectives make this infeasible or undesirable. With implementation of these measures, recreation-related effects on the Swainson's hawk are expected to be minimal.

5.6.11.1.5 Impact of Take on Species

The Swainson's hawk breeds in the open grasslands, shrub-steppe and agricultural regions of western North America from southern Canada to northern Mexico, and winters primarily in the

Pampas region of Argentina. With the conversion of much of the species' historical range to agriculture, the Swainson's hawk has adapted to agricultural landscapes compatible with its foraging needs where suitable nesting habitat is also available. Most nesting Swainson's hawks in California are found in the Central Valley, from Tehama County south to Kern County, an area almost entirely converted to agricultural landscapes. The species is generally found in this area from early March through mid-September. Recent surveys documented more than 2,000 breeding pairs in the Central Valley (Anderson et al. 2007), with the density of nesting Swainson's hawks in the Yolo/Solano/Sacramento/San Joaquin County area, considered the core of the Central Valley breeding population, higher than anywhere else in the species' range. The population in the Plan Area is also large and widely distributed, with over 400 reported nesting records. At least 300 of these are considered independent nesting territories that are potentially active in any given year, representing about 14% of the statewide population. In the Plan Area, nesting densities are highest in the northern (north of State Route 12) and southern (south of State Route 12) portions, areas that support a relative abundance of potential nest sites in an agricultural landscape that is suitable for Swainson's hawk foraging. The hypothetical footprint for covered activities overlaps with at least 27 of the documented nesting records from the Plan Area. The Plan Area constitutes an important portion of the species' California range.

Based on modeled habitat for the Swainson's hawk, the Plan Area supports 480,120 acres of potentially suitable habitat, including 9,796 acres of nesting habitat and 470,324 acres of foraging habitat. Sustainability of the Swainson's hawk population in the Plan Areas is dependent on providing and maintaining suitable nesting sites interspersed in sufficient acreage of compatible agricultural and grassland landscapes that support abundant, accessible prey. Covered activities are projected to permanently affect a total of 52,845 acres of foraging habitat (11% of the available habitat) in the Plan Area, and 430 acres (5%) of modeled Swainson's hawk nesting habitat. In addition, 2,948 acres of habitat will be temporarily removed, 183 acres of which consist of borrow and spoil areas that may not be returned to their original topography.

There are 32 documented Swainson's hawk occurrences that overlap with the hypothetical restoration footprint, suggesting that some nest sites could be directly affected by restoration activities. However, whether restoration to a tidal wetland will actually result in displacement of active nesting territories is unknown. If nesting trees are retained, many pairs may continue to use the restored landscape as long as suitable foraging habitat occurs within 1 to 2 miles (England et al 1995). In addition, some displaced nesting pairs may successfully relocate to alternative nest sites within their nesting territories in the Plan Area. However, because of the very large nesting population in the Plan Area, and because suitable nesting habitat is limited in some areas, such as the Central Delta, it is reasonable to suggest that the nesting population is fairly saturated in the Plan Area and that some displaced pairs may not find alternative nesting opportunities outside of their nesting territories within the Plan Area. So there is some potential for a reduction in the number of nesting pairs in the Plan Area as a result of project actions, particularly tidal restoration actions. However, the BDCP's beneficial effects on the species, described below, are expected to offset potential adverse effects and provide for the conservation and management of the species in the Plan Area.

5.6.11.2 Beneficial Effects

The Implementation Office will restore or create 5,000 acres of valley/foothill riparian forest, with at least 3,000 acres occurring on restored seasonally inundated floodplain, and protect 750 acres of existing valley/foothill riparian forest. Portions of these restored and protected riparian areas are expected to provide nesting structure for Swainson's hawks (i.e., large, mature trees) over the term of the BDCP. Restoration of valley/foothill riparian forest is expected to substantially increase available nest sites in the Plan Area for the Swainson's hawk. Restored habitats (e.g., valley/foothill riparian nesting areas) may require several years to several decades to achieve conditions suitable for nesting by Swainson's hawks; however, there is currently sufficient nesting habitat available in the Plan Area to support a very large and dense nesting population. Restored riparian habitats are designed to provide future nesting habitat in order to increase nesting opportunities during the permit period.

Conservation measures will also protect 55,019 acres of Swainson's hawk foraging and nesting habitat, including 8,000 acres of grassland, 150 acres of alkali seasonal wetland complex, 600 acres of existing vernal pool complex, 8,100 acres of managed wetlands (an estimated 2,552 acres of which are expected to provide habitat for Swainson's hawk based on 26% of managed wetlands consists of modeled habitat), and 43,325 acres of cultivated land compatible as foraging habitat. This protection of compatible foraging habitat has minimum requirements to protect and maintain high-value foraging crops such as alfalfa. For example, at least 21,663 acres of very high-value foraging habitat will be maintained each year on conservation lands. Protection of these communities will ensure that these high-value crops are not converted to crops that would reduce foraging value for the Swainson's hawk.

Additional conservation measures are designed to further increase habitat functions for Swainson's hawks by improving habitat diversity in the Plan Area. Because agricultural practices have removed so much of the species' historical nesting habitat, Swainson's hawks often nest in isolated trees, tree rows along field borders or roads, or small clusters of trees in farmyards or at rural residences. Protection and maintenance of these small isolated nesting habitats (*CM3 Natural Communities Protection and Restoration*, *CM11 Natural Communities Enhancement and Management*) is essential to sustaining the distribution and abundance of the species in the Plan Area. Agricultural practices have also steadily degraded foraging habitat by removing uncultivated lands and habitat edge that support prey populations. To help retain these important habitat elements in the agricultural matrix, small existing nest sites will be protected and future nesting opportunities will be expanded by planting native trees along roadsides and field borders in protected agricultural lands (CM3, CM11). In addition, remnant noncultivated areas of high wildlife value will be protected in conserved cultivated lands, and new hedgerows will be established along field borders and roadsides to enhance prey populations (CM3, CM11). These conservation efforts will help ensure that Swainson's hawk populations are sustained throughout the protected cultivated landscape and that the long-term viability of the species is enhanced in the Plan Area.

5.6.11.3 Net Effects

Including both the habitat loss described in Section 5.6.11.1, *Adverse Effects*, and the habitat restoration and protection described in Section 5.6.11.2, *Beneficial Effects*, implementation of the BDCP will result in an estimated net decrease of 51,028 acres (11%) of foraging habitat and an estimated net increase of 2,183 acres (22%) in nesting habitat. BDCP implementation will result in an increase of 45,760 acres (47%) of protected foraging habitat, and an increase of 2,672 acres (80%) of protected riparian habitat (Table 5.6-7). Additional nesting opportunities will be provided by planting, maintaining, and protecting small patches of potential nest trees in conserved cultivated lands that provide foraging habitat for Swainson's hawks.

The protection of a significant proportion of the species foraging habitat from potential loss or degradation associated with future changes in land use is highly beneficial because most of the species foraging habitat in the Plan Area is currently under private ownership and managed without consideration of Swainson's hawk habitat needs. Without protection, habitat value for the Swainson's hawk is expected to decline over time. The conservation lands will be managed to provide a significantly higher value than the affected lands.

Swainson's hawk foraging habitat will be managed such that 8,750 acres of grassland, vernal pool complex, and alkali seasonal wetland complex will be protected, managed, and available for Swainson's hawk foraging on the reserve system once all acquisition and restoration is completed.

The net effect of covered activities on the Swainson's hawk is expected to be beneficial for the following reasons.

- The extent of nesting habitat protection and restoration will result in significantly greater available nesting habitat in the Plan Area than currently exists (an estimated 22% increase).
- Protection of foraging habitats will maintain or increase the habitat value of agricultural foraging habitats as compared to the foraging habitat lost to covered activities.
- The extent of protected foraging habitat in the Plan Area will increase 47% above existing conditions. The protection of a significant proportion of the species foraging habitat from potential loss or degradation associated with future changes in land use is highly beneficial because most of the species foraging habitat in the Plan Area is currently under private control and managed without consideration of Swainson's hawk habitat needs.
- In a region where agricultural cover types suitable for the Swainson's hawk are increasingly being converted to cover types unsuitable for the species, the BDCP will increase the extent of protected suitable foraging habitats and manage these habitats to maximize their value for the Swainson's hawk and other covered species.
- To address the conversion of an estimated 14,229 acres of very high-value foraging habitat to tidal wetlands, with BDCP implementation, approximately 20,005 acres of very high-value foraging habitat will be maintained each year on conservation lands.
- Swainson's hawk foraging habitat, including both cultivated and noncultivated lands, will be protected at a ratio of at least one acre protected for each acre lost as a result of covered activities.
- BDCP conservation lands will be managed to enhance other important habitat elements that support Swainson's hawk use such as protecting and restoring nesting habitat and creating hedgerows to promote high prey density.

In summary, covered activities are not expected to have an adverse population-level effect on the Swainson's hawk. Although a net reduction to foraging habitat will occur, these losses mostly occur to lower-value foraging habitat. These losses will be offset by a substantial net increase in protected high-value foraging and nesting habitat, a substantial net increase in the availability of nesting habitat and potential nest sites through restoration, and the improved management of foraging and nesting habitat under protection in ways beneficial to Swainson's hawks. Through these implementation actions, the BDCP is expected to sustain the current range and abundance of the Swainson's hawk in the Plan Area and provide for potential population and range increases in and adjacent to the Plan Area. In combination, these actions are expected to improve habitat suitability for Swainson's hawks in the Plan Area. Therefore, the BDCP will minimize and mitigate impacts, to the maximum extent practicable, and provide for the conservation and management of Swainson's hawk in the Plan Area.

5.6.12 Tricolored Blackbird

This section describes the adverse, beneficial, and net effects of the covered activities, including conservation measures, on the tricolored blackbird. The methods used to assess these effects are described in Section 5.2.8, *Effects Analysis for Wildlife and Plants*, and Table 5.J.1, *Quantitative Effects Analysis Methods and Assumptions*, in Appendix 5.J, *Effects on Natural Communities, Wildlife, and Plants*. The habitat model used to assess effects for the tricolored blackbird considers two primary life requisites – breeding habitat and nonbreeding habitat. Modeled breeding habitat includes bulrush/cattail wetlands and shrub communities that may provide suitable nesting substrate, and adjacent high- value foraging areas that occur within 5 miles of nesting colonies documented in the Plan Area over the last 15 years. The foraging component includes cultivated lands and noncultivated land-cover types known to support abundant insect populations important in egg formation and rearing of young, such as grasslands, pasturelands (including alfalfa), natural seasonal wetlands, and sunflower croplands. Modeled nonbreeding habitat includes emergent wetlands and shrub stands that provide suitable roosting habitat, as well as cultivated lands and noncultivated habitats that provide vegetable and animal foods sought by tricolored blackbirds during the winter. Outside of the breeding season, tricolored blackbirds are primarily granivores that forage opportunistically across the Plan Area in grasslands, pasturelands, croplands, dairies, and livestock feed lots. Further details regarding the habitat model, including assumptions on which the model is based, are provided in Appendix 2.A, *Covered Species Accounts.* Factors considered in assessing the value of affected habitat for the tricolored blackbird, to the extent that information is available, include habitat patch size, suitability of vegetation, and proximity to recorded occurrences.

5.6.12.1 Adverse Effects

5.6.12.1.1 Permanent Habitat Loss, Conversion, and Fragmentation

Covered activities will result in the permanent loss or conversion of up to 42,766 acres[14] of habitat for the tricolored blackbird (10% of the habitat in the Plan Area), including 13,235 acres of breeding habitat and 29,530 acres of nonbreeding habitat (Table 5.6-1). Most breeding season effects will be on foraging habitat, including 10,954 acres of cultivated lands and 2,204 acres of noncultivated habitats. Loss of nesting habitat is expected to be much smaller, estimated at up to 77 acres. Permanent effects on nonbreeding season habitat will affect 26,282 acres of cultivated lands and 1,586 acres of noncultivated habitats that providing foraging habitat. Losses to roosting habitat for tricolored blackbirds are expected to reach 1,662 acres. Covered activities resulting in adverse effects on tricolored blackbirds include water conveyance facility construction, transmission line construction, Fremont Weir/Yolo Bypass improvements, tidal natural communities restoration, floodplain restoration, nontidal marsh restoration, and conservation hatcheries facilities. The effects are described below for each covered activity.

[14] Habitat or natural community loss acreage estimates are based on hypothetical footprints and models rather than detailed project-level design and represent the maximum allowed under the permit. Actual losses will be tracked through compliance monitoring to ensure that they do not exceed estimates.

Water Conveyance Facility Construction

This activity will result in the permanent removal of 1,646 acres of tricolored blackbird breeding habitat (4 acres of nesting habitat; plus 1,429 acres of cultivated lands and 213 acres of noncultivated lands suitable for foraging) and 2,591 acres of nonbreeding habitat (19 acres of roosting habitat; 2,327 acres of cultivated and 245 acres of noncultivated lands suitable for foraging) (Table 5.6-1). These losses are expected to occur primarily in Conservation Zones 3, 4, 5, 6, and 8.

An estimated 847 of the 1,646 acres will be lost due to placement of reusable tunnel material. The material will likely be moved to other sites for use in levee build-up and restoration, and the affected area will likely be restored. While this effect is categorized as permanent, because there is no assurance that the material will eventually be moved, the effect will likely be temporary. Furthermore, the amount of storage area needed for reusable tunnel material is flexible, and the footprint used in the effects analysis is based on a worst-case scenario; the actual area to be affected by reusable tunnel material storage will likely be less than the estimated acreage.

Fremont Weir/Yolo Bypass Improvements

Yolo Bypass fisheries enhancements are expected to permanently remove 595 acres of breeding habitat (13 acres of nesting habitat; plus 477 acres of cultivated lands and 105 acres of noncultivated habitats suitable for foraging) and 8 acres of nonbreeding roosting habitat (Table 5.6-1).These losses will occur in Conservation Zones 2 and 3.

Tidal Natural Communities Restoration

This activity will result in tidal inundation of an estimated 3,937 acres of tricolored blackbird breeding habitat (21 acres of nesting habitat; plus 2,814 acres of cultivated lands and 1,102 acres of noncultivated habitats suitable for foraging) and 10,794 acres of nonbreeding habitat (1,633 acres of roosting habitat; plus 8,489 acres of cultivated lands and 672 acres of noncultivated habitats suitable for foraging) (Table 5.6-1). An estimated 13,692 acres of the 28,424 acres to be permanently lost are expected to convert to tidal emergent wetland communities that could provide nonbreeding season roosting habitat for tricolored blackbirds, depending on future vegetation density and composition. Conversion will result in the loss of an estimated 4,316 acres of tricolored blackbird breeding habitat (34 acres of nesting habitat; plus 3,635 acres of cultivated lands and 647 acres of noncultivated habitats suitable for foraging) and 9,375 acres of nonbreeding habitat (8,716 acres of cultivated lands and 659 acres of noncultivated habitats suitable for foraging) (Table 5.6-1). These habitat losses and conversions will occur primarily in Conservation Zones 1, 2, 4, 5, 6, 8, and 11. Although quantified in this section for the purpose of establishing take limits, any areas that develop into riparian scrub-shrub could constitute habitat conversion rather than habitat loss because they could provide suitable nesting and roosting habitat for tricolored blackbirds. Although the actual tidal restoration effects are likely to differ from the hypothetical footprint used to estimate losses, the Implementation Office will not exceed these upper limits of habitat loss or conversion for the tricolored blackbird.

Floodplain Restoration

Levee construction associated with floodplain restoration will result in the permanent removal of up to 554 acres of tricolored blackbird breeding habitat (4 acres of nesting habitat plus 503 acres of cultivated lands and 47 acres of noncultivated habitats suitable for foraging) and 656 acres of nonbreeding habitat (1 acre of roosting habitat plus 652 acres of cultivated lands and 3 acres of noncultivated habitats suitable for foraging) in Conservation Zone 7 (Table 5.6-1). In addition to these losses, another 3,991 acres of nonbreeding habitat (all cultivated lands that provide foraging habitat) will be permanently converted to riparian habitat (Table 5.6-1). Although these restored riparian habitats are counted as a permanent loss, the portion maintained as early- to midsuccessional habitats (an amount not to exceed 1,000 acres) could provide suitable nesting, roosting or foraging habitat for tricolored blackbirds. Although the actual floodplain restoration effects are likely to differ from the hypothetical footprint used to estimate losses, the Implementation Office will not exceed these upper limits of habitat loss or conversion for the tricolored blackbird.

Nontidal Marsh Restoration

This activity will result in the permanent removal or conversion of an estimated 568 acres of tricolored blackbird breeding habitat (all cultivated habitats suitable for foraging) and 945 acres of nonbreeding habitat (all cultivated habitats suitable for foraging) in Conservation Zones 2, 4, and 5 (Table 5.6-1). Nontidal marsh restoration is intended primarily to benefit the giant garter snake. Although about two-thirds of the restored marsh will be open water, the remainder will support emergent wetland vegetation that could provide nesting and roosting habitat for tricolors, depending on vegetation density and composition.

Grassland Restoration

This activity will result in the permanent removal of an estimated 1,521 acres of tricolored blackbird breeding habitat and 210 acres of nonbreeding habitat, all of which are modeled as cultivated habitats suitable for foraging (Table 5.6-1). Since these cultivated habitats will be converted to grassland, which provides high-value foraging habitat for the tricolored blackbird, no actual loss of foraging habitat would result from this activity. These losses and conversion would occur in Conservation Zones 2, 4, and 5.

Conservation Hatcheries Facilities

This activity will result in the permanent removal of an estimated 35 acres of tricolored blackbird breeding habitat (all noncultivated habitats suitable for foraging) in Conservation Zone 1 (Table 5.6-1).

Permanent loss and fragmentation of tricolored blackbird nesting habitat will be minimized with implementation of the *AMM21 Tricolored Blackbird*, described in Appendix 3.C, *Avoidance and Minimization Measures*. Preconstruction surveys will be conducted during the breeding season in known or suitable nesting habitat that lies within 1,300 feet of proposed construction areas to identify active tricolored blackbird nesting colonies. To the extent practicable, covered activities will be avoided up to 1,300 feet, but not less than a minimum of 250 feet from an active nesting colony until breeding has ceased. Monitoring will occur to ensure that construction does not adversely affect the nesting colony.

5.6.12.1.2 Periodic Inundation

Yolo Bypass Operations

Appendix 5.J, *Effects on Natural Communities, Wildlife, and Plants,* provides the method used to estimate periodic inundation effects in the Yolo Bypass. Based on this method, periodic inundation could affect the tricolored blackbird occupying areas ranging from an estimated 2,845 acres of habitat during a notch flow of 1,000 cfs to an estimated 5,820 acres during a notch flow of 4,000 cfs. The inundation could affect from 2,448 to 4,759 acres of tricolored blackbird breeding habitat (11 to 26 acres of nesting habitat, plus 1,847 to 2,961 acres of cultivated lands and 600 to 1,957 acres of noncultivated habitats suitable for foraging); and from 380 to 1,238 acres of nonbreeding habitat (0 to 4 acres of roosting habitat, plus 42 to 191 acres of cultivated lands and 222 to 1,057 acres of noncultivated habitats suitable for foraging) (Table 5.6-3). However, project-associated inundation of areas that would not otherwise have been inundated is expected to occur in no more than 30% of all years, since Fremont Weir is expected to overtop the remaining estimated 70% of all years, and during those years notch operations will not typically affect the maximum extent of inundation. In more than half of all years under existing conditions, an area greater than the project-related inundation area already inundates in the bypass. Therefore, habitat conditions in the bypass are not expected to change substantially as a result of Yolo Bypass operations. Increased duration of inundation during years of Fremont Weir operation, however, may delay the period for which foraging habitat is available to tricolored blackbirds by up to several weeks. More frequent flooding in the Yolo Bypass is not expected to adversely affect the suitability of emergent wetlands and riparian vegetation that provide nesting and roosting structure for tricolored blackbirds. These actions could prove beneficial if the additional floodwaters extend the duration of inundation in some seasonal wetlands to lengths that become attractive to nesting birds. The extent of suitable foraging habitat in the Yolo Bypass will be temporarily reduced during periods of increased inundation until floodwaters recede and food resources recover.

Floodplain Restoration

This activity will periodically inundate 5,202 acres of habitat for the tricolor blackbird, including 2,509 acres of modeled breeding habitat and 2,693 acres of modeled nonbreeding habitat (Table 5.6-1). Breeding season effects will be on cultivated (2,124 acres) and noncultivated (355 acres) lands that provide potential foraging habitat for tricolored blackbirds; an estimated 30 acres of potential nesting habitats will be affected. Effects on nonbreeding habitat are primarily expected to affect cultivated lands used for foraging (2,506 acres), with limited losses to noncultivated foraging habitats (29 acres) and to roosting habitat (158 acres). Whenever periodic inundation occurs, suitable foraging habitats in restored floodplains will be unavailable for use by tricolored blackbirds until floodwaters recede and food resources recover. Periodic inundation is not expected to affect tricolored blackbird nesting habitat because most inundation is unlikely to occur during the breeding season.

5.6.12.1.3 Construction-Related Effects

Direct and permanent effects of construction are described above in Section 5.6.12.1.1, *Permanent Habitat Loss, Conversion, and Fragmentation*. Additional construction-related effects on the tricolored blackbird include temporary habitat loss as a result of grading and ground disturbance, construction-related injury or mortality, and indirect noise and visual disturbance to habitat in the vicinity of construction. Effects on the tricolored blackbird are described below for each effect category. Effects are described collectively for all covered activities, and are also described for specific covered activities to the extent that this information is pertinent for assessing the value of affected habitat or specific nature of the effect.

Temporary Habitat Loss

Grading and ground disturbance associated with water conveyance facility construction, Yolo Bypass fisheries enhancement, and floodplain restoration levee construction will temporarily disturb up to 1,950 acres of modeled habitat for the tricolor blackbird (0.4% of the habitat in the Plan Area), including 884 acres of breeding habitat and 1,067 acres of nonbreeding habitat (Table 5.6-1). Most breeding season effects will be on foraging habitat, including 507 acres of cultivated lands and 298 acres of noncultivated lands (primarily grassland) that support insect prey vital to egg formation and rearing of young. Temporary removal of nesting habitat is estimated at 79 acres. Temporary disturbance to nonbreeding season habitat will predominately affect cultivated lands (995 acres) used by foraging tricolored blackbirds. Limited temporary losses of noncultivated lands that providing foraging habitat (50 acres) and to roosting habitat (22 acres) are expected.

Water conveyance facility construction will temporarily remove 294 acres of tricolored blackbird breeding habitat (148 acres of cultivated and 114 acres of noncultivated lands suitable for foraging; 2 acres of nesting habitat) and 642 acres of nonbreeding habitat (575 acres of cultivated and 47 acres of noncultivated lands suitable for foraging; 20 acres of roosting habitat), primarily in Conservation Zones 3, 4, 5, 6, and 8. Yolo Bypass fisheries enhancements are expected to temporary disturb 314 acres of breeding habitat, cultivated lands (84 acres) and noncultivated lands (155 acres) suitable for foraging and nesting habitat (75 acres). Most of these losses are expected to occur in Conservation Zone 2. Temporary effects on nonbreeding habitat are expected to include 54 acres of noncultivated lands suitable for foraging and 2 acres of roosting habitat. Construction of setback levees to restore seasonally inundated floodplain is expected to temporarily remove up to 307 acres of tricolored blackbird breeding habitat (predominately cultivated lands suitable for foraging) and 371 acres of nonbreeding habitat (predominately cultivated lands suitable for foraging) in Conservation Zone 7.

These temporarily disturbed areas will be restored to their previous habitat condition within 1 year following completion of construction and management activities. Because most temporary losses to tricolored blackbird habitat will affect agricultural and grassland foraging habitats that can be restored relatively quickly to suitable habitat, the replaced vegetation is expected to meet habitat requirements for the tricolored blackbird within the first few years after the initial restoration activities are complete.

Of the 1,950 acres of modeled tricolored habitat to be temporarily removed, establishment and use of borrow and spoil areas associated with water conveyance facility construction will result in the temporary removal of an estimated 82 acres of modeled habitat (>0.1% of the habitat in the Plan Area). This will include 81 acres of breeding season foraging habitat and 1 acre of nesting habitat for the tricolored blackbird (Table 5.6-1). Most of these temporary losses will occur in Conservation Zones 4 and 8. Although this habitat will be restored within 1 year following construction, it might not be restored to its original topography. Affected grassland habitat will be restored to grasslands, and affected cultivated lands will either be restored to either cultivated lands or grasslands. Therefore, most areas will be restored to high-value tricolored blackbird habitat.

Construction-Related Injury or Mortality

Operation of construction equipment could result in injury or mortality of tricolored blackbirds. Risk will be greatest to eggs and nestlings susceptible to land clearing activities, nest abandonment, or increased exposure to the elements or to predators. Injury to adults and fledged juveniles is less likely as these individuals are expected to avoid contact with construction equipment. However, injury or mortality will be minimized through planning and preconstruction surveys that follow established protocols to identify tricolored blackbird nesting colonies, and through the design of projects to avoid locations with nesting colonies. To the maximum extent practicable, construction activity will be avoided up to 1,300 feet, but not less than a minimum of 250 feet, from an active tricolored blackbird nesting colony. If monitoring determines an activity is adversely affecting a nesting colony, construction will be modified, as practicable, by either delaying construction until the colony site is abandoned or until the end of the breeding season, whichever occurs first, by temporarily relocating staging areas, or temporarily rerouting access to the construction site. These measures to avoid injury or mortality of nesting tricolored blackbirds are described in AMM21 (Appendix 3.C).

Indirect Construction-Related Effects

Construction-associated disturbances (e.g., noise, dust, visual) outside the project footprint but within 1,300 feet of tricolored blackbird nesting colonies are indirect effects that could temporarily affect the use of up to 232 acres (less than 1%) of modeled tricolored blackbird nesting habitat (Table 5.6-5). Construction noise above background noise levels (greater than 50 dBA) is expected to extend 500 to 5,250 feet from the edge of construction activity (Table 4, *Estimated Impacts on the Delta Wintering Population of Greater Sandhill Cranes from Collisions with Proposed BDCP Power Lines*, Appendix 5.J, Attachment 5J.D, *Indirect Effects of the Construction of the BDCP Conveyance Facility on Sandhill Crane*). There are no available data to determine the extent to which these noise levels could affect tricolored blackbird. Disturbance near active nesting colonies could lead to increased mortality of eggs and young due to increased exposure of nests to the elements or to predators, the avoidance or reduced use of high-value foraging areas, or the abandonment of nests and nesting colonies. However, preconstruction surveys will be conducted in known or suitable nesting habitat to identify active tricolored blackbird nesting colonies. Covered activities will be avoided within a minimum 250 feet of an active nesting colony and up to 1,300 feet where practicable until breeding has ceased, and monitoring will occur to ensure that construction does not adversely affect the nesting colony, as described further in AMM21 (Appendix 3.C). Because the area of effect for nesting tricolors can extend up to 1,300 feet from nesting colonies, some disturbance effects may remain in those cases where avoidance for the full 1,300-foot disturbance zone is not possible. Construction-associated disturbance to tricolored blackbirds is not expected during the nonbreeding season when adults and fledged young forage opportunistically across the Plan Area.

Construction activities may result in the accidental release of petroleum or other contaminants that could affect tricolored blackbirds if present. Implementation of the construction BMPs described in *AMM2 Construction Best Management Practices and Monitoring* (Appendix 3.C) will minimize the likelihood of such spills occurring. Should a spill occur, implementation of the avoidance and minimization measures will greatly reduce the likelihood that individuals will be affected.

5.6.12.1.4 Effects of Ongoing Activities

Transmission Lines

New transmission lines will increase the risk for bird- transmission line strikes, which could result in injury or mortality of tricolored blackbirds. This species is expected to be at moderate risk of bird strike mortality based on factors assessed in the bird strike vulnerability analysis (Appendix 5.J, Attachment 5J.C, *Analysis of Potential Bird Collisions at Proposed BDCP Powerlines*) including wing morphology, flight altitude and timing, foraging behavior, and social behavior. Tricolored blackbirds have the potential to intersect the proposed transmission line routes largely due to winter movements throughout the Plan Area. While migratory flight behavior may increase the risk of strike hazard, daily movements associated with winter foraging likely occur below the height of the lines. In addition, tricolored blackbirds are considered strong and agile flyers with moderately maneuverability (i.e., low wing loading/low aspect ratio) (Beedy and Hamilton 1999) and are therefore physically well-equipped to avoid collision with transmission lines. Current scientific evidence and best professional judgment suggest that transmission lines are not a significant cause of mortality for tricolored blackbirds (Meese pers. comm.). Transmission line poles and towers also provide perching substrate for raptors, which could result in increased predation pressure on local tricolored blackbirds. The existing network of transmission lines in the Plan Area currently poses this risk for tricolored blackbirds, and any incremental risk associated with the new transmission line corridors (up to approximately 9.3 miles in the Plan Area) is expected to be low. Mortality associated with transmission line collision is not anticipated to affect the Plan Area population.

Facilities Operation and Maintenance

Activities associated with ongoing operation and maintenance of facilities may result in local adverse habitat effects, injury, or mortality of tricolored blackbirds, and temporary noise and disturbance effects if individuals are present in work sites over the term of the BDCP. These potential effects are currently not quantifiable but will be minimized with implementation of AMM21.

Habitat Enhancement and Management

Activities associated with natural communities enhancement and management in protected habitats, such as ground disturbance or removal of nonnative vegetation, could result in local adverse habitat effects and injury or mortality of tricolored blackbirds, and temporary noise and visual disturbance effects if individuals are present in or adjacent to work sites over the term of the BDCP. These potential effects are currently not quantifiable but will be minimized with implementation of AMM21.

Management of the 5,000 acres of managed wetlands to be protected for waterfowl and shorebirds is not expected to result in overall adverse effects on the tricolored blackbird. Management actions that will improve wetland quality and diversity on managed wetlands include control and eradication of invasive plants; maintenance of a diversity of vegetation types and elevations; water management and leaching to reduce salinity; and enhancement of water management infrastructure (improvements to enhance drainage capacity, levee maintenance). These management actions will potentially benefit the tricolored blackbird. The 5,000 acres of protected managed wetlands will be monitored and adaptively managed to ensure that management options are implemented to avoid adverse effects on the tricolored blackbird.

Recreation

Passive recreation in the reserve system, where that recreation is compatible with the biological goals and objectives, could result in disturbance of tricolored blackbird nesting colonies in the vicinity of trails. *AMM37 Recreation* (Appendix 3.C) prohibits the construction of new trails within 100 feet of wetlands that provide suitable habitat for breeding tricolored blackbirds, unless topography or other landscape features shield these trails from the habitat or a lack of effect of the trail on the species can be otherwise demonstrated. Trails will be closed within 250 feet of active nesting colonies until it can be demonstrated that the nesting cycle has completed. With implementation of these measures, recreation-related effects on the tricolored blackbird are expected to be minimal.

5.6.12.1.5 Other Indirect Effects

Mercury

Covered activities have the potential to increase exposure to mercury in covered species that feed in aquatic environments, including the tricolored blackbird. The operational impacts of new flows under *CM1 Water Facilities and Operation* were analyzed using a DSM-2-based model to assess potential effects on mercury concentration and bioavailablity resulting from new flows. Subsequently, a regression model was used to estimate fish-tissue concentrations in striped bass under these future conditions. Results indicated that changes in total mercury levels in water and fish tissues under future conditions with the BDCP were insignificant (Appendix 5.D, Attachment 5.D.A, *Bioaccumulation Model Development for Mercury Concentrations in Fish*, Tables 5.D.A-1, 5.D.A-2, 5.D.A-3, and 5.D.A-4).

Marsh and floodplain restoration also has the potential to increase exposure to methylmercury. Mercury is transformed into the more bioavailable form of methylmercury in aquatic systems, especially areas subjected to regular wetting and drying such as tidal marshes and flood plains. Thus, restoration activities that create newly inundated areas could increase bioavailability of mercury. In general, the highest methylation rates are associated with high tidal marshes that experience intermittent wetting and drying and associated anoxic conditions (Alpers et al. 2008). The potential mobilization or creation of methylmercury in the Plan Area varies with site-specific conditions and will need to be assessed at the project level. The Suisun Marsh Plan (Bureau of Reclamation et al. 2010) anticipates that tidal wetlands restored under the plan will generate less methylmercury than the existing managed wetlands. Along with minimization and mitigation measures and adaptive management and monitoring, *CM12 Methylmercury Management* is expected to reduce amount of methylmercury resulting from the restoration of natural communities and floodplains.

Susceptibility of breeding tricolored blackbirds to methylmercury exposure is likely low because tidal wetlands are not expected to be a major foraging area for the species. Furthermore, the Suisun Marsh Plan (Bureau of Reclamation et al. 2010) anticipates that tidal wetlands restored under the plan will generate less methylmercury than the existing managed wetlands, potentially reducing the overall risk.

5.6.12.1.6 Impact of Take on Species

The tricolored blackbird is a colonial nesting passerine that is largely restricted to California. More than 95% of the California breeding population of tricolored blackbirds occurs in the Central Valley

(Kyle and Kelsey 2011). Breeding also occurs in the foothills of the Sierra Nevada south to Kern County, the coastal slopes from Sonoma County to the Mexican border, and sporadically in the Modoc Plateau. The Plan Area constitutes a relatively small portion of the species' total range. While the overall range of the tricolored blackbird is largely unchanged since the 1930s (Neff 1937; DeHaven et al. 1975; Beedy et al. 1991; Hamilton 1998), large gaps now exist in the species' former range. Surveys during the 1990s (Hamilton et al. 1995; Beedy and Hamilton 1997; Hamilton 2000) indicated a significant declining trend in California populations since the 1930s, and a particularly dramatic decline since 1994. Statewide surveys conducted during the 2000s indicated some recovery from the recent (1999) population low; however, the population increases have primarily been limited to the San Joaquin Valley and the Tulare Basin (Kyle and Kelsey 2011).

Although there are few reported historical nesting records of tricolored blackbirds nesting in the Plan Area (Neff 1937; Beedy et al. 1991; California Department of Fish and Wildlife 2013d), more recent surveys have documented occasional nesting colonies along the fringe of Suisun Marsh, in the Yolo Bypass, and along the southwestern perimeter of the Plan Area (University of California Davis n.d.). While breeding colonies are uncommon, the Delta is recognized as a major wintering area for the species (Hamilton 2004, Beedy 2008).

There are an estimated 416,745 acres of modeled tricolored blackbird habitat in the Plan Area (about 45% of the Plan Area), consisting of 160,120 acres of breeding habitat and 256,625 acres of nonbreeding habitat. BDCP implementation will result in the permanent loss of 13,235 acres of breeding habitat (8%) in the Plan Area, including 77 acres of nesting habitat and 13,158 acres of foraging habitat. BDCP implementation will also result in loss of 29,530 acres of nonbreeding habitat (12%) in the Plan Area, including 1,662 acres of roosting habitat and 27,868 acres of foraging habitat.

Take resulting from this permanent habitat loss and other adverse effects as described above and shown for the tricolored blackbird in Table 5.6-1 is not expected to adversely affect the long-term survival and conservation of the species for the following reasons.

- Very little loss of nesting structure (up to 77 acres) will occur.
- Most of the loss of breeding and nonbreeding habitat will be to cultivated lands that are abundant throughout the Plan Area, so the loss due to covered activities is not expected to substantially affect the population in the Plan Area.
- The effect of periodic inundation on breeding and nonbreeding habitat is expected to be minor.
- Most temporary effects will affect cultivated lands and grassland habitats that can be restored relatively quickly to suitable foraging habitat.
- Measures will be implemented to protect nesting colony sites and avoid injury or mortality to adults, nestlings, and eggs.
- The Plan Area represents a very small proportion of the species statewide range.

5.6.12.2 Beneficial Effects

Assuming the restored and protected grassland, alkali seasonal wetland complex, vernal pool complex, managed wetland, tidal brackish emergent wetland, nontidal freshwater perennial emergent wetland, and valley/foothill riparian natural communities will provide suitable breeding habitat for tricolored blackbird proportional to the amount of modeled habitat that currently exists in these natural communities in the Plan Area (50%, 93%, 65%, 10%, 22%, 9%, 19%, and 8%, respectively), implementation of the BDCP will result in the protection of an estimated 5,376 acres of breeding habitat. Based on the same assumptions, implementation of the BDCP will result in the restoration of an estimated 2,190 acres of breeding habitat.

Assuming restored and protected grassland, alkali seasonal wetland complex, vernal pool complex, managed wetland, other seasonal wetland, tidal brackish emergent wetland, tidal freshwater emergent wetland, and valley /foothill riparian natural communities will also provide nonbreeding habitat for tricolored blackbird proportional to the amount of modeled habitat that currently exists in these natural communities in the Plan Area (41%, 3%, 2%, 16%, 60%, 95% and 21%, respectively), implementation of the BDCP will result in the protection of an estimated 4,790 acres of nonbreeding habitat. Based on the same assumptions, implementation of the BDCP will result in the restoration of an estimated 28,811 acres of nonbreeding habitat.

Additionally, the Plan will protect 50 acres of occupied or recently occupied (within the last 15 years) tricolored blackbird nesting habitat located within 5 miles of high-value foraging habitat in Conservation Zones 1, 2, 8, or 11 (Objective TRBL1.1); and the Plan will protect at least 11,050 acres of cultivated lands in Conservation Zones 1, 2, 3, 4, 7, 8, or 11 that support tricolored blackbird breeding-foraging habitat of which at least 1,000 acres of will be within 5 miles of the 50 acres of nesting habitat protected (Objective TRBL1.1). The Plan will also protect at least 26,300 acres of nonbreeding foraging habitat (Objective TRBL1.2).

The Implementation Office will protect at least 48,625 acres of cultivated lands in agricultural reserves (*CM3 Natural Communities Protection and Restoration*), a large portion of which is expected to be suitable foraging habitat for the tricolored blackbird. At least 26,300 acres (54%) will be in crop types that are of at least moderate-, high-, or very high- value to tricolored blackbirds during the nonbreeding season when birds forage widely across the Plan Area, with 13,150 (50%) consisting of high- or very high-value crop types, while 11,050 acres will be maintained in crop types of high- to very high-value foraging habitat for breeding tricolored blackbirds. High-value cultivated lands for nesting tricolored blackbirds include those in proximity to nesting habitat (within 5 miles) that can support large insect populations vital to egg formation and rearing of young, such as pasturelands, alfalfa and other hay crops, and some croplands such as sunflower.

In addition to these cultivated lands, the Implementation Office will also restore and protect noncultivated habitats, portions of which are expected to provide tricolored blackbird foraging habitat. Habitats beneficial to tricolored blackbirds include grasslands (8,000 acres protected, *CM3 Natural Communities Protection and Restoration*; 2,000 acres restored, *CM8 Grassland Natural Community Restoration*), alkali seasonal wetlands (150 acres protected, restoration or creation for all affected acreage in Conservation Zones 1, 8 or 11 to achieve no net acreage loss, CM3), and vernal pool complexes (600 acres protected, CM3; restoration or creation for all affected acreage in Conservation Zones 1, 8 or 11 to achieve no net acreage loss, *CM9 Vernal Pool and Alkali Seasonal Wetland Complex Restoration*). All of these communities are known to support large insect populations, a vital food resource for successful reproduction. In addition, protected grasslands will be managed to increase insect prey through techniques such as grazing practices and minimizing use of pesticides (*CM11 Natural Communities Enhancement and Management*). Also, levees associated with managed wetlands (6,500 acres protected), which are maintained as grasslands and other suitable habitats, will also provide foraging habitat for tricolors. Those conservation lands that lie within a few miles of active nesting colonies will provide high-value foraging areas to support breeding tricolors, while all areas may be used opportunistically by tricolors during other times of the year.

As described above, to successfully maintain or increase breeding by tricolored blackbirds in the Plan Area, the Implementation Office will protect and manage 50 acres of occupied or recently occupied tricolored blackbird nesting habitat located in close proximity to high-value foraging habitat. Tricolors are highly dependent on disturbance events to maintain suitable nesting conditions at nesting colony sites. To sustain nesting habitat characteristics, bulrush/cattail emergent vegetation will be subject to periodic management (e.g., burning, mowing, discing) to ensure that young, actively growing stands preferred by tricolored blackbirds for nesting are maintained over the term of the BDCP. In addition to these actively managed nesting areas, restoration and protection of nontidal freshwater perennial emergent wetland and valley/foothill riparian habitat will also provide nesting opportunities whenever suitable nest structure is present. The Plan Area currently includes modeled tricolored blackbird nesting habitat in 22% of nontidal freshwater perennial emergent wetland and 8% of valley/foothill riparian. Assuming similar proportions of modeled habitat on restored conservation lands, an estimated 721 acres of nesting habitat will be periodically provided by these natural communities.

Actions taken by the Implementation Office will also benefit nonbreeding by tricolored blackbirds in the Plan Area. Portions of the 65,000 acres of the restored or protected tidally influenced natural communities (*CM3 Natural Communities Protection and Restoration, CM4 Tidal Natural Communities Restoration*) will provide suitable nonbreeding roosting habitat for tricolored blackbirds. Tidal restoration sites will incorporate hydrologic and elevation gradients that provide for a diversity of inundation characteristics and plant composition. Areas of tidal emergent wetlands that support tall or dense vegetation, such as cattails and bulrushes, will be suitable as roosting habitat for tricolored blackbirds.

Full implementation of the BDCP is expected to result in the protection of an estimated 46,566 acres of tricolored blackbird habitat (16,476 acres breeding habitat and 31,090 acres nonbreeding habitat) and restoration of 31,001 acres of tricolored blackbird habitat (2,190 acres breeding habitat and 28,811 acres nonbreeding habitat) (Table 5.6-7).

5.6.12.3 Net Effects

Including both the habitat loss described in Section 5.6.12.1, *Adverse Effects*, and the habitat restoration and protection described in Section 5.6.12.2, *Beneficial Effects*, implementation of the BDCP will result in an estimated net decrease of up to 11,127 acres (21%) of breeding habitat for the tricolored blackbird, although the amount of breeding habitat in protected status will increase by at least 15,915 acres (63%) (Table 5.6-7). Breeding habitat losses primarily affect lands suitable for foraging, particularly cultivated lands. A net increase in habitat suitable for nesting (461 acres) will occur. Because nesting by tricolored blackbirds is dependent on periodic disturbance to retain favorable vegetative structure (at least in optimal bulrush/cattail wetland nesting stands), the amount of modeled breeding habitat suitable for use by tricolored blackbirds in any given year is variable. Under the BDCP, management for tricolored blackbirds will ensure that at least 50 acres of suitable emergent wetland nesting structure is maintained at all times, in close association with high-value foraging habitats that can support abundant insect populations necessary for good reproductive success. Although the overall amount of foraging habitat will decline, foraging habitat under protective status will increase by 15,270 acres under the BDCP, a 40% increase over existing conditions. Furthermore, 11,050 acres of cultivated lands in agricultural reserves will be maintained in crop types that provide high- to very high-value foraging habitat for breeding tricolored blackbirds in any given year. These increases in protected foraging habitat, managed to provide for optimal foraging conditions, will offset the decline in breeding season foraging habitat for tricolored blackbirds.

Assuming the restored and protected natural communities will provide suitable tricolored blackbird breeding habitat proportional to the amount of modeled habitat that currently exists in those natural communities in Plan Area, implementation will also result in a decrease of up to 719 acres (less than 1%) of nonbreeding habitat for the tricolored blackbird, although the amount of nonbreeding habitat in protected status will increase by at least 52,869 acres (Table 5.6-7). Again, most of the nonbreeding season habitat decline involves lands suitable for foraging (a decrease of 26,925 acres), primarily cultivated lands (a decrease of 26,282 acres). However, a large increase in roosting habitat (26,206 acres) is estimated, in part due to expected development of bulrush/cattail emergent wetlands in restored tidelands. The net declines in nonbreeding foraging habitat for the tricolored blackbird will be offset by a 25343-acre increase in protected foraging habitat under the BDCP. Furthermore, at least 12,825 acres of cultivated lands in agricultural reserves will be maintained in crop types that provide a moderate or higher foraging value for nonbreeding tricolored blackbirds in any given year, 50% of which will be of high or very high value. These increases in protected foraging habitats, managed to provide for moderate or higher foraging conditions, will offset the decline in nonbreeding season foraging habitat for the tricolored blackbird.

About 43% of the losses in tricolored blackbird habitat will occur in the near-term and early long-term periods, with the remaining losses during the late long-term period. Tidal restoration efforts account for about 65% of these permanent habitat losses, and primarily involve lands suitable for foraging during the breeding and nonbreeding seasons. The Implementation Office will secure, protect, and manage lands suitable as breeding and nonbreeding habitat for the tricolored blackbird as part of the reserve design requirements for this species.

The potential take of the tricolored blackbird as a result of permanent and temporary habitat loss and indirect effects, is not expected to adversely affect the long-term survival and conservation of this species. AMM21 (Appendix 3.C) will be implemented to specifically protect nesting colony sites and avoid injury or mortality to adults, nestlings, and eggs. Habitat management and enhancement will further benefit the species.

Overall, the BDCP will provide a net benefit to the tricolored blackbird by improving overall habitat value for tricolored blackbirds, and by substantially increasing the protection of breeding and nonbreeding habitat. These protected areas will be managed, enhanced, and monitored to support the species. Therefore, the BDCP will minimize and mitigate impacts, to the maximum extent practicable, and provide for the conservation and management of the tricolored blackbird in the Plan Area.

5.6.13 Western Burrowing Owl

This section describes the adverse, beneficial, and net effects of the covered activities, including conservation measures, on the western burrowing owl. The methods used to assess these effects are described in Section 5.2.8, *Effects Analysis for Wildlife and Plants*, and more specific assessment methods are described below. The habitat model used for the western burrowing owl includes vegetation and land cover types used by the species for nesting and foraging characterized as high-and low-value habitat depending on reported use patterns from the literature. Vegetation types were assigned to a suitability category based on the species requirements as described in Appendix 2.A, *Covered Species Accounts*. Further details regarding the habitat model, including assumptions on which the model is based, are also provided in Appendix 2.A. Factors considered in assessing the value of affected habitat for the western burrowing owl, to the extent that information is available, include vegetation type and structural characteristics, topographical and other land form characteristics, potential for ground squirrels, and cultivation practices.

5.6.13.1 Adverse Effects

5.6.13.1.1 Permanent Habitat Loss, Conversion, and Fragmentation

Covered activities will result in the permanent loss of up to 43,969 acres[15] of modeled habitat (11% of the modeled habitat in the Plan Area) for the western burrowing owl (Table 5.6-1), of which 12,450 acres is of high value and 31,519 acres is of low value. Most of the loss will result from tidal natural communities restoration.

Most burrowing owl occurrences in the Plan Area are associated with the high-value habitat category, and thus the large number of acres of low-value habitat affected represents marginally suitable but unoccupied habitat. Western burrowing owl habitat will be permanently lost due to tidal restoration, water conveyance facility construction, bypass improvements, floodplain restoration, riparian restoration, nontidal marsh restoration, grassland restoration, and construction of conservation hatcheries.

Water Conveyance Facility Construction

The construction of the conveyance facility and associated infrastructure will result in the permanent loss of 3,894 acres of modeled burrowing owl habitat in Conservation Zones 3, 4, 5, 6, and 8, the majority of which is low-value cultivated land (3,013 acres). An estimated 881 acres of high-value grassland habitat will be removed, the majority of which is associated with the construction of the Byron Forebay. There are several occurrences of western burrowing owls in the vicinity of the conveyance facilities near the forebay. Removal of high-value habitat in this area from construction of project facilities could remove occupied habitat, displace nesting and wintering owls, and fragment occupied habitats.

An estimated 2,865 of the 3,894 acres of burrowing owl habitat (2,324 acres of which are low-value habitat) will be lost due to placement of reusable tunnel material. The material will likely be moved to other sites for use in levee build-up and restoration, and the affected area will likely be restored. While this effect is categorized as permanent, because there is no assurance that the material will eventually be moved, the effect will likely be temporary. Furthermore, the amount of storage area needed for reusable tunnel material is flexible, and the footprint used in the effects analysis is based on a worst-case scenario; the actual area to be affected by reusable tunnel material storage will likely be less than the estimated acreage.

[15] Habitat or natural community loss acreage estimates are based on hypothetical footprints and models rather than detailed project-level design and represent the maximum allowed under the permit. Actual losses will be tracked through compliance monitoring to ensure that they do not exceed estimates.

Fremont Weir/Yolo Bypass Improvements

These activities will permanently remove an estimated 979 acres of modeled burrowing owl habitat in Conservation Zone 2, the majority of which is of high value (882 acres).

Tidal Natural Communities Restoration

This activity will result in the permanent removal of an estimated 29,668 acres of modeled burrowing owl habitat from Conservation Zones 1, 2, 3, 4, 5, 6, 7, 8, 10, and 11. The majority of removed acres (19,739 acres) are low-value cultivated land; however, some of the loss (9,929 acres) will consist of high-value grassland habitat. Tidal restoration will directly remove and fragment remaining high-value grassland habitat just north of Rio Vista in and around French and Prospect Islands, and in an area south of Rio Vista around Threemile Slough. Tidal natural communities restoration will affect one extant record of burrowing owl just northeast of Oakley along Dutch Slough and one possibly extirpated occurrence in Suisun Marsh. Because the estimates of the habitat loss resulting from tidal inundation are based on projections of where restoration may occur, actual effects are expected to be lower because sites will be selected to minimize effects on western burrowing owl occupied habitat.

Floodplain Restoration

Levee construction associated with floodplain restoration will result in the permanent removal of an estimated 1,594 acres of modeled burrowing owl habitat in Conservation Zones 2, 4, and 7 for the western burrowing owl (Table 5.6-1). Most of the acres removed (1,452 acres) are low- value cultivated lands. Only 142 acres are high-value grasslands, occurring in small patches along the San Joaquin, Old, and Middle Rivers in Conservation Zone 7.

Riparian Restoration

This activity will result in the permanent loss of an estimated 4,962 acres of burrowing owl habitat, most of which is low value (4,951 acres) (Table 5.6-1). Most of this loss will occur in Conservation Zone 7, in areas with no known burrowing owl occurrences.

Nontidal Marsh Restoration

This activity will result in the permanent loss of about 952 acres of low-value burrowing owl habitat in Conservation Zones 2 and 4 and 159 acres of high-value habitat (Table 5.6-1).

Grassland Restoration

This activity will affect an estimated 1,675 acres of burrowing owl habitat, most of which is low value (1,314 acres) (Table 5.6-1). However, the restoration of grasslands in modeled burrowing owl habitat constitutes habitat conversion rather than permanent loss, since the restored grassland will provide high value for the species. Grassland restoration in cultivated lands will convert low-value habitat to high-value habitat for the species.

Conservation Hatcheries Facilities

This activity will result in the permanent loss of about 35 acres of high-value burrowing owl habitat in Conservation Zone 1.

5.6.13.1.2 Periodic Inundation

Yolo Bypass Operations

Appendix 5.J, *Effects on Natural Communities, Wildlife, and Plants,* provides the method used to estimate periodic inundation effects in the Yolo Bypass. Based on this method, periodic inundation could affect western burrowing owls occupying areas ranging from an estimated 2,912 acres of modeled habitat during a notch flow of 1,000 cfs to an estimated 6,231 acres during a notch flow of 4,000 cfs. The inundation could affect western burrowing owls in 1,390 to 3,303 acres of high-value habitat and 1,522 to 2,927 acres of low-value habitat (Table 5.6-3). However, project-associated inundation of areas that would not otherwise have been inundated is expected to occur in no more than 30% of all years, since Fremont Weir is expected to overtop the remaining estimated 70% of all years, and during those years notch operations will not typically affect the maximum extent of inundation. In more than half of all years under existing conditions, an area greater than the project-related inundation area already inundates in the bypass. Therefore, habitat conditions in the bypass are not expected to change substantially as a result of Yolo Bypass operations and effects on the western burrowing owl, if any, are expected to be minimal.

Floodplain Restoration

Floodplain restoration could result in periodic inundation of up to 6,941 acres of western burrowing owl habitat. The majority of this habitat (6,162 acres) is low-value habitat. No CNDDB occurrences of western burrowing owls will be affected by these actions.

5.6.13.1.3 Construction-Related Effects

Direct and permanent effects of construction are described in Section 5.6.13.1.1, *Permanent Habitat Loss, Conversion, and Fragmentation*. Additional construction-related effects on the western burrowing owl include short-term temporary effects from water conveyance facility construction and long-term temporary effects from establishment of borrow and spoils sites. Construction-related injury and mortality and associated indirect effects are also described. Effects are described collectively for all covered activities and are also described for specific covered activities to the extent that this information is pertinent to assessing the value of affected habitat or the specific nature of the effect.

Covered activities are expected to temporarily remove a total of 2,339 acres of modeled burrowing owl habitat (Table 5.6-1). Nearly all of the affected modeled habitat is cultivated land. Most of the affected modeled habitat (1,659 acres) is low-value cultivated land. Approximately 679 acres represent high-value grassland habitat.

Temporary Habitat Loss

Construction-related effects will temporarily disturb 2,339 acres of habitat for the western burrowing owl (Table 5.6-1). Of this, 1,659 acres (71%) is low-value, cultivated habitat, and 679 acres (29%) is high-value grassland habitat. Temporarily disturbed areas will be restored in kind as western burrowing owl habitat within 1 year following completion of construction and management activities.

Of the 2,339 acres of modeled burrowing owl habitat to be temporarily removed, establishment and use of borrow and spoil areas associated with water facility construction will result in temporary removal of an estimated 102 acres (low value habitat) of modeled habitat for this species in Conservation Zones 4, 5, and 8 (Table 5.6-1).

Construction-Related Injury or Mortality

Construction will not likely cause injury or mortality to the western burrowing owl; however, under *AMM23 Western Burrowing Owl* (Appendix 3.C, *Avoidance and Minimization Measures*), preconstruction surveys, construction monitoring, and no-disturbance buffers will be implemented to avoid and minimize injury or mortality of this species during construction.

Indirect Construction-Related Effects

Construction activities, including conveyance construction, tidal restoration, Yolo Bypass enhancement, and floodplain restoration could cause noise and visual disturbances, which could in turn affect burrowing owl nesting and foraging behavior adjacent to activity areas. Any disturbance in the vicinity of a burrow occupied by burrowing owl will potentially displace winter owls or cause abandonment of active nests. A total of 15,260 acres of modeled burrowing owl habitat, 5,807 acres of which is high-value habitat within 500 feet of covered activities will temporarily be made less suitable as a result of construction noise and visual disturbances (Table 5.6-1). Construction noise above background noise levels (greater than 50 dBA) is expected to extend 500 to 5,250 feet from the edge of construction activity (Table 4, *Estimated Impacts on the Delta Wintering Population of Greater Sandhill Cranes from Collisions with Proposed BDCP Power Lines*, in Appendix 5.J, Attachment 5J.D, *Indirect Effects of the Construction of the BDCP Conveyance Facility on Sandhill Crane*). There are no available data to determine the extent to which these noise levels could affect the western burrowing owl. Potential effects of these disturbances on western burrowing owls will be minimized with implementation of AMM23, which requires surveys to determine the presence of active sites and the establishment of no-disturbance set-backs around active sites.

5.6.13.1.4 Effects of Ongoing Activities

Transmission Lines

New transmission lines will increase the risk for bird strikes, which could result in injury or mortality of the western burrowing owl. This species is expected to be at low risk of bird strike mortality based on factors assessed in the bird strike vulnerability analysis (Appendix 5.J, Attachment 5J.C, *Analysis of Potential Bird Collisions at Proposed BDCP Powerlines*), including wing morphology, flight altitude and timing, foraging behavior, social behavior. The species is large bodied but with relatively long and rounded wings, making it moderately maneuverable. While burrowing owls may nest in loose colonies, they do not flock or congregate in roosts or foraging groups. Collectively, the species' keen eyesight and largely ground-based hunting behavior make it a relatively low risk species for transmission line collision. While the species in not widespread in the Plan Area, it may become more widely distributed as grassland enhancement improves habitat for the species. Even so, the risk of impacts to the population are low, given its physical and behavioral characteristics. Transmission line poles and towers also provide perching substrate for raptors, which could result in increased predation pressure on local western burrowing owls. The existing network of transmission lines in the Plan Area currently poses this risk for western burrowing owls, and any incremental risk associated with the new transmission line corridors (up to an estimated 9.3 miles in the Plan Area) is expected to be low.

Facilities Operation and Maintenance

Activities associated with ongoing operation and maintenance of facilities could result in localized loss of western burrowing owl habitat, injury or mortality of burrowing owls, and temporary noise and disturbance effects over the term of the BDCP. These activities may include road, levee, and facilities maintenance that remove or disturb active burrows, and rodent abatement programs around conveyance facilities. These effects will be minimized to the extent possible with the implementation of AMM23, which requires surveys to determine presence or absence and the establishment of no-disturbance set-backs around active sites.

Habitat Enhancement and Management

Activities associated with habitat enhancement and management intended to maintain and improve habitat functions in protected habitats could result in localized loss of western burrowing owl habitat, injury or mortality of burrowing owls, and temporary noise and disturbance effects over the term of the BDCP. These effects will be minimized with implementation of AMM23, which requires surveys to determine presence or absence and the establishment of no-disturbance set-backs around active sites. Over the term of the BDCP, enhancement and management actions on conservation lands are expected to result in a net benefit because these actions are intended to improve habitat functions for the western burrowing owl and other covered species.

Management of the 5,000 acres of managed wetlands to be protected for waterfowl and shorebirds is not expected to result in overall adverse effects on the western burrowing owl. Management actions that will improve diversity on managed wetlands include control and eradication of invasive plants and maintenance of a diversity of vegetation types and elevations including upland areas. These management actions will potentially benefit the western burrowing owl. The 5,000 acres of protected managed wetlands will be monitored and adaptively managed to ensure that management options are implemented to avoid adverse effects on the western burrowing owl.

Recreation

Passive recreation in the reserve system, where that recreation is compatible with the biological goals and objectives, could result in disturbance of burrowing owl nest sites in the vicinity of trails. *AMM37 Recreation* (Appendix 3.C) prohibits new trails within 200 meters of active western burrowing owl nests. Rodent control will be prohibited in the vicinity of trails, including equestrian-access areas, within 200 meters of burrowing owl burrows, except as necessary to protect important infrastructure. With implementation of these measures, recreation-related effects on the western burrowing owl are expected to be minimal.

5.6.13.1.5 Impact of Take on Species

The breeding range of the western burrowing owl extends south from southern Canada throughout most of the western half of the United States and south to central Mexico. The winter range extends from central California southeastward through Arizona, New Mexico, and Texas and south into northern and central Mexico and coincides with southern breeding range where the species is resident year-round (Haug et al. 1993). Burrowing owls were once widespread and generally common over western North America in treeless, well-drained grasslands, steppes, deserts, prairies, and agricultural lands (Haug et al. 1993). Owl population throughout the species' North American range are reportedly declining (James and Espie 1997; Klute et al. 2003).

There are an estimated 401,550 acres of modeled habitat for the western burrowing owl in the Plan Area; however an estimated 251,767 acres of this habitat (roughly 63%) is low-value cultivated land. Permanent loss of habitat can be described based on the proportion of low- and high-value habitat removed. Due to the distribution of burrowing owls in the Plan Area and the species' preference for grassland and pastureland (high value) land cover types, the loss of these habitat categories are more directly associated with direct effects on the species. The removal of most modeled cultivated land (low value) is not expected to affect the distribution or abundance of the species and in most cases is unlikely to affect individual active burrow sites. An estimated 8% of the modeled high-value habitat t will be permanently removed by covered activities. The loss of this habitat is more likely to affect the local distribution and abundance of the species. Therefore, to more effectively address the loss of high-value habitats, the primary conservation elements are also directed at the conservation of high-value habitat types.

The species is a year-round resident in the Plan Area; however, local migratory patterns and the extent to which migrants occupy the Plan Area during the nonbreeding season are unclear. Data from CNDDB and surveys conducted by DWR in 2009, 2010, and 2011 (California Department of Water Resources 2012) indicate that almost all burrowing owls that occur in the Plan Area nest in the southeast portion in grassland habitat. No burrowing owls were found on Delta islands or in seasonal wetlands. This area also corresponds with the distribution of moderate to high-value habitat. Therefore, the removal of high-value habitat also has a substantially greater likelihood of directly affecting active nesting or wintering burrows. In this region, which includes primarily Conservation Zones 1, 8, 9, and 11, the largest proportion of the known nesting population with potential to be affected by covered activities is in the vicinity of Clifton Court Forebay in Conservation Zone 8. Occupied habitats in Conservation Zones 1, 9, and 11 will be less affected by covered activities.

Although BDCP implementation will result in permanent, temporary, and indirect effects on the western burrowing owl as discussed above, take resulting from these actions will not have an adverse population-level effect on the species. Implementation of the BDCP will result in loss of one extant and two possibly extirpated burrowing owl occurrences in the Plan Area; however, there may be others. Ten of the 128 documented burrowing owl occurrences in the Plan Area are in locations that already have some degree of protection from development or other adverse effects.

5.6.13.2 Beneficial Effects

Assuming the restored and protected grassland, alkali seasonal wetland complex, vernal pool complex, and managed wetland natural communities will provide suitable western burrowing owl habitat proportional to the amount of modeled habitat that currently exists in these natural communities in the Plan Area (76%, 83%, 88%, and 10%, respectively), implementation of the BDCP will result in the protection of an estimated 7,589 acres of high-value habitat and 25,177 acres of low-value burrowing owl habitat consisting of these natural communities. Based on the same assumptions, implementation of the BDCP will result in the restoration of an estimated 1,642 acres of high-value and 3 acres of low-value burrowing owl habitat consisting of these natural communities. Additionally, Objective WBO1.1 calls for protection of at least 1,000 acres of cultivated lands in Conservation Zones 1 and 11 that support high-value burrowing owl habitat and are within 0.5 mile of high-value grassland habitat or occupied low-value habitat. Full implementation of the BDCP is therefore expected to result in an estimated 33,766 acres of total western burrowing owl habitat (8,589 acres high-value and 25,177 acres low-value habitat) and restoration of 1,645 acres of total western burrowing owl habitat (1,642 acres high-value and 3 acres low-value habitat) (Table 5.6-7).

Protection of natural communities used by burrowing owls will protect these lands from future threats of land conversion and reduce the effects of current levels of fragmentation, expand the amount of suitable protected habitat in the Plan Area. Protected grasslands, in particular, will support existing western burrowing owl populations that occur to the west of Conservation Zone 8 in Contra Costa County (linkage #2, Figure 3.2-16, *Landscape Linkages*, in Chapter 3) and in the areas surrounding Conservation Zones 1 and 11 in Solano County (linkage #1, Figure 3.2-16), which will especially benefit declining populations in the vicinity of Suisun Marsh and San Pablo Bay. Grassland protection will also take place in Conservation Zones 2, 4, 5, and 7.

The BDCP will further benefit the western burrowing owl by increasing the amount of burrows in protected and restored grasslands (*CM11 Natural Communities Enhancement and Management*), which will open opportunities for dispersing western burrowing owls to establish new territories, and by increasing the diversity of prey options (CM11) and thus minimizing the effect that population swings of any one prey species will have on western burrowing owls.

Although cultivated lands are in the low suitability category for burrowing owl use, western burrowing owls are known to use road, canal, and levee embankments that have ground squirrel burrows or culverts, and thus the management of cultivated lands for western burrowing owl foraging habitat may further expand and support populations in the Plan Area in the long term. At least 1,000 acres of pasture lands and other highly valued foraging habitat for the western burrowing owl will be protected in Conservation Zones 1 and 11 near or adjacent to occupied grassland habitats (*CM3 Natural Communities Protection and Restoration*). Patches of habitat in cultivated lands that may support western burrowing owl prey species (insects and small mammals) will be protected (CM3). Implementation of this objective may allow western burrowing owls to establish a greater presence in the central portion of the Delta.

The BDCP will provide for the conservation and management of the western burrowing owl in cooperation and in conjunction with neighboring and overlapping HCP/NCCPs. Conservation actions will occur where they most benefit the regional western burrowing owl population and where they are compatible with the conservation of other species associated with grassland and cultivated land. The western burrowing owl conservation strategy is expected to sustain the existing population of western burrowing owls and provide for future increases in the species' abundance and distribution in and adjacent to the Plan Area.

5.6.13.3 Net Effects

Including both the habitat loss described in Section 5.6. 13.1, *Adverse Effects*, and the habitat restoration and protection described in Section 5.6.13.2, *Beneficial Effects*, implementation of the BDCP will result in an estimated net decrease of at least 42,425 acres (11%) of habitat for the western burrowing owl, mostly of low-value unoccupied habitat, and an estimated net increase of at least 25,859 acres (30%) of western burrowing owl habitat, mostly of high-value habitat, in conservation lands (Table 5.6-7).

Specific covered activities are expected to adversely affect burrowing owls through the permanent removal of 43,969 acres of modeled burrowing owl habitat, including 12,450 acres of high-value habitat. While this will result in a net loss of high-value modeled habitat, the loss represents only a small percentage of the available high-value habitat in the Plan Area and the majority of affected acres are lands that are unoccupied by burrowing owls. With the exception of the area in the vicinity of the Clifton Court Forebay, most of the loss of modeled burrowing owl habitat will not affect current breeding or wintering sites. Therefore, most of the loss of burrowing owl habitat will not affect the distribution or abundance of the species in the Plan Area. The remaining high-value habitat is expected to sustain the current population.

The loss of high-value western burrowing owl habitat is offset by three key conservation objectives: protection of 8,000 acres of grassland in Conservation Zones 1, 2, 4, 5, 7, 8, and 11; protection of an additional 1,000 acres of high-value pastureland with the grassland-pastureland matrix of Conservation Zones 1 and 11, and restoration of 2,000 acres of grassland. Other conservation objectives that target cultivated-land protection will be sufficient to sustain and expand existing burrowing owl populations in low-value habitat areas. Therefore, although the total acreage of available high-value habitat will decrease in the Plan Area, the protection, enhancement, and management of 11,000 acres of habitat in key areas known to be occupied by burrowing owls will increase the extent of burrowing habitat under protected status in the Plan Area by at least 37% (Table 5.6-7), and will provide sufficient habitat for the protection and expansion of the burrowing owl population.

Overall, the BDCP will provide a net benefit to the western burrowing owl through the protection, management, and enhancement of high--value habitats in the Plan Area where the species is known to occur, and the increase in extent of habitat in protected status. These protected areas will be managed and monitored to support the species. Therefore, the BDCP will minimize and mitigate impacts, to the maximum extent practicable, and provide for the conservation and management of the western burrowing owl in the Plan Area.

5.6.14 Western Yellow-Billed Cuckoo

This section describes the adverse, beneficial, and net effects of the covered activities, including conservation measures, on the western yellow-billed cuckoo. The methods used to assess these effects are described in Section 5.2.8, *Effects Analysis for Wildlife and Plants*. The habitat model used to assess effects for the western yellow-billed cuckoo includes two habitat types: potential breeding habitat and migratory habitat. The model for potential breeding habitat includes plant alliances from the valley/foothill riparian modeled habitat that contain a dense forest canopy for foraging with understory willow for nesting, and a minimum patch size of 25 acres. Western yellow-billed cuckoo nesting in the Plan Area has not been confirmed for an estimated 100 years: the western yellow-billed cuckoo was observed in the Plan Area during 2009 BDCP surveys, but nesting was not confirmed and the bird was likely a migrant (California Department of Water Resources 2011a). The model for migratory habitat includes the same valley/foothill riparian plant alliances as potential breeding habitat, but without the minimum patch size designation. Further details regarding the habitat model, including assumptions on which the model is based, are provided in Appendix 2.A, *Covered Species Accounts.* Factors considered in assessing the value of affected habitat for the western yellow-billed cuckoo, to the extent that information is available, include location in relation to species occurrences and existing conservation lands (Types 1 and 2)[16], and habitat patch size and configuration.

[16] See Chapter 3, Section 3.2.4.2.2, *Existing Conservation Lands*, for definitions of conservation land types.

5.6.14.1 Adverse Effects

5.6.14.1.1 Permanent Habitat Loss, Conversion, and Fragmentation

Covered activities will result in the permanent loss of up to 547 acres[17] of habitat (4% of the habitat in the Plan Area) for the western yellow-billed cuckoo, including 150 acres of potential breeding habitat and 397 acres of migratory habitat (Table 5.6-1). Covered activities resulting in permanent habitat loss for the western yellow-billed cuckoo include water conveyance facility construction, Fremont Weir/Yolo Bypass improvements, tidal natural communities restoration, and floodplain restoration. The covered activity resulting in most (77%) of the habitat loss is tidal natural communities restoration.

Water Conveyance Facility Construction

Construction of all conveyance facilities, including transmission lines, will result in the permanent removal of an estimated 23 acres of western yellow-billed cuckoo habitat. An estimated 9 acres of breeding habitat and up to 14 acres of migratory habitat for the western yellow-billed cuckoo (less than 1% of migratory habitat in the Plan Area) will be lost (Table 5.6-1). The majority of this habitat is of low value for the species; it consists of small patches scattered through Conservation Zones 3, 4, 5, 6, and 8, most of which are narrow strips along irrigation and drainage channels. The western yellow-billed cuckoo is likely not present in habitat along the conveyance facility alignment; the alignment was surveyed by DWR biologists in 2009 and 2010, and the western yellow-billed cuckoo was not detected (California Department of Water Resources 2012).

An estimated 16 of the 23 acres of western yellow-billed cuckoo habitat (10 acres of which are migratory habitat) will be lost due to placement of reusable tunnel material. The material will likely be moved to other sites for use in levee build-up and restoration, and the affected area will likely be restored: while this effect is categorized as permanent because there is no assurance that the material will eventually be moved, the effect will likely be temporary. Furthermore, the amount of storage area needed for reusable tunnel material is flexible, and the footprint used in the effects analysis is based on a worst-case scenario; the actual area to be affected by reusable tunnel material storage will likely be less than the estimated acreage.

Fremont Weir/Yolo Bypass Improvements

This activity will result in the permanent removal of an estimated 83 acres of habitat for the western yellow-billed cuckoo (less than 1% of the habitat in the Plan Area), including an estimated 26 acres of potential breeding habitat and 57 acres of migratory habitat (Table 5.6-1). Most of this habitat is of low to moderate value; although it is located in and near existing conservation lands (Type 1), the modeled habitat to be affected in the vicinity of Fremont Weir includes grasslands with scattered small patches of willows and other riparian vegetation rather than contiguous riparian vegetation. There are no western yellow-billed cuckoo occurrences near the Fremont Weir, although the extent to which this area has been surveyed for the species is unknown.

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[17] Habitat or natural community loss acreage estimates are based on hypothetical footprints and models rather than detailed project-level design and represent the maximum allowed under the permit. Actual losses will be tracked through compliance monitoring to ensure that they do not exceed estimates.

Tidal Natural Communities Restoration

This activity will result in the permanent removal of an estimated 420 acres of western yellow-billed cuckoo habitat (3% of the habitat in the Plan Area), including 110 acres of potential breeding habitat and 310 acres of migratory habitat (Table 5.6-1). This habitat loss will take place in the Suisun, Cache Slough, Cosumnes/Mokelumne, West Delta, and South Delta ROAs. The majority of the habitat to be lost is in Conservation Zones 2 (36%) and 5 (34%), and the remainder is scattered in Conservation Zones 1, 4, 6, 7, 8, and 11. Most of the habitat loss in Conservation Zone 2 is in Cache Slough ROA, around Prospect Island, and is of moderate to high value as it includes some relatively large habitat patches. Most of the habitat loss in Conservation Zone 5 is located in the vicinity of Frank's Tract and Brannan Island State Recreation Areas (Type 2 conservation land) and is also of moderate to high value in that it includes relatively large habitat patches. The remainder of the habitat loss potentially resulting from tidal natural communities restoration is of low to moderate value, mostly in relatively small patches and narrow strips along drainage channels and surrounded by agricultural lands. The western yellow-billed cuckoo was detected by DWR in 2009 in Conservation Zone 4 just west of the Cosumnes/Mokelumne ROA, but nesting was not confirmed (California Department of Water Resources 2011a). There are no western yellow-billed cuckoo occurrences in the ROAs, although the extent to which these areas have been surveyed for the species is unknown. Because the estimates of habitat loss resulting from tidal inundation are based on projections of where restoration may occur, actual effects are expected to be lower because sites will be selected to minimize effects on western yellow-billed cuckoo habitat.

Floodplain Restoration

Levee construction associated with floodplain restoration will result in the permanent removal of an estimated 21 acres of western yellow-billed cuckoo habitat (0.2% of the habitat in the Plan Area), including 6 acres of potential breeding habitat and 16 acres of migratory habitat (Table 5.6-1). This habitat is of moderate value: although it consists primarily of small patches, these patches are in proximity to other habitat along the San Joaquin River, and some of the patches are adjacent to existing conservation lands (Type 1 and Type 2). Because the estimates of habitat loss resulting from floodplain restoration are based on projections of where restoration may occur, actual habitat loss is expected to be lower because of sites will be selected to minimize effects on western yellow-billed cuckoo habitat.

5.6.14.1.2 Periodic Inundation

Yolo Bypass Operations

Appendix 5.J, *Effects on Natural Communities, Wildlife, and Plants*, provides the methodology used to estimate periodic inundation effects in the Yolo Bypass. Based on this methodology, periodic inundation could affect western yellow-billed cuckoos occupying areas ranging from an estimated 48 acres of habitat during a notch flow of 6,000 cfs (B) to an estimated 85 acres during a notch flow of 4,000 cfs. The inundation could affect western yellow-billed cuckoos in 11 to 20 acres of breeding habitat and 37 to 64 acres of migratory habitat (Table 5.6-3). However, project-associated inundation of areas that would not otherwise have been inundated is expected to occur in no more than 30% of all years, since Fremont Weir is expected to overtop the remaining estimated 70% of all years, and during those years notch operations will not typically affect the maximum extent of inundation. In more than half of all years under existing conditions, an area greater than the project-related inundation area already inundates in the bypass. Therefore, habitat conditions in the bypass are not expected to change substantially as a result of Yolo Bypass operations and effects on yellow-billed cuckoo, if any, are expected to be minimal.

Floodplain Restoration

Based on hypothetical floodplain restoration, this activity will periodically inundate 142 acres of habitat for the western yellow-billed cuckoo (1% of the habitat in the Plan Area), including 17 acres of potential breeding and 125 acres of migratory habitat. The floodplains will transition from areas that flood frequently (i.e., every 1 to 2 years) to areas that flood infrequently (i.e., every 10 years or more). Periodic inundation as a result of Yolo Bypass operations and floodplain restoration is not expected to adversely affect the yellow-billed cuckoo because flooding is unlikely to occur during the breeding season when the cuckoo could be present, and the potential effects of inundation on existing riparian vegetation are expected to be minimal. While frequent flooding in the lower elevation portions of the floodplain may result in scouring of riparian vegetation, this is expected to have a beneficial rather than an adverse effect on the species (Section 5.6.14.2, *Beneficial Effects*).

5.6.14.1.3 Construction-Related Effects

Direct and permanent effects of construction are described above in Section 5.6.14.1.1, *Permanent Habitat Loss, Conversion, and Fragmentation*. Additional construction-related effects on this species include temporary habitat loss, potential construction-related injury or mortality, and indirect noise and visual disturbance. Effects on the species are described below for each effect category. Effects are described collectively for all covered activities, and are also described for specific covered activities to the extent that this information is pertinent for assessing the value of affected habitat or specific nature of the effect.

Temporary Habitat Loss

Construction-related effects will temporarily disturb 123 acres of habitat for the western yellow-billed cuckoo (1% of the habitat in the Plan Area), including 11 acres of potential breeding habitat and 112 acres of migratory habitat (Table 5.6-1). Temporarily removed areas will be restored as riparian habitat in 1 year following completion of construction activities. Although the effects are considered temporary, five years to several decades may be required for ecological succession to occur and for restored riparian habitat to functionally replace habitat that has been affected. However, most of the riparian vegetation to be temporarily removed in the Plan Area is early to midsuccessional: therefore, the replaced riparian vegetation is expected to have structural components comparable to the temporarily removed vegetation within the first 5 to 10 years after the initial restoration activities are complete.

Construction-Related Injury or Mortality

Although western yellow-billed cuckoo nesting has not been confirmed in the Delta for an estimated 100 years, a 2009 sighting by DWR (in unconfirmed nesting habitat) and the presence of suitable habitat indicates that the species may nest in the Plan Area presently or in the future (California Department of Water Resources 2011a). If the western yellow-billed cuckoo nests where covered activities are to occur, the operation of equipment for construction activities could result in injury or mortality of individuals. Risk will be greatest to eggs and nestlings that could be injured or killed through crushing from heavy equipment, nest abandonment, or increased exposure to the elements or to predators. Injury to adults and fledged juveniles is unlikely as these individuals are expected to avoid contact with construction equipment. Under AMM22, injury or mortality to nesting western yellow-billed cuckoos will be avoided through preconstruction surveys and establishment of a 500-foot no-disturbance buffer around active nests.

Indirect Construction-Related Effects

Noise and visual disturbance outside the project footprint but within 500 feet of construction activities are indirect effects that could temporarily affect the use of 1,014 acres (8%) of modeled western yellow-billed cuckoo habitat, including 201 acres of potential breeding and 813 acres of migratory habitat (Table 5.6-5). Construction noise above background noise levels (greater than 50 dBA) is expected to extend 500 to 5,250 feet from the edge of construction activity (Table 4, *Estimated Impacts on the Delta Wintering Population of Greater Sandhill Cranes from Collisions with Proposed BDCP Power Lines*, Appendix 5.J, Attachment 5J.D, *Indirect Effects of the Construction of the BDCP Conveyance Facility on Sandhill Crane*). There is no available data to determine the extent to which these noise levels could affect the western yellow-billed cuckoo. As described above, there are no nesting records for this species in the Plan Area over the last an estimated 100 years but recent sightings indicate that the species may become established in the Plan Area during Plan implementation. Indirect noise and visual effects on nesting cuckoos, if found, will be minimized under AMM22 by establishing 250-foot no-disturbance buffers around active nests.

5.6.14.1.4 Effects of Ongoing Activities

Transmission Lines

New transmission lines will increase the risk for bird- transmission line strikes, which could result in injury or mortality of the western yellow-billed cuckoo. The potential for this risk, however, is considered minimal based on factors assessed in the bird strike vulnerability analysis (Appendix 5.J, *Effects on Natural Communities, Wildlife, and Plants*, Attachment 5J.C, *Analysis of Potential Bird Collisions at Proposed BDCP Powerlines*), including wing morphology, flight altitude and timing, foraging behavior, and social behavior. The yellow-billed cuckoo's wing shape is characterized by low wing loading and moderate aspect ratio, making it moderately maneuverable (Bevanger 1998) and presumably able to avoid collisions, especially during high-visibility conditions. Because of its rarity in the Plan Area, its proclivity to remain within the riparian canopy, its presence during periods of relative high visibility, and its overall ability to successfully negotiate around overhead wires that it may encounter, the yellow-billed cuckoo is considered to have very low susceptibility to collision with overhead wires. Transmission line poles and towers also provide perching substrate for raptors, which could result in increased predation pressure on local black rails. This is expected to have few adverse effects on the western yellow-billed cuckoo population, if any.

Operation and Maintenance

Activities associated with operation and maintenance activities that could affect yellow-billed cuckoo habitat include transmission line and substation maintenance, excavation to repair pipeline, and levee maintenance, These activities could result in local, temporary adverse habitat effects, injury or mortality of cuckoos, and temporary noise and disturbance effects if individuals are present in or near work sites over the term of the BDCP. Vegetation clearing in Yolo Bypass to improve flood conveyance may temporarily adversely affect yellow-billed cuckoo habitat: however, vegetation is already regularly removed from the bypass to improve flood conveyance, and no occupied nesting habitat will be removed during the nesting season. Maintenance effects will be avoided and minimized with implementation of AMM22.

Habitat Enhancement and Management

Activities associated with natural communities enhancement and management in protected western yellow-billed cuckoo habitat, such as ground disturbance or herbicide use to control nonnative vegetation, could result in local adverse habitat effects, injury or mortality of cuckoos, and temporary noise and disturbance effects if individuals are present in work sites over the term of the BDCP. These effects will be avoided and minimized with implementation of AMM22.

Recreation

Passive recreation in the reserve system, where that recreation is compatible with the biological goals and objectives, could result in disturbance of western yellow-billed cuckoos using habitat in the vicinity of trails. Nests could be disturbed during construction and ongoing use of trails and other amenities. Due to placement of trails, passive recreation on established trails is expected to result in limited disturbance. *AMM37 Recreation* (Appendix 3.C) limits trail construction to outside the breeding season for nesting birds. The number and length of trails that parallel the edge of the riparian forest will be limited unless located sufficiently away from those communities to minimize disturbance and allow use of open habitats by edge-dependent species. When adjacent to riparian communities, trails will be on the top of a levee or behind the top of bank except where topographic, resource management, or other constraints or management objectives make this infeasible or undesirable. With implementation of these measures, recreation-related effects on the western yellow-billed cuckoo are expected to be minimal.

5.6.14.1.5 Impact of Take on Species

There are two recognized subspecies of yellow-billed cuckoo, *C. a. occidentalis*, found west of the Rocky Mountains and *C. a. americanus*, found in deciduous forests east of the Rocky Mountains. There is a continuing debate over the taxonomic separation of the two subspecies, based on genetics studies initiated by USFWS during the status review for federal listing. While the eastern subspecies' range includes all states east of the Rocky Mountains and the southern regions of Quebec and Ontario, breeding populations of the western subspecies are limited to California, Arizona, and western New Mexico (Halterman 1991). Studies conducted since the 1970s indicate that there may be fewer than 50 breeding pairs of the western yellow-billed cuckoo in California (Gaines 1974; Halterman 1991;, Laymon et al. 1997). Although sustained breeding populations occur to the north of the Plan Area at isolated sites along the Sacramento River, there are no recent breeding records of western yellow-billed cuckoos in the Plan Area. The scattered sightings over the last 50 years are presumed to be from migrating birds.

Based on modeled habitat for the western yellow-billed cuckoo, the Plan Area supports 1,970 acres of potentially suitable breeding habitat and 10,425 acres of migratory habitat. Of this, up to 150 acres of potential breeding habitat (8% of the potential breeding habitat in the Plan Area) and 397 acres of migratory habitat (4% of the migratory habitat in the Plan Area) will be permanently removed by covered activities. This and other adverse effects on the western yellow-billed cuckoo resulting from covered activities, as described above, are not expected to adversely affect the long-term survival and conservation of the species for the following reasons.

- Cuckoo presence in the Plan Area is currently limited to infrequent migrants passing through the area.
- The potential breeding and migratory habitat to be lost is small relative to the species range and the amount that will remain in the Plan Area.

- Most permanently removed habitat consists of relatively small, fragmented riparian stands that do not provide high-value habitat for the cuckoo.

5.6.14.2 Beneficial Effects

At least 500 acres of the mature riparian forest to be maintained in the reserve system (Objective VFRNC2.3) will be intermixed with a portion of the early- to midsuccessional riparian vegetation (Objective VFRNC2.2) in large blocks with a minimum patch size of 50 acres and minimum width of 330 feet (VFRNC2.4). This will provide over 500 acres of breeding habitat for the western yellow-billed cuckoo. The restored and protected riparian natural community will be managed as a mosaic of seral stages, age classes, and plant heights and types characteristic of the valley/foothill riparian community (*CM11 Natural Communities Enhancement and Management*). This is expected to provide optimal conditions for western yellow-billed cuckoos to nest and reproduce, and is expected to increase the likelihood that the western yellow-billed cuckoo will reinitiate breeding in the Plan Area. Riparian restoration and protection will focus along riparian systems within the Plan Area (linkages #5, 6, and 7, Figure 3.2-16, *Landscape Linkages*, in Chapter 3), and on connectivity with preserved riparian lands south of the Plan Area (linkage #4, Figure 3.2-16). Additionally, assuming the restored riparian natural community will provide suitable western yellow-billed cuckoo migratory habitat proportional to the amount of modeled migratory habitat that currently exists in this natural community in the Plan Area (an estimated 58%), the restoration of 5,000 acres of riparian natural community (*CM7 Riparian Natural Community Restoration*) will provide an estimated 2,897 acres of habitat that is comparable to or of higher value than existing modeled migratory habitat (Table 5.6-7).

5.6.14.3 Net Effects

Including both the habitat loss described in Section 5.6. 14.1, *Adverse Effects*, and the riparian habitat restoration and protection described in Section 5.6.14.2, *Beneficial Effects*, implementation of the BDCP will result in an estimated net increase of at least 2,850 acres (23%) of habitat for the western yellow-billed cuckoo and an estimated net increase of at least 3,493 acres (77%) of western yellow-billed cuckoo habitat in conservation lands (Table 5.6-7).

The habitat that will be lost as a result of covered activities is of low to moderate value, consisting primarily of relatively small, isolated patches and narrow strips of riparian vegetation in a cultivated landscape. The restored and protected habitat will consist of large, contiguous areas, at least 500 acres of which will be managed to sustain appropriate vegetation structural requirements for the species. Restoration, protection, and management of western yellow-billed cuckoo habitat in the Plan Area will increase opportunities for a breeding population of western yellow-billed cuckoos to become reestablished in the Plan Area after an estimated 100 years with no nesting records.

Overall, the BDCP will provide a substantial net benefit to the western yellow-billed cuckoo through the increase in available habitat and habitat in protected status. These protected areas will be managed and monitored to support the species. Therefore, the BDCP will minimize and mitigate impacts, to the maximum extent practicable, and provide for the conservation and management of the western yellow-billed cuckoo in the Plan Area.

5.6.15 White-Tailed Kite

This section describes the adverse, beneficial, and net effects of the covered activities and conservation measures on the white-tailed kite. The methods used to assess these effects are described in Section 5.2.8, *Effects Analysis for Wildlife and Plants*. The model maps the distribution of suitable white-tailed kite habitat in the Plan Area according to the species' two primary life requisites, nesting habitat and foraging habitat. The modeled habitat for the white-tailed kite is based on selected mapping units from the valley/foothill riparian, grasslands, alkali seasonal wetlands, managed wetlands, vernal pool complexes, and cultivated lands. Breeding habitat for the white-tailed kite includes all valley riparian types that support an overstory component. Further details regarding the habitat model, including assumptions on which the model is based, are provided in Appendix 2.A, *Covered Species Accounts.* Size and configuration is considered in assessing the value of affected nesting habitat for the white-tailed kite.

5.6.15.1 Adverse Effects

5.6.15.1.1 Permanent Habitat Loss, Conversion and Fragmentation

Covered activities will result in the permanent loss or conversion of up to 533 acres[18] of breeding habitat (4% of the breeding habitat in the Plan Area) and 57,015 acres of foraging habitat (11% of foraging habitat in the Plan Area) for the white-tailed kite (Table 5.6-1). Covered activities resulting in permanent loss or conversion of habitat for the white-tailed kite include water conveyance facility construction, Fremont Weir/Yolo Bypass improvements, tidal natural communities restoration, floodplain restoration, nontidal marsh restoration, riparian and grassland restoration, and the construction of conservation hatcheries facilities. The covered activity resulting in the majority (73%) of the loss or conversion is tidal natural communities restoration; most of this involves conversion from one type of habitat used by the white-tailed kite to another, rather than actual habitat loss.

Water Conveyance Facility Construction

This activity will result in the permanent removal of an estimated 26 acres of breeding habitat (less than 1% of breeding habitat in the Plan Area) and 4,339 acres of foraging habitat (less than 1% of foraging habitat in the Plan Area) for the white-tailed kite (Table 5.6-1). Breeding habitat to be lost consists of narrow strips of riparian vegetation adjacent to canals.

An estimated 3,255 of the 4,366 acres of white-tailed kite habitat (3,239 acres of which are foraging habitat) will be lost due to placement of reusable tunnel material. The material will likely be moved to other sites for use in levee build-up and restoration, and the affected area will likely be restored. While this effect is categorized as permanent, because there is no assurance that the material will eventually be moved, the effect will likely be temporary. Furthermore, the amount of storage area needed for reusable tunnel material is flexible, and the footprint used in the effects analysis is based on a worst-case scenario; the actual area to be affected by reusable tunnel material storage will likely be less than the estimated acreage.

[18] Habitat or natural community loss acreage estimates are based on hypothetical footprints and models rather than detailed project-level design and represent the maximum allowed under the permit. Actual losses will be tracked through compliance monitoring to ensure that they do not exceed estimates.

Fremont Weir/Yolo Bypass Improvements

This activity will result in the permanent removal of an estimated 82 acres of breeding habitat (less than 1% of breeding habitat in the Plan Area) and 1,008 acres of foraging habitat (less than 1% of the foraging habitat in the Plan Area) for the white-tailed kite (Table 5.6-1). Although the 82 acres of modeled breeding habitat is located in and near existing conservation lands (Type 1), it consists of grasslands with scattered small patches of willows and other riparian vegetation rather than contiguous riparian vegetation.

Tidal Natural Communities Restoration

This activity will result in the permanent removal or conversion of an estimated 383 acres of breeding habitat (3% of breeding habitat in the Plan Area) and an estimated 42,008 acres of foraging habitat for the white-tailed kite (8% of foraging habitat in the Plan Area) (Table 5.6-1).

Floodplain Restoration

Levee construction associated with floodplain restoration will result in the permanent removal of an estimated 42 acres of breeding habitat (less than 1% of breeding habitat in the Plan Area) and 1,706 acres of foraging habitat (less than 1% of foraging habitat in the Plan Area) for the white-tailed kite.

Riparian Restoration

Riparian restoration will result in the conversion of an estimated 4,962 acres of foraging habitat (less than 1% of foraging habitat in the Plan Area) to nesting habitat for the white-tailed kite (Table 5.6-1)

Nontidal Marsh Restoration

This activity will result in the permanent conversion of an estimated 1,440 acres of cultivated lands providing foraging habitat (less than 1% of foraging habitat in the Plan Area) for the white-tailed kite in Conservation Zones 2 and 4 (Table 5.6-1). This will result in conversion from cultivated land to nontidal marsh but will not result in loss of white-tailed kite foraging habitat, as restored nontidal marsh will also provide foraging habitat for the kite.

Grassland Restoration

Grassland restoration will result in the permanent conversion of an estimated 1,849 acres of foraging habitat (less than 1% of foraging habitat in the Plan Area) for the white-tailed kite (Table 5.6-1). This will result in conversion from cultivated land to grasslands but will not result in loss of white-tailed kite foraging habitat, as restored grasslands will also provide foraging habitat for the kite.

Conservation Hatcheries Facilities

This activity will result in the permanent removal of an estimated 35 acres of foraging habitat (less than 1% of foraging habitat in the Plan Area) for the white-tailed kite (Table 5.6-1).

5.6.15.1.2 Periodic Inundation

Yolo Bypass Operations

Appendix 5.J, *Effects on Natural Communities, Wildlife, and Plants*, provides the method used to estimate periodic inundation effects in the Yolo Bypass. Based on this method, periodic inundation could affect white-tailed kites occupying areas ranging from an estimated 3,091 acres of habitat during notch flow of 1,000 cfs to an estimated 6,733 acres during a notch flow of 4,000 cfs. The inundation could affect white-tailed kites in 48 to 82 acres of breeding habitat and 3,030 to 6,651 acres of foraging habitat (Table 5.6-3). However, project-associated inundation of areas that would not otherwise have been inundated is expected to occur in no more than 30% of all years, since Fremont Weir is expected to overtop the remaining estimated 70% of all years, and during those years notch operations will not typically affect the maximum extent of inundation. In more than half of all years under existing conditions, an area greater than the project-related inundation area already inundates in the bypass. Therefore, habitat conditions in the bypass are not expected to change substantially as a result of Yolo Bypass operations. Increased duration of inundation during years of Fremont Weir operation, however, may delay the period for which foraging habitat is available to white-tailed kites by up to several weeks.

Floodplain Restoration

Based on hypothetical floodplain restoration, this activity will periodically flood 230 acres of breeding habitat (2% of the breeding habitat in the Plan Area) and 7,402 acres of foraging habitat (less than 1% of foraging habitat in the Plan Area) for the white-tailed kite. Periodic flooding is not expected to adversely affect nesting or foraging value for the white-tailed kite in the restored floodplain.

Habitat inundated by both Yolo Bypass improvements and floodplain restoration is expected to recover following draw-down and to provide suitable foraging conditions until the following inundation period. Thus, this is considered a periodic effect that is unlikely to affect white-tailed kite distribution and abundance, or foraging use of the Plan Area.

5.6.15.1.3 Construction-Related Effects

Direct and permanent effects of construction are described above in Section 5.6.15.1.1, *Permanent Habitat Loss, Conversion, and Fragmentation*. Additional construction-related effects on the white-tailed kite include temporary habitat loss (short- and long-term), potential construction-related injury or mortality, and indirect effects outside of the project footprint such as noise and visual disturbance. Effects on the species are described below for each effect category. Effects are described collectively for all covered activities, and are also described for specific covered activities to the extent that this information is pertinent for assessing the value of affected habitat or specific nature of the effect.

Temporary Habitat Loss

Construction-related effects will temporarily disturb 144 acres of nesting breeding habitat (1% of nesting breeding habitat in the Plan Area) and 2,780 acres of foraging habitat (less than 1% of foraging habitat in the Plan Area) for the white-tailed kite (Table 5.6-1). Temporarily removed areas will be restored as riparian habitat within 1 year following completion of construction activities. Although the effects are considered temporary, 5 years to several decades may be required for ecological succession to occur and for restored riparian habitat to functionally replace habitat that has been affected. However, most of the riparian vegetation to be temporarily removed in the Plan Area is early to midsuccessional; therefore, the replaced riparian vegetation is expected to have structural components comparable to the temporarily removed vegetation within the first 5 to 10 years after the initial restoration activities are complete.

Of the 2,780 acres of foraging habitat to be temporarily removed, establishment and use of borrow and spoil areas associated with water facility construction will result in temporary removal of an estimated 183 acres of foraging habitat (less than 1% of foraging habitat in the Plan Area) for the white-tailed kite (Table 5.6-1). Although areas temporarily disturbed for borrow and spoils areas will be restored within 1 year following construction, these areas might not be restored to their original topography. Grasslands affected will be returned to grasslands, but cultivated lands will be converted to grasslands if they cannot be restored as cultivated lands. Whether the affected areas are restored to cultivated lands or grasslands, they will provide foraging habitat value for the white-tailed kite.

Construction-Related Injury or Mortality

If the white-tailed kite nests where covered activities are to occur, the operation of equipment for construction activities could result in injury or mortality of individuals. Risk will be greatest to eggs and nestlings that could be injured or killed through crushing by heavy equipment, nest abandonment, or increased exposure to the elements or to predators. Injury to adults and fledged juveniles is unlikely as these individuals are expected to avoid contact with construction equipment. Under *AMM18 Swainson's Hawk and White-Tailed Kite*, injury or mortality of nesting white-tailed kites will be avoided through preconstruction surveys and establishment of 600-foot-radius no-disturbance buffers around active nests (Appendix 3.C, *Avoidance and Minimization Measures*).

Indirect Construction-Related Effects

Noise and visual disturbance outside the project footprint but within 600 feet of construction activities are indirect effects that could temporarily affect the use of 1,159 acres of breeding habitat (8% of breeding habitat in the Plan Area) and 20,486 acres of foraging habitat for the white-tailed kite during construction (Table 5.6-5). Construction noise above background noise levels (greater than 50 dBA) is expected to extend 500 to 5,250 feet from the edge of construction activity (Table 4, *Estimated Impacts on the Delta Wintering Population of Greater Sandhill Cranes from Collisions with Proposed BDCP Power Lines*, in Appendix 5.J, Attachment 5J.D, *Indirect Effects of the Construction of the BDCP Conveyance Facility on Sandhill Crane*). There is no available data to determine the extent to which these noise levels could affect white-tailed kite. Indirect noise and visual effects on nesting white-tailed kites, if found, will be minimized by establishing a 600-foot-radius no-disturbance buffer around active nests, as described in AMM18.

5.6.15.1.4 Effects of Ongoing Activities

Transmission Lines

New transmission lines will increase the risk for bird- transmission line strikes, which could result in injury or mortality of white-tailed kites. This species is expected to be at moderate risk of bird strike mortality based on factors assessed in the bird strike vulnerability analysis (Appendix 5.J, Attachment 5J.C, *Analysis of Potential Bird Collisions at Proposed BDCP Powerlines*) including wing morphology, flight altitude and timing, foraging behavior, and social behavior. The existing network of transmission lines in the Plan Area currently poses this risk to white-tailed kites, and any incremental risk associated with the new transmission line corridors (up to an estimated 9.3 miles in the Plan Area) is expected to be low.

Operation and Maintenance

Maintenance of the above-ground water conveyance facilities could result in ongoing but periodic postconstruction noise and visual disturbances that could affect white-tailed kite use of surrounding habitat. These effects may include periodic vehicle use along the conveyance corridor, and inspection and maintenance of above-ground facilities. These potential effects will be minimized with implementation of AMM18.

Habitat Enhancement and Management

Activities associated with natural communities enhancement and management in protected white-tailed kite habitat, such as ground disturbance or herbicide use to control nonnative vegetation, could result in local adverse habitat effects, injury or mortality of nesting white-tailed kites, and temporary noise and disturbance effects if individuals are present in work sites over the term of the BDCP. These effects will be avoided and minimized under AMM18 with the implementation of a 600-foot-radius no-disturbance buffer around active nest sites.

Management of the 5,000 acres of managed wetlands to be protected for waterfowl and shorebirds is not expected to result in overall adverse effects on the white-tail kite. Management actions that will improve wetland quality and diversity on managed wetlands include control and eradication of invasive plants and maintenance of a diversity of vegetation types and elevations including upland areas. These management actions will potentially benefit the white-tailed kite. The 5,000 acres of protected managed wetlands will be monitored and adaptively managed to ensure that management options are implemented to avoid adverse effects on the white-tailed kite.

Recreation

Passive recreation in the reserve system, where that recreation is compatible with the biological goals and objectives, could result in disturbance of white-tailed kites nesting in the vicinity of trails. *AMM37 Recreation*, described in Appendix 3.C, limits trail construction in and near riparian areas to outside the breeding season. The number and length of trails that parallel the edge of the riparian forest will be limited unless located sufficiently away from those communities to minimize disturbance and allow use of open habitats by edge-dependent species. When adjacent to riparian communities, trails will be on the top of a levee or behind the top of bank except where topographic, resource management, or other constraints or management objectives make this infeasible or undesirable. During the breeding season, trails will be closed within 600 feet of active nests. With implementation of these measures, recreation-related effects on the white-tailed kite are expected to be minimal.

5.6.15.1.5 Impact of Take on Species

The distribution of the white-tailed kite includes the east coast and southeast United States, the southwest United States from Texas to California, and north to Washington State, and from Mexico to South America. California is currently considered the breeding range stronghold for the white-tailed kite in North America, with nearly all areas up to elevations at the western Sierra Nevada foothills and southeastern deserts occupied (Small 1994; Dunk 1995). The Plan Area represents a small portion of the species' range-wide distribution. The permanent loss or conversion of up to 4% of the breeding habitat and 10% of foraging habitat in the Plan Area as a result of covered activities, and other effects described above, are not expected to adversely affect the long-term survival of the white-tailed kite for the following reasons.

- An estimated 95% of the foraging habitat effects involve conversion from one habitat type to another alternate form of suitable foraging habitat.
- The Plan Area represents a small portion of the species' range.
- The disturbance of active nests will be avoided with implementation of AMM18, as described in Appendix 3.C.

5.6.15.2 Beneficial Effects

Assuming the restored and protected valley/foothill riparian natural community will provide suitable white-tailed kite breeding habitat proportional to the amount of modeled habitat that currently exists in this natural community in the Plan Area (76%), implementation of the BDCP will result in protection of an estimated 570 acres and restoration of an estimated 3,800 acres of breeding habitat. Similarly, assuming the cultivated land, alkali seasonal wetland complex, grassland, managed wetland, and vernal pool complex natural communities will provide suitable white-tailed kite habitat proportional to the amount of modeled habitat that currently exists in these natural communities in the Plan Area (73%, 93%, 96%, 72%, and 93%, respectively), implementation of the BDCP will result in protection of an estimated 49,875 acres and restoration of an estimated 2,050 acres of foraging habitat (Table 5.6-7).

Large patches of riparian habitat provide higher value nesting habitat than narrow bands of trees, where white-tailed kites are often displaced by Swainson's hawks. Achieving the riparian natural community restoration and protection objectives will improve white-tailed kite breeding habitat in the Plan Area in the long term by providing large patches of riparian habitat. Riparian restoration and protection will focus along riparian systems within the Plan Area (linkages #5, 6, and 7, Figure 3.2-16, *Landscape Linkages*, in Chapter 3), and on connectivity with preserved riparian lands south of the Plan Area (linkage #4, Figure 3.2-16). Suitable foraging habitat for the white-tailed kite (i.e., low, herbaceous vegetation including marshes, grasslands, and many types of cultivated lands) will be present throughout the Plan Area, and most of the riparian restoration will be within 5 to 8 miles of suitable foraging habitat.

Grassland protection and enhancement will benefit the white-tailed kite by increasing the abundance of voles and other small mammals upon which white-tailed kites prey. Protection of cultivated lands will provide additional foraging habitat for white-tailed kites in the reserve system. This will benefit the white-tailed kite by reducing any future losses of or changes to suitable foraging habitat on cultivated lands and reduce current, as well as the threat of habitat fragmentation. Protection, restoration, and creation of alkali seasonal wetland complexes and vernal pool complexes are also expected to provide high-value foraging habitat for the kite. Maintenance and protection of small patches of wildlife habitats that occur in BDCP conserved cultivated lands, including isolated valley oak trees, trees and shrubs along field borders and roadsides, remnant groves, riparian corridors, and wetlands, will provide additional nesting and foraging habitat for the white-tailed kite.

5.6.15.3 Net Effects

Including both the habitat loss described in Section 5.6.15.1, *Adverse Effects*, and the habitat restoration and protection described in Section 5.6.15.2, *Beneficial Effects*, implementation of the BDCP will result in an estimated net decrease of 51,881 acres (11%) of habitat for the white-tailed kite and an estimated net increase of 39,359 acres (30%) of white-tailed kite habitat in conservation lands (Table 5.6-7). Breeding habitat that will be lost as a result of covered activities consists of narrow strips and small patches of riparian vegetation, while the restored valley/foothill riparian natural community will provide large, contiguous areas of nesting habitat that are of higher value for the species and will reduce the species' vulnerability to competition from Swainson's hawks. Most of the foraging habitat to be lost consists of cultivated lands. The restored wetlands will provide high-value foraging habitat that is expected to provide an abundance of prey and to expose white-tailed kites to fewer human-related disturbances and pesticides than cultivated lands.

Overall, the BDCP will provide a net benefit to the white-tailed kite through an increase in the availability of habitat on conservation lands and an increase in habitat value. Protected areas will be managed and monitored to support the species. Therefore, the BDCP will minimize and mitigate impacts, to the maximum extent practicable, and provide for the conservation and management of the white-tailed kite in the Plan Area.

5.6.16 Yellow-Breasted Chat

This section describes the adverse, beneficial, and net effects of the covered activities, including conservation measures, on the yellow-breasted chat. The methods used to assess these effects are described in Section 5.2.8, *Effects Analysis for Wildlife and Plants*, and Table 5.J.1, *Quantitative Effects Analysis Methods and Assumptions*, in Appendix 5.J, *Effects on Natural Communities, Wildlife, and Plants*. The habitat model used to assess effects for the yellow-breasted chat identifies suitable nesting and migratory habitat as those plant alliances from the valley/foothill riparian modeled habitat that contain a shrub component of blackberry, California wild rose, dogwood, coyote bush, willow, and other shrub species, and an overstory component that includes valley oak, coast live oak, Fremont cottonwood, white alder, box elder, Oregon ash, willow, or walnut. Primary nesting and migratory habitat is qualitatively distinguished from secondary habitat in Delta areas as those plant associations that support a greater percentage of a suitable shrub cover, particularly blackberry and California wild rose, and have an open to moderately dense overstory canopy, using data from Hickson and Keeler-Wolf (2007). No distinction is made between primary and secondary habitat for Suisun Marsh/Yolo Basin habitats because supporting information is lacking: for this reason, and to facilitate the discussion of species effects, this effects analysis only provides the breakdown between primary and secondary habitat in the habitat loss totals and associated tables, and does not provide this breakdown in the text by activity or effect type. Further details regarding the habitat model, including assumptions on which the model is based, are provided in Appendix 2.A, *Covered Species Accounts.* Factors considered in assessing the value of affected habitat for the yellow-breasted chat, to the extent that information is available, include location in relation to species occurrences and existing conservation lands (Type 1 and Type 2)[19], and habitat patch size and configuration.

[19] See Chapter 3, Section 3.2.4.2.2, *Existing Conservation Lands*, for definitions of conservation land types.

5.6.16.1 Adverse Effects

5.6.16.1.1 Permanent Habitat Loss, Conversion, and Fragmentation

Covered activities will result in the permanent loss of up to 684 acres[20] of habitat (5% of the habitat in the Plan Area) for the yellow-breasted chat, including 232 acres of primary habitat, 367 acres of secondary habitat, and 85 acres of habitat in the Suisun/Upper Yolo Bypass area (Table 5.6-1). Covered activities resulting in adverse effects on the yellow-breasted chat include water conveyance facility construction, tidal natural communities restoration, Fremont Weir/Yolo Bypass improvements, and floodplain restoration. A majority (67%) of the permanent loss is from tidal communities restoration.

Water Conveyance Facility Construction

Construction of conveyance facilities, including transmission line construction, will result in the permanent removal of an estimated 28 acres of habitat for the yellow-breasted chat (less than 1% of habitat in the Plan Area) (Table 5.6-1). This habitat is of low value for the species: it consists of small patches scattered through Conservation Zones 3, 4, 5, 6, and 8, most of which are narrow strips along irrigation and drainage channels. The yellow-breasted chat does not likely nest in habitat along the conveyance facility alignment: the alignment was surveyed by DWR biologists in 2009, 2010, and 2011 and nesting chats were not detected.

An estimated 18 of the 28 acres of yellow-breasted chat habitat will be lost due to placement of reusable tunnel material. The material will likely be moved to other sites for use in levee build-up and restoration, and the affected area will likely be restored. While this effect is categorized as permanent, because there is no assurance that the material will eventually be moved, the effect will likely be temporary. Furthermore, the amount of storage area needed for reusable tunnel material is flexible, and the footprint used in the effects analysis is based on a worst-case scenario; the actual area to be affected by reusable tunnel material storage will likely be less than the estimated acreage.

Fremont Weir/Yolo Bypass Improvements

This activity will result in the permanent removal of an estimated 83 acres of yellow-breasted chat habitat (Table 5.6-1) (less than 1% of habitat in the Plan Area). Most of this loss is Suisun Marsh/upper Yolo Bypass nest and migratory habitat. Although it is located in and near existing conservation lands (Type 1), the modeled habitat to be affected in the vicinity of Fremont Weir includes grasslands with scattered small patches of willows and other riparian vegetation rather than contiguous riparian vegetation. There are no yellow-breasted chat occurrences near the Fremont Weir, although the extent to which this area has been surveyed for the species is unknown.

Tidal Natural Communities Restoration

This activity will result in the permanent removal of an estimated 545 acres of habitat (4% of habitat in the Plan Area) in the Suisun, Cache Slough, Cosumnes, West Delta, and South Delta ROAs for the yellow-breasted chat (Table 5.6-1). The largest habitat loss (65%) is in Conservation Zone 2 in Cache Slough ROA, at Prospect Island (Type 1 conservation land); this area is considered of

[20] Habitat or natural community loss acreage estimates are based on hypothetical footprints and models rather than detailed project-level design and represent the maximum allowed under the permit. Actual losses will be tracked through compliance monitoring to ensure that they do not exceed estimates.

moderate to high value, because it includes relatively large habitat patches in or adjacent to conservation lands. DWR recorded two yellow-breasted chat occurrences just east of the Cache Slough ROA in 2009 (California Department of Water Resources 2011a). The remainder of the habitat that will potentially be lost to tidal natural communities restoration is scattered in Conservation Zones 1, 4, 7, 8, and 11 and is of low to moderate value, mostly in relatively small patches and narrow strips along drainage channels and surrounded by cultivated lands. There are several occurrences in Conservation Zone 5, in and around the West Delta ROA from 2009 (California Department of Water Resources 2011a). There are no yellow-breasted chat occurrences in the other affected ROAs, although the extent to which these areas have been surveyed for the species is unknown. DWR recorded two occurrences in the vicinity of the South Delta ROA from their 2009 surveys (California Department of Water Resources 2011a). Because the estimates of habitat loss resulting from tidal inundation are based on projections of where restoration may occur, actual effects are expected to be lower because sites will be selected to minimize effects on the yellow-breasted chat.

Floodplain Restoration

Based on the hypothetical floodplain restoration footprint, levee construction associated with floodplain restoration will result in the permanent removal of an estimated 28 acres of habitat in Conservation Zone 6 (less than 1% of habitat in the Plan Area) (Table 5.6-1). This habitat is of moderate value: although it consists primarily of small patches, these patches are in proximity to other habitat along the San Joaquin River, and some of the patches are adjacent to existing conservation lands (Type 1 and Type 2). There are no yellow-breasted chat occurrences in this area, but the extent to which the area has been surveyed for the species is unknown. The estimates of habitat loss resulting from floodplain restoration are based on projections of where restoration may occur, and actual habitat loss is expected to be lower because sites will be selected to minimize effects on yellow-breasted chat habitat.

5.6.16.1.2 Periodic Inundation

Yolo Bypass Operations

Appendix 5.J, *Effects on Natural Communities, Wildlife, and Plants,* provides the method used to estimate periodic inundation effects in the Yolo Bypass. Based on this method, periodic inundation could affect yellow-breasted chats occupying areas ranging from an estimated 48 acres of habitat during a notch flow of 6,000 cfs (B) to an estimated 85 acres during a notch flow of 4,000 cfs. The inundation could affect yellow-breasted chats in 19 to 38 acres of primary nesting and migratory habitat, 6 to 18 acres of secondary nesting and migratory habitat, and 23 to 32 acres of Suisun Marsh/Upper Yolo Bypass nest and migratory habitat (Table 5.6-2). However, project-associated inundation of areas that would not otherwise have been inundated is expected to occur in no more than 30% of all years, since Fremont Weir is expected to overtop the remaining estimated 70% of all years, and during those years notch operations will not typically affect the maximum extent of inundation. In more than half of all years under existing conditions, an area greater than the project-related inundation area already inundates in the bypass. Therefore, habitat conditions in the bypass are not expected to change substantially as a result of Yolo Bypass operations and effects on the yellow-breasted chat, if any, are expected to be minimal.

Floodplain Restoration

This activity will periodically inundate an estimated 148 acres of yellow-breasted chat habitat (1% of the habitat in the Plan Area). The floodplains will transition from areas that flood frequently (i.e., every 1 to 2 years) to areas that flood infrequently (i.e., every 10 years or more).

Periodic inundation as a result of Yolo Bypass operations and floodplain restoration is not expected to adversely affect the yellow-breasted chat because flooding is unlikely to occur during the breeding season when the chat could be present, and the potential effects of inundation on existing riparian vegetation are expected to be minimal. While frequent flooding in the lower elevation portions of the floodplain may result in scouring of riparian vegetation, this is expected to have a beneficial rather than an adverse effect on the species (Section 5.6.16.2, *Beneficial Effects*).

5.6.16.1.3 Construction-Related Effects

Direct and permanent effects of construction are described above in Section 5.6.16.1.1, *Permanent Habitat Loss, Conversion, and Fragmentation*. Additional construction-related effects on this species include temporary habitat loss; construction-related injury or mortality; and indirect effects such as noise and visual disturbance. Effects on the species are described below for each effect category. Effects are described collectively for all covered activities, and are also described for specific covered activities to the extent that this information is pertinent for assessing the value of affected habitat or specific nature of the effect.

Temporary Habitat Loss

Construction-related effects will temporarily disturb 132 acres of habitat for the yellow-breasted chat (1% of the habitat in the Plan Area) (Table 5.6-1). Temporarily removed areas will be restored as riparian habitat within 1 year following completion of construction activities. Although the effects are considered temporary, 5 years to several decades may be required for ecological succession to occur and for restored riparian habitat to functionally replace habitat that has been affected. However, yellow-breasted chats occur in early- to midsuccessional riparian vegetation; therefore, actively restored areas are expected to provide suitable habitat characteristics for this species within a few years. Furthermore, most of the riparian vegetation to be temporarily removed in the Plan Area is early- to midsuccessional; therefore, the replaced riparian vegetation is expected to have structural components comparable to the temporarily removed vegetation within the first 5 to 10 years after the initial restoration activities are complete.

Of the 132 acres of habitat to be temporarily removed, establishment and use of borrow and spoil areas associated with water facility construction will result in temporary removal of an estimated 1 acre of secondary habitat (less than 1% of foraging habitat in the Plan Area) for the yellow-breasted chat (Table 5.6-1). Although areas temporarily disturbed for borrow and spoils areas will be restored within 1 year following construction, these areas might not be restored to their original topography.

Construction-Related Injury or Mortality

If the yellow-breasted chat nests where covered activities are to occur, the operation of equipment for construction activities could result in injury or mortality of individuals. Risk will be greatest to eggs and nestlings that could be injured or killed through crushing by heavy equipment, nest abandonment, or increased exposure to the elements or to predators. Injury to adults and fledged juveniles is unlikely as these individuals are expected to avoid contact with construction equipment.

Under AMM22, injury or mortality to nesting yellow-breasted chats will be avoided through preconstruction surveys and establishment of 250-foot no-disturbance buffers around active nests (Appendix 3.C, *Avoidance and Minimization Measures*).

Indirect Construction-Related Effects

Noise and visual disturbance that occur outside the project footprint but within 500 feet of construction activities are indirect effects that could temporarily affect the use of 1,198 acres (8%) of modeled yellow-breasted chat habitat (Table 5.6-3). Construction noise above background noise levels (greater than 50 dBA) is expected to extend 500 to 5,250 feet from the edge of construction activity (Table 4, *Estimated Impacts on the Delta Wintering Population of Greater Sandhill Cranes from Collisions with Proposed BDCP Power Lines*, in Appendix 5.J, Attachment 5J.D, *Indirect Effects of the Construction of the BDCP Conveyance Facility on Sandhill Crane*). There are no available data to determine the extent to which these noise levels could affect yellow-breasted chat. Noise and visual disturbance on nesting chats, if present, will be minimized under AMM22 by establishing 250-foot no-disturbance buffers around active nests, as described in Appendix 3.C.

5.6.16.1.4 Effects of Ongoing Activities

Ongoing activities that may affect the yellow-breasted chat include operation and maintenance activities, and habitat enhancement and management.

Transmission Lines

New transmission lines will increase the risk for bird- transmission line strikes, which could result in injury or mortality of yellow-breasted chat. This species is expected to be at low risk of bird strike mortality based on factors assessed in the bird strike vulnerability analysis (Appendix 5.J, Attachment 5J.C, *Analysis of Potential Bird Collisions at Proposed BDCP Powerlines*) including wing morphology, flight altitude and timing, foraging behavior, and social behavior. Yellow-breasted chats are migratory and usually arrive at California breeding grounds in April from their wintering grounds in Mexico and Guatemala. Departure for wintering grounds occurs from August to September. These are periods of relative high visibility, making risk of transmission line collision with the BDCP proposed lines low. The species' small, relatively maneuverable body, its foraging behavior, and its presence in the Plan Area during the summer collectively contribute to a low risk of collision with the proposed transmission lines.

Operation and Maintenance

Activities associated with operation and maintenance activities that could affect yellow-breasted chat habitat include transmission line and substation maintenance, excavation to repair pipeline, and levee maintenance, These activities could result in local, temporary adverse habitat effects, injury or mortality of chats, and temporary noise and disturbance effects if individuals are present in or near work sites over the term of the BDCP. Vegetation clearing in Yolo Bypass to improve flood conveyance may temporarily adversely affect yellow-breasted chat habitat: however, vegetation is already regularly removed from the bypass to improve flood conveyance, and no occupied nesting habitat will be removed during the nesting season. Maintenance effects will be avoided and minimized with implementation of AMM22.

Habitat Enhancement and Management

Activities associated with natural communities enhancement and management in protected yellow-breasted chat habitat, such as ground disturbance or herbicide use to control nonnative vegetation, could result in local adverse habitat effects, injury or mortality of chats, and temporary noise and disturbance effects if individuals are present in work sites over the term of the BDCP. These effects will be avoided and minimized with implementation of AMM22.

Recreation

Passive recreation in the reserve system, where that recreation is compatible with the biological goals and objectives, could result in disturbance of yellow breasted chats using habitat in the vicinity of trails. Nests could be disturbed during construction and ongoing use of trails and other amenities. Due to placement of trails, passive recreation on established trails is expected to result in limited disturbance. *AMM37 Recreation*, described in Appendix 3.C, limits trail construction to outside the breeding season for nesting birds. The number and length of trails that parallel the edge of the riparian forest will be limited unless located sufficiently away from those communities to minimize disturbance and allow use of open habitats by edge-dependent species. When adjacent to riparian communities, trails will be on the top of a levee or behind the top of bank except where topographic, resource management, or other constraints or management objectives make this infeasible or undesirable. With implementation of these measures, recreation-related effects on the yellow breasted chat are expected to be minimal.

5.6.16.1.5 Impact of Take on Species

The yellow-breasted chat breeds throughout much of North America and winters primarily in Mexico and Central America; a few birds also winter in California (Small 1994). According to Grinnell and Miller (1944), the species' breeding distribution includes the entire length and breadth of California exclusive of the higher mountains and coastal islands. In the Plan Area, recent field surveys for the Delta Habitat Conservation and Conveyance Program documented a total of 51 nest sites from 2009 to 2011 (Delta Habitat Conservation and Conveyance Program 2011). The National Audubon Society (2008) also noted pairs of yellow-breasted chats at Liberty Island, Sherman Island, and Piper Slough in the central Delta. No confirmation of breeding by yellow-breasted chats has been documented. The Plan Area represents a very small proportion of the species' range-wide distribution throughout much of North America.

The permanent loss of 684 acres of habitat (less than 5% of the habitat in the Plan Area) for the yellow-breasted chat and other adverse effects described above are not expected to adversely affect the long-term survival and conservation of the species for the following reasons.

- The nesting and migratory habitat to be lost is small relative to the species' range throughout California and North America.
- Most of the permanently removed habitat consists of relatively small, fragmented riparian stands.
- Measures will be implemented to avoid injury or mortality of nesting yellow-breasted chats.

5.6.16.2 Beneficial Effects

Assuming the restored and protected riparian natural community will provide suitable yellow-breasted chat habitat proportional to the amount of modeled habitat that currently exists in this natural community in the Plan Area (an estimated 82%), the restoration of 5,000 acres of riparian natural community (*CM7 Riparian Natural Community Restoration*) and the protection of 750 acres of riparian natural community (*CM3 Natural Communities Protection and Restoration*) will provide an estimated 2,683 acres of restored and 594 acres of protected habitat for this species (Table 5.6-7). To ensure that a sufficient amount of the restored valley/foothill riparian natural community provides vegetation structure that is suitable for the yellow-breasted chat and other species with similar habitat requirements, the Implementation Office will maintain at least 1,000 acres of the valley/foothill riparian natural community as early- to midsuccessional vegetation with dense, shrubby understory on restored seasonally inundated floodplain. Fluvial disturbance in restored floodplains is expected to help maintain this early- to midsuccessional vegetation. Riparian systems subject to natural erosional and depositional processes provide conditions conducive to the establishment of dense willow stands preferred by the yellow-breasted chat for nesting. These restoration actions will improve habitat conditions and increase the likelihood of breeding by yellow-breasted chats in the Plan Area. Increasing the size and connectivity of the reserve system by acquiring lands adjacent to and between existing conservation lands will benefit the yellow-breasted chat by reducing the risks of habitat fragmentation and adverse effects from adjacent lands uses. Riparian restoration and protection will focus along riparian systems within the Plan Area (linkages #5, 6, and 7, Figure 3.2-16, *Landscape Linkages*, in Chapter 3), and on connectivity with preserved riparian lands south of the Plan Area (linkage #4, Figure 3.2-16). If the Implementation Office determines through population monitoring that the yellow-breasted chat population in the Plan Area is declining as a result of cowbird parasitism, a cowbird control program will be implemented to maintain the chat population in the Plan Area.

5.6.16.3 Net Effects

Including both the habitat loss described in Section 5.6.16.1, *Adverse Effects*, and the riparian habitat restoration and protection described in Section 5.6.16.2, *Beneficial Effects*, implementation of the BDCP will result in an estimated net increase of 1,998 acres (14%) of habitat for the yellow-breasted chat and an estimated net increase of 2,738 acres (54%) of yellow-breasted chat habitat in conservation lands (Table 5.6-7).

The habitat that will be lost as a result of covered activities is of low to moderate value, consisting primarily of relatively small, isolated patches and narrow strips of riparian vegetation in a cultivated landscape. The restored and protected habitat will consist of large, contiguous areas, at least 1,000 acres of which will be managed to sustain appropriate vegetation structural requirements for the species. Increasing the size and connectivity of the reserve system by acquiring lands adjacent to and between existing conservation lands will benefit the yellow-breasted chat by reducing the risks of habitat fragmentation and adverse effects from adjacent lands uses.

Overall, the BDCP will provide a net benefit to the yellow-breasted chat through the increase in available habitat and habitat in protected status. These protected areas will be managed and monitored to support the species. Therefore, the BDCP will minimize and mitigate impacts, to the maximum extent practicable, and provide for the conservation and management of the yellow-breasted chat in the Plan Area.

5.6.17 Giant Garter Snake

This section describes the adverse, beneficial, and net effects of the covered activities, including conservation measures, on the giant garter snake. The methods used to assess these effects are described in Section 5.2.8, *Effects Analysis for Wildlife and Plants,* and Table 5.J.1, *Quantitative Effects Analysis Methods and Assumptions*, in Appendix 5.J, *Effects on Natural Communities, Wildlife, and Plants*.

The habitat model used to assess effects for the giant garter snake includes aquatic habitat and upland habitat. Modeled aquatic habitat includes tidal perennial aquatic (except in Suisun Marsh), tidal freshwater emergent wetland, nontidal freshwater emergent wetland, and nontidal perennial aquatic natural communities, rice, and artificial canals and ditches. Modeled upland habitat includes nonwetland and nonaquatic natural communities within 200 feet of modeled aquatic habitat features. The modeled upland habitat is ranked as being of high, moderate, or low value based on giant garter snake associations between vegetation and cover types (U.S. Fish and Wildlife Service 2006) and historical and recent occurrence records (California Department of Fish and Wildlife 2013e; Hansen pers. comm. [A]), and presence of features necessary to fulfill the species' life life-history requirements. Further details regarding the habitat model, including assumptions on which the model is based, are provided in Appendix 2.A, *Covered Species Accounts*. Other factors considered in assessing the value of affected habitat for the giant garter snake, to the extent that information is available, include proximity to conserved lands and recorded occurrences of the species, proximity to giant garter snake subpopulations identified in the draft recovery plan for this species (U.S. Fish and Wildlife Service 1999b), and contribution to connectivity between giant garter snake subpopulations.

5.6.17.1 Adverse Effects

5.6.17.1.1 Permanent Habitat Loss, Conversion, and Fragmentation

Covered activities will result in the permanent loss of up to 581 acres[21] of modeled aquatic habitat (2% of the aquatic habitat in the Plan Area), up to 2,855 acres of modeled upland habitat (5% of the upland habitat in the Plan Area), and up to 156 miles of the channels providing aquatic movement habitat (6% of movement habitat in Plan Area) for the giant garter snake (Table 5.6-1). Of the modeled aquatic habitat to be permanently lost, 28 acres are tidal and 553 are nontidal. Of the modeled upland habitat to be permanently lost, 944 acres are of high value, 1,718 acres are of moderate value, and 193 acres are of low value. The majority of the giant garter snake habitat permanent loss (73%) is due to tidal natural communities restoration.

Covered activities resulting in the permanent loss of giant garter snake habitat include water conveyance facility construction, transmission line construction, Fremont Weir/Yolo Bypass improvements, tidal natural communities restoration, floodplain restoration, and construction of conservation fish hatcheries, each of which is described below.

Water Conveyance Facility Construction

This activity will result in the permanent removal of approximately 496 acres of habitat for the giant garter snake, including, 83 acres of aquatic habitat and 411 acres of upland habitat for the giant garter snake (Table 5.6-1). Approximately 13 miles (less than 1% of total miles in Plan Area) of channels providing giant garter snake habitat for movements will be removed as a result of conveyance facility construction. Most of the habitat to be lost is in Conservation Zone 6 on

[21] Habitat or natural community loss acreage estimates are based on hypothetical footprints and models rather than detailed project-level design and represent the maximum allowed under the permit. Actual losses will be tracked through compliance monitoring to ensure that they do not exceed estimates.

Mandeville Island. Of the aquatic habitat to be lost, 17 acres are tidal and 66 acres are nontidal. The aquatic habitat to be affected on Mandeville Island is of moderate value in that it is Type 1 conservation land [22] and is approximately 1.5 miles west of a recorded CNDDB giant garter snake occurrence but is not located near or between subpopulations identified in the draft giant garter snake recovery plan (U.S. Fish and Wildlife Service 1999b). Of the 411 acres of upland habitat removed for the construction of the conveyance facility, 172 acres are high-, 221 acres are moderate-, and 18 acres are low-value upland habitat.

An estimated 222 of the 496 acres of giant garter snake habitat will be lost due to placement of reusable tunnel material. The material will likely be moved to other sites for use in levee build-up and restoration, and the affected area will likely be restored. While this effect is categorized as permanent, because there is no assurance that the material will eventually be moved, the effect will likely be temporary. Furthermore, the amount of storage area needed for reusable tunnel material is flexible, and the footprint used in the effects analysis is based on a worst-case scenario; the actual area to be affected by reusable tunnel material storage will likely be less than the estimated acreage.

Fremont Weir/Yolo Bypass Improvements

This activity will result in the permanent removal of approximately 83 acres of aquatic habitat and 458 acres of upland habitat for the giant garter snake (Table 5.6-1). Approximately 14 miles (less than 1% of total miles in Plan Area) of channels providing giant garter snake movement habitat will be removed as a result of Fremont Weir/Yolo Bypass improvements. The aquatic habitat to be removed consists of 11 acres of tidal and 72 acres of nontidal habitat: it is primarily of moderate to high value based on its location in and near Type 1 conservation land approximately 2.5 miles from the nearest giant garter snake occurrences and approximately 5 miles north of occurrences in the Yolo Basin/Willow Slough subpopulation. The upland habitat to be removed includes 336 acres of high-value, 121 acres of moderate-value, and 1 acre of low-value upland habitat.

In addition to habitat loss from construction-related activities in Yolo Bypass, late-season flooding in the bypass may result in loss of rice habitat by precluding the preparation and planting of rice fields. The methods for estimating loss of rice in the bypass and results are provided in Appendix 5.J, Attachment 5J.E, *Estimation of BDCP Impact on Giant Garter Snake Summer Foraging Habitat in the Yolo Bypass.* This analysis concludes that the estimated loss of rice is 1,662 acres.

Tidal Natural Communities Restoration

This activity will result in the permanent loss of approximately 395 acres of aquatic habitat and 2,123 acres of upland habitat for the giant garter snake (Table 5.6-1). Approximately 138 miles (5% of total miles in the Plan Area) of channels providing giant garter snake movement habitat will be removed as a result of tidal natural communities restoration. The aquatic habitat to be lost includes 2 acres of tidal and 393 acres of nontidal habitat. Most of the aquatic habitat to be lost is in Conservation Zones 1 and 2, in the Cache Slough ROA. This aquatic habitat is of low to moderate value: it is in and near Type 1 conservation land but is not near any giant garter snake occurrences and is not near or between giant garter snake subpopulations identified in the draft recovery plan. Tidal natural communities restoration is expected to have little to no adverse effects on giant garter snake aquatic habitat in the Cache Slough ROA. There are no giant garter snake occurrences in this area, which is already tidally influenced so it has limited value for the giant garter snake (giant

[22] See Chapter 3, Section 3.2.4.2.2, *Existing Conservation Lands*, for definitions of conservation land types.

garter snakes may occur in tidally muted areas but are not likely to use aquatic areas with a strong tidal influence). The upland habitat affected by tidal inundation includes 594 acres of high-value, 1,375 acres of moderate-value, and 154 acres of low-value habitat.

Floodplain Restoration

Levee construction associated with floodplain restoration will result in the permanent removal of approximately 36 acres of aquatic habitat and 47 acres of upland habitat for the giant garter snake (Table 5.6-1). Approximately 2 miles (less than 1% of total miles in the Plan Area) of channels providing giant garter snake movement habitat will be removed as a result of floodplain restoration. The aquatic habitat to be removed consists of 2 acres of tidal and 34 acres of nontidal habitat: it is of low value, there are no existing conservation lands or giant garter snake occurrences in the vicinity, and the habitat to be affected is not near or between giant garter snake subpopulations identified in the draft recovery plan. The upland habitat to be removed includes 27 acres of moderate-value and 20 acres of low-value upland habitat.

Conservation Hatcheries Facilities

This activity will result in the permanent removal of 35 acres of moderate-value upland habitat in Conservation Zone 2 for the giant garter snake (Table 5.6-1).

5.6.17.1.2 Periodic Inundation

Yolo Bypass Operations

The proposed changes in Fremont Weir operations will occur intermittently from as early as mid-November through as late as mid-May. The core operations will occur during the winter/spring period, which corresponds mostly with the giant garter snake's inactive season when snakes are overwintering underground. Giant garter snakes that occur in the bypass during the active season will potentially overwinter in the bypass during the inactive season: these snakes may be vulnerable to inundation of the bypass and could be drowned or displaced from overwintering sites. However, most typically, Fremont Weir notch operations will occur on the shoulders of time periods in which the Sacramento River rises enough for Fremont Weir to overtop passively. Inundation of areas as a result of covered activities is expected to occur in no more than 30% of all years, because Fremont Weir is expected to overtop the remaining 70% of all years, and during those years notch operations will not typically affect the maximum extent of inundation. Currently, in more than half of all years, an area greater than the area that will be inundated as a result of covered activities is already inundated during the snake's inactive season (Kirkland pers. comm.). Duration of inundation may also be an important factor determining effects on overwintering giant garter snakes. Radiotelemetry studies have revealed giant garter snakes surviving in burrows that had been inundated for 2 to 3 weeks, but it is unknown what duration of inundation the snakes can survive while overwintering in their burrows (Hansen pers. comm. [B]).

Appendix 5.J, *Effects on Natural Communities, Wildlife, and Plants,* provides the method used to estimate periodic inundation effects in the Yolo Bypass. Based on this method, periodic inundation could affect giant garter snakes overwintering in upland areas ranging from an estimated 582 acres of upland habitat during notch flow of 1,000 cfs to an estimated 1,402 acres during a 4,000-cfs notch flow. The 4,000-cfs notch flow would affect an estimated 888 acres of high-value habitat and 514 acres of moderate-value habitat (Table 5.6-3).

Floodplain Restoration

This activity will periodically inundate 606 acres of upland habitat for the giant garter snake in Conservation Zone 7. The upland habitat to be inundated includes 432 acres of moderate-value and 174 acres of low-value habitat. The area between existing levees will be breached, and the newly constructed setback levees will be inundated through seasonal flooding. The restored floodplain will include a range of elevations from low-lying areas that flood frequently (i.e., every 1 to 2 years) to high-elevation areas that flood infrequently (i.e., every 10 years or more). There are no records of giant garter snakes in the vicinity of where floodplain restoration is expected to occur.

5.6.17.1.3 Construction-Related Effects

Direct, permanent construction-related effects are described above in Section 5.6.17.1.1, *Permanent Habitat Loss, Conversion, and Fragmentation.* Other construction-related effects on the giant garter snake include short- and long-term temporary habitat loss, construction-related injury and mortality, and indirect construction-related effects. Effects on the species are described below for each effect category. Effects are described collectively for all covered activities, and are also described for specific covered activities to the extent that this information is pertinent for assessing the value of affected habitat or the specific nature of the effect.

Temporary Habitat Loss

Construction will temporarily disturb 60 acres of tidal aquatic habitat, 47 acres of nontidal aquatic habitat, and 449 acres of upland habitat for the giant garter snake (less than 1% of the aquatic habitat and less than 1% of the upland habitat in the Plan Area), including 206 acres of high-value, 220 acres of moderate-value, 23 acres of low-value upland habitat, and approximately 16 miles of channels providing giant garter snake movement habitat (Table 5.6-1). Temporarily disturbed areas will be restored as giant garter snake habitat within 1 year following completion of construction and management activities.

Construction-Related Injury or Mortality

Construction may cause injury or mortality to the giant garter snake through crushing by vehicles or heavy equipment. If snakes reside where covered activities are to occur (most likely in Conservation Zones 2 and 4), the operation of equipment for land clearing, construction, and restoration activities could result in injury or mortality of giant garter snakes. This risk is highest from late fall through early spring, when the snakes are dormant. Increased vehicular traffic associated with covered activities could contribute to a higher incidence of road kill. However, construction monitoring and other measures will be implemented to avoid and minimize injury or mortality of this species during construction, as described in *AMM16 Giant Garter Snake* (Appendix 3.C, *Avoidance and Minimization Measures*).

Indirect Construction-Related Effects

Noise and visual disturbance outside the project footprint but within 200 feet of construction activities are indirect effects that could temporarily affect the use of 776 acres of modeled aquatic (2%) and 2,552 acres of modeled upland habitat (5%) for the giant garter snake (Table 5.6-5), including 891 acres of high-value, 1,379 acres of moderate-value, and 282 acres of low-value upland habitat. Approximately 74 miles (3% of total miles in the Plan Area) of channels providing giant garter snake movement habitat will be indirectly affected. These effects will be minimized by siting construction 200 feet away from the banks of giant garter snake aquatic habitat, where feasible, as described in AMM16 (Appendix 3.C).

5.6.17.1.4 Effects of Ongoing Activities

Ongoing effects on giant garter snake will result from habitat enhancement and management activities, and operation and maintenance activities.

Habitat Enhancement and Management

Habitat enhancement and management activities, such as ground disturbance or removal of nonnative vegetation, could result in local adverse habitat effects, injury or mortality of giant garter snakes, and temporary noise and disturbance effects if individuals are present in or near work sites over the term of the BDCP. These effects cannot be quantified, but are expected to be minimal and will be avoided and minimized with implementation of AMM16, described in Appendix 3.C.

Operation and Maintenance Activities

Operation and maintenance activities related to the conveyance facility and associate transmission lines, such as transmission line and substation maintenance (routine tower/pole maintenance and replacement), road and fence repairs, and excavation to access pipelines could result in local, temporary adverse habitat effects, injury or mortality of giant garter snakes, and temporary noise and disturbance effects if individuals are present in or near work sites over the term of the BDCP. Routine maintenance of Fremont Weir and Yolo Bypass could temporarily remove vegetative cover for giant garter snakes in upland habitat, although the vegetation to be removed will primarily be riparian, and giant garter snakes typically rely on burrows and low-growing vegetation rather than riparian vegetation for cover in their upland habitat. Maintenance will also include sediment removal in Fremont Weir, which could result in injury or mortality of giant garter snakes. These effects cannot be quantified, but are expected to be minimal and will be avoided and minimized with implementation of AMM16, described in Appendix 3.C.

Recreation

Passive recreation in the reserve system, where that recreation is compatible with the biological goals and objectives, could result in human disturbance of giant garter snakes basking in upland areas and compaction of upland burrow sites used for brumation. However, AMM37 Recreation (Appendix 3.C) requires setbacks for trails in giant garter snake habitat. With this measure in place, recreation-related effects on giant garter snake are expected to be minimal.

5.6.17.1.5 Other Indirect Effects

Mercury

Covered activities have the potential to increase exposure to mercury in covered species that feed on aquatic species, including the giant garter snake. The operational impacts of new flows under *CM1 Water Facilities and Operation* were analyzed using a DSM-2 model to assess potential effects on mercury concentration and bioavailablity. Subsequently, a regression model was used to estimate fish-tissue concentrations in striped bass under these future operational conditions. Results indicated that changes in total mercury levels in water and fish tissues due to future operational conditions were insignificant (Appendix 5.D, Attachment 5.D.A, *Bioaccumulation Model Development for Mercury Concentrations in Fish,* Tables 5.D.A-1, 5.D.A-2, 5.D.A-3, and 5.D.A-4).

Marsh and floodplain restoration also have the potential to increase exposure to methylmercury. Mercury is transformed into the more bioavailable form of methylmercury in aquatic systems, especially areas subjected to regular wetting and drying such as tidal marshes and floodplains. Thus, restoration activities that create newly inundated areas could increase bioavailability of mercury. Increased methylmercury associated with natural community and floodplain restoration may indirectly affect the giant garter snake, which feeds on small fishes, tadpoles, and small frogs, especially introduced species, such as small bullfrogs (*Rana catesbeiana*) and their larvae, carp (*Cyprinus carpio*), and mosquitofish (*Gambusia affinis*) (Appendix 5.D, *Contaminants*). In general, the highest methylation rates are associated with high tidal marshes that experience intermittent wetting and drying and associated anoxic conditions (Alpers et al. 2008). Along with minimization and mitigation measures and adaptive management and monitoring, *CM12 Methylmercury Management* is expected to reduce the amount of methylmercury resulting from the restoration of natural communities and floodplains.

Extant populations of giant garter snakes in the Plan Area are known only from the upper Yolo Basin and at the Coldani Marsh/White Slough area (Appendix 2.A, *Covered Species Accounts*). Davis et al. (2007) found mercury concentrations in fish at White Slough (and the Central Delta in general) to be relatively low compared to other areas of the Delta. No restoration activities involving flooding (and subsequent methylation of mercury) are planned in the known range of the Coldani Marsh/White Slough giant garter snake population. Modeled habitat for giant garter snakes occurs at other locations in the Plan Area (Appendix 2.A), although definitive information on distribution is incomplete. Effects on giant garter snakes from increased methylmercury exposures is more likely in the Yolo Basin, where some of the highest concentrations of mercury and methylmercury have been documented (Foe et al. 2008). Effects from exposure to methylmercury may include decreased predator avoidance, reduced success in prey capture, difficulty in shedding, and reduced ability to move between shelter and foraging or thermoregulation areas (Wylie et al. 2009). Planned floodplain restoration activities in the Yolo Basin are expected to seasonally increase methylmercury production, although production will be minimized by *CM12 Methylmercury Mitigation*, Further, the periods of production and increased exposure to methylmercury do not overlap with giant garter snake seasonal activity periods. This seasonal trend should help to decrease risk to the giant garter snake, although snakes could prey on individuals that have been exposed to methylmercury during the previous season.

5.6.17.1.6 Impact of Take on Species

The giant garter snake is endemic to the wetlands of the Central Valley. There are 268 extant CNDDB occurrences of the giant garter snake range-wide, of which 26 are in the Plan Area. There are also 13 non-CNDDB extant occurrences for this species in the Plan Area. The Plan Area includes 2 of the 13 giant garter snake subpopulations identified in the draft recovery plan for this species: the two subpopulations are in the Yolo Basin/Willow Slough (Conservation Zone 2) and Coldani Marsh-White Slough (Conservation Zone 4) areas. The Plan Area is therefore important for the long-term survival and conservation of the giant garter snake.

Based on modeled habitat for the giant garter snake, the Plan Area supports approximately 31,124 acres of aquatic and 52,671 acres of upland habitat for the giant garter snake. Of this, up to

581 acres[23] of modeled aquatic habitat (2% of the aquatic habitat in the Plan Area), up to 2,855 acres of modeled upland habitat (5% of the upland habitat in the Plan Area), and up to 156 miles of the channels providing aquatic movement habitat (6% of movement habitat in Plan Area) for the giant garter snake. Up to 60 acres of tidal aquatic habitat, 47 acres of nontidal aquatic habitat, and 449 acres of upland habitat for the giant garter snake (less than 1% of the aquatic habitat and less than 1% of the upland habitat in the Plan Area), including 206 acres of high-value, 220 acres of moderate-value, 23 acres of low-value upland habitat, and approximately 16 miles of channels providing giant garter snake movement habitat will be temporarily removed and restored to preproject conditions. Approximately 4 to 888 acres of giant garter snake upland habitat (less than 1% of total in the Plan Area) may be adversely affected as a result of periodic flooding as a consequence of floodplain restoration and the operation of the Fremont Weir: however, these areas are already expected to have very low upland value for the giant garter snake because under existing conditions, these areas already inundate in more than half of all years. Furthermore, inundation effects in Yolo Bypass resulting from covered activities are only expected to occur in approximately 30% of all years.

These losses of aquatic and upland habitat for the giant garter snake are not expected to adversely affect the long-term conservation of the species for the following reasons.

- The giant garter snake habitat to be lost is small relative to habitat availability in the Plan Area and will occur in multiple, widely separate areas (therefore not affecting one area disproportionately). Approximately 33% (944 out of 2,855 acres) of the total affected upland habitat is of high value, while the remainder is of low or moderate value.
- Most of the affected habitat is in areas where the giant garter snake is not expected to occur, as the species has never been detected in or near these areas.

The BDCP's beneficial effects on the species, described below, are expected to offset the potential adverse impact of take and to provide for the conservation and management of the giant garter snake in the Plan Area.

5.6.17.2 Beneficial Effects

The Implementation Office will create 1,200 acres of nontidal marsh specifically to benefit the giant garter snake (*CM10 Nontidal Marsh Restoration*). This will include two 600-acre blocks on nontidal marsh restoration, one of which will be located in the Yolo Basin/Willow Slough giant garter snake subpopulation in Conservation Zone 2, and the second of which will be located in or near the Coldani Marsh/White Slough giant garter snake population in Conservation Zone 4 and/or 5. At least 200 acres of grassland will be protected or restored adjacent to each 600-acre block. Buffers of 200 feet will protect giant garter snake habitat from adjacent roads, and giant garter snake reserves will be established at least 2,500 feet from urban areas or areas zoned for urban development. Additionally, 1,500 acres of rice land or habitat of equivalent value (e.g., perennial aquatic habitat) will be restored or protected to create connections from the Coldani Marsh/White Slough population to other areas in the giant garter snake historical range (*CM3 Natural Communities Protection and Restoration, CM4 Tidal Natural Communities Restoration,* and *CM10 Nontidal Marsh Restoration*) (linkage #11, Figure 3.2-16, *Landscape Linkages*, in Chapter 3). To provide a buffer to the newly

[23] Habitat or natural community loss acreage estimates are based on hypothetical footprints and models rather than detailed project-level design and represent the maximum allowed under the permit. Actual losses will be tracked through compliance monitoring to ensure that they do not exceed estimates.

restored/created nontidal perennial habitat in Conservation Zone 2, 700 acres of cultivated lands will be protected, at least 500 acres of which will consist of rice land and the remaining acreage of which will compatible cultivated land that can support giant garter snakes. Additionally, at least 2,740 acres of rice land or habitat of equivalent value will be protected and restored for the giant garter snake to achieve a 1:1 ratio of habitat conserved to habitat affected (habitat affected includes uplands periodically flooded and rice lost due to late-season flooding in Yolo Bypass under *CM2 Yolo Bypass Fisheries Enhancement*). Lands to be protected and restored specifically for the giant garter snake total 6,540 acres (1,200 acres nontidal marsh, 400 acres of grassland, 700 acres of cultivated lands including at least 500 acres of rice in Conservation Zone 2, and acres of rice or habitat of equivalent value in Conservation Zones 2/4/5).

In addition to the 6,540 acres of high-value habitat targeted specifically for giant garter snake, the protection and restoration of other natural communities is expected to provide habitat for this species. For natural communities with no specific habitat conservation targets for giant garter snake, the estimate of the natural community contribution of giant garter snake habitat is based on the assumption that the natural community on conserved (protected and restored) land supports giant garter snake habitat proportional to the amount of that natural community that currently supports giant garter snake habitat in the Plan Area. Based on that assumption, in addition to species-specific objectives, an estimated 4,430 acres of additional giant garter snake habitat will be restored and 3,733 acres will be protected.

Protection and management of cultivated lands (*CM3 Natural Communities Protection* and *Restoration,* and *CM11 Natural Communities Enhancement and Management*) will also benefit the giant garter snake by providing connectivity and maintaining irrigation and drainage channels that provide aquatic habitat for the snake. Protection of cultivated land will be prioritized in areas that provide connectivity between other conservation lands. Small patches of important wildlife habitat associated with cultivated lands, such as drainages, grasslands, ponds, and wetlands, will be protected. Conservation of cultivated lands will help to maintain in the landscape a matrix of suitable interconnected canals with reliable water, associated emergent vegetation, and adjacent upland habitats essential for conservation of this species. Assuming the length of canals and ditches providing giant garter snake movement habitat on the protected cultivated lands is proportional to the modeled habitat on cultivated lands in the Plan Area, the 45,405 acres of protected cultivated lands will support approximately 281 miles of movement habitat for the giant garter snake (2,784 miles multiplied by 0.101 [48,625 acres protected of 481,909 acres in Plan Area]).

Giant garter snake habitat will be restored and protected specifically, to conserve and expand the Coldani Marsh/White Slough and Yolo Basin/Willow Slough subpopulations of the giant garter snake. Protecting and expanding existing giant garter snake subpopulations, and providing connectivity between protected areas, is considered the most effective approach to giant garter snake conservation in the Plan Area. The Coldani Marsh/White Slough and Yolo Basin/Willow Slough subpopulations are the only known populations of giant garter snakes in the Plan Area and are identified as important for the recovery of the species in the draft recovery plan for the species (U.S. Fish and Wildlife Service 1999b). Implementation actions that target giant garter snake habitat will focus on these two important subpopulations.

5.6.17.3 Net Effects

Including both the habitat loss described in Section 5.6.17.1, *Adverse Effects*, and the riparian habitat restoration and protection described in Section 5.6.17.2, *Beneficial Effects*, full implementation of the

BDCP will result in an estimated net increase of 994 acres (1%) of giant garter snake habitat in the Plan Area, including an estimated net increase of 2,869 acres (9%) of aquatic habitat and an estimated net decrease of 1,875 acres (3%) of adjacent uplands. BDCP implementation will also result in an estimated increase of 6,321 acres (21%) of giant garter snake habitat in conservation lands (Table 5.6-7), including estimated increases of 1,325 acres (4%) of protected aquatic habitat and 566 acres (1%) of adjacent uplands. The conserved lands will be enhanced and managed to improve and sustain habitat values for giant garter snake. Most of the habitat that will be lost as a result of covered activities is located in areas with low or moderate habitat value that have no known species occurrences and are not near or between the two giant garter snake subpopulations in the Plan Area. Giant garter snake habitat will be protected and restored in and around these two subpopulations to protect and facilitate their expansion. Additional lands will be protected and restored to provide connectivity and facilitate genetic exchange between these two important subpopulations

These net acreages do not include effects on 582 to 1,402 acres of giant garter snake upland habitat that may be periodically inundated in the Yolo Bypass at a frequency and duration greater than current conditions, in an area where an important population of giant garter snakes is known to occur. These net acreages also do not take into account the estimated loss of 1,662 acres of rice in the Yolo Bypass due to late-season flooding that is expected to prevent planting of rice on this acreage. However, the loss of rice and inundation of giant garter snake upland habitat in the bypass are accounted for in the habitat loss acreage to achieve a 1:1 ratio of conservation to loss for this species, as specified in the giant garter snake goals and objectives.

Overall, the BDCP will provide a substantial net benefit to the giant garter snake through the increase of available high-value habitat and of high-value habitat in protected status. These protected areas will be managed and monitored to support the species. Therefore, the BDCP will minimize and mitigate impacts, to the maximum extent practicable, and provide for the conservation and management of the giant garter snake in the Plan Area.

5.6.18 Western Pond Turtle

This section describes the adverse, beneficial, and net effects of the covered activities and conservation measures on the western pond turtle. The methods used to assess these effects are described in Section 5.2.8, *Effects Analysis for Wildlife and Plant Species*. The habitat suitability model is based on three habitat types: aquatic, upland nesting and overwintering habitat, and dispersal habitat. Further details regarding the habitat model, including assumptions on which the model is based, are provided in Appendix 2.A, *Covered Species Accounts.*

Factors considered in assessing the value of affected aquatic habitat include natural community type and availability of adjacent nesting and dispersal habitat. The aquatic habitat types of highest value in the Plan Area consist of nontidal freshwater perennial emergent wetlands and ponds adjacent to suitable nesting and overwintering habitat (Patterson pers. comm.). Less detail is provided on effects on dispersal habitat because, although dispersal habitat is important for maintaining and increasing distribution and genetic diversity, turtles have been known to travel over many different land cover types; therefore, this habitat type is not considered limiting. The value of dispersal habitat depends less on the habitat type itself than on the proximity of that habitat type to high-value aquatic and nesting and overwintering habitat.

5.6.18.1 Adverse Effects

5.6.18.1.1 Permanent Habitat Loss, Conversion and Fragmentation

Covered activities will result in the permanent loss or conversion of up to 351 acres[24] of aquatic habitat (less than 1% of the aquatic habitat in the Plan Area), 805 acres of upland nesting and overwintering habitat (5% of upland habitat in the Plan Area), 501 acres of upland nesting and overwintering habitat based on the U.S. Geological Survey National Hydrography Dataset (NHD) (4% of nesting and overwintering NHD habitat in the Plan Area), and up to 188 miles of aquatic linear habitat (13% of aquatic linear habitat in Plan Area) for the western pond turtle (Table 5.6-1). Covered activities resulting in adverse effects on the western pond turtle include water conveyance facility construction, Fremont Weir/Yolo Bypass improvements, tidal natural communities restoration, and floodplain restoration. The covered activity accounting for most (54%) of the habitat loss or conversion is tidal natural communities restoration.

Water Conveyance Facility Construction

This activity will result in the permanent loss of approximately 516 acres of western pond turtle habitat, including, 237 acres of aquatic habitat (less than 1% of aquatic habitat in the Plan Area), 202 acres of upland nesting and overwintering habitat (1% of this habitat type in the Plan Area), 77 acres of upland nesting and overwintering NHD habitat (less than 1% of upland nesting and overwintering NHD habitat in the Plan Area), and 9 miles of aquatic linear habitat (less than 1% of aquatic linear habitat in the Plan Area) for the western pond turtle (Table 5.6-1). The majority of the permanent loss of aquatic habitat (167 of the 237 acres) and nesting and overwintering habitat (94 of the 214 acres) is in Conservation Zone 8, near Clifton Court Forebay. The aquatic habitat near Clifton Court Forebay is considered to be of reasonably high value as it consists of agricultural ditches in or near known occurrences. The nesting and overwintering and dispersal habitat to be lost consists primarily of cultivated lands with some small portion of ruderal grassland habitat. Except for remnant, uncultivated patches, the cultivated lands are not suitable for nesting and overwintering unless left fallow. The remaining effects from the construction of the water conveyance facility are mostly on dispersal habitat. The dispersal habitat in this region is primarily cultivated lands. While there are western pond turtle occurrences scattered throughout Conservation Zones 3, 4, 5, and 6, this effect is widely dispersed because of the long, linear nature of the pipeline footprint.

An estimated 201 of the 516 acres and 6 of the 9 miles of western pond turtle habitat will be lost due to placement of reusable tunnel material. The material will likely be moved to other sites for use in levee build-up and restoration, and the affected area will likely be restored. While this effect is categorized as permanent, because there is no assurance that the material will eventually be moved, the effect will likely be temporary. Furthermore, the amount of storage area needed for reusable tunnel material is flexible, and the footprint used in the effects analysis is based on a worst-case scenario; the actual area to be affected by reusable tunnel material storage will likely be less than the estimated acreage.

[24] Habitat or natural community loss acreage estimates are based on hypothetical footprints and models rather than detailed project-level design and represent the maximum allowed under the permit. Actual losses will be tracked through compliance monitoring to ensure that they do not exceed estimates.

Fremont Weir/Yolo Bypass Improvements

This activity will result in the permanent removal of approximately 37 acres of aquatic habitat (less than 1% of aquatic habitat in the Plan Area), 109 acres of upland nesting and overwintering habitat (1% of this habitat type in the Plan Area), 21 acres of upland nesting and overwintering NHD habitat (less than 1% of upland nesting and overwintering NHD habitat in the Plan Area) for the western pond turtle (Table 5.6-1). Although there are no CNDDB occurrences of the western pond turtle in the Yolo Bypass, the species is known to be present in the Yolo Bypass Wildlife Area (California Department of Fish and Game 2012).

Tidal Natural Communities Restoration

Based on the hypothetical tidal restoration footprint, this activity will result in the permanent loss or conversion of approximately 45 acres of aquatic habitat (less than 1% of aquatic habitat in the Plan Area), 473 acres of upland nesting and overwintering habitat (3% of this habitat type in the Plan Area), 399 acres of upland nesting and overwintering NHD (3% of upland nesting and overwintering NHD habitat in the Plan Area), and 106 miles of aquatic linear habitat (6% of aquatic linear habitat in the Plan Area) for the western pond turtle (Table 5.6-1). Tidal habitat restoration is expected to change existing salinity and flow conditions rather than lead to complete loss of aquatic habitat. Restoration of tidal flow where habitat consists of the calm waters of managed freshwater ponds and wetlands could have an adverse effect on the western pond turtle. Tidal restoration outside Suisun Marsh is likely to create suitable, slow-moving freshwater slough and marsh habitat.

Although the aquatic habitat model includes all tidal perennial aquatic, tidal brackish emergent wetland, and managed wetland as habitat, nearly all the pond turtle observations that have been made in Suisun Marsh are in drainage ditches or near water control structures (Patterson pers. comm.). While the model does not include an aquatic class type called *drainage ditches* and therefore an effect on this habitat type cannot be calculated, it is likely that this general type of habitat accounts for a very small portion of the total modeled aquatic effects; almost certainly less than 5%, or less than 287 acres of the modeled aquatic habitat affected by tidal restoration. The suitable nesting and overwintering habitat that will be affected in the interior of Suisun Marsh is limited, as the levees likely function as the primary nesting and overwintering habitat. The nesting and overwintering habitat of highest value to be affected is on the fringe of the marsh where the aquatic habitat is adjacent to undeveloped grassland habitat.

The habitat affected in the interior Delta (West Delta and South Delta) is of low value, consisting of levees and intensively farmed cultivated lands, while the Cache Slough and Cosumnes/Mokelumne ROAs are less intensively farmed and have higher-value habitat for the turtle.

Floodplain Restoration

Based on the hypothetical floodplain restoration footprint, levee construction associated with floodplain restoration will result in the permanent removal of approximately 32 acres of aquatic habitat (less than 1% of aquatic habitat in the Plan Area), 12 acres of upland nesting and overwintering habitat (less than 1% of this habitat type in the Plan Area), 4 acres of upland nesting and overwintering NHD habitat (less than 1% of upland nesting and overwinter NHD habitat in the Plan Area), and 2 miles of aquatic linear habitat (less than 1% of aquatic linear habitat in the Plan Area) for the western pond turtle (Table 5.6-1). Although there are no CNDDB occurrences of the western pond turtle in the areas where floodplain restoration is likely to occur, the species is known to occur along the San Joaquin River to the south in the San Joaquin River National Wildlife Refuge.

5.6.18.1.2 Periodic Inundation

Yolo Bypass Operations

Appendix 5.J, *Effects on Natural Communities, Wildlife, and Plants*, provides the method used to estimate periodic inundation effects in the Yolo Bypass. Based on this method, periodic inundation could affect from an estimated 283 acres of habitat during 1,000 cfs notch flow to an estimated 798 acres of habitat during 4,000 cfs notch flow. The inundation could affect 134 to 210 acres of upland nesting and overwintering habitat, and 130 to 589 acres of upland nesting and overwintering NHD habitat (Table 5.6-3). This effect will only occur during an estimated maximum of 30% of years, in areas that are already inundated in more than half of all years; therefore, these areas are expected to provide only marginal overwintering habitat for the western pond turtle under existing conditions. Furthermore, Yolo Bypass inundation is not expected to affect nesting western pond turtles because operations will not occur during the nesting season (approximately May through October). Therefore, Yolo Bypass operations are expect to have a minimal effect, if any, on western pond turtles in the Yolo Bypass.

Floodplain Restoration

Seasonal flooding in restored floodplains could affect 289 acres of upland nesting and overwintering habitat, 42 acres of upland nesting and overwintering NHD habitat, and 2 miles of aquatic linear habitat. Floodplains are not expected to be inundated during the nesting season, although turtle hatchlings may overwinter in the nest, and may be affected by flooding. Restored floodplains will transition for areas that flood frequently (i.e., every 1 to 2 years) to areas that flood infrequently (i.e., every 10 years or more); adverse effects on turtle hatchlings are most likely at the lower elevations of the restored floodplain, where frequent flooding occurs.

5.6.18.1.3 Construction-Related Effects

Direct, permanent construction-related effects are described above in Section 5.6.18.1.1, *Permanent Habitat Loss, Conversion, and Fragmentation*. Other construction-related effects on the western pond turtle include long-term temporary habitat loss; construction-related mortality or injury; and indirect effects including noise and visual effects. Effects on the species are described below for each effect category. Effects are described collectively for all covered activities, and are also described for specific covered activities to the extent that this information is pertinent for assessing the value of affected habitat or specific nature of the effect.

Temporary Habitat Loss

Construction-related effects will temporarily disturb 2,141 acres of aquatic habitat (3% of aquatic habitat in the Plan Area), 119 acres of nesting and overwintering habitat (less than 1% of nesting and overwintering habitat in the Plan Area), 85 acres of upland nesting and overwintering NHD habitat (less than 1% of upland nesting and overwintering NHD habitat in the Plan Area), and 7 miles of aquatic linear habitat (less than 1% of aquatic linear habitat in the Plan Area) for the western pond turtle (Table 5.6-1). Most of the temporary disturbance to aquatic habitat will result from dredging Clifton Court Forebay, which provides low-value habitat for western pond turtle. Temporarily disturbed areas will be restored within 1 year following completion of construction and management activities.

Construction-Related Injury or Mortality

Use of heavy equipment during construction may result in injury or mortality of western pond turtles. However, to avoid injury or mortality, preconstruction surveys will be conducted in suitable aquatic and riparian habitat for the western pond turtle, and turtles found will be located outside the construction areas, as described in *AMM17 Western Pond Turtle* (Appendix 3.C, *Avoidance and Minimization Measures*).

Indirect Construction-Related Effects

Noise and visual disturbance outside the project footprint but within 200 feet of construction activities are indirect effects that could temporarily affect the use of 2,777 acres of aquatic habitat (4% of aquatic habitat in the Plan Area), 752 acres of upland nesting and overwintering habitat (5% of this habitat type in the Plan Area), 401 acres of upland nesting and overwintering NHD habitat (3% of upland nesting and overwintering NHD habitat in the Plan Area), and 34 miles of aquatic linear habitat (2% of aquatic linear habitat in the Plan Area) for the western pond turtle (Table 5.6-5). These short-term effects are not expected to adversely affect the western pond turtle populations in the Plan Area.

These effects will be minimized with implementation of AMM17.

5.6.18.1.4 Effects of Ongoing Activities

Facilities Operation and Maintenance

Operation and maintenance activities related to the conveyance facility and associate transmission lines, such as transmission line and substation maintenance (routine tower/pole maintenance and replacement), vehicle traffic along maintenance access roads, road and fence repairs, and excavation to access pipelines, could result in local adverse habitat effects, injury or mortality of western pond turtles, and temporary noise and disturbance effects if individuals are present in or near work sites over the term of the BDCP. Sediment removal at Fremont Weir could result in injury or mortality of the western pond turtle. These effects cannot be quantified, but are expected to be minimal and will be avoided and minimized with implementation of AMM17, described in Appendix 3.C.

Habitat Enhancement and Management

Activities associated with natural communities enhancement and management in protected western pond turtle habitat, such as ground disturbance or herbicide use to control nonnative vegetation, could result in local adverse habitat effects, injury, or mortality of western pond turtles. These effects will be avoided and minimized with implementation of *AMM2 Construction Best Management Practices and Monitoring*, described in Appendix 3.C.

Management of the 5,000 acres of managed wetlands to be protected for waterfowl and shorebirds is not expected to result in overall adverse effects for the western pond turtle. Management actions that will improve wetland quality and diversity on managed wetlands include control and eradication of invasive plants; maintenance of a diversity of vegetation types and elevations, including upland areas to provide flood refugia; water management and leaching to reduce salinity; and enhancement of water management infrastructure (improvements to enhance drainage capacity, levee maintenance). These management actions will potentially benefit the western pond turtle. The 5,000 acres of protected managed wetlands will be monitored and adaptively managed to ensure that management options are implemented to avoid adverse effects on the western pond turtle.

5.6.18.1.5 Other Indirect Effects

Water operations will have an effect on salinity gradients in Suisun Marsh. This effect mechanism cannot be disaggregated from tidal natural communities restoration in Suisun Marsh. It is expected that the salinity of water in Suisun Marsh will generally increase as a result of water operations, and operations of salinity control gates to mimic a more natural water flow. Results of modeling BDCP implementation show salinity to double by the late long-term period compared to current conditions in late fall and winter months. Western pond turtles are primarily a freshwater species, although they are often found in brackish marsh, and they could respond negatively to increased salinity in Suisun Marsh. Changes in salinity will not be uniform across Suisun Marsh as they will likely be more pronounced in some tidal channels and sloughs than others. Most of the Suisun Marsh pond turtle observations have been in the interior drainage ditches or near water control structures not connected to tidal channels and sloughs in Suisun Marsh, which is where increases in salinity would occur.

5.6.18.1.6 Impact of Take on Species

The Plan Area represents only a small portion of the range of the western pond turtle in California (which includes most of the Pacific drainages) and southern Oregon. Take resulting from the permanent and temporary loss or conversion habitat for the western pond turtle, and other effects described above, are not expected to result in an adverse effect on the long-term conservation of the western pond turtle for the following reasons.

- The Plan Area represents a small portion of the species' entire range.
- Only 1% of the habitat in the Plan Area will be removed or converted.

5.6.18.2 Beneficial Effects

Assuming the restored and protected natural communities will provide suitable western pond turtle habitat proportional to the amount of modeled habitat in these natural communities in the Plan Area, the Implementation Office will restore 27,739 acres of pond turtle aquatic habitat, 480 acres of upland nesting and overwintering habitat, and 329 acres of upland nesting and overwintering NHD habitat (*CM3 Natural Communities Protection, CM4 Tidal Natural Communities Restoration, CM7 Riparian Natural Community Restoration, CM8 Grassland Natural Community Restoration, CM9 Vernal Pool and Alkali Seasonal Wetland Complex Restoration,* and *CM10 Nontidal Marsh Restoration*). The conservation strategy includes restoration of at least 24,000 acres of tidal freshwater emergent wetland, at least 6,000 acres of tidal brackish emergent wetlands, and 1,200 acres of nontidal freshwater emergent wetland and tidal perennial aquatic natural communities. In addition, the protection and management of existing managed wetland habitat in Suisun Marsh may increase the value of aquatic habitat. The most beneficial restoration will occur in freshwater emergent wetland consisting of slow-moving slough and marsh adjacent to protected, undisturbed grassland. Aquatic features (e.g., ditches and ponds) and adjacent uplands that are preserved and managed as part of the 45,405 acres of agricultural preserve are also expected to benefit the species. Additionally, basking platforms will be installed as needed in restored freshwater marsh to benefit the western pond turtle.

Riparian and floodplain restoration will potentially increase the quantity and value of aquatic and nesting and overwintering habitat. Where the floodplain is widened and restored, this will allow oxbows and slow-moving side channels to form, providing suitable aquatic habitat for this species (Bury and Germano 2008; Ernst and Lovich 2009). Where riparian vegetation is restored adjacent to slower-moving channels, sloughs, and ponds, downed trees can provide important basking habitat and cover habitat for turtles. Riparian restoration in those more interior portions of Old and Middle Rivers that will be managed for riparian brush rabbit habitat have potential to benefit resident western pond turtles as riparian-adjacent grassland is an important habitat characteristic for the rabbit.

5.6.18.3 Net Effects

Including both the habitat loss described in Section 5.6.18.1, *Adverse Effects*, and the riparian habitat restoration and protection described in Section 5.6.18.2, *Beneficial Effects*, implementation of the BDCP will result in an estimated net increase of 29,217 acres (29%) of habitat for the western pond turtle and an estimated net increase of 34,185 acres (70%) of western pond turtle habitat in conservation lands (Table 5.6-7). However, implementation will result in an estimated net decrease of 41 miles (-8%) of liner aquatic habitat and an estimated net increase of 31 miles (27%) of aquatic linear habitat on conservation lands (Table 5.6-7).

BDCP implementation will increase the extent and distribution of high-value aquatic and upland nesting and overwintering habitat for the western pond turtle in the Plan Area. In Suisun Marsh, tidal restoration is likely, in the long term, to have neutral or negative effects on the western pond turtle, although the protection and management of upland grassland areas that surround Suisun Marsh have the potential to increase the value of nesting and overwintering habitat.

Overall, the BDCP will provide a substantial net benefit to the western pond turtle through the increase in available aquatic and nesting and overwintering habitat, habitat value, and habitat in protected status. These protected areas will be managed and monitored to support the species. Therefore, the BDCP will minimize and mitigate impacts, to the maximum extent practicable, and provide for the conservation and management of the western pond turtle in the Plan Area.

5.6.19 California Red-Legged Frog

This section describes the adverse, beneficial, and net effects of the covered activities, including conservation measures, on the California red-legged frog. The methods used to assess these effects are described in Section 5.2.8, *Effects Analysis for Wildlife and Plants*. Modeled California red-legged frog habitat in the Plan Area is restricted to freshwater aquatic, grassland, and immediately adjacent cultivated lands along the Plan Area's southwestern edge in Conservation Zones 7, 8, 9, and 11. Further details regarding the habitat model, including assumptions on which the model is based, are provided in Appendix 2.A, *Covered Species Accounts.*

Factors considered in assessing the value of affected habitat for the California red-legged frog, to the extent that information is available, include presence of limiting habitat (aquatic breeding habitat), known occurrences and clusters of occurrences, proximity of the affected habitat to existing conservation lands, and the overall degraded or fragmented nature of the habitat. The Plan Area represents the extreme eastern edge of the species' coastal range (Appendix 2.A) and species' occurrences are reported only from Conservation Zones 8 and 11. While covered activities and conservation measures in other Conservation Zones have potential effects on the California red-legged frog, those activities near the species occurrences in Conservation Zones 8 and 11 are considered to have a disproportionately larger effect.

5.6.19.1 Adverse Effects

5.6.19.1.1 Permanent Habitat Loss, Conversion, and Fragmentation

Covered activities will result in the permanent loss or conversion of up to 1 acre of aquatic habitat (less than 1% of the aquatic habitat in the Plan Area) and 30 acres of upland cover and dispersal habitat (less than 1% of upland cover and dispersal habitat in the Plan Area) for the California red-legged frog (Table 5.6-1). Covered activities resulting in adverse effects on the California red-legged frog include water conveyance facility construction and construction of recreation-related facilities. The covered activity accounting for most (77%) of the habitat loss or conversion is the construction of recreation-related facilities.

Water Conveyance Facility Construction

This activity, including transmission-line construction, will result in the permanent loss or conversion of up to 6 acres of California red-legged frog habitat, including 1 acre of modeled aquatic habitat (less than 1% of aquatic habitat in Plan Area), and 5 acres of upland cover and dispersal habitat (less than 1% of upland cover and dispersal habitat in the Plan Area (Table 5.6-1). The modeled aquatic habitat is not known to be used for breeding. The removed upland cover and dispersal habitat is of moderate value: it is in the vicinity of Clifton Court Forebay and within 0.5 mile of a cluster of known occurrences to the west, and past and current surveys in this area have not found any evidence that this habitat is being used (California Department of Water Resources 2011a).

Recreation

Based on the recreation assumptions described in Chapter 4, *Covered Activities and Associated Federal Actions*, an estimated 24 acres of upland cover and dispersal habitat for the California red-legged frog will be removed as a result of constructing trails and associated recreational facilities. *AMM37 Recreation* will be implemented to ensure that aquatic habitat is avoided for all recreational activities, as described in Appendix 3.C, *Avoidance and Minimization Measures*.

5.6.19.1.2 Periodic Inundation

No periodic inundation effects on the California red-legged frog will occur as a result of covered activities.

5.6.19.1.3 Construction-Related Effects

Direct, permanent, construction-related effects are described above in Section 5.6.19.1.1, *Permanent Habitat Loss, Conversion, and Fragmentation*. Other construction-related effects on the California red-legged frog include short- and long-term temporary habitat loss, construction-related injury or mortality, and indirect effects including noise and visual disturbance. Effects on the species are described below for each effect category. Effects are described collectively for all covered activities, and are also described for specific covered activities to the extent that this information is pertinent for assessing the value of affected habitat or specific nature of the effect.

Temporary Habitat Loss

Construction-related effects will temporarily disturb 39 acres of habitat for the California red-legged frog, all of which is upland cover and dispersal habitat (less than 1% of this habitat type in the Plan Area) (Table 5.6-1). Surveys have not found any evidence that this habitat is being used by the species (California Department of Water Resources 2011a). Temporarily disturbed areas will be restored within 1 year following completion of construction activities.

Construction-Related Injury or Mortality

Construction activities associated with the water conveyance facilities, vernal pool complex restoration, and habitat and management enhancement-related activities, including operation of construction equipment, could result in injury or mortality of California red-legged frogs if present. Frogs occupying burrows could be trapped and crushed during ground-disturbing activities. Injury or mortality will be avoided and minimized through implementation of seasonal constraints and preconstruction surveys in suitable habitat, collapsing unoccupied burrows, and relocating frogs outside of the construction area, as described in *AMM14 California Red-Legged Frog* (Appendix 3.C).

Indirect Construction-Related Effects

Noise and visual disturbance outside the project footprint but within 500 feet of construction activities are indirect effects that could temporarily affect the use of 64 acres of California red-legged frog habitat, the majority of which (60 acres) is upland cover and dispersal habitat (less than 1% of this habitat type in the Plan Area). The areas to be affected are near Clifton Court Forebay, and no California red-legged frogs were detected during recent surveys conducted in this area (California Department of Water Resources 2011a).

Petroleum or other contaminant spills from construction equipment, drilling operations, or other activities could also affect California red-legged frogs if present. These effects will be minimized with implementation of *AMM5 Spill Prevention, Containment, and Countermeasure Plan* and *AMM32 Hazardous Material Management*, described in Appendix 3.C.

5.6.19.1.4 Effects of Ongoing Activities

Facilities Operation and Maintenance

Ongoing facilities operation and maintenance are expected to have little if any adverse effect on the California red-legged frog. Postconstruction operation and maintenance of the above-ground water conveyance facilities could result in ongoing but periodic postconstruction disturbances that could affect the California red-legged frog use of the surrounding habitat. Operation of maintenance equipment, including vehicle use along transmission corridors in Conservation Zone 8, could also result in injury or mortality of California red-legged frogs if present in work sites. These effects, however, will be minimized with implementation of AMM14, described in Appendix 3.C.

Habitat Enhancement and Management

Activities associated with natural communities enhancement and management in protected California red-legged frog habitat, such as ground disturbance or herbicide use to control nonnative vegetation, could result in local adverse habitat effects, injury or mortality of California red-legged frogs. These effects will be avoided and minimized with implementation of *AMM2 Construction Best Management Practices and Monitoring*, described in Appendix 3.C. Herbicides will only be used in

California red-legged frog habitat in accordance with the written recommendation of a licensed, registered Pest Control Advisor and in conformance with label precautions and federal, state, and local regulations in a manner that avoids or minimizes harm to the California red-legged frog.

Recreation

Passive recreation in the reserve system, where that recreation is compatible with the biological goals and objectives, could result in trampling and disturbance of egg masses in water bodies, degradation of water quality through erosion and sedimentation, and trampling of sites adjacent to upland habitat used for cover and movement. However, *AMM37 Recreation* requires protection of water bodies from recreational activities and requires trail setbacks from wetlands. With these restrictions, recreation-related effects on California red-legged frog are expected to be minimal.

5.6.19.1.5 Other Indirect Effects

Mercury

Covered activities have the potential to increase exposure to mercury in covered species, including the California red-legged frog. The operational impacts of new flows under *CM1 Water Facilities and Operation* were analyzed using a DSM-2 model to assess potential effects on mercury concentration and bioavailablity. Subsequently, a regression model was used to estimate fish-tissue concentrations in striped bass under these future operational conditions. Results indicated that changes in total mercury levels in water and fish tissues due to future operational conditions were insignificant (Appendix 5.D, Attachment 5.D.A, *Bioaccumulation Model Development for Mercury Concentrations in Fish,* Tables 5.D.A-1, 5.D.A-2, 5.D.A-3, and 5.D.A-4).

Marsh and floodplain restoration also have the potential to increase exposure to methylmercury. Mercury is transformed into the more bioavailable form of methylmercury in aquatic systems, especially in areas subjected to regular wetting and drying such as tidal marshes and flood plains. Thus, restoration activities that create newly inundated areas could increase bioavailability of mercury. Increased methylmercury associated with natural community and floodplain restoration may indirectly affect the California red-legged frog, via uptake in lower tropic levels (Appendix 5.D, *Contaminants*). In general, the highest methylation rates are associated with high tidal marshes that experience intermittent wetting and drying and associated anoxic conditions (Alpers et al. 2008). Along with minimization and mitigation measures and adaptive management and monitoring, *CM12 Methylmercury Management* is expected to reduce the amount of methylmercury resulting from the restoration of natural communities and floodplains.

Recent discoveries of high mercury levels in some frog species (Ugarte et al. 2005; Bank et al. 2007) have elevated concerns about the possible relationship of mercury contamination with frog population declines (Schweiger et al. 2006). Hothem et al. (2010) examined mercury levels in northern Pacific tree frogs, foothill yellow-legged frogs, and American bullfrogs in the Cache Creek watershed contaminated by historical mercury mining. They found mercury levels elevated above U.S. Environmental Protection Agency criteria for fish in one or more species at 40% of the 35 sites examined. California red-legged frog is a species of concern in the Plan Area, but it does not occupy the marsh natural communities where methylmercury concerns are greatest. Therefore its risk of uptake is likely to be significantly lower than for frog species that inhabit areas of high exposure.

California red-legged frogs could be affected by the chitrid fungus, which could be spread by humans or equipment moving between aquatic habitat areas during restoration, management, or enhancement activities. This effect will be minimized through decontamination requirements of AMM14, described in Appendix 3.C.

5.6.19.1.6 Impact of Take on Species

The historical range of the California red-legged frog generally extends south along the coast from the vicinity of Point Reyes National Seashore, Marin County, California, and inland from the vicinity of Redding, Shasta County, California, southward along the interior Coast Ranges and Sierra Nevada foothills to northwestern Baja California, Mexico (U.S. Fish and Wildlife Service 2007b). While primarily absent from the valley floor, California red-legged frogs are found along the perimeter of the valley in the surrounding foothills. In the Plan Area, they are found along the very western edge of the Plan Area, in Conservation Zones 7,8, 9, and 11. There are 1,326 extant CNDDB records for California red-legged frogs in the state, 12 of which (1%) are found in the Plan Area.

Take resulting from permanent and temporary habitat loss, and other adverse effects described above, are not expected to have an adverse population-level effect on California red-legged frog or an adverse effect on the species' conservation in the Plan Area for the following reasons.

- The Plan Area represents a small proportion of the species' range.
- There are few occurrences of California red-legged frogs in the Plan Area.
- The area where habitat will be lost near Clifton Court Forebay has been surveyed for California red-legged frogs and survey results were negative.

5.6.19.2 Beneficial Effects

Assuming the protected grasslands and vernal pool complex natural communities will provide suitable California red-legged frog upland cover and dispersal habitat proportional to the amount of modeled habitat in these natural communities in the Plan Area, an estimated 724 acres of upland cover and dispersal habitat will be protected for this species. However, at least 1,000 acres of grassland will be protected in Conservation Zone 8 (Objective GNC1.1), mostly west of Byron Highway in the Plan Area where the habitat has the highest long-term conservation value for the species based on known species occurrences and large, contiguous habitat areas. Ponds and other aquatic features in the grasslands will be protected to provide aquatic habitat for this species, and surrounding grassland will provide dispersal and aestivation habitat. Conservation lands in Conservation Zone 8 will connect with the East Contra Costa County HCP/NCCP reserve system and the extensive Los Vaqueros Watershed lands, including grasslands supporting this species (linkage #2, Figure 3.2-16, *Landscape Linkages*, in Chapter 3). This will ensure that the California red-legged frog upland and associated aquatic habitats will be preserved and enhanced in the largest possible patch sizes adjacent to occupied habitat within and adjacent to the Plan Area. Additionally, assuming restored freshwater tidal will provide suitable California red-legged frog aquatic habitat proportional to the amount that currently exists in these natural communities in the Plan Area, an estimated 10 acres of aquatic habitat suitable for the California red-legged frog will be restored.

Aquatic features in the protected grasslands in Conservation Zone 8 will be maintained and enhanced to provide suitable inundation depth and duration and suitable composition of vegetative cover to support breeding California red-legged frogs (*CM11 Natural Communities Enhancement and Management*). Additionally, livestock exclusion from streams and ponds and other measures will be implemented as described in CM11 to promote growth of aquatic vegetation with appropriate cover characteristics favorable to California red-legged frogs.

5.6.19.3 Net Effects

Assuming the restored and protected natural communities will provide suitable California red-legged frog habitat proportional to the amount of modeled habitat in these natural communities in the Plan Area, implementation of the BDCP will result in an estimated net increase of 337 acres (less than 4%) of habitat for the California red-legged frog, and an estimated net increase of 1,413 acres (79%) of California red-legged frog habitat in conservation lands (Table 5.6-7).

The habitat that will be lost as a result of covered activities is of moderate value: it is within several miles of species occurrences but consists of cultivated lands and small patches of grasslands, and the species has not been found in the areas to be affected despite recent surveys. The habitat that will be protected will consist of large, contiguous areas that will support the California red-legged frog and will be managed to sustain favorable habitat conditions for the species.

Overall, the BDCP will provide a substantial net benefit to the California red-legged frog through the increase in habitat value and habitat in protected status. These protected areas will be managed and monitored to support the species. Therefore, the BDCP will minimize and mitigate impacts, to the maximum extent practicable, and provide for the conservation and management of the California red-legged frog in the Plan Area.

5.6.20 California Tiger Salamander

This section describes the adverse, beneficial, and net effects of the covered activities, including conservation measures, on the California tiger salamander. The methods used to assess these effects are described in Section 5.2.8, *Effects Analysis for Wildlife and Plants*. The habitat model used to assess effects for the California red-legged frog includes two habitat types: terrestrial cover and aestivation habitat, and aquatic breeding habitat. The model for terrestrial cover and aestivation habitat includes all grassland types and alkali seasonal wetland with a minimum patch size of 100 acres and within a geographic area defined by species records and areas most likely to support the species (see detailed description of geographic limits in Appendix 2.A, *Covered Species Accounts*). The model for aquatic breeding habitat includes vernal pool complex and degraded vernal pool complex. Further details regarding the habitat model, including assumptions on which the model is based, are provided in Appendix 2.A*.* Factors considered in assessing the value of affected habitat for the California tiger salamander, to the extent that information is available, include habitat patch size and configuration, density of aquatic of features, and proximity to existing conservation lands (Type 1 and Type 2)[25].

5.6.20.1 Adverse Effects

5.6.20.1.1 Permanent Habitat Loss, Conversion and Fragmentation

Covered activities will result in the permanent loss of up to 639[26] acres of California tiger salamander habitat (less than 2% of the habitat in the Plan Area) all of which is aestivation and cover habitat. Covered activities resulting in permanent California tiger salamander habitat loss

[25] See Chapter 3, Section 3.2.4.2.2, *Existing Conservation Lands*, for definitions of conservation land types.

[26] Habitat or natural community loss acreage estimates are based on hypothetical footprints and models rather than detailed project-level design and represent the maximum allowed under the permit. Actual losses will be tracked through compliance monitoring to ensure that they do not exceed estimates.

include water conveyance facility construction, Fremont Weir/Yolo Bypass improvements, tidal natural communities restoration, and conservation hatcheries facilities. The covered activity resulting in the most habitat loss is tidal natural communities restoration (81% of habitat loss).

Water Conveyance Facility Construction

This activity will result in the permanent loss of approximately 6 acres of terrestrial cover and aestivation habitat for the California tiger salamander (less than 1% of this habitat type in the Plan Area) (Table 5.6-1). This habitat loss will occur primarily in Zone 8. There is a large concentration of California tiger salamander occurrences outside the Plan Area immediately to the east of Conservation Zone 8, in the Byron Hills area. The area to be affected by conveyance facility construction is south of Clifton Court Forebay, where modeled California tiger salamander habitat is of relatively low value in that it consists of fragmented patches of primarily terrestrial habitat surrounded by cultivated lands. All recorded CNDDB occurrences of California tiger salamanders in Zone 8 are west of the conveyance facility alignment, and lands to the east consist primarily of actively cultivated lands that are not suitable for the species. Habitat loss in this area is not expected to contribute to habitat fragmentation or impede important California tiger salamander dispersal.

Fremont Weir/Yolo Bypass Improvements

This activity will result in the permanent loss of approximately 42 acres of terrestrial cover and aestivation habitat for the California tiger salamander (less than 1% of this habitat type in the Plan Area) (Table 5.6-1).

Tidal Natural Communities Restoration

This activity will result in the permanent removal of approximately 517 acres of terrestrial cover and aestivation habitat (1% of this habitat type in the Plan Area) for the California tiger salamander (Table 5.6-1). Tidal restoration in the Cache Slough ROA will result in habitat loss along the edges of Lindsey Slough and Duck Slough, and adjacent to cultivated land along the eastern edge of a block of modeled habitat in this area. The modeled aquatic breeding habitat in this area is of relatively high value consisting of vernal pool complex along Lindsey Slough within the Jepson Prairie area, in and near Type 1 conservation land. The Jepson Prairie area includes numerous CNDDB recorded occurrences of California tiger salamanders and overlaps with a critical habitat unit for this species, although the hypothetical tidal restoration footprint does not overlap with critical habitat or recorded occurrences in this area. The pools in the Jepson Prairie area are relatively large and undisturbed, although they are present in very low densities within the areas to be affected by tidal restoration along Lindsey Slough. The tidal restoration at Lindsey Slough will occur along the northeastern edge of the Jepson Prairie block of habitat and will not contribute to fragmentation. Because the estimates of habitat loss resulting from tidal inundation are based on projections of where restoration may occur, actual effects are expected to be lower because of the ability to select sites that minimize effects on the California tiger salamander.

Conservation Hatcheries Facilities

This activity will result in the permanent removal of approximately 35 acres of terrestrial cover and aestivation habitat (less than 1% of this habitat type in the Plan Area) for California tiger salamanders near Rio Vista. The hatcheries facilities will be constructed on cultivated lands in low-value habitat for the species.

Recreation

Based on the recreation assumptions described in Chapter 4, *Covered Activities and Associated Federal Actions*, an estimated 40 acres of terrestrial cover and aestivation habitat for the California tiger salamander will be removed as a result of constructing trails and associated recreational facilities. *AMM37 Recreation* will be implemented to ensure that aquatic habitat is avoided for all recreational activities, as described in Appendix 3.C, *Avoidance and Minimization Measures*.

5.6.20.1.2 Periodic Inundation

Yolo Bypass operations is the only covered activity expected to result in periodic inundation of California tiger salamander habitat.

Yolo Bypass Operations

Appendix 5.J, *Effects on Natural Communities, Wildlife, and Plants*, provides the method used to estimate periodic inundation effects in the Yolo Bypass. Based on this method, periodic inundation could affect from an estimated 191 acres of terrestrial cover and aestivation habitat during a notch flow of 1,000 cfs, to an estimated 639 acres of terrestrial cover and aestivation habitat during a notch flow of 4,000 cfs (Table 5.6-3). This effect will only occur during an estimated maximum of 30% of years, in areas that are already inundated in more than half of all years; therefore, these areas are expected to provide only marginal terrestrial cover and aestivation habitat for the California tiger salamander under existing conditions. No aquatic breeding habitat will be affected (Table 5.6-3): the modeled habitat in the Yolo Bypass, in the vicinity of terrestrial cover and aestivation habitat is of low value in that there are no California tiger salamander records in this area and the bypass lacks vernal pool complexes with large, deep pools, or large grassland areas with stock ponds and similar aquatic features that provide the habitat of highest value for this species. Therefore, the terrestrial cover and aestivation habitat to be affected has a small likelihood of supporting California tiger salamanders, and Yolo Bypass operations are expected to have a minimal effect on the species, if any.

5.6.20.1.3 Construction-Related Effects

Direct, permanent, construction-related effects are described above in Section 5.6.20.1.1, *Permanent Habitat Loss, Conversion, and Fragmentation*. Other construction-related effects on this species include short- and long-term temporary habitat loss, construction-related injury or mortality, and indirect construction-related effects. Effects on the species are described below for each effect category. Effects are described collectively for all covered activities, and are also described for specific covered activities to the extent that this information is pertinent for assessing the value of affected habitat or specific nature of the effect.

Temporary Habitat Loss

Construction-related effects will temporarily disturb 32 acres of terrestrial cover and aestivation habitat for the California tiger salamander (less than 1% of this habitat type in the Plan Area) (Table 5.6-1). Temporarily disturbed areas will be restored within 1 year following completion of construction and management activities.

Construction-Related Injury or Mortality

The operation of equipment during construction could result in injury or mortality of California tiger salamanders if present. This effect will be minimized by restricting initial ground disturbance in suitable aquatic habitat to the dry season, and through implementation of preconstruction surveys in and near suitable habitat and installation of salamander exclusion fencing as described in Appendix 3.C.

Indirect Construction-Related Effects

Noise and visual disturbance outside of the project footprint but within 500 feet of construction activities are indirect effects and could temporarily affect the use of 201 acres of aquatic breeding habitat (3% of aquatic habitat in the Plan Area) and 774 acres of terrestrial cover and aestivation habitat (3% of this habitat type in the Plan Area) (Table 5.6-5). There are no known occurrences of California tiger salamanders in the areas that may experience indirect effects adjacent to construction, and these effects are therefore expected to have a minimal effect on the species.

Petroleum or other contaminant spills from construction equipment, drilling operations, or other activities could have indirect effects on the California tiger salamander if they occur and beyond the project footprint. This effect will be minimized with implementation of *AMM5 Spill Prevention, Containment, and Countermeasure Plan* and *AMM32 Hazardous Material Management*, described in Appendix 3.C.

Recreation

Passive recreation in the reserve system, where that recreation is compatible with the biological goals and objectives, could result in trampling and disturbance of eggs and larvae in water bodies, degradation of water quality through erosion and sedimentation, and trampling of sites adjacent to upland habitat used for cover and movement. However, AMM37 requires protection of water bodies from recreational activities and requires trail setbacks from wetlands. With these restrictions, recreation-related effects on California red-legged frog are expected to be minimal.

5.6.20.1.4 Effects of Ongoing Activities

The only ongoing activities expected to adversely affect the California tiger salamander are habitat enhancement and management.

Habitat Enhancement and Management

Activities associated with natural communities enhancement and management in protected California tiger salamander habitat, such as ground disturbance or herbicide use to control nonnative vegetation, could result in local adverse habitat effects, injury or mortality of the California tiger salamander, and temporary noise and disturbance effects if individuals are present in work sites over the term of the BDCP. These effects will be avoided and minimized with implementation of *AMM2 Construction Best Management Practices and Monitoring*, described in Appendix 3.C.

5.6.20.1.5 Impact of Take on Species

The California tiger salamander occurs from southern San Mateo County south to San Luis Obispo County, with isolated populations in Sonoma and northwestern Santa Barbara Counties. In the

Central Valley and surrounding Sierra Nevada foothills, the species occurs from northern Yolo County southward to northwestern Kern County and northern Tulare and Kings Counties. There are 1,003 CNDDB California tiger salamander occurrences throughout California, four of which (less than 1% range-wide) are in the Plan Area. The Plan Area consists of less than 10% of the species' range (Appendix 2.A, *Covered Species Accounts*).

The permanent loss of less than 2% of the California tiger salamander modeled habitat in the Plan Area, and other effects described above that may result in take of this species, are not expected to result in an adverse impact on the species' long-term conservation in the Plan Area for the following reasons.

- The Plan Area represents a small proportion of the species' geographic range (less than 10%) and known occurrences (less than 1%).
- A small proportion of the modeled habitat in the Plan Area will be affected.
- The habitat of highest value that is potentially affected is in the Cache Slough ROA, where tidal restoration projects can be designed to reduce the loss of California tiger salamander habitat.

5.6.20.2 Beneficial Effects

Assuming the protected and restored grasslands and alkali seasonal wetland complex (*CM3 Natural Communities Protection*, *CM8 Grassland Natural Community Restoration,* and *CM9 Vernal Pool and Alkali Seasonal Wetland Complex Restoration*) will provide terrestrial cover and aestivation habitat and the vernal pool complex will provide aquatic breeding habitat for the California tiger salamander proportional to the amount of modeled habitat in these natural communities in the Plan Area, an estimated 2,675 acres of terrestrial cover and aestivation habitat and 539 acres of aquatic breeding habitat will be protected, and an estimated 706 acres of terrestrial cover and aestivation habitat and 60 acres of aquatic breeding habitat will be restored for the California tiger salamander.

Protection of at least 2,000 acres of grasslands in Conservation Zone 1 will benefit the California tiger salamander by providing habitat in the portions of the Plan Area with the highest long-term conservation value for the species based on known species occurrences and large, contiguous habitat areas. Ponds and other aquatic features in the grasslands will be protected to provide aquatic habitat for this species, and surrounding grassland will provide dispersal and aestivation habitat. Protection in Conservation Zones 1 and 11 will focus on connectivity with preserved lands on the Jepson Prairie, outside the Plan Area (linkage #1, Figure 3.2-16, *Landscape Linkages*, in Chapter 3). Protected grasslands and vernal pool complex in Conservation Zone 8 will connect with the East Contra Costa County HCP/NCCP reserve system, including grassland areas supporting this species (linkage #2, Figure 3.2-16). Conservation lands in Conservation Zone 11 will connect with the future Solano County reserve system, including grassland and vernal pool complex areas supporting this species. The increased habitat extent and connectivity will increase opportunities for genetic exchange and allow for colonization of extirpated populations and restored habitats.

Protecting seasonal ponds associated with grasslands will ensure that California tiger salamander aquatic habitat and associated uplands will be protected, managed, and enhanced (*CM3 Natural Communities Protection and Restoration* and *CM11 Natural Communities Enhancement and Management*) in the largest possible patch sizes adjacent to occupied habitat within and adjacent to the Plan Area. Grassland restoration (*CM8 Grassland Natural Community Restoration*) will focus specifically on connecting fragmented patches of protected grasslands, thereby increasing dispersal opportunities for the California tiger salamander. Grasslands will be enhanced to increase burrow availability to provide refugia and cover for aestivating and dispersing California tiger salamanders (CM11).

5.6.20.3 Net Effects

Including both the habitat loss described in Section 5.6.20.1, *Adverse Effects*, and the habitat restoration and protection described in Section 5.6.20.2, *Beneficial Effects*, implementation of the BDCP will result in an estimated net increase of 48 acres (less than 1%) of habitat for the California tiger salamander and an estimated net increase of 6,389 acres (43%) of California tiger salamander habitat in conservation lands (Table 5.6-7).

The habitat that could be lost as a result of tidal natural communities restoration is of relatively high value based on location within and adjacent to conservation lands and near the Jepson Prairie, which includes a well-documented population of California tiger salamanders and designated critical habitat, although the tidal restoration will not affect designated critical habitat. However, the estimates of habitat loss resulting from tidal inundation are based on projections of where restoration may occur, and actual habitat loss is expected to be lower because of the ability to select sites that minimize effects on California tiger salamanders. Habitat lost to other covered activities is of relatively low value based on the fragmentation of the affected habitat and lack of conservation lands or species occurrences in the vicinity. Grasslands and vernal pool complex to be protected and restored will consist of large, continuous expanses of high-value habitat in areas that support known populations of the California tiger salamander and will be managed and enhanced to sustain these populations.

Overall, the BDCP will provide a net benefit to the California tiger salamander through the increase in aquatic breeding habitat, overall habitat value, and habitat in protected status. These protected areas will be managed and monitored to support the species. Therefore, the BDCP will minimize and mitigate impacts, to the maximum extent practicable, and provide for the conservation and management of the California tiger salamander in the Plan Area.

5.6.21 Valley Elderberry Longhorn Beetle

This section describes the adverse, beneficial, and net effects of the covered activities, including conservation measures, on the valley elderberry longhorn beetle. The methods used to assess these effects are described in Section 5.2.8, *Effects Analysis for Wildlife and Plants*, and Table 5.J.1, *Quantitative Effects Analysis Methods and Assumptions*, in Appendix 5.J, *Effects on Natural Communities, Wildlife, and Plants*. The habitat model used to assess effects for the valley elderberry longhorn beetle includes plant associations in the Plan Area where elderberry shrubs are expected to be found. This is represented by selected plant alliances from the valley/foothill riparian modeled habitat, and the grassland and vernal pool modeled habitats within 200 feet of streams. Details regarding the habitat model, including assumptions on which the model is based, are provided in Appendix 2.A, *Covered Species Accounts.* The model grossly overestimates the actual amount of occupied valley elderberry longhorn beetle habitat in the Plan Area, as only those areas supporting elderberry shrubs are capable of being occupied, and only a small proportion of those shrubs are expected to occupied at any given time. The distribution of elderberry shrubs in modeled habitat in the Plan Area cannot be determined at this time, but will be determined during Plan implementation and all loss of elderberry shrubs will be offset.

5.6.21.1 Adverse Effects

Because the valley elderberry longhorn beetle habitat model does not accurately predict the amount of actual valley elderberry longhorn beetle habitat in the Plan Area (areas with elderberry shrubs), the analysis below does not discuss acreages and locations of adverse effects in detail for each covered activity and effect type. Rather, it quantifies total modeled acreage affected for each effect type and generally describes the covered activities that will result in these effects. The analysis also describes adverse effects in relation to distribution of known occurrences. However, this assessment is incomplete because the entire Plan Area has not been surveyed for this species (elderberry shrubs were surveyed and mapped along the conveyance facility alignment, but this did not include surveys for sign of the species) and known occurrences may not accurately represent the species' distribution in the Plan Area. Preconstruction surveys, avoidance and minimization measures, and monitoring will be implemented to ensure that loss of elderberry shrubs is minimized, and that any loss is mitigated as described in Section 5.6.21.2, *Beneficial Effects*.

5.6.21.1.1 Permanent Habitat Loss, Conversion, and Fragmentation

Covered activities will result in permanent removal of 1,250[27] acres of modeled valley elderberry longhorn beetle habitat (4% of habitat in the Plan Area), including 712 acres of modeled riparian habitat and 538 acres of nonriparian channels and grassland modeled habitat (Table 5.6-1). This estimate is conservative because it overestimates actual effects on occupied habitat, as elderberry shrubs are present in only a fraction of the modeled habitat and beetles occupy only a fraction of elderberry shrubs. Covered activities that will result in the permanent loss of modeled valley elderberry longhorn beetle habitat include water conveyance facility construction (261 acres), tidal natural communities restoration (813 acres), Fremont Weir/Yolo Bypass improvements (125 acres), and floodplain restoration (52 acres).

An estimated 119 of the 261 acres of valley elderberry longhorn beetle habitat lost from conveyance facility construction will likely be moved to other sites for use in levee build-up and restoration, and the affected area will likely be restored. While this effect is categorized as permanent, because there is no assurance that the material will eventually be moved, the effect will likely be temporary. Furthermore, the amount of storage area needed for reusable tunnel material is flexible, and the footprint used in the effects analysis is based on a worst-case scenario; the actual area to be affected by reusable tunnel material storage will likely be less than the estimated acreage.

Based on surveys conducted by DWR, the conveyance facility construction could result in permanent loss of approximately 25 elderberry shrubs; no evidence of valley elderberry longhorn beetles (e.g., exit holes) was detected in these shrubs (California Department of Water Resources 2011a). The exact number of shrubs to be removed will be determined during preconstruction surveys of the disturbance footprints.

The modeled habitat to be lost is dispersed widely throughout the Plan Area (137 acres in Conservation Zone 1, 456 acres in Conservation Zone 2, 20 acres in Conservation Zone 3, 97 acres in Conservation Zone 4, 216 acres in Conservation Zone 5, 113 acres in Conservation Zone 6, 74 acres in Conservation Zone 7, 87 acres in Conservation Zone 8, and 42 acres in Conservation Zone 11). In Conservation Zone 2, where much of the habitat loss will occur, 118 acres of loss are associated with

[27] Habitat or natural community loss acreage estimates are based on hypothetical footprints and models rather than detailed project-level design and represent the maximum allowed under the permit. Actual losses will be tracked through compliance monitoring to ensure that they do not exceed estimates.

Fremont Weir improvements: this habitat is less than 1 mile from a valley elderberry longhorn beetle occurrence west of Yolo Bypass in Yolo County. Approximately 338 acres of loss in Conservation Zone 2 will occur as a result of tidal natural communities restoration in the Cache Slough ROA. There are no known valley elderberry longhorn beetle occurrences in this area or any of the other areas to be permanently affected except in Conservation Zone 7, where the hypothetical footprint for levee construction associated with floodplain restoration is within 1 mile of a known valley elderberry longhorn beetle occurrence.

5.6.21.1.2 Periodic Inundation

Elderberry shrubs have been found to be intolerant of long periods of (Griggs 2009). Talley et al (2006), in their report for the USFWS 5-year review of the species, note that elderberry shrubs respond negatively to saturated soil conditions and that they can only tolerate temporary root crown inundation. During monitoring of a restoration project at the San Joaquin River National Wildlife Refuge, River Partners found that nearly all (99 to 100%) of the four year old elderberry shrubs in restoration plots died after 15 to 17 weeks of inundation and they noted in general that the shrubs died very quickly after even short periods of flooding (River Partners 2008).

Yolo Bypass Operations

Appendix 5.J, *Effects on Natural Communities, Wildlife, and Plants*, provides the method used to estimate periodic inundation effects in the Yolo Bypass. Based on this method, periodic inundation could affect valley elderberry longhorn beetles occupying areas ranging from an estimated 161 acres of habitat during a notch flow of 1,000 cfs to an estimated 325 acres during a notch flow of 4,000 cfs. The inundation could affect valley elderberry longhorn beetles in 44 to 80 acres of riparian vegetation habitat and 103 to 244 acres of nonriparian channel and grasslands habitat (Table 5.6-3).

Fremont Weir notch operations will occur on the shoulders of time periods in which the Sacramento River rises enough for Fremont Weir to overtop passively under current conditions. As the covered activities are implemented, inundation of areas that would not otherwise have been inundated is expected to occur in no more than 30% of all years, since Fremont Weir is expected to overtop an estimated 70% of all years, and during those years notch operations will not typically affect the maximum extent of inundation. In more than half of all years under existing conditions, an area greater than the BDCP-related inundation area already inundates in the bypass. Because elderberry shrubs have a very low tolerance for flooding, it is likely that there are few, if any, mature elderberry shrubs in the affected areas of the bypass because under current conditions these areas would be inundated in about 50% of all years for approximately 7 weeks. Yolo Bypass flooding is therefore expected to have a minimal effect on the species, if any.

Floodplain Restoration

This activity will periodically inundate approximately 553 acres of modeled valley elderberry longhorn beetle habitat (2% of habitat in Plan Area), including 266 acres of riparian habitat and 287 acres of nonriparian channels and grassland habitat. The area to be inundated will transition from areas that flood frequently (i.e., every 1 to 2 years) to areas that flood infrequently (i.e., every 10 years or more). While elderberry shrubs are not expected to be sustained in the lower elevation areas that frequently flood, the higher floodplain is expected to remain as high-value habitat for the species.

It is unknown at this time how much of the modeled habitat that will be inundated in the lower restored floodplain as a result of these activities consists of elderberry shrubs. To address this uncertainty, the exact number of shrubs within areas to be restored as lower floodplain will be determined during preconstruction surveys of the floodplain footprints, and any elderberry shrubs present in these areas will be mitigated by transplanting shrubs and establishing riparian vegetation with elderberry plantings, consistent with *Valley Elderberry Longhorn Beetle Conservation Guidelines* (Talley et al. 2006) and described in Section 5.6.21.2, *Beneficial Effects.*

5.6.21.1.3 Construction-Related Effects

Direct and permanent construction-related effects on this species are described above in Section 5.6.21.1.1, *Permanent Habitat Loss, Conversion, and Fragmentation.* Additional construction-related effects may include temporary habitat loss, injury or mortality, and indirect effects.

Temporary Habitat Loss

Construction-related effects will temporarily disturb approximately 310 acres of modeled valley elderberry longhorn beetle habitat (1% of habitat in the Plan Area), including 140 acres of riparian habitat and 170 acres of nonriparian channels and grassland. Temporarily disturbed areas will be restored within 1 year following completion of construction and management activities.

Construction-Related Injury or Mortality

Construction may result in injury or mortality of valley elderberry longhorn beetle larvae occupying elderberry shrubs; however, preconstruction surveys will be conducted and 100-foot no-disturbance buffers will be established where possible to avoid and minimize injury or mortality of this species during construction, as described in *AMM15 Valley Elderberry Longhorn Beetle* (Appendix 3.C, *Avoidance and Minimization Measures*).

Indirect Construction-Related Effects

Dust, vibrations, and other indirect disturbance outside the project footprint but within 100 feet of construction activities are indirect effects that could temporarily affect the use of 834 acres of modeled valley elderberry longhorn beetle habitat (2% of modeled habitat in the Plan Area), including 302 acres of riparian habitat and 532 acres of nonriparian channel and grassland habitat (Table 5.6-5). These adverse effects will be minimized by conducting preconstruction surveys and establishing 100-foot no-disturbance buffers where possible to avoid and minimize injury or mortality of this species during construction, as described in AMM15.

5.6.21.1.4 Effects of Ongoing Activities

Ongoing covered activities with the potential to adversely affect the valley elderberry longhorn beetle are those related to habitat enhancement and management activities and facility operation and maintenance.

Habitat Enhancement and Management

Activities associated with natural communities enhancement and management, such as ground disturbance or herbicide use in the control of nonnative vegetation, intended to maintain and improve habitat functions of conservation lands for covered species in Conservation Zones 1 and 11 could result in loss of host plants and the potential for injury or mortality to beetles. These effects will be minimized by establishing 100-foot no-disturbance buffers around elderberry shrubs, to the extent possible, and through implementation of other avoidance and minimization measures consistent with the conservation guidelines (Appendix 3.F, *Conservation Guidelines for the Valley Elderberry Longhorn Beetle*) and described in AMM15 (Appendix 3.C).

Operation and Maintenance

Activities associated with facilities operation and maintenance, pipeline or transmission line repair, or levee maintenance, could result in loss of host plants and the potential for injury or mortality to beetles. These effects will be minimized by establishing 100-foot no-disturbance buffers around elderberry shrubs, to the extent possible, and through implementation of other avoidance and minimization measures consistent with conservation guidelines (Appendix 3.F, *Conservation Guidelines for the Valley Elderberry Longhorn Beetle*) and described in AMM15.

5.6.21.1.5 Impact of Take on Species

The valley elderberry longhorn beetle occurs throughout the Central Valley. There are 201 extant CNDDB occurrences of valley elderberry longhorn beetle in California, three of which (less than 2% range-wide) are in the Plan Area.

Covered activities will permanently remove 1,383 acres (4% of habitat in the Plan Area) and temporarily remove 366 acres (1% of habitat in the Plan Area) of valley elderberry longhorn beetle modeled habitat. However, the model greatly overestimates the area that is actually suitable for this species because elderberry shrubs only constitute a small portion of the modeled habitat, and the beetle is only expected to occupy a small portion of these shrubs. Although the hypothetical footprint for covered activities does not overlap with any CNDDB occurrences for this species, the Plan Area has not been extensively surveyed for the valley elderberry longhorn beetle, and the species likely occurs in portions of the Plan Area where surveys have not yet been conducted. Take of the valley elderberry longhorn beetle as a result of permanently removing 1,383 acres and temporarily removing 366 acres, and other effects described above, is not expected to result in an adverse impact on the long-term survival and conservation of the valley elderberry longhorn beetle for the following reasons.

- The Plan Area represents less than 10% of the species' range-wide distribution.
- The amount of modeled habitat that will be lost is a small fraction (1%) of the total modeled habitat in the Plan Area.
- Habitat loss will be widely dispersed throughout the Plan Area and will not be concentrated in any one location that might place disproportional loss on an occupied area.
- Actual loss of elderberry shrubs from construction of the water conveyance facility is likely to be very small (estimated at 25 shrubs [California Department of Water Resources 2011b]).
- Projects will be designed to avoid and minimize effects on elderberry shrubs.

5.6.21.2 Beneficial Effects

Assuming the restored and protected riparian natural community will provide suitable valley elderberry longhorn beetle habitat proportional to the amount of modeled habitat in this natural community in the Plan Area (99%), restoration of 5,000 acres of valley/foothill riparian (*CM7 Riparian Natural Community Restoration*) will provide approximately 4,857 acres of riparian habitat and protection of 750 acres valley/foothill riparian (*CM3 Natural Communities Protection and Restoration*) will provide approximately 729 acres of modeled habitat for this species (Appendix 5.J, *Effects on Natural Communities, Wildlife, and Plants*). Most of the riparian restoration and protection will take place within the restored floodplain, which will transition from areas that flood frequently (i.e., every 1 to 2 years) to areas that flood infrequently (i.e., every 10 years or more). While the frequently flooded areas are not expected to provide suitable habitat for the valley elderberry longhorn beetle, the upper floodplain is expected to provide large, contiguous expanses of riparian habitat, which are necessary for sustainable populations of this species (Collinge et al. 2001). Elderberry plantings will be incorporated into riparian restoration plantings in the upper floodplain, which is expected to directly benefit the valley elderberry longhorn beetle by increasing the abundance and distribution of its host plant species. In turn, this will provide opportunities to expand the distribution and increase the abundance of valley elderberry longhorn beetle populations in the Plan Area.

Assuming the restored (*CM7 Riparian Natural Community Restoration*) and protected (*CM3 Natural Communities Protection and Restoration*) nonriparian natural community will provide suitable valley elderberry longhorn beetle habitat proportional to the amount of modeled habitat in these natural communities in the Plan Area (20% of grasslands, less than 1% of managed wetlands, 1% of tidal brackish emergent wetland, 2% of vernal pool complex), an estimated 130 acres of modeled habitat will be restored and 854 acres will be protected (Appendix 5.J). As with the nonriparian natural communities that will be affected, a very small proportion of these restored and protected natural communities are expected to support elderberry shrubs.

In addition to the riparian restoration described above, the Implementation Office will mitigate for loss of elderberry shrubs by creating valley elderberry longhorn beetle habitat consistent with the conservation guidelines (Appendix 3.F, *Conservation Guidelines for the Valley Elderberry Longhorn Beetle*), and planting elderberry shrubs in high-density clusters (*CM7 Riparian Natural Community Restoration*, *CM11 Natural Communities Enhancement and Management*). These guidelines require transplanting shrubs from the areas of effect to restoration sites, and planting additional elderberry seedlings at ratios ranging from 1:1 to 8:1 (seedlings planted to stems affected) for all stems more than 1 inch in diameter. As specified in the conservation guidelines, the mitigation ratio will depend on the diameter of each stem affected, presence or absence of valley elderberry longhorn beetle exit holes in each shrub, and whether or not each shrub lost is in a riparian area.

Valley elderberry longhorn beetle habitat restoration will be sited in drainages immediately adjacent to or in the vicinity of sites known to be occupied by valley elderberry longhorn beetles. This objective will focus restoration on the drainages close to sites occupied by the valley elderberry longhorn beetle. This species has distinct, relatively isolated populations in individual drainages, likely due to the beetle's limited dispersal capability (Collinge et al. 2001). The species is unlikely to colonize unoccupied drainages, even if suitable habitat is present. This necessitates siting habitat restoration within or in the vicinity of occupied drainages. Known occupied habitat in the Plan Area occurs in Conservation Zones 2 and 7 in three occurrences, but additional known occurrences are expected to be found as the reserve system is assembled. Some occurrences are known from agricultural ditches and railroad tracks, and these do not provide opportunities to restore dense patches of elderberry shrubs within a riparian matrix directly adjacent to occupied areas. In these cases, restoration will be located within reasonable dispersal distance for the valley elderberry longhorn beetle from known occurrences.

5.6.21.3 Net Effects

Including both the habitat loss described in Section 5.6.21.1, *Adverse Effects*, and the habitat restoration and protection described in Section 5.6.21.2, *Beneficial Effects*, implementation of the BDCP will result in an estimated net increase of 3,606 acres (11%) of modeled habitat for the valley elderberry longhorn beetle and an estimated net increase of at least 6,454 acres (64%) modeled valley elderberry longhorn beetle habitat in conservation lands (Table 5.6-7).

The habitat that will be lost as a result of covered activities is widely distributed throughout the Plan Area and is not in any area known to be occupied by the species. Only a small fraction of the modeled habitat to be lost supports elderberry shrubs. The habitat to be restored will include elderberry shrubs, which will be planted near sites known to be occupied by the species. The valley elderberry longhorn beetle has poor dispersal ability, and only by restoring suitable habitat near occupied areas can populations be expanded. Any loss of elderberry shrubs will be offset consistent with conservation guidelines (Appendix 3.F, *Conservation Guidelines for the Valley Elderberry Longhorn Beetle*), and occupied shrubs that are removed will be transplanted to restoration sites. These measures are expected to offset any population effects resulting from covered activities, and to facilitate expansion of valley elderberry longhorn beetle populations in the Plan Area.

Overall, the BDCP will provide a substantial net benefit to the valley elderberry longhorn beetle through the increase in available habitat adjacent to known occupied habitat. These restored areas will be protected, and will be managed and monitored to support the species. Therefore, the BDCP will minimize and mitigate impacts, to the maximum extent practicable, and provide for the conservation and management of the valley elderberry longhorn beetle in the Plan Area.

5.6.22 Vernal Pool Crustaceans

This section describes the adverse, beneficial, and net effects of the covered activities, including conservation measures, on the vernal pool tadpole shrimp, conservancy fairy shrimp, longhorn fairy shrimp, vernal pool fairy shrimp, midvalley fairy shrimp, and California linderiella, collectively referred to as vernal pool crustaceans. The methods used to assess these effects are described in Section 5.2.8, *Effects Analysis for Wildlife and Plants*. The habitat model used to assess effects for the vernal pool crustaceans comprises two layers: vernal pool complex, which consists of vernal pools and uplands that display characteristic vernal pool and swale visual signatures that have not been significantly affected by agricultural or development practices; and degraded vernal pool complex, which consists of low-value ephemeral habitat ranging from areas with vernal pool and swale visual signatures that display clear evidence of significant disturbance due to plowing, discing, or leveling to areas with clearly artificial basins such as shallow agricultural ditches, depressions in fallow fields, and areas of compacted soils in pastures.

For the purpose of the effects analysis, vernal pool complex is considered of high value for vernal pool crustaceans and degraded vernal pool complex is categorized as low-value habitat for these species. Also included as low-value habitat for vernal pool crustaceans are areas along the eastern boundary of Conservation Zone 1 that are mapped as vernal pool complex because they flood seasonally and support typical vernal pool plants, but do not include topographic depressions that are characteristic of vernal pool crustacean habitat. Further details regarding the habitat model, including assumptions on which the model is based, are provided in Appendix 2.A, *Covered Species Accounts.* Factors considered in assessing the value of affected habitat for the vernal pool crustaceans, to the extent that information is available, include habitat patch size, density of vernal pools, and proximity to existing conservation lands (Type 1 and Type 2)[28].

5.6.22.1 Adverse Effects

5.6.22.1.1 Permanent Habitat Loss, Conversion, and Fragmentation

The only covered activities that may result in permanent loss of vernal pool crustacean habitat are conveyance facility construction and tidal natural communities restoration.

Water Conveyance Facility Construction

This activity will result in the permanent loss of 15 acres of vernal pool complex providing modeled habitat for vernal pool crustaceans, including 8 acres of vernal pool complex (high-value habitat) and 7 acres of degraded vernal pool complex (low-value habitat). The area to be affected by conveyance facility construction is south of Clifton Court Forebay. Habitat loss in this area is not expected to contribute to habitat fragmentation for vernal pool crustaceans.

Tidal Natural Communities Restoration

Based on the hypothetical restoration footprint, this activity will result in the permanent removal of an estimated 372 acres[29] of vernal pool crustacean habitat (3% of habitat in the Plan Area), all of which is low-value habitat (i.e., low density of vernal pools; see Table 5.6-1). No permanent high-value habitat will be permanently removed by this activity.

The low-value habitat within the hypothetical tidal restoration footprint includes lands in the Suisun Marsh ROA, along the eastern boundary of Conservation Zone 1, that are mapped as vernal pool complex because they flood seasonally and support typical vernal pool plants, but do not include topographic depressions that are characteristic of vernal pool crustacean habitat. This habitat occurs along the northern and eastern boundaries of Suisun Marsh and consists of small patches within or adjacent to protected lands, but not within the core recovery area. Other low-value habitat in the hypothetical tidal restoration footprint includes a large patch of degraded vernal pool complex near Duck Slough, and small patches of degraded vernal pool complex south of Lindsey Slough.

Because the estimates of habitat loss resulting from tidal inundation are based on projections of where restoration may occur, actual effects are expected to be lower because sites will be selected and restoration projects designed to minimize or avoid effects on the covered vernal pool crustaceans. Tidal restoration projects will be designed to ensure that no more than 10 wetted acres of vernal pool crustacean habitat are permanently lost as a result of covered activities. Assuming a 15% density of vernal pools, this would result in a loss of 67 acres of vernal pool complex. However, if the density of affected pools is lower, then the acreage of vernal pool complex lost will be higher.

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[28] See Chapter 3, Section 3.2.4.2.2, *Existing Conservation Lands*, for definitions of conservation land types.

[29] Habitat or natural community loss acreage estimates are based on hypothetical footprints and models rather than detailed project-level design and represent the maximum allowed under the permit. Actual losses will be tracked through compliance monitoring to ensure that they do not exceed the maximum allowable loss, which is 10 wetted acres for this natural community.

5.6.22.1.2 Periodic Inundation

The only covered activity potentially resulting in periodic inundation effects on vernal pool crustaceans is Yolo Bypass operations.

Yolo Bypass Operations

Appendix 5.J, *Effects on Natural Communities, Wildlife, and Plants*, provides the method used to estimate periodic inundation effects in the Yolo Bypass. Based on this method, periodic inundation could affect vernal pool crustaceans occupying areas ranging from 0 acres of habitat during most notch flows, to an estimated 4 acres during a notch flow of 6,000 cfs (A) (Table 5.6-3). BDCP-associated inundation of areas that would not otherwise have been inundated is expected to occur in no more than 30% of all years, because Fremont Weir is expected to overtop the remaining 70% of all years, and during those years notch operations will not typically affect the maximum extent of inundation. In more than half of all years under existing conditions, an area greater than the BDCP-related inundation area already inundates in the bypass. Yolo Bypass flooding is expected to have a minimal effect on vernal pool crustaceans, if any.

5.6.22.1.3 Construction-Related Effects

Direct and permanent construction-related effects on this species are described above in Section 5.6.22.1.1, *Permanent Habitat Loss, Conversion, and Fragmentation.* Additional construction-related effects include dust and hydrologic effects, and construction-related mortality. Temporary habitat loss is not expected, because all work areas for tidal restoration will occur within the footprint for permanent loss or in nonhabitat areas. Effects on the species are described below for each effect category. Effects are described collectively for all covered activities, and are also described for specific covered activities to the extent that this information is pertinent for assessing the value of affected habitat or the specific nature of the effect.

Construction-Related Injury or Mortality

Construction may cause mortality to vernal pool crustaceans or their cysts if vernal pools are affected by ground-disturbing activities. Projects will be designed to avoid direct and indirect effects on vernal pool crustacean habitat to the extent possible as described in *AMM12 Vernal Pool Crustaceans* (Appendix 3.C, *Avoidance and Minimization Measures*). No more than 10 wetted acres of vernal pool crustacean habitat will be removed throughout the permit term (this cap applies to both temporary and permanent loss).

Indirect Construction-Related Effects

Dust and hydrological modification outside the project footprint but within 250 feet of construction activities could temporarily affect the use of 145 acres of modeled vernal pool crustacean habitat (Table 5.6-5), including 98 acres of high-value habitat and 47 acres of low-value habitat, based on the hypothetical footprint. However, as described in AMM12, projects will be designed to avoid vernal pool complexes to the extent possible, with 250-foot no-disturbance buffers between construction activities and vernal pools. To minimize these indirect construction-related effects, restoration projects will be designed to ensure that tidally inundated areas are restored within 250 feet of no more than 20 wetted acres of vernal pools.

5.6.22.1.4 Effects of Ongoing Activities

The only ongoing covered activities with potential to adversely affect vernal pool crustaceans are habitat enhancement and management activities.

Habitat Enhancement and Management

Activities associated with natural communities enhancement and management in protected vernal pool complexes, such as ground disturbance to control nonnative vegetation, could result in local, temporary adverse habitat effects. These effects are expected to be minimal, and will be avoided and minimized with measures described in Appendix 3.C.

5.6.22.1.5 Impact of Take on Species

The take of vernal pool crustaceans is not expected to adversely affect the long-term survival and conservation of these species for the following reasons.

- A small proportion (less than 3%) of modeled habitat in the Plan Area will be removed, and this will consist of low-value habitat with a low density of pools.
- The degraded vernal pool complex that will be lost level has a high level of disturbance and a paucity of aquatic habitat.
- Tidal restoration projects will be designed to ensure that restoration results in direct loss of no more than 10 wetted vernal pool acres, and indirect effects (i.e., direct impacts within 250 feet of pools) to no more than 20 wetted vernal pool acres.
- AMM12, described in Appendix 3.C, will be implemented.

Reasons specific to each species are discussed below.

Conservancy Fairy Shrimp

There are only 34 known occurrences of the conservancy fairy shrimp range-wide, six (18%) of which are in the Plan Area. The Plan Area includes a portion of Jepson Prairie, which is a core recovery area for the conservancy fairy shrimp and supports 12 (35%) of the range-wide occurrences for this species (four in the Plan Area and eight outside the Plan Area but in the vicinity).

Of the six existing CNDDB recorded occurrences in the Plan Area, five are on existing conservation lands. None of these occurrences overlaps with footprints for activities that could result in permanent or temporary habitat loss.

Take of the conservancy fairy shrimp as a result of BDCP implementation is not expected to adversely affect the long-term survival and conservation of this species for the reasons common to all vernal pool crustaceans.

Longhorn Fairy Shrimp

There are only 10 known CNDBB recorded occurrences of the longhorn fairy shrimp range-wide. The Plan Area, however, does not include any CNDDB recorded occurrences of the longhorn fairy shrimp, although there are occurrences near the Plan Area to the southwest, in the Byron Hills area. The portion of the Plan Area most likely to support this species is in Conservation Zone 8, the zone nearest to known occurrences. There will be no effects on modeled habitat for the longhorn fairy shrimp in Conservation Zone 8. However, it is possible that the longhorn fairy shrimp also occurs in modeled habitat that will be lost in Conservation Zones 1 and 11. This species is very rare, with only 11 recorded occurrences throughout the state; any loss of occupied habitat may adversely affect the species' long-term survival and conservation. Preproject surveys will confirm presence or absence of the longhorn fairy shrimp and avoidance measures will be implemented, as described in AMM12.

Take of the longhorn fairy shrimp as a result of BDCP implementation is not expected to adversely affect the long-term survival and conservation of this species for the reasons common to all vernal pool crustaceans, and for the following specific reason.

- There are no CNDDB recorded occurrences of this species in the Plan Area.

Vernal Pool Fairy Shrimp

The vernal pool fairy shrimp is one of the more widespread covered vernal pool crustacean species, with 608 recorded occurrences throughout the state. The Plan Area includes 16 (3%) of the state-wide occurrences, six (38%) of which are on conservation lands. Based on the hypothetical footprint for tidal natural communities restoration, two existing vernal pool fairy shrimp CNDDB recorded occurrence will be affected. An occurrence north of Suisun Marsh near Highway 12 and an occurrence near Clifton Court will be affected. Additional suitable habitat to be affected may also be occupied by this species. However, loss of occupied habitat will be minimized as described in AMM12.

Take of the vernal pool fairy shrimp as a result of BDCP implementation is not expected to adversely affect the long-term survival and conservation of this species for the reasons common to all vernal pool crustaceans, and for the following specific reason.

- A small proportion of this species' range and known occurrences are present in the Plan Area.

Midvalley Fairy Shrimp

There are 101 occurrences of the midvalley fairy shrimp in the state, of which nine (9%) occur in the Plan Area. None of these occurrences overlap with footprints for activities that could result in permanent or temporary habitat loss.

Take of the midvalley fairy shrimp as a result of BDCP implementation is not expected to adversely affect the long-term survival and conservation of this species for the reasons common to all vernal pool crustaceans, and for the following specific reason.

- A small proportion (9%) of known species occurs in the Plan Area.

California Linderiella

There are 382 CNDDB occurrences of the California linderiella range-wide, of which 12 (3%) occur in the Plan Area. One of these occurrences (occurrence number 387) slightly overlaps with footprints for BDCP activities; however, impact of this occurrence will be avoided.

Take of the California linderiella as a result of BDCP implementation is not expected to adversely affect the long-term survival and conservation of this species for the reasons common to all vernal pool crustaceans, and for the following specific reason.

- A small proportion (3%) of known species occurs in the Plan Area.

5.6.22.2 Beneficial Effects

With full implementation of the BDCP, 600 acres of vernal pool complex will be protected (*CM3 Natural Communities Protection and Restoration*) and additional restoration will be implemented to achieve no net loss of vernal pool complex (*CM9 Vernal Pool and Alkali Seasonal Wetland Complex Restoration*: restoration of 10 acres of vernal pool complex at approximately 15% vernal pool density, for an estimated 67 acres of restored vernal pool complex). The protection and restoration will take place primarily in core recovery areas for the vernal pool crustaceans as identified in the recovery plan (U.S. Fish and Wildlife Service 2005), and will increase the size and connectivity of vernal pool complex reserves in and adjacent to the Plan Area. Protection in Conservation Zones 1 and 11 will focus on connectivity with preserved vernal pool complexes on the Jepson Prairie, outside the Plan Area (linkage #1, Figure 3.2-16, *Landscape Linkages*, in Chapter 3). Protection in Conservation Zone 8 will focus on connectivity with preserved lands in the adjacent East Contra Costa County NCCP plan area (linkage #2, Figure 3.2-16). The vernal pool reserve system will incorporate a range of inundation characteristics in order to accommodate the varying needs of all the covered vernal pool crustacean species. These core recovery areas where protection and restoration will be focused have the highest concentrations of covered vernal pool crustacean occurrences in the Plan Area, and they also coincide with the conservation zones that include relatively large, unfragmented blocks of unprotected vernal pool complex adjacent to conservation lands. One currently unprotected occurrence of conservancy fairy shrimp will be protected in the reserve system.

Additionally, the vernal pool complexes in the reserve system will be managed and enhanced (*CM11 Natural Communities Enhancement and Management*) to provide the appropriate ponding characteristics for supporting and sustaining the vernal pool crustaceans, and to increase native biodiversity and reduce invasive plant species detrimental to vernal pool hydrology.

5.6.22.3 Net Effects

Full implementation of the BDCP will result in no net loss of wetted acres of vernal pool crustacean habitat, and an estimated net increase of 642 acres (10%) of vernal pool crustacean habitat in conservation lands (Table 5.6-7).

The modeled habitat that may be lost as a result of tidal restoration, primarily in Cache Slough ROA (Conservation Zone 1), is of low value in that it consists of areas lacking topographic depressions or with disturbed, degraded vernal pool complex with a low density of vernal pools. The areas that will be conserved will consist of high-value vernal pool complex in core vernal pool recovery areas that will be interconnected and managed to sustain populations of covered vernal pool crustaceans.

Overall, the BDCP will provide a substantial net benefit to the covered vernal pool crustaceans through the increase in available habitat, habitat value, and habitat in protected status. These protected areas will be managed and monitored to support the species. Therefore, the BDCP will minimize and mitigate impacts, to the maximum extent practicable, and provide for the conservation and management of the covered vernal pool crustaceans in the Plan Area.

5.6.23 Brittlescale, Heartscale, and San Joaquin Spearscale

This section describes the adverse, beneficial, and net effects of the covered activities, including conservation measures, on brittlescale, heartscale, and San Joaquin spearscale modeled habitat and occurrences[30]. The methods used to assess these effects are described in Section 5.2.8, *Effects Analysis for Wildlife and Plant Species*. The brittlescale habitat model includes hydrological features such as stream corridors and playa pools with either alluvium associated with the Montezuma Block along the western boundary of the Plan Area (Band 1998; Graymer et al. 2002) or on alluvium associated with tertiary formations located along the southwest boundary of the Plan Area (Schruben et al. 1998). The heartscale model includes alkali seasonal wetland, vernal pool, and grassland natural communities underlain by Solano, Pescadero, Willows soil series. The San Joaquin spearscale model includes alkali seasonal wetland complex, the upland annual grasslands and forbs formation, and vernal pool complex.

The habitat model for vernal pool plants includes the vernal pool complex natural community as well as degraded vernal pool natural complex, which is mapped as part of the grassland natural community. The vernal pool complex consists of vernal pools and uplands that display characteristic vernal pool and swale visual signatures that have not been significantly affected by agricultural or development practices. Degraded vernal pool complex includes low-value ephemeral habitat ranging from areas with vernal pool and swale visual signatures that display clear evidence of significant disturbance due to plowing, discing, or leveling to areas with clearly artificial basins such as shallow agricultural ditches, depressions in fallow fields, and areas of compacted soils in pastures. Further details regarding the habitat models, including assumptions on which the models are based, are provided in Appendix 2.A, *Covered Species Accounts.* Factors considered in assessing the value of affected habitat for brittlescale, heartscale, and San Joaquin spearscale, to the extent that information is available, include patch size and connectivity to other habitat patches, especially those that are currently protected.

5.6.23.1 Adverse Effects

5.6.23.1.1 Permanent Habitat Loss, Conversion, and Fragmentation

Based on the hypothetical footprints, covered activities will result in the permanent loss of an estimated 4 acres[31] of brittlescale modeled habitat, 306 acres of heartscale modeled habitat, and 732 acres of San Joaquin spearscale habitat (less than 1, 5, and 5% of modeled habitat, respectively, in the Plan Area) (Table 5.6-2). To provide flexibility in implementation of restoration projects, the take limit for brittlescale modeled habitat is set higher than the amount of loss estimated under the hypothetical footprint: up to 20 acres of brittlescale habitat may be removed through covered activities.

Covered activities resulting in permanent adverse effects on brittlescale, heartscale, and spearscale include construction of water-conveyance and floodplain-restoration infrastructure, Fremont Weir and Yolo Bypass improvements, and tidal natural communities restoration. There will be no loss of brittlescale, heartscale or San Joaquin spearscale occurrences associated with covered activities (Table 5.6-9).

[30] Range-wide occurrences described for all species include CNDDB occurrences, as well as non-CNDDB occurrences mapped for the BDCP. See Appendix 2.A, *Covered Species Accounts*, Section 2A.0.1.2, *Species Distribution and Status*, for a description of plant occurrence data sources.

[31] Habitat loss acreage estimates are based on hypothetical footprints and models and anticipated take levels rather than detailed project-level design and represent the maximum allowed under the permit. Actual losses will be tracked through compliance monitoring to ensure that they do not exceed estimates.

Water Conveyance Facility Construction

This activity, including transmission-line construction, will result in the permanent loss of approximately 53 acres of San Joaquin spearscale modeled habitat (Table 5.6-2) in Conservation Zone 8. The 53 acres comprise modeled habitat patches south and west of the Clifton Court Forebay. Although the current land use on these small patches is unknown, based on aerial photography interpretation, these sites have been disturbed and do not provide habitat for known occurrences of San Joaquin spearscale.

An estimated 30 of the 53 acres of San Joaquin spearscale modeled habitat will be lost due to placement of reusable tunnel material. The material will likely be moved to other sites for use in levee build-up and restoration, and the affected area will likely be restored. While this effect is categorized as permanent, because there is no assurance that the material will eventually be moved, the effect will likely be temporary. Furthermore, the amount of storage area needed for reusable tunnel material is flexible, and the footprint used in the effects analysis is based on a worst-case scenario; the actual area to be affected by reusable tunnel material storage will likely be less than the estimated acreage.

Fremont Weir and Yolo Bypass Improvements

Construction of the Fremont Weir will result in the permanent removal of up to 56 acres of San Joaquin spearscale habitat, all of which can be found along the eastern edge of the Yolo Bypass Wildlife Area in Conservation Zone 2 (Table 5.6-2). This habitat, and that on adjacent lands, is owned by CDFW but is managed primarily for wintering waterfowl and shorebirds. There are no known occurrences of San Joaquin spearscale (or any other covered plant species) in this area.

Floodplain Restoration

Levee construction associated with floodplain restoration will result in the permanent loss of approximately 1 acre of San Joaquin spearscale modeled habitat (Table 5.6-2) in Conservation Zone 7.

Tidal Natural Communities Restoration

Based on the hypothetical restoration footprint, this activity will result in the removal of 4 acres of brittlescale modeled habitat, 306 acres of heartscale modeled habitat, and 622 acres of San Joaquin spearscale habitat in Conservation Zones 1, 2, and 11. However, the actual tidal restoration effects are likely to differ from the hypothetical footprint used to estimate loss. To provide flexibility in implementation of tidal restoration projects, the take limit for brittlescale habitat is set higher than the amount of loss estimated under the hypothetical footprint. Up to 20 acres of brittlescale habitat may be lost through covered activities (Table 5.6-2).

Tidal restoration in Conservation Zone 1 has potential to inundate 300 acres of heartscale modeled habitat, 3 acres of brittlescale habitat, and 567 acres of spearscale habitat. The effects on heartscale, brittlescale, and San Joaquin spearscale modeled habitat from tidal natural communities restoration are described below.

The 4 acres of brittlescale modeled habitat within the hypothetical footprint are composed of two small patches of degraded vernal pool complex located south of Lindsey Slough in Conservation Zone 1. The majority of the 306 acres of heartscale habitat overlapping with the hypothetical restoration footprint is mapped as degraded vernal pool complex and found in Conservation Zone 1, north and south of Lindsey Slough, and in Conservation Zone 2, immediately north of Liberty Island. The distribution of San Joaquin spearscale modeled habitat within the hypothetical restoration footprint is the same as that of brittlescale and heartscale, with patches of modeled habitat mapped as degraded vernal pool complex found north and south of Lindsey Slough, north of Liberty Island, and along the eastern edge of Suisun Marsh, with one additional patch immediately north of Duck Slough.

5.6.23.1.2 Periodic Inundation

Yolo Bypass operations are the only covered activity with the potential to affect brittlescale, heartscale, and San Joaquin spearscale through periodic inundation.

Yolo Bypass Operations

Appendix 5.J, *Effects on Natural Communities, Wildlife, and Plants,* provides the method used to estimate periodic inundation effects in the Yolo Bypass. Based on this method, periodic inundation could affect heartscale and San Joaquin Spearscale modeled habitat (brittlescale modeled habitat does not occur in the Yolo Bypass). For heartscale, periodic inundation could affect from 37 acres of modeled habitat during a notch flow of 1,000 cfs to an estimated 96 acres of modeled habitat during a notch flow of 4,000 cfs (Table 5.6-4). Periodic inundation could affect from 300 acres of San Joaquin spearscale modeled habitat during a notch flow of 1,000 cfs to 1,324 acres during a notch flow of 4,000 cfs (Table 5.6-4). Project-associated inundation of areas that would not otherwise have been inundated will likely occur in no more than 30% of all years, because Fremont Weir is expected to overtop the remaining estimated 70% of all years, and during those years notch operations will not typically affect the maximum extent of inundation. In more than half of all years under existing conditions, an area greater than the project-related inundation area already inundates in the bypass. That is, under current conditions, the area of inundation in 50% of all years is greater than the estimated maximum periodic inundation for modeled habitat associated with Yolo Bypass notch operations (96 acres for heartscale and 1,324 acres for San Joaquin spearscale).

Heartscale and San Joaquin spearscale occur in microhabitats that have seasonally saturated soils for short periods but typically are not inundated. The moderate increase in periodic inundation frequency expected from Yolo Bypass notch operations will likely increase the number of years modeled habitat experiences altered seasonal wetland hydrology, creating wetter conditions that will potentially be unsuitable for heartscale and San Joaquin spearscale in a greater number of years. There are no known occurrences of heartscale within the Yolo Bypass. There are two known occurrences of San Joaquin spearscale, both of which are located west of the area of maximum inundation associated with Yolo Bypass operations. Because the existing condition includes the inundation of modeled habitat beyond the maximum estimated footprint of covered activities in 50% of all years and because there are no known occurrences within the maximum estimated inundation footprint, the moderate increase in Yolo Bypass flooding frequency is expected to have a minimal effect on heartscale and San Joaquin spearscale, if any.

5.6.23.1.3 Construction-Related Effects

Permanent construction-related effects are described in Section 5.6.23.1.1, *Permanent Habitat Loss, Conversion, and Fragmentation*. Other construction-related effects include construction-related injury or mortality and indirect effects associated with construction of the Fremont Weir/Yolo Bypass.

Temporary Habitat Loss

Construction-related effects will temporarily disturb 30 acres of San Joaquin spearscale habitat (less than 1% of the modeled habitat in the Plan Area) (Table 5.6-2). Temporarily disturbed areas will be restored within 1 year following completion of construction and management activities.

Construction-Related Injury or Mortality

Construction may cause injury or mortality to brittlescale, heartscale, or San Joaquin spearscale plants by crushing individuals or disturbing the soil near occurrences; however, preconstruction surveys, construction monitoring, and other measures will be implemented to avoid and minimize injury or mortality of this species during construction, as described in *AMM2 Construction Best Management Practices and Monitoring* (Appendix 3.C, *Avoidance and Minimization Measures*).

Indirect Construction-Related Effects

Disturbance outside the project footprint but within 250 feet of construction activities could indirectly and temporarily affect the use of 193 acres of modeled heartscale habitat (3%), 3 acres of modeled brittlescale habitat (less than 1%), and 236 acres of modeled spearscale habitat (1%) (Table 5.6-6). These construction-related effects are due to tidal marsh restoration and, for San Joaquin spearscale only, Fremont Weir/Yolo Bypass enhancements, conveyance facility construction, and seasonally inundated floodplain restoration. Indirect effects could include growth inhibition, life-cycle changes, and mortality resulting from fugitive dust and runoff (water, contaminants) generated by construction activities. Construction-related indirect effects will be minimized with implementation of AMM2. In addition, construction traffic and construction and restoration activities that create temporary ground disturbances could introduce propagules of nonnative invasive plant species or cause existing populations of nonnative invasive plant species to expand, potentially reducing habitat suitability for native plants. Adverse effects caused by nonnative plant introduction will be minimized with implementation of *AMM11 Covered Plant Species* (Appendix 3.C).

5.6.23.1.4 Effects of Ongoing Activities

Habitat Enhancement and Management

Habitat management and enhancement activities in protected vernal pool and alkali seasonal wetland natural communities and restored and protected grassland natural community, such as the control of nonnative vegetation, could result in the mortality of individual brittlescale, heartscale, and San Joaquin spearscale plants, if species are present in these sites over the permit term. *CM11 Natural Communities Enhancement and Management* addresses guidelines and techniques used in invasive plant control to minimize impacts on species and habitat (Chapter 3, Section 3.4.11.2.3, *General Enhancement and Management Actions, Invasive Plant Control*). Operation and maintenance of the water conveyance facilities will not affect heartscale, brittlescale, or San Joaquin modeled habitat.

Recreation

Passive recreation in the reserve system, where that recreation is compatible with the biological goals and objectives, could result in disturbance of brittlescale, heartscale, or San Joaquin spearscale plants if hikers or dogs illegally travel off trail. However, *AMM37 Recreation* (Appendix 3.C) limits trail placement to within 50 feet of occurrences to reduce risk of accidental trampling. AMM37 also requires trail construction to avoid all occurrences of brittlescale, heartscale, and San Joaquin spearscale. With recreation restrictions in place, as required under AMM37, recreation-related effects on brittlescale, heartscale, and San Joaquin spearscale are expected to be minimal.

5.6.23.1.5 Other Indirect Effects

No other known indirect effects on brittlescale, heartscale, or San Joaquin spearscale will result from covered activities.

Impact of Take on Species

Brittlescale, heartscale, and San Joaquin spearscale are endemic to California, with all range-wide occurrences entirely within the state. Brittlescale is currently known from 62 extant occurrences range-wide, 7 of which are in the Plan Area. Three of the seven known occurrences in the Plan Area are located on existing conservation lands categorized as Type 1, and two are located on existing conservation lands categorized as Type 2, 3, or 4. Heartscale is known from 57 extant occurrences range-wide. Within the Plan Area, there are eight extant heartscale occurrences (Table 5.6-9). Two of the eight known occurrences in the Plan Area are located on existing conservation lands categorized as Type 1 and one is located on existing conservation lands categorized as Type 2, 3, or 4. San Joaquin spearscale is known from 107 extant occurrences range-wide, 19 of which are in the Plan Area. Four of the 19 known occurrences in the Plan Area are located on existing conservation lands categorized as Type 1 and three are located on existing conservation lands categorized as Type 2, 3, or 4. There will be no loss of brittlescale, heartscale, or San Joaquin spearscale occurrences associated with covered activities (Table 5.6-9). Twenty acres of brittlescale modeled habitat, 306 acres of heartscale modeled habitat, and 713 acres of San Joaquin spearscale habitat may be permanently affected by covered activities. Because a low proportion of species' occurrences are in the Plan Area and because the area of potentially suitable habitat affected is considered of low value (degraded vernal pool complex) (Table 5.6-2), covered activities will not adversely affect the species' long-term survival and conservation.

5.6.23.2 Beneficial Effects

Assuming the restored grassland, alkali seasonal wetland complex, and vernal pool complex natural communities will provide suitable brittlescale habitat proportional to the amount of modeled habitat that currently exists in these natural communities in the Plan Area (0.6%, 0.2%, 1.5% respectively), implementation of the BDCP will result in the restoration of an estimated 5 acres of brittlescale habitat. Additionally, under Objective BRIT/HART/SJSC1.1, of the 150 acres of alkali seasonal wetland complex protected under Objective ASWNC1.1, 600 acres of vernal pool complex protected under Objective VPNC1.1, and 8,000 acres of grassland natural community protected under Objective GNC1.1, implementation of the BDCP will protect at least 75 acres of suitable brittlescale habitat in Conservation Zones 1, 8, or 11.

Assuming the restored grassland, alkali seasonal wetland complex, and vernal pool complex natural communities will provide suitable heartscale habitat proportional to the amount of modeled habitat that currently exists in these natural communities in the Plan Area (14.5%, 4.1%, 22.4% respectively), implementation of the BDCP will result in the restoration of an estimated 107 acres of heartscale habitat. Additionally, under Objective BRIT/HART/SJSC1.1, of the 150 acres of alkali seasonal wetland complex protected under Objective ASWNC1.1, 600 acres of vernal pool complex protected under Objective VPNC1.1, and 8,000 acres of grassland natural community protected under Objective GNC1.1, implementation of the BDCP will protect at least 75 acres of suitable heartscale habitat in Conservation Zones 1, 8, or 11.

The restoration and protection of alkali seasonal wetland complex, vernal pool complex, and grassland natural communities will also benefit the San Joaquin spearscale. Assuming restored and protected natural communities will provide species habitat proportional to the amount of modeled habitat within the natural communities in the Plan Area, an estimated 259 acres of San Joaquin spearscale habitat will be restored and an estimated 1,070 acres of San Joaquin spearscale habitat will be protected (Table 5.6-8).

Additionally, alkali seasonal wetlands, vernal pool complex and grassland natural communities will be managed and enhanced to control nonnative, invasive plant species detrimental to covered plant species, increase native biodiversity, and sustain suitable conditions for vernal pool pollinators (Chapter 3, Section 3.4.11.2.6, *Grasslands and Associated Seasonal Wetland Natural Communities*).

5.6.23.3 Net Effects

Assuming the restored and protected natural communities will provide suitable habitat proportional to the amount of modeled habitat for each species that currently exists in these natural communities in the Plan Area, full implementation of the BDCP will result in an estimated net decrease of 15 acres (-3%) of suitable brittlescale habitat and an estimated net increase of 80 acres (56%) of brittlescale habitat on conservation lands. Heartscale modeled habitat will decrease by an estimated 199 acres (-3%), while protected habitat for heartscale will increase by an estimated 178 acres (5%). San Joaquin spearscale habitat will decrease by an estimated 472 acres (-3%), and protected habitat will increase by an estimated 1,202 acres (14%) (Table 5.6-8). The brittlescale, heartscale, and San Joaquin spearscale modeled habitat lost in Conservation Zone 1, 2, 8, and 11 as a result of covered activities is composed primarily of degraded vernal pool complex, as mapped within the vernal pool natural community. However, alkali seasonal-wetland complex, vernal pool complex, and grassland natural community restoration and protection will occur primarily in the vernal pool recovery areas, providing substantial increases—56% for brittlescale, 5% for heartscale, and 14% for San Joaquin spearscale—in the protection of large, relatively unfragmented blocks of suitable habitat adjacent to existing conservation lands. These protected areas will be monitored and managed to sustain these species. Therefore, the BDCP will minimize and mitigate impacts, to the maximum extent practicable, and provide for the conservation and management of the brittlescale, heartscale, and San Joaquin spearscale in the Plan Area.

5.6.24 Carquinez Goldenbush

This section describes the adverse, beneficial, and net effects of the covered activities, including conservation measures, on the Carquinez goldenbush. The methods used to assess these effects are described in Section 5.2.8, *Effects Analysis for Wildlife and Plant Species*. The habitat model developed for the Carquinez goldenbush includes intermittent and perennial stream corridors on alluvium soil units related to the Montezuma Block. Further details regarding the habitat model, including assumptions on which the model is based, are provided in Appendix 2.A, *Covered Species Accounts.* Factors considered in assessing the value of affected habitat for the Carquinez goldenbush, to the extent that information is available, include the presence of occurrences of either Carquinez goldenbush or another covered species, patch size, proximity to conservation lands, and connectivity between patches.

5.6.24.1 Adverse Effects

5.6.24.1.1 Permanent Habitat Loss, Conversion, and Fragmentation

Based on the hypothetical footprints, covered activities will result in the permanent loss or fragmentation of up to 4 acres[32] of modeled Carquinez goldenbush habitat. (Table 5.6-2). However, to provide flexibility in implementation of tidal restoration projects, the take limit for Carquinez goldenbush habitat is set higher than the amount of loss estimated under the hypothetical footprint. Up to 50 acres of Carquinez goldenbush habitat (4% of habitat in the Plan Area) may be lost through covered activities.

The only covered activities resulting in adverse effects on Carquinez goldenbush is tidal natural communities restoration. There will be no loss of Carquinez goldenbush occurrences (Table 5.6-9).

Tidal Natural Communities Restoration

Based on the hypothetical restoration footprint, tidal natural communities restoration could result in the permanent removal of up to 4 acres (less than 4% of modeled habitat in the Plan Area) of Carquinez goldenbush modeled habitat (Table 5.6-2). However, the actual tidal restoration effects are likely to differ from the hypothetical footprint used to estimate loss. To provide flexibility in implementation of tidal restoration projects, the take limit for Carquinez goldenbush habitat is set higher than the amount of loss estimated under the hypothetical footprint. Up to 50 acres of Carquinez goldenbush habitat may be lost through covered activities.

The 4 acres of predicted habitat loss based on the hypothetical footprints occur in Conservation Zone 11 and are located between Denverton and Bird's Landing on the eastern border of Suisun Marsh. These acres are considered high-value habitat because they are currently protected within a large matrix of relatively intact vernal pools, alkali seasonal wetlands, and grasslands; they contribute to connectivity between northern and southern habitat; and there are several occurrences of Carquinez goldenbush in the vicinity.

5.6.24.1.2 Periodic Inundation

There are no periodic inundation effects on Carquinez goldenbush.

5.6.24.1.3 Construction-Related Effects

Permanent construction-related effects are described in Section 5.6.24.1.1, *Permanent Habitat Loss, Conversion, and Fragmentation*. Other construction-related effects on this species are construction-related injury or mortality and indirect, temporary effects associated with tidal marsh restoration.

Construction-Related Injury or Mortality

Construction may cause injury or mortality to Carquinez goldenbush plants by crushing individuals or disturbing the soil near occurrences; however, preconstruction surveys, construction monitoring, and other measures under *AMM2 Construction Best Management Practices and Monitoring* will be

[32] Habitat loss acreage estimates are based on hypothetical footprints and models and anticipated take levels rather than detailed project-level design and represent the maximum allowed under the permit. Actual losses will be tracked through compliance monitoring to ensure that they do not exceed estimates.

implemented to avoid and minimize injury or mortality of this species during construction, as described in Appendix 3.C, *Avoidance and Minimization Measures*.

Indirect Construction-Related Effects

Tidal marsh restoration disturbance outside of the project footprint but within 250 feet of construction activities could indirectly and temporarily affect 9 acres (less than 1%) of modeled Carquinez goldenbush habitat (Table 5.6-6). Such effects could include growth inhibition, life-cycle changes, and mortality resulting from fugitive dust and runoff (water, contaminants) generated by construction activities. Construction-related indirect effects will be minimized as with implementation of AMM2. In addition, construction traffic and construction and restoration activities that create temporary ground disturbances could introduce propagules of nonnative invasive plant species or cause existing populations of nonnative invasive plant species to expand, potentially reducing habitat suitability for native plants. Adverse effects caused by nonnative plant introduction will be minimized with implementation of *AMM11 Covered Plant Species*.

5.6.24.1.4 Effects of Ongoing Activities

Habitat Enhancement and Management

Activities associated with natural communities enhancement and management in Conservation Zones 1 and 11, such as grazing practices and ground disturbance or herbicide use in the control of nonnative vegetation, could result in local adverse effects on habitat and the mortality of Carquinez goldenbush individuals if present in work sites over the permit term. *CM11 Natural Communities Enhancement and Management* addresses grazing restrictions related to Carquinez goldenbush in Chapter 3, Section 3.4.11.2.6, *Grasslands and Associated Seasonal Wetland Natural Communities*, and requires the creation of reserve management plans that will include vegetation management in Chapter 3, Section 3.4.11.2.2, *Reserve Unit Management Plans*. CM11 also addresses guidelines and techniques used in invasive plant control to minimize impacts on covered plants (Chapter 3, Section 3.4.11.2.3, *General Enhancement and Management Actions, Invasive Plant Control*). Operation and maintenance of the water conveyance facilities will not affect Carquinez goldenbush modeled habitat.

Recreation

Passive recreation in the reserve system, where that recreation is compatible with the biological goals and objectives, could result in the loss of Carquinez goldenbush plants from erosion associated with existing roads or newly constructed trails. However, *AMM37 Recreation* (Appendix 3.C) requires trails to be designed and placed to avoid future erosion. With design requirements in place, as required under AMM37, recreation-related effects on Carquinez goldenbush are expected to be minimal.

5.6.24.1.5 Other Indirect Effects

No other known indirect effects on Carquinez goldenbush will result from covered activities.

5.6.24.1.6 Impact of Take on Species

Carquinez goldenbush is endemic to California, with all range-wide occurrences within or just outside the Plan Area. There are 14 known, extant occurrences of Carquinez goldenbush from

Solano and Contra Costa Counties, 10 of which are in the Plan Area (California Department of Fish and Wildlife 2013f). All but the Contra Costa occurrence are found in the greater Jepson Prairie/Montezuma Hills area, either just inside or just outside the Plan Area. One of the 10 occurrences found in the Plan Area is located on existing conservation lands categorized as Type 1, and five of the 10 occurrences found within the Plan Area are located on existing conservation lands categorized as Types 2, 3, or 4. Fifty acres of high-value habitat could be lost as a result of tidal habitat restoration. The loss of 50 acres of modeled habitat will not adversely affect the long-term survival and conservation of the species.

5.6.24.2 Beneficial Effects

The restoration and protection of alkali seasonal wetland complex, vernal pool complex, and grassland natural communities will benefit the Carquinez goldenbush. Assuming restored and protected natural communities will provide species habitat proportional to the amount of modeled habitat within the natural communities in the Plan Area, an estimated 18 acres of Carquinez goldenbush habitat will be restored and an estimated 86 acres of Carquinez goldenbush habitat will be protected (Table 5.6-8). In Conservation Zones 1 and 11, alkali seasonal wetland complex, vernal pool complex, and grassland natural community restoration and protection will target large blocks of undeveloped, relatively unfragmented landscape blocks adjacent to existing conservation lands where Carquinez goldenbush occurrences are found. In addition, three occurrences of Carquinez goldenbush will be protected. Carquinez goldenbush suitable habitat and occurrences in the reserve system will be managed and enhanced as detailed in *CM11 Natural Communities Enhancement and Management* (Chapter 3, Section 3.4.11.2.6, *Grasslands and Associated Seasonal Wetlands Natural Communities*).

5.6.24.3 Net Effects

Assuming the restored and protected natural communities will provide suitable habitat proportional to the amount of modeled habitat that currently exists in these natural communities in the Plan Area, the restoration and protection of high-value alkali seasonal wetland complex, vernal pool complex, and grassland natural communities will result in an estimated increase of 14 acres (1%) of high-value habitat and an estimated increase of 104 acres (15%) of Carquinez goldenbush protected modeled habitat (Table 5.6-8). In addition, three occurrences of Carquinez goldenbush will be protected. This will increase the number of protected occurrences by 300% (Table 5.6-9).

Overall, the BDCP will provide a net benefit to Carquinez goldenbush through the increase in available habitat and habitat in protected status as well as the protection of three currently unprotected occurrences. These protected areas will be managed and monitored to support the species. Therefore, the BDCP will minimize and mitigate impacts, to the maximum extent practicable, and provide for the conservation and management of the Carquinez goldenbush in the Plan Area.

5.6.25 Delta Button Celery

This section describes the adverse, beneficial, and net effects of the covered activities on the delta button celery. The methods used to assess these effects are described in Section 5.2.8, *Effects Analysis for Wildlife and Plant Species*. The habitat model for the delta button celery includes alkali seasonal wetland complex, vernal pool complex, and grassland on selected soil types in the San Joaquin Basin, including all areas between the levees from the Mossdale Bridge to Vernalis. Further details regarding the habitat model, including assumptions on which the model is based, are provided in Appendix 2.A, *Covered Species Accounts.* Factors considered in assessing the value of affected habitat for the delta button celery, to the extent that information is available, include fragmentation, presence of ground disturbance, such as disking, proximity to known or historical occurrences, hydrology, and connectivity between large patches of suitable or potential habitat.

5.6.25.1 Adverse Effects

5.6.25.1.1 Permanent Habitat Loss, Conversion, and Fragmentation

Covered activities will result in the permanent loss of up to 79 acres[33] of modeled delta button celery habitat (less than 2% of the modeled habitat in the Plan Area) (Table 5.6-2). Covered activities resulting in loss of delta button celery habitat include water conveyance facility construction and floodplain restoration. There will be no loss of delta button celery occurrences (Table 5.6-9).

Water Conveyance Facility Construction

This activity, including transmission line construction, will result in the permanent loss of an estimated 73 acres of delta button celery modeled habitat (Table 5.6-2) in Conservation Zone 8, immediately south of the Clifton Court Forebay. The affected modeled habitat is composed of two small, degraded patches of grassland (California annual grasslands-herbaceous) that are considered to be of very low value. These small patches of modeled habitat are not near known or historical delta button celery occurrences and are isolated from other delta button celery modeled habitat by surrounding agriculture. These patches are not adjacent to existing conservation lands or near occurrences of other rare species, nor do they provide connectivity between larger, intact patches of delta button celery modeled habitat. An estimated 39 of the 73 acres of delta button celery habitat will be lost due to placement of reusable tunnel material. The material will likely be moved to other sites for use in levee build-up and restoration, and the affected area will likely be restored. While this effect is categorized as permanent, because there is no assurance that the material will eventually be moved, the effect will likely be temporary. Furthermore, the amount of storage area needed for reusable tunnel material is flexible, and the footprint used in the effects analysis is based on a worst-case scenario; the actual area to be affected by reusable tunnel material storage will likely be less than the estimated acreage.

Floodplain Restoration

Levee construction associated with floodplain restoration will result in the permanent loss of an estimated 7 acres of delta button celery modeled habitat (Table 5.6-2) in Conservation Zone 7, between Mossdale Bridge and Vernalis. The area just north of the Mossdale Bridge includes an historical occurrence that is possibly extirpated (California Department of Fish and Wildlife 2013g). This portion of the San Joaquin River is considered low-value delta button celery habitat. The river in this section is much more narrow and confined and does not possess native biologic, hydrologic, or geomorphic signatures as the more southern reaches do.

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[33] Habitat loss acreage estimates are based on hypothetical footprints and models and anticipated take levels rather than detailed project-level design and represent the maximum allowed under the permit. Actual losses will be tracked through compliance monitoring to ensure that they do not exceed estimates.

Construction activity for floodplain restoration will primarily occur outside the levees, where there is no delta button celery modeled habitat. However, where levee breaches are made, the construction footprint will reach inside the levees, thus causing small, dispersed effects on delta button celery modeled habitat along this portion of the San Joaquin River.

The habitat of highest value to be affected by construction of levee breeches occurs at the very southern tip of the Plan Area, near Vernalis, and effects in this area are less than 1 acre. This area is presumed to include the modeled delta button celery habitat of highest value in the Plan Area because it includes the visual signature of overland flood flows and is downstream of two possibly extant delta button celery occurrences that are located just outside the Plan Area.

5.6.25.1.2 Periodic Inundation

Floodplain restoration is the only covered activity expected to result in periodic inundation of delta button celery habitat.

Floodplain Restoration

This activity will periodically inundate an estimated 18 acres of modeled habitat for the delta button celery (less than 1% of the modeled habitat in the Plan Area: Table 5.6-4). Under *AMM11 Covered Plant Species*, ground disturbance to known or discovered occurrences within the floodplain restoration footprint will be avoided, and restoration design at the location of these occurrences will consider flood inundation and frequency compatible with delta button celery life-history needs (Appendix 3.C, *Avoidance and Minimization Measures*). Floodplain restoration is expected to benefit this species, as described below in Section 5.6.25.2, *Beneficial Effects*.

5.6.25.1.3 Construction-Related Effects

Permanent construction-related effects are described Section 5.6.25.1.1, *Permanent Habitat Loss, Conversion, and Fragmentation*. Other construction-related effects on delta button celery are associated with floodplain restoration and include temporary habitat loss, construction-related injury or mortality, and indirect effects.

Temporary Habitat Loss

Construction of conveyance facilities will temporarily disturb 23 acres of delta button celery habitat (1% of the modeled habitat in the Plan Area) in Conservation Zone 8 (Table 5.6-2). The remaining 8 acres of temporary ground disturbance will occur in discrete patches between Mossdale Bridge and Vernalis, where delta button celery modeled habitat overlaps with the hypothetical floodplain restoration (CM5) footprint. Occupied delta button celery habitat may be incorporated into floodplain and riparian restoration sites providing disturbance of occupied habitat from construction activities is avoided as described in AMM11 (Appendix 3.C). Temporarily disturbed areas will be restored within 1 year following completion of construction and management activities. Because delta button celery occurs in areas of exposed soil in river-adjacent wetlands that experience slow overland flow, the habitat is expected to be suitable for recolonization almost immediately upon completion of restoration.

Construction-Related Injury or Mortality

Under AMM11, construction activities will avoid direct injury or mortality of individual delta button celery plants, should any occurrences be identified during planning and preconstruction surveys.

Indirect Construction-Related Effects

Disturbance of modeled delta button celery habitat outside of the project footprint could indirectly and temporarily affect 123 acres (4%) of modeled delta button celery habitat (Table 5.6-6). These construction activities will include the construction of water-conveyance and floodplain-restoration facilities. Indirect effects may include growth inhibition, life cycle changes, and mortality resulting from fugitive dust and runoff (water, contaminants) generated by construction activities. Construction-related indirect effects will be minimized as described in AMM2. In addition, construction traffic and construction and restoration activities that create temporary ground disturbances could introduce propagules of nonnative invasive plant species or cause existing populations of nonnative invasive plant species to expand, potentially reducing habitat suitability for native plants. Adverse effects caused by nonnative plant introduction will be minimized with implementation of AMM11.

5.6.25.1.4 Effects of Ongoing Activities

Habitat Enhancement and Management

Habitat management and enhancement activities in restored seasonally inundated floodplain and in protected alkaline habitats, such as the control of nonnative vegetation, could result in the mortality of individual delta button celery plants if this species is present in these sites over the permit term. *CM11 Natural Communities Enhancement and Management* addresses the guidelines and techniques used in invasive plant control to minimize impacts to species and habitat (Chapter 3, Section 3.4.11.2.3, *General Enhancement and Management Actions, Invasive Plant Control*).

Recreation

Passive recreation in the reserve system, where that recreation is compatible with the biological goals and objectives, could result in disturbance of delta button celery plants if hikers or dogs illegally travel off trail. However, *AMM37 Recreation* (Appendix 3.C) limits trail placement to within 50 feet of occurrences to reduce risk of accidental trampling. AMM37 also requires trail construction to avoid all occurrences of delta button celery. With recreation restrictions in place, as required under AMM37, recreation-related effects on delta button celery are expected to be minimal.

5.6.25.1.5 Other Indirect Effects

No other known indirect effects on delta button celery will result from covered activities.

5.6.25.1.6 Impact of Take on Species

Delta button celery is endemic to California, with all range-wide occurrences entirely within the state. There are 26 occurrences of delta button celery range-wide. The two Plan Area occurrences are possibly extirpated, one on the alluvial plain of Kellogg and Marsh Creeks immediately west of Discovery Bay (Conservation Zone 9) and one along the San Joaquin River northeast of Tracy (Conservation Zone 7) (California Department of Fish and Wildlife 2013g). The species is still found throughout its historical range, with the greatest density of occurrences in Merced County.

Full implementation of the BDCP will permanently remove up to 25 acres out of a total of 3,329 acres of modeled delta button celery habitat. Based on recent field surveys and an assessment of the California Natural Diversity Database (California Department of Fish and Wildlife 2013g), the two Plan Area occurrences are possibly extirpated and therefore effects on individual plants are unlikely. In addition, AMM11, described in Appendix 3.C*,* requires complete avoidance of occupied delta button celery during floodplain restoration activities. The effects on modeled habitat are minimal and not expected to adversely affect the species' long-term survival and conservation.

5.6.25.2 Beneficial Effects

If occurrences of delta button celery are located in the Plan Area and protected, they will be managed and enhanced by covered activities. Otherwise, full implementation of the BDCP will establish and manage two occurrences of delta button celery[34] within the restored floodplain habitat on the mainstem of the San Joaquin River in Conservation Zone 7 (see Chapter 3, Section 3.4.11.2.5, *Riparian Natural Community, Enhancement and Management Actions*, for a description of occurrence creation, enhancement, and management actions and considerations; and Section 3.4.11.2.4, *Aquatic and Emergent Wetland Natural Communities, Vegetation Management*, for seed banking and nursery considerations associated with occurrence establishment). The mainstem of the San Joaquin River, especially south of Mossdale, contains the delta button celery habitat of highest value. This habitat is just north (i.e., downstream) of two extant delta button celery occurrences, is adjacent to existing conservation lands, and has geomorphic signatures more consistent with historical conditions. Occurrences will be created in those areas with suitable soils and hydrology.

Assuming the restored and protected natural communities will provide suitable species habitat proportional to the amount of modeled habitat that currently exists within these natural communities, an estimated 257 acres of suitable habitat will be restored and an estimated 213 acres of habitat will be protected (Table 5.6-8). The conservation strategy includes restoration of 5,000 acres riparian and 2,000 acres grassland natural communities and the protection of 8,000 acres grassland, 48,625 acres cultivated lands, and 750 acres riparian natural communities in Conservation Zones 7, 8, and 9 where modeled delta button celery habitat occurs. Delta button celery suitable habitat and occurrences in the reserve system will be managed and enhanced as detailed in *CM11 Natural Communities Enhancement and Management* (Chapter 3, Section 3.4.11.2.4, *Aquatic and Emergent Wetland Natural Communities*).

5.6.25.3 Net Effects

Assuming the restored and protected natural communities will provide suitable species habitat proportional to the amount of modeled habitat that currently exists in these natural communities in the Plan Area, full implementation of the BDCP will result in an estimated net increase of 178 acres (5%) of delta button celery habitat and an estimated net increase of 441 acres of delta button celery habitat on conservation lands (91%) (Table 5.6-8).

The habitat that will be lost as a result of water conveyance and floodplain restoration varies from low to high value and occurs in small, isolated patches. The habitat protected and restored in Conservation Zone 7 is expected to be of high value in that it will restore the necessary vernally mesic habitat in the floodplain of the San Joaquin River, where appropriate soils are known to occur. In addition, the Implementation Office will protect, manage, and enhance two discovered or established occurrences along this stretch of high-value habitat.

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[34] Objective DBC1.1 allows for the establishment of up to two occurrences of delta button celery in absence of discovery of extant occurrences. Protection and management is preferable to occurrence creation given ecological and genetic concerns.

Overall, the BDCP will provide a net benefit to delta button celery primarily through the increase in available protected habitat and the protection of two discovered or established occurrences at the northern-most extent of the plant's known range (Table 5.6-9). These protected areas will be managed and monitored to support the species. Therefore, the BDCP will minimize and mitigate impacts, to the maximum extent practicable, and provide for the conservation and management of the delta button celery in the Plan Area.

5.6.26 Delta Mudwort and Mason's Lilaeopsis

This section describes the adverse, beneficial, and net effects of the covered activities on the delta mudwort and Mason's lilaeopsis. The methods used to assess these effects are described in Section 5.2.8, *Effects Analysis for Wildlife and Plant Species*. The habitat model for delta mudwort and Mason's lilaeopsis are the same and include areas within 10 feet on either side of the landward boundary of tidal perennial aquatic land cover type. Further details regarding the habitat model, including assumptions on which the model is based, are provided in Appendix 2.A, *Covered Species Accounts.* Because these species are so widely distributed throughout the Plan Area, the primary factor considered in assessing the value of affected habitat for the delta mudwort and Mason's lilaeopsis is the presence of extant occurrences.

5.6.26.1 Adverse Effects

5.6.26.1.1 Permanent Habitat Loss, Conversion and Fragmentation

Covered activities will result in the permanent loss of up to 25 acres[35] (less than 1% of the habitat in the Plan Area) of delta mudwort and Mason's lilaeopsis habitat (Table 5.6-2). Covered activities resulting in the majority of permanent loss or conversion of delta mudwort and Mason's lilaeopsis habitat include water conveyance facility construction (15 acres or 48% of all habitat loss), Fremont Weir and Yolo Bypass improvements (3 acres or 12% of all habitat loss), and tidal natural communities restoration (6 acres or 24% of all habitat loss) and levee construction (1 acre or 4% of all habitat loss). There will be no loss of delta mudwort and Mason's lilaeopsis occurrences, although some occurrences may have temporary losses of some individuals (i.e., partial loss) (Table 5.6-9).

Water Conveyance Facility Construction

This activity will result in the permanent loss of approximately 15 acres of delta mudwort and Mason's lilaeopsis habitat (Table 5.6-2) in Conservation Zones 3, 6, and 8. Four acres of modeled habitat will be removed in Conservation Zone 3 associated with the construction of the intake pumps along the Sacramento River. There are no occurrences of either species in this northern region of the Plan Area. In Conservation Zones 6 and 8, 10 acres and 5 acres of modeled habitat will be removed, respectively, where tunnel/pipeline construction passes over river sections. An estimated 3 acres of delta mudwort and Mason's lilaeopsis habitat will be lost due to placement of reusable tunnel material. This material will likely be moved to other sites for use in levee build-up and restoration, and the affected area will likely be restored. While this effect is categorized as permanent, because there is no assurance that the material will eventually be moved, the effect will likely be temporary. Furthermore, the amount of storage area needed for reusable tunnel material is

[35] Habitat loss acreage estimates are based on hypothetical footprints and models and anticipated take levels rather than detailed project-level design and represent the maximum allowed under the permit. Actual losses will be tracked through compliance monitoring to ensure that they do not exceed estimates.

flexible, and the footprint used in the effects analysis is based on a worst-case scenario; the actual area to be affected by reusable tunnel material storage will likely be less than the estimated acreage.

There are occurrences near the tunnel alignment in Conservation Zone 6 but none close enough to be affected by tunnel construction. In Conservation Zone 8, occurrences of both delta mudwort and Mason's lilaeopsis overlap with the conveyance facility alignment. The overlapping occurrences, like most occurrences of both of these species, is comprised of numerous patches or stands of plants scattered along the transitional intertidal habitat; therefore, only a portion of each occurrence (and suitable habitat) is expected to be lost as a result of this covered activity. For delta mudwort and Mason's lilaeopsis, the loss of individual plants is allowed up to a maximum of 5% of the total number of individuals within the occurrence, if the affected occurrence is composed of 10 individuals or more, as described in *AMM11 Covered Plant Species* (Appendix 3.C, *Avoidance and Minimization Measures*).

Fremont Weir and Yolo Bypass improvements

This activity will result in the permanent removal of an estimated 3 acres of delta mudwort and Mason's lilaeopsis habitat (Table 5.6-2).

Tidal Natural Communities Restoration

This activity will result in the permanent removal and conversion of an estimated 6 acres of delta mudwort and Mason's lilaeopsis habitat (Table 5.6-2). Desiccation effects are attributed to tidal muting, a localized effect of tidal restoration. Tidal muting is described further in Section 5.6.26.1.5, *Other Indirect Effects*.

5.6.26.1.2 Periodic Inundation

Yolo Bypass Operations

Appendix 5.J, *Effects on Natural Communities, Wildlife, and Plants,* provides the method used to estimate periodic inundation effects in the Yolo Bypass. Based on this method, periodic inundation could affect delta mudwort and Mason's lilaeopsis. For these species, periodic inundation could affect from an estimated 15 acres of modeled habitat during a notch flow of 1,000 cfs, up to an estimated 29 acres of modeled habitat during a notch flow of 4,000 cfs (Table 5.6-4). Project-associated inundation of areas that would not otherwise have been inundated will likely occur in no more than 30% of all years, because Fremont Weir is expected to overtop the remaining estimated 70% of all years, and during those years notch operations will not typically affect the maximum extent of inundation. In more than half of all years under existing conditions, an area greater than the project-related inundation area already inundates in the bypass. That is, under current conditions, the area of inundation in 50% of all years is greater than the estimated maximum periodic inundation of delta mudwort and Mason's lilaeopsis modeled habitat associated with Yolo Bypass notch operations (29 acres). There are no known, extant occurrences of delta mudwort or Mason's lilaeopsis within Yolo Bypass.

Floodplain Restoration

This activity will periodically inundate 12 acres of habitat for delta mudwort and Mason's lilaeopsis (less than 1% of the modeled habitat in the Plan Area) (Table 5.6-4). The project related inundation is expected to be within the natural range of inundation for these species and therefore is expected to have either no effect or possibly beneficial effects on delta mudwort and Mason's lilaeopsis (Table 5.6-4).

5.6.26.1.3 Construction-Related Effects

Permanent, construction-related effects are described in Section 5.6.26.1.1, *Permanent Habitat Loss, Conversion, and Fragmentation*. Other construction-related effects on these species consist of temporary habitat loss, construction-related injury or mortality, and indirect effects.

Temporary Habitat Loss

Construction activities are expected to result in temporary loss of an estimated 19 acres of habitat for the delta mudwort and Mason's lilaeopsis (less than 1% of the modeled habitat in the Plan Area) (Table 5.6-2). Temporarily disturbed areas will be restored as delta mudwort and Mason's lilaeopsis habitat within 1 year following completion of construction and management activities.

Construction-Related Injury or Mortality

Construction may cause injury or mortality to the delta mudwort and Mason's lilaeopsis plants by crushing individuals or disturbing the soil near occurrences; however, preconstruction surveys, construction monitoring, and other measures will be implemented to avoid and minimize injury or mortality of this species during construction, as described in *AMM2 Construction Best Management Practices and Monitoring* (Appendix 3.C).

Indirect Construction-Related Effects

Disturbance outside of the project footprint could indirectly and temporarily affect 375 acres (6%) of modeled habitat (Table 5.6-6). These construction activities will include those associated with tidal marsh restoration, tunnel/pipeline construction, Fremont Weir and Yolo Bypass improvements, and levee construction for floodplain restoration. Such effects include growth inhibition, life cycle changes, and mortality resulting from fugitive dust and runoff (water, contaminants) generated by construction activities. Construction-related indirect effects will be minimized with implementation of AMM2. These effects are temporary and are not expected to last more than 1 year. In addition, construction traffic and construction and restoration activities that create temporary ground disturbances could introduce propagules of nonnative invasive plant species or cause existing populations of nonnative invasive plant species to expand, potentially reducing habitat suitability for native plants. Adverse effects caused by nonnative plant introduction will be minimized as with implementation of AMM11.

5.6.26.1.4 Effects of Ongoing Activities

The only ongoing direct effects on delta mudwort and Mason's lilaeopsis are habitat enhancement and management. Ultimately, management actions are expected to result in net benefits for both species.

Habitat Enhancement and Management

Habitat enhancement and management activities will affect habitat for delta mudwort and Mason's lilaeopsis. Conducting these activities, such as the control of nonnative vegetation, in tidal aquatic habitats to maintain and improve habitat functions of restored tidal aquatic habitats could result in mortality of delta mudwort and Mason's lilaeopsis, if they are present in work sites over the permit term. *CM11 Natural Communities Enhancement and Management* discusses the guidelines and techniques used in invasive plant control to minimize impacts on species and habitat (Chapter 3, Section 3.4.11.2.3, *General Enhancement and Management Actions, Invasive Plant Control*). The range of habitat enhancement and management activities that will be implemented in restored delta mudwort and Mason's lilaeopsis habitat is expected to maintain and improve habitat functions for these species over the permit term. No permanent direct effects or permanent or temporary indirect effects are expected for delta mudwort and Mason's lilaeopsis modeled habitat associated with habitat enhancement and management activities.

5.6.26.1.5 Other Indirect Effects

Salinity

Water operations (*CM1 Water Facilities and Operation*), tidal natural communities restoration (*CM4 Tidal Natural Communities Restoration*), and sea level rise are all expected to affect salinity throughout the Delta. These effects will be most significant in Suisun Marsh and the west Delta, less significant in the central Delta, and minimal in the north and south Delta (Appendix 5.C, *Flow, Passage, Salinity, and Turbidity*). In the late long-term period, salinity is expected to increase by 10 to 50% in Suisun Bay and in the west Delta; this is in addition to what would have been expected without the BDCP. Conditions are expected to be slightly more saline (10 to 20%) in the winter and spring, moderately more saline in the summer (20 to 30%), and significantly more saline (50%) between July and September. These salinity changes would not exceed the normal range of tolerance for these species and no adverse effects are expected. The covered activities will have no other indirect effects on delta mudwort or Mason's lilaeopsis.

Tidal Damping

Tidal muting or damping is a reduction in tidal amplitude or elevation range (the distance between the highest and lowest tidal elevation). Tidal damping causes the average elevation of low tide to increase and the average elevation of high tide to decrease. BDCP models predict tidal damping will occur throughout the Delta as a result of tidal natural communities restoration and the related increase in wetted surface area caused by reintroducing tidal action into previously leveed areas. The effect is localized and therefore greatest in those areas nearest tidal restoration sites. For a more detailed description of the modeling methods and results, see Appendix 5.C, Attachment 5C.A, *CALSIM and DSM2 Modeling Results for the Evaluated Starting Operations Scenarios*.

Tidal damping may cause currently available habitat for delta mudwort and Mason's lilaeopsis to contract near tidal restoration sites. In these areas, a decrease in the average elevation of high tide may result in desiccation and conversion of habitat such that is becomes unsuitable. Similarly, an increase in the mean elevation of low tide may result in loss of low-elevation habitat through flooding, resulting in a potential loss of habitat in both the upper and lower elevation ranges of the species. While the tidal damping effect will occur throughout the range of delta mudwort and Mason's lilaeopsis in the Plan Area, the timing of the effect will be widely dispersed both spatially and temporally. Tidal natural communities restoration will occur in Conservation Zones 1, 2, 3, and 4, and will be constructed gradually, in phases, between years 1 and 40 of the permit term (see Table 6-1, *Implementation Schedule for Water Facilities and Other Stressors Conservation Measures*, in Chapter 6, *Plan Implementation*, for the implementation schedule). In addition to the widely dispersed nature of the effect, occurrences of delta mudwort and Mason's lilaeopsis are configured in long, linear stretches with patches of individuals scattered throughout; only a portion of any given occurrence will be exposed to the most severe, localized effect of habitat flooding or conversion.

Overall, the net effects of tidal damping are not well understood. Climate change is likely to attenuate the effects of tidal damping over time, as sea level rises. Furthermore, the restoration of tidal inundation is expected to create additional habitat and foster the establishment of additional stands and occurrences of delta mudwort and Mason's lilaeopsis; a benefit that is expected to contribute to the conservation of the species in the Plan Area.

5.6.26.1.6 Impact of Take on Species

Delta mudwort and Mason's lilaeopsis are nearly endemic to the Plan Area. Thus, covered activities have the potential to affect the range-wide status of both species, as described below.

Delta Mudwort

In the west, delta mudwort occurs only in California. However, it is also found along the eastern seaboard from Maine to North Carolina. There are 58 extant occurrences of delta mudwort in California, all of which are in the Plan Area. Four (26%) of the occurrences are located partly or entirely on existing conservation lands categorized as Type 1, and 11 are located partly or entirely on existing conservation lands categorized as Type 2, 3, or 4 (Figure 2A.42-2, *Delta Mudwort Habitat Model and Recorded Occurrences*, in Appendix 2.A, *Covered Species Accounts*). Tidal damping has potential to affect an unknown number of occurrences. However, as mentioned above, tidal damping is expected to result in the loss of a small number of individuals or stands within any given occurrence of delta mudwort. An estimated 28 acres (less than 1%) of modeled habitat in the Plan Area will be lost. While the loss of individual plants is allowed up to a maximum of 5% of the total number of individuals within the occurrence, the BDCP will institute a no-net-loss policy for any take of occurrences. For delta mudwort and Mason's lilaeopsis, if the affected occurrence is composed of 10 individuals or more, mitigation will occur as described in AMM11 (Appendix 3.C). Therefore, implementation is not expected to adversely affect the long-term survival and conservation of delta mudwort.

Mason's Lilaeopsis

Mason's lilaeopsis is endemic to California, with all range-wide occurrences entirely within the state. Currently, there are 196 extant occurrences of Mason's lilaeopsis. Of these occurrences, 181 (92%) are located in the Plan Area. Twelve occurrences in the Plan Area (29%) are located partly or entirely on existing conservation lands categorized as Type 1, and 41 are located partly or entirely on existing conservation lands categorized as Type 2, 3, or 4. Five occurrences overlap partially with the permanent disturbance footprint of the tunnel/pipeline alignment for water conveyance facilities, and an unknown number of occurrences will be subject to the tidal damping effect of tidal restoration. The 28 acres of potential permanent habitat loss will occur in small, localized patches. The long, linear configuration of occurrences is ideal protection against a small, localized effect. While the loss of individual plants is allowed up to a maximum of 5% of the total number of individuals within the occurrence, the BDCP will institute a no-net-loss policy for any take of occurrences. However, because of the uncertainty surrounding the effect, it is possible that the implementation of the BDCP could adversely affect the species. The beneficial effects, described below, are expected to offset potential adverse effects of habitat loss and contribute to the conservation of the species in the Plan Area.

5.6.26.2 Beneficial Effects

Assuming the restored and protected natural communities will provide suitable species habitat proportional to the amount of modeled habitat that currently exists in these natural communities in the Plan Area, an estimated 2,587 acres of suitable delta mudwort and Mason's lilaeopsis habitat will be restored (Table 5.6-8), with full implementation of the BDCP. The conservation strategy includes restoration of 20 linear miles of transitional intertidal areas including tidal mudflat natural community and patches of subtidal and lower marsh. In addition, within the 65,000 acres of restored tidal natural communities and transitional uplands, the Implementation Office will restore or create at least 6,000 acres of tidal brackish emergent wetland in Conservation Zone 11 and at least 24,000 acres of tidal freshwater emergent wetland in Conservation Zones 1, 2, 4, 5, 6, and/or 7 (see Chapter 3, Section 3.3.7.36, *Delta Mudwort and Mason's Lilaeopsis*, for a description of the landscape and natural community objectives that will benefit these species).

Restored sites are expected to significantly increase the amount of available, high-value habitat. Restored habitat is expected to be of very high value primarily because of the topographic improvements that will be made in restored areas and the proximity of restored habitat to existing occurrences that will be necessary to provide propagules and seed for colonization. All restored delta mudwort and Mason's lilaeopsis habitat is expected to provide for the expansion of existing occurrences as well as the colonization of new ones. No net loss of Mason's lilaeopsis and delta mudwort occurrences within the restoration footprint, or the area of affected tidal range, will be permitted.

5.6.26.3 Net Effects

Assuming the restored and protected natural communities will provide species habitat proportional to the amount of modeled habitat that currently exists in these natural communities in the Plan Area, full implementation of the BDCP will result in an estimated net increase of 12,562 acres (42%) of high-value habitat for delta mudwort and Mason's lilaeopsis. Protected habitat will increase from 2,105 acres to an estimated 2,576 acres (122%) (Table 5.6-8). The habitat that will be lost as a result of water conveyance facilities construction, tidal restoration, Fremont Weir and Yolo Bypass improvements, and floodplain restoration is either occupied or in proximity to an occurrence. For this reason, habitat to be removed is considered to be of high value. However, habitat removal is expected to be scattered throughout the Delta in small patches and will only result in the partial loss of some occurrences (Table 5.6-9). The habitat that will be protected and restored is expected to be of equal or higher value than that which will be lost. This is primarily because small patches of occupied and unoccupied habitat will be lost, but large patches of habitat will be protected and restored. The improvement in habitat value is primarily due to more natural tidal channel form in restored areas. In addition, all conserved habitat will be protected and managed *in perpetuity* to ensure species-specific biological goals and objectives are achieved.

Overall, the BDCP will provide a net benefit to delta mudwort and Mason's lilaeopsis through the increase in available and protected habitat. These protected areas will be monitored and managed to sustain the species. Therefore, the BDCP will minimize and mitigate impacts, to the maximum extent practicable, and provide for the conservation and management of the delta mudwort and Mason's lilaeopsis in the Plan Area.

5.6.27 Delta Tule Pea and Suisun Marsh Aster

This section describes the adverse, beneficial, and net effects of the covered activities on the Delta tule pea and Suisun Marsh aster. The methods used to assess these effects are described in Section 5.2.8, *Effects Analysis for Wildlife and Plant Species*. The habitat model for the Delta tule pea and Suisun Marsh aster includes freshwater emergent wetland within the legal Delta and tidal brackish emergent marsh with an elevation range of 7 to 10 feet in Suisun Marsh. Further details regarding the habitat model, including assumptions on which the model is based, are provided in Appendix 2.A, *Covered Species Accounts.* Because these species are so widely distributed throughout the Plan Area, the primary factor considered in assessing the value of Delta tule pea and Suisun Marsh aster is the presence of occurrences.

5.6.27.1 Adverse Effects

5.6.27.1.1 Permanent Habitat Loss, Conversion, and Fragmentation

Covered activities will result in the permanent loss of up to 3 acres[36] of habitat (less than 1% of the habitat in the Plan Area) for Delta tule pea and Suisun Marsh aster (Table 5.6-2). To provide flexibility in implementation of tidal restoration projects, the take limit for Delta tule pea and Suisun Marsh aster is set higher than the amount of loss estimated under the hypothetical footprint. Up to 50 acres of Delta tule pea and Suisun Marsh aster habitat may be lost through covered activities. Covered activities resulting in adverse effects on Delta tule pea and Suisun Marsh aster include water conveyance facility construction and tidal natural communities restoration. There will be no loss of Delta tule pea and Suisun Marsh aster occurrences (Table 5.6-9).

Water Conveyance Facility Construction

This activity, including transmission-line construction, will result in the permanent loss of approximately 2 acre of Delta tule pea and Suisun Marsh aster modeled habitat (Table 5.6-2).

Tidal Natural Communities Restoration

Based on the hypothetical restoration footprint, this activity will result in the permanent removal or fragmentation of an estimated 1 acre of modeled habitat (less than 1% of modeled habitat) for the Delta tule pea and Suisun Marsh aster (Table 5.6-2) in Conservation Zone 6. However, the actual tidal restoration effects are likely to differ from the hypothetical footprint used to estimate loss. Up to 50 acres of Delta tule pea and Suisun Marsh aster habitat may be lost through covered activities.

5.6.27.1.2 Periodic Inundation

Floodplain restoration and flooding of Yolo Bypass are expected to result in periodic inundation of Delta tule pea and Suisun Marsh aster habitat.

Yolo Bypass Operations

Appendix 5.J, *Effects on Natural Communities, Wildlife, and Plants,* provides the method used to estimate periodic inundation effects in the Yolo Bypass. Based on this method, periodic inundation

[36] Habitat loss acreage estimates are based on hypothetical footprints and models and anticipated take levels rather than detailed project-level design and represent the maximum allowed under the permit. Actual losses will be tracked through compliance monitoring to ensure that they do not exceed estimates.

could affect Delta tule pea and Suisun Marsh aster. For Delta tule pea and Suisun Marsh aster, periodic inundation could affect from an estimated 2 acres of modeled habitat during a notch flow of 5,000 cfs, up to an estimated 3 acres of modeled habitat during a notch flow of 4,000 cfs (Table 5.6-4). Project-associated inundation of areas that would not otherwise have been inundated will likely occur in no more than 30% of all years, because Fremont Weir is expected to overtop the remaining estimated 70% of all years, and during those years notch operations will not typically affect the maximum extent of inundation. In more than half of all years under existing conditions, an area greater than the project-related inundation area already inundates the bypass. That is, under current conditions, the area of inundation in 50% of all years is greater than the estimated maximum periodic inundation of modeled habitat associated with Yolo Bypass operations (3 acres for Delta tule pea and Suisun Marsh aster). There are no known extant occurrences of Delta tule pea or Suisun Marsh aster in the Yolo Bypass.

Floodplain Restoration

Implementation of *CM5 Seasonally Inundated Floodplain*, by setting back levees and encouraging an expansion of flooded habitat, is expected to increase the frequency and duration of flooding in Conservation Zone 7. One acre of Delta tule pea and Suisun Marsh aster modeled habitat overlaps with floodplain areas in Conservation Zone 7 likely to be restored and therefore periodically inundated during the implementation of the BDCP (Table 5.6-4). There are no known occurrences of the Delta tule pea or Suisun Marsh aster known in Conservation Zone 7. Increased inundation and floodplain scour associated with a more natural flood regime is expected to be within the normal range of flood tolerance and disturbance for these two plant species.

5.6.27.1.3 Construction-Related Effects

Permanent, construction-related effects are described in Section 5.6.27.1.1, *Permanent Habitat Loss, Conversion, and Fragmentation*. Other construction-related effects on this species consist of temporary habitat loss, construction-related injury or mortality, and the indirect effects of construction-related activities.

Temporary Habitat Loss

Construction-related effects will temporarily disturb 1 acre (less than 1%) of habitat for Delta tule pea and Suisun Marsh aster (Table 5.6-2). Temporary disturbance of Delta tule pea and Suisun Marsh aster has potential to remove individuals and partially disturb occurrences. Temporarily disturbed areas will be restored as tidal freshwater emergent wetland and valley/foothill riparian habitat within 1 year following completion of construction and management activities.

Construction-Related Injury or Mortality

Construction may cause injury or mortality to Delta tule pea and Suisun Marsh aster by crushing individuals or disturbing the soil near occurrences; however, preconstruction surveys, construction monitoring, and other measures will be implemented to avoid and minimize injury or mortality of this species during construction, as described in *AMM2 Construction Best Management Practices and Monitoring* (Appendix 3.C, *Avoidance and Minimization Measures*).

Indirect Construction-Related Effects

Disturbance outside of the project footprint but within 250 feet of construction activities could indirectly and temporarily affect the use of 426 acres (7%) of modeled habitat (Table 5.6-6). These construction activities will include tidal marsh restoration, water conveyance construction, and floodplain restoration levee construction. Indirect effects may include growth inhibition, life-cycle changes (e.g., changes to normal flowering or dormancy patterns), and mortality resulting from fugitive dust and runoff (water, contaminants) generated by construction activities. Construction-related indirect effects will be minimized with implementation of AMM2, as described in Appendix 3.C. In addition, construction traffic and construction and restoration activities that create temporary ground disturbances may introduce propagules of nonnative invasive plant species or cause existing populations of nonnative invasive plant species to expand, potentially reducing habitat suitability for native plants. Adverse effects caused by nonnative plant introduction will be minimized with implementation of *AMM11 Covered Plant Species*.

5.6.27.1.4 Effects of Ongoing Activities

The only ongoing direct effects on Delta tule pea and Suisun Marsh aster are habitat enhancement and management. Ultimately, management actions are expected to result in net benefits for both species.

Habitat Enhancement and Management

Habitat enhancement and management activities will affect habitat for Delta tule pea and Suisun Marsh aster. Conducting these activities, such as the control of nonnative vegetation, in tidal aquatic habitats in order to maintain and improve habitat functions of restored tidal aquatic habitats could result in mortality of Delta tule pea and Suisun Marsh aster if they are present in work sites over the permit term. *CM11 Natural Communities Enhancement and Management* discusses the guidelines and techniques used in invasive plant control to minimize impacts to species and habitat (Chapter 3, Section 3.4.11.2.3, *General Enhancement and Management Actions, Invasive Plant Control*). The range of habitat enhancement and management activities that will be implemented in restored Delta tule pea and Suisun Marsh aster habitat is expected to maintain and improve the functions of the habitat for these species over the permit term. No permanent direct effects or permanent or temporary indirect effects are expected for Delta tule pea and Suisun Marsh aster modeled habitat associated with habitat enhancement and management activities.

5.6.27.1.5 Other Indirect Effects

Salinity

Water operations (*CM1 Water Facilities and Operation*), tidal natural communities restoration (*CM4 Tidal Natural Communities Restoration*), and sea level rise are all expected to affect salinity throughout the Delta. Most significantly affected will be Suisun Bay and the west Delta, with less significant effects in the central Delta, and little to no anticipated effects in the north and south Deltas. Salinity is expected to increase by 10 to 50% in Suisun Bay and the west Delta in addition to what would have been expected without the BDCP. Conditions are expected to be only slightly more saline (10 to 20%) in the winter and spring, moderately more saline in the summer (20 to 30%) and significantly more saline (50%) between July and September. For more detail regarding the increase in salinity see Appendix 5.C, *Flow, Passage, Salinity, and Turbidity*.

The change in salinity associated with BDCP implementation is expected to be within the range of salinity tolerance for Delta tule pea and Suisun Marsh aster, based on the distribution of the species throughout its range within similar salinity regimes. There are occurrences found as far west as the Carquinez Strait area between the cities of Rodeo and Martinez. Geographically speaking, these occurrences are much closer to the ocean and thus experience increased concentrations of salinity. Therefore, no further attempt was made to quantify the effect of salinity change on these species. While some change in spatial distribution is expected, changes to salinity overall are not expected to have a measurable effect on Delta tule pea and Suisun Marsh aster.

Tidal Damping

Tidal muting or damping is a reduction in tidal amplitude or elevation range (the distance between the highest and lowest tidal elevation). The potential effects of tidal damping on habitat are described in for delta mudwort and Mason's lilaeopsis, in Section 5.6.26.1.5, *Other Indirect Effects*.

Overall, the effects of tidal damping are not well understood. Climate change is likely to attenuate the effects of tidal damping over time, as sea level rises. Furthermore, the restoration of tidal inundation is expected to create additional habitat and foster the establishment of new stands or occurrences of Delta tule pea and Suisun Marsh aster; a benefit that is expected to contribute to the conservation of the species in the Plan Area.

5.6.27.1.6 Impact of Take on Species

Delta tule pea and Suisun Marsh aster are endemic to California, with all range-wide occurrences entirely within the state. Currently, there are 133 extant occurrences of Delta tule pea range-wide, of which 106 are within the Plan Area. There are 174 extant occurrences of Suisun Marsh aster range-wide, 164 of which are in the Plan Area. These two species are limited to the North Bay region of the San Francisco Bay, so the remainder of the occurrences are found in Napa and Petaluma marshes or along the edge of the bay. Of the 106 Delta tule pea Plan Area occurrences, eight occur on existing conservation lands categorized as Type 1, and 51 occur on existing conservation lands categorized as Type 2, 3, or 4. Fourteen of the 174 Suisun Marsh aster occurrences occur on existing conservation lands (Type 1), and 49 occur on existing conservation lands (Type 2, 3, or 4) (Table 5.6-9).

The 50 acres of potential permanent loss will occur in small, localized patches. The long, linear configuration of occurrences is ideal protection against a small, localized effect. While it is expected that some portion of an occurrence could be affected by tidal range contraction, it is not expected that any one entire occurrence will be lost. However, because of the uncertainty surrounding the effect, it is possible that the implementation of the BDCP could adversely affect the species. Beneficial effects of covered activities, described below, are expected to offset potential adverse effects of habitat loss and contribute to the conservation of the species in the Plan Area.

5.6.27.2 Beneficial Effects

Assuming the restored and protected natural communities will provide suitable habitat proportional to the amount of modeled habitat that currently exists within these natural communities in the Plan Area, full implementation of the BDCP will result in restoration of an estimated 3,792 acres of Delta tule pea and Suisun Marsh habitat (Table 5.6-8). The breaching of levees and the restoration of sinuous, high-density, dendritic networks of tidal channels provides the bulk of the 3,792 acres of restored suitable habitat. Restored sites are expected to significantly increase the amount of available, high-value habitat. Restored habitat is expected to be of very high value primarily because of the topographic improvements that will be made in restored areas and the proximity of restored habitat to existing occurrences that will be necessary to provide propagules and seed for colonization. Restored and protected Delta tule pea and Suisun Marsh aster habitat is expected to provide for the expansion of existing occurrences as well as the colonization of new ones (see Chapter 3, Section 3.3.7.37, *Delta Tule Pea and Suisun Marsh Aster,* for a more complete description of the landscape and natural community objectives that will benefit these species).

5.6.27.3 Net Effects

Assuming the restored and protected riparian natural communities will provide suitable habitat proportional to the amount of modeled habitat that currently exists in these natural communities in the Plan Area, full implementation of the BDCP will result in an estimated net increase of 3,789 acres (65%) of high-value habitat and 3,791 acres (70%) of additional protected habitat for the Delta tule pea and Suisun Marsh aster (Table 5.6-8). The habitat that will be lost as a result of covered activities is either occupied or in proximity to an occurrence and is therefore considered of high value. However, habitat that will be removed is expected to be scattered throughout the Delta in small patches and will only result in the partial loss of occurrences rather than permanent loss of entire occurrences. The habitat that will be protected and restored is expected to be of equal or higher value than that which is expected to be lost. This is primarily because small patches of occupied and unoccupied habitat will be lost, but large patches of habitat will be protected and restored. The improvement in habitat value is primarily due to the more natural tidal channel form that restored areas will have. In addition, all conserved habitat will be protected and managed to ensure species-specific biological goals and objectives are achieved *in perpetuity.*

Overall, the BDCP will provide a substantial net benefit to the Delta tule pea and Suisun Marsh aster through the increase in suitable, protected habitat. Protected areas will be managed and monitored to support the species. Therefore, the BDCP will minimize and mitigate impacts, to the maximum extent practicable, and provide for the conservation and management of the Delta tule pea and Suisun Marsh aster in the Plan Area.

5.6.28 Side-Flowering Skullcap

This section describes the adverse, beneficial, and net effects of the covered activities on the side-flowering skullcap. The methods used to assess these effects are described in Section 5.2.8, *Effects Analysis for Wildlife and Plant Species*. The habitat model for the side-flowering skullcap includes a subset of nine vegetation types in the valley/foothill riparian natural community. These vegetation types were mapped by Hickson and Keeler Wolf (2007) and could generally be described as cottonwood, alder, willow, and oak riparian forest. Further details regarding the habitat model, including assumptions on which the model is based, are provided in Appendix 2.A, *Covered Species Accounts.* Factors considered in assessing the value of affected habitat for the side-flowering skullcap, to the extent that information is available, include the size and density of riparian patches, connectivity between patches as well as with other natural communities, proximity to existing conservation lands, and the presence of recorded occurrences of side-flowering skullcap as well as other rare species.

5.6.28.1 Adverse Effects

5.6.28.1.1 Permanent Habitat Loss, Conversion, and Fragmentation

Covered activities will result in the permanent loss and/or fragmentation of up to 8 acres[37] of habit (less than 1% of the habitat in the Plan Area) for the side-flowering skullcap (Table 5.6-2). Covered activities resulting in adverse effects on side-flowering skullcap include water conveyance facility construction, tidal habitat restoration, and floodplain restoration. There will be no loss of side-flowering skullcap occurrences (Table 5.6-9).

Water Conveyance Facility Construction

This activity will result in the permanent removal and/or fragmentation of approximately 3 acres (less than 1%) of side-flowering skullcap modeled habitat (Table 5.6-2). Water conveyance facility construction in Conservation Zone 3 occurs in five distinct but proximate locations along the Sacramento River west and south of Elk Grove. The side-flowering skullcap modeled habitat that overlaps with the facility footprint are composed of long, linear patches of riparian habitat along the Sacramento River. Due to the small patch size and fragmented nature, these acres of riparian habitat are considered to be of low to moderate value. There are no known occurrences of side-flowering skullcap along this reach of the Sacramento River.

Tidal Natural Communities Restoration

Based on the hypothetical restoration footprint, this activity will result in the permanent removal and/or fragmentation of an estimated 4 acres (less than 1%) of side-flowering skullcap modeled habitat (Table 5.6-2). However, the actual tidal restoration effects are likely to differ from the hypothetical footprint used to estimate loss. To provide flexibility in implementation of tidal restoration projects, the take limit for side-flowering skullcap habitat is set higher than the amount of loss estimated under the hypothetical footprint. Up to 50 acres of side-flowering skullcap habitat may be lost through covered activities.

The hypothetical restoration footprint overlaps with 2 acres of side-flowering skullcap modeled habitat Conservation Zones 1 and 2, these areas are considered to be of low to moderate value as there is very little riparian habitat and no known occurrences of side-flowering skullcap. In Conservation Zones 4 and 5, 2 acres of side-flowering skullcap modeled habitat are affected. Habitat is considered to be of higher value in this area, especially in Conservation Zone 4, as this is where the highest concentration of occurrences is found. Tidal restoration will not result in the removal of occurrences and is expected to benefit the species by creating additional transitional intertidal habitat.

Floodplain Restoration

The associated levee construction will result in the permanent removal of approximately 1 acre of side-flowering skullcap modeled habitat (Table 5.6-2). This area is located just south of the Interstate 205 bridge at Mossdale Landing and just west of Weatherbee Lake. This area is of low or moderate habitat value due to the small and fragmented nature of the patch, the adjacent land use,

[37] Habitat loss acreage estimates are based on hypothetical footprints and models and anticipated take levels rather than detailed project-level design and represent the maximum allowed under the permit. Actual losses will be tracked through compliance monitoring to ensure that they do not exceed estimates.

which is often cultivated lands, and the lack of side-flowering skullcap occurrences or adjacent conservation land.

5.6.28.1.2 Periodic Inundation

Yolo Bypass Operations

Appendix 5.J, *Effects on Natural Communities, Wildlife, and Plants,* provides the method used to estimate periodic inundation effects in the Yolo Bypass. Based on this method, periodic inundation could affect side-flowering skullcap. For this species, periodic inundation could affect from an estimated 2 acres of modeled habitat during a notch flow of 1,000 cfs to an estimated 3 acres of modeled habitat during a notch flow of 4,000 cfs (Table 5.6-4). Project-associated inundation of areas that would not otherwise have been inundated will likely occur in no more than 30% of all years, because Fremont Weir is expected to overtop the remaining estimated 70% of all years, and during those years notch operations will not typically affect the maximum extent of inundation. In more than half of all years under existing conditions, an area greater than the project-related inundation area already inundates the bypass. That is, under current conditions, the area of inundation in 50% of all years is greater than the estimated maximum periodic inundation of modeled habitat associated with Yolo Bypass operations (3 acres). There are no known occurrences of side-flowering skullcap in Yolo Bypass.

Floodplain Restoration

This activity will periodically inundate 6 acres (less than 1%) of side-flowering skullcap habitat, primarily in Conservation Zone 7, where there are no known occurrences of side-flowering skullcap. The inundation effect is expected to be within the natural range of inundation tolerance of this species and therefore is expected to have either no or possibly beneficial effects on side-flowering skullcap habitat.

5.6.28.1.3 Construction-Related Effects

Permanent, construction-related effects are described in Section 5.6.28.1.1, *Permanent Habitat Loss, Conversion, and Fragmentation*. Other construction-related effects on this species consist of temporary habitat loss associated with the conveyance facility construction and floodplain restoration, construction-related injury or mortality, and temporary disturbance associated with indirect, construction-related effects.

Temporary Habitat Loss

Construction activities will result in temporary removal of an estimated 6 acres (less than 1%) of side-flowering skullcap habitat (Table 5.6-2). Construction of the conveyance facility accounts for 5 acres of temporary impacts, and levee construction accounts for 1 acre of temporary impacts. Temporarily disturbed areas will be restored as side-flowering skullcap habitat within 1 year following completion of construction and management activities.

Construction-Related Injury or Mortality

Construction may cause injury or mortality to side-flowering skullcap individuals or stands by crushing individuals or disturbing the soil near occurrences; however, preconstruction surveys, construction monitoring, and other measures will be implemented under *AMM2 Construction Best*

Management Practices and Monitoring to avoid and minimize injury or mortality of this species during construction, as described in Appendix 3.C, *Avoidance and Minimization Measures*.

Indirect Construction-Related Effects

Disturbance of side-flowering skullcap habitat outside of the project footprint could indirectly and temporarily affect 125 acres (5%) of modeled habitat for the species (Table 5.6-6). Such effects may include growth inhibition, life cycle changes, and mortality resulting from fugitive dust and runoff (water, contaminants) generated by construction activities. Construction-related indirect effects will be minimized with implementation of AMM2. Construction may also introduce propagules of nonnative invasive plant species or cause existing populations of nonnative invasive plant species to expand, potentially reducing habitat suitability for side-flowering skullcap. Adverse effects caused by nonnative plant introduction will be minimized as with implementation of *AMM11 Covered Plant Species*.

5.6.28.1.4 Effects of Ongoing Activities

The only ongoing activities that will affect the species are habitat enhancement and management activities.

Habitat Enhancement and Management

Habitat enhancement and management activities will affect habitat for side-flowering skullcap. Habitat management and enhancement related activities in tidal aquatic habitats, such as the control of nonnative vegetation, to maintain and improve habitat functions of restored tidal aquatic habitats could result in the mortality of side-flowering skullcap individuals if present in work sites over the permit term. *CM11 Natural Communities Enhancement and Management* discusses the guidelines and techniques used in invasive plant control to minimize impacts to species and habitat (Chapter 3, Section 3.4.11.2.3, *General Enhancement and Management Actions, Invasive Plant Control*). The range of habitat management and enhancement activities that could be implemented in restored side-flowering skullcap habitat is expected to maintain and improve the functions of the habitat for side-flowering skullcap over the permit term.

5.6.28.1.5 Other Indirect Effects

Tidal Damping

Tidal damping is a reduction in tidal amplitude or elevation range (the distance between the highest and lowest tidal elevation). The potential effects of tidal damping on habitat are described in Section 5.6.26.1.5, *Other Indirect Effects.*

Overall, the effects of tidal damping are not well understood. Climate change is likely to attenuate the effects of tidal damping over time, as sea level rises. Furthermore, the restoration of tidal inundation is expected to create additional habitat and foster the establishment of additional stands or occurrences of delta mudwort and Mason's lilaeopsis; a benefit that is expected to contribute to the conservation of the species in the Plan Area.

5.6.28.1.6 Impact of Take on Species

Side-flowering skullcap is found throughout the continental United States, with the exception of Nevada, Utah and Wyoming. While occurrences in California are rare (California Native Plant Society

2011) and localized to the Plan Area, side-flowering skullcap is widely distributed elsewhere and is known to be relatively common in the Midwest and on the East Coast.

All 12 of the known, extant occurrences of side-flowering skullcap in the state are in the Plan Area (Table 5.6-9). Ten of the 12 known occurrences occur on existing conservation lands (Type 1). In summer 2009, during botanical surveys of the Plan Area, side-flowering skullcap was found growing on rotting pilings and stumps in and along the channels of Snodgrass Slough, Lost Slough, and the Mokelumne River. The habitat is this area is considered of high value for this species, as evidenced by the high density of occurrences.

The permanent loss of 8 acres (less than 1%) and the temporary loss of 3 acres of modeled habitat are not expected to adversely affect the long-term survival and conservation of side-flowering skullcap as the majority of effects do not occur in the area known to provide habitat for current, extant occurrences.

5.6.28.2 Beneficial Effects

Assuming riparian natural community restoration and protection will provide suitable side-flowering skullcap habitat proportional to the amount of modeled habitat that currently exists in these natural communities in the Plan Area, full implementation of the BDCP will increase modeled habitat by an estimated 695 acres (26%) (Table 5.6-8). Riparian restoration will be performed at the same time and in the same locations as the following conservation measures: floodplain restoration (*CM5 Seasonally Inundated Floodplain*), tidal marsh restoration (*CM4 Tidal Natural Communities Restoration*), and channel margin enhancement (*CM6 Channel Margin Enhancement*). The restored habitat is expected to be of moderate to high value for side-flowering skullcap in that it is likely to contain larger, better-connected patches where woody debris can collect and provide new habitat.

5.6.28.3 Net Effects

Full implementation of the BDCP will result in an estimated net increase of 687 acres (28%) of available habitat and an estimated net increase of 693 acres (103%) on conservation lands (Table 5.6-8). Restored and protected habitat is expected to be of moderate to high value for the side-flowering skullcap. Riparian restoration associated with tidal restoration in Conservation Zone 4 is expected to produce the side-flowering skullcap habitat of highest value because the greatest density of occurrences is found in the Cosumnes/Mokelumne ROA. Restoration in this area has the greatest potential to expand the range and distribution of the side-flowering skullcap in the Plan Area. Therefore, the BDCP will minimize and mitigate impacts, to the maximum extent practicable, and provide for the conservation and management of the side-flowered skullcap in the Plan Area.

5.6.29 Slough Thistle

This section describes the adverse, beneficial, and net effects of the covered activities on the slough thistle. The methods used to assess these effects are described in Section 5.2.8, *Effects Analysis for Wildlife and Plant Species*. The habitat model for the slough thistle includes all areas between the levees from the Interstate 205 Bridge near Mossdale Landing to the southern border of the Plan Area in Vernalis. There is one presumed extant and one possibly extirpated occurrence of slough thistle in this area. Further details regarding the habitat model, including assumptions on which the model is based, are provided in Appendix 2.A, *Covered Species Accounts.* Factors considered in assessing the value of affected habitat for the slough thistle, to the extent that information is available, include patch size, level of fragmentation, adjacency to existing conservation lands, proximity to extant slough thistle occurrences, known ability to support a robust slough thistle population, hydrology, geomorphology, and patch connectivity.

5.6.29.1 Adverse Effects

5.6.29.1.1 Permanent Habitat Loss, Conversion, and Fragmentation

Covered activities will result in the permanent loss and/or fragmentation of up to 5 acres[38] (less than 1% of the habitat in the Plan Area) of slough thistle habitat (Table 5.6-2). Covered activities resulting in adverse effects on slough thistle include floodplain restoration. No loss of slough thistle occurrences will occur as a result of covered activities (Table 5.6-9).

Floodplain Restoration

Based on the hypothetical floodplain restoration footprint, levee construction associated with floodplain restoration will result in the permanent removal of an estimated 5 acres of modeled slough thistle habitat (Table 5.6-2). However, the actual tidal restoration effects are likely to differ from the hypothetical footprint used to estimate loss. To provide flexibility in implementation of tidal restoration projects, the take limit for slough thistle habitat is set higher than the amount of loss estimated under the hypothetical footprint. Up to 50 acres of slough thistle habitat may be lost through covered activities.

The 5 acres of estimated loss based on the hypothetical footprint represent many small overlaps between the hypothetical floodplain restoration footprint, which occurs almost exclusively outside the levees of the San Joaquin, Old, and Middle Rivers, and slough thistle modeled habitat, which occurs exclusively inside the levees of the San Joaquin River. The permanent effects associated with floodplain restoration will occur almost exclusively outside the levees, on cultivated lands. The effects on slough thistle habitat acreage occur in the location of large levee breaches, where flood flows will access newly restored floodplain.

The 5 acres of slough thistle modeled habitat that overlapped with the hypothetical floodplain restoration footprint are considered high-value habitat. These acres occur in modeled habitat that is proximate to a presumed extant occurrence of slough thistle. The San Joaquin River in this portion of the Plan Area has some of the river and floodplain habitat of highest value in that it has some remnant geomorphological traits such as river meanders, riffles, and gravel bars. Conservation lands are interspersed throughout this reach of the San Joaquin River and just outside the Plan Area, to the south and east, is the San Joaquin River National Wildlife Refuge, which represents some of the largest, most intact riparian scrub and forest habitat in the greater Delta area.

5.6.29.1.2 Periodic Inundation

Floodplain restoration is the only covered activity expected to result in periodic inundation of slough thistle habitat.

[38] Habitat loss acreage estimates are based on hypothetical footprints and models and anticipated take levels rather than detailed project-level design and represent the maximum allowed under the permit. Actual losses will be tracked through compliance monitoring to ensure that they do not exceed estimates.

Floodplain Restoration

This activity will periodically inundate an estimated 6 acres of habitat for the slough thistle (less than 1% of the modeled habitat in the Plan Area). This periodic effect, however, is within the tolerance range of the slough thistle and is expected to increase the value of the existing habitat by reestablishing scour processes that create and maintain this species' habitat.

5.6.29.1.3 Construction-Related Effects

Permanent, construction-related effects are described in Section 5.6.29.1.1, *Permanent Habitat Loss, Conversion, and Fragmentation*. Other construction-related effects on this species consist of temporary habitat loss, construction-related injury or mortality, and other indirect effects.

Temporary Habitat Loss

Construction-related effects will temporarily disturb 6 acres of habitat for the slough thistle (less than 1% of the modeled habitat in the Plan Area) (Table 5.6-2). Temporary ground disturbance will occur in discrete patches between Mossdale Bridge and Vernalis, where slough thistle modeled habitat overlaps with the planned location of floodplain restoration. Restoration design that may include occupied slough thistle habitat providing direct, temporary loss of occupied habitat from construction activities will be avoided under *AMM11 Covered Plant Species*, as described in Appendix 3.C, *Avoidance and Minimization Measures*.

Temporarily affected areas will be restored as riparian habitat within 1 year following the completion of construction activities but are not expected to mature to existing conditions for several years or more, depending on the successional stage of the affected area. Because slough thistle depends on early successional riparian habitat, the habitat is expected to meet requirements for this species within the first few years after restoration construction in the temporarily disturbed area is completed.

Construction-Related Injury or Mortality

Under AMM11, construction activities will avoid direct injury or mortality to individual slough thistle plants.

Indirect Construction-Related Effects

Disturbance of modeled slough thistle habitat outside of the project footprint could indirectly and temporarily affect 25 acres (1%) of modeled habitat for slough thistle (Table 5.6-6). Should additional occurrences be located near but outside the project footprint, construction-related indirect effects will be minimized with implementation of *AMM2 Construction Best Management Practices and Monitoring*, as described in Appendix 3.C. In addition, construction traffic and construction and restoration activities that create temporary ground disturbances could introduce propagules of nonnative invasive plant species or cause existing populations of nonnative invasive plant species to expand, potentially reducing habitat suitability for native plants. Adverse effects caused by nonnative plant introduction will be minimized as with implementation of AMM11.

5.6.29.1.4 Effects of Ongoing Activities

Habitat Enhancement and Management

Habitat enhancement and management activities will affect habitat for the slough thistle in restored floodplains in Conservation Zone 7. Activities such as the control of nonnative vegetation to maintain and improve habitat functions of existing floodplains or channel margin habitat, could result in mortality of slough thistle if plants are present in work sites or treated habitat over the permit term. *CM11 Natural Communities Enhancement and Management* addresses the guidelines and techniques used in invasive plant control to minimize impacts to species and habitat (Chapter 3, Section 3.4.11.2.3, *General Enhancement and Management Actions, Invasive Plant Control*). The range of habitat management and enhancement activities that could be implemented in restored slough thistle habitat is expected to maintain and improve the functions of the habitat for slough thistle over the permit term.

Recreation

Passive recreation in the reserve system, where that recreation is compatible with the biological goals and objectives, could result in disturbance of slough thistle plants if hikers or dogs illegally travel off trail. However, *AMM37 Recreation* (Appendix 3.C) limits trail placement to within 50 feet of occurrences to reduce risk of accidental trampling. AMM37 also requires trail construction to avoid all occurrences of delta button celery. With recreation restrictions in place, as required under AMM37, recreation-related effects on slough thistle are expected to be minimal.

5.6.29.1.5 Other Indirect Effects

No other known indirect effects on slough thistle will result from covered activities.

5.6.29.1.6 Impact of Take on Species

Slough thistle is endemic to the San Joaquin Valley and is known from 19 occurrences, two of which are in the Plan Area (Table 5.6-9). The remaining occurrences are from San Joaquin County in the north and in Kings and Kern Counties in the south (California Department of Fish and Wildlife 2013h). A possibly extirpated occurrence in the Plan Area is located just north of the Interstate 205 bridge near Mossdale Landing (California Department of Fish and Wildlife 2013h). The extant occurrence is from a 1974 account and is described as being 1 mile north of the San Joaquin River Club on the San Joaquin River. The Plan Area occurrence, if extant as presumed, would be the northernmost occurrence of the species, with a considerably large gap separating it from those in the south.

The permanent loss of 5 acres of slough thistle habitat is not expected to adversely affect the long-term survival and conservation of this species. While those 5 acres are considered of high value, they exist in small, fragmented patches along the linear extent of the riparian community between the levees of the San Joaquin River. Direct effects on slough thistle individuals will be avoided by the application of avoidance and minimization measures described in Appendix 3.C.

Temporary and periodic effects on slough thistle habitat are minimal, as described above. These effects, like permanent effects, are in small, scattered patches and will not be incurred upon individual plants or on the population. Preconstruction surveys will identify and avoid individual plants. Because the remaining occurrence is within the levees, the levees will not be graded for the purposes of restoration. However, grading and levee setbacks in and around the remaining occurrence could have potential adverse effects on the occurrence by creating small- or moderate-scale hydrologic or geomorphologic changes to areas that support the occurrence. Careful restoration siting and planning will be necessary to avoid any and all effects on the remaining slough thistle occurrence in the Plan Area (AMM11 in Appendix 3.C). The small area of permanent and temporary effects on modeled habitat is not expected to adversely affect the species' long-term survival and conservation.

5.6.29.2 Beneficial Effects

Absent the persistence or discovery of slough thistle occurrences that can be managed and enhanced, under BDCP[39], full implementation of the BDCP will result in the establishment and management of two occurrences of slough thistle within the restored floodplain habitat on the mainstem of the San Joaquin River in Conservation Zone 7. See Chapter 3, Section 3.4.11.2.5, *Riparian Natural Community, Enhancement and Management Actions*, for a description of occurrence creation, enhancement, and management actions and considerations and Section 3.4.11.2.4, *Aquatic and Emergent Wetland Natural Communities*, *Vegetation Management*, for seed banking and nursery considerations associated with establishing an occurrence. The mainstem of the San Joaquin River, especially south of Mossdale, contains the slough thistle habitat of highest value: it is proximate to one extant and one possibly extirpated occurrence, is adjacent to existing conservation lands, and has geomorphic signatures more consistent with historical conditions. Occurrences will be established in those areas with suitable soils and hydrology.

Assuming the restored valley/foothill riparian forest natural community will provide suitable species habitat proportional to the amount of modeled habitat that currently exists within these natural communities in the Plan Area, an estimated 214 acres of slough thistle habitat will be restored (*CM7 Riparian Natural Community Restoration*). In addition, an estimated 750 acres of habitat will be protected (*CM3 Natural Communities Protection and Restoration*) (Table 5.6-8).

Restored and protected riparian acres will be part of the larger restored floodplain (*CM5 Seasonally Inundated Floodplain Restoration*) and managed and enhanced as part of the BDCP reserve system (*CM11 Natural Communities Enhancement and Management*). BDCP conservation lands will expand on, and provide connectivity between, existing conservation lands such as the San Joaquin National Wildlife Refuge. In addition, the BDCP will protect or establish two occurrences of slough thistle in the newly created floodplain on the San Joaquin River between Mossdale and Vernalis.

5.6.29.3 Net Effects

Full implementation of the BDCP will result in the permanent loss of 50 acres (3%). Assuming the restored and protected natural communities will provide suitable species habitat proportional to the amount of modeled habitat that currently exists in the Plan Area, valley/foothill riparian natural community restoration will result an estimated net increase of 209 acres (11%) of slough thistle habitat and an estimated net increase of 964 acres (260%) of slough thistle habitat on conservation lands (Table 5.6-8). Newly restored and protected acres are expected to be of equal or greater habitat value than those lost. The protection and management of two occurrences within newly

[39] Objective ST1.1 allows for the establishment of up to two occurrences of slough thistle in absence of discovery of extant occurrences. Protection and management is preferable to occurrence establishment given ecological and genetic concerns.

restored riparian areas and a reconnection of this habitat with an active floodplain will contribute to the conservation of the species in the northern-most extent of its range. In addition, protected habitat and occurrences will be managed and monitored to support the species. Therefore, the BDCP will minimize and mitigate impacts, to the maximum extent practicable, and provide for the conservation and management of the slough thistle in the Plan Area.

5.6.30 Soft Bird's-Beak and Suisun Thistle

This section describes the adverse, beneficial, and net effects of the covered activities on soft bird's-beak and Suisun thistle. The methods used to assess these effects are described in Section 5.2.8, *Effects Analysis for Wildlife and Plant Species*. The habitat model for soft bird's-beak and Suisun thistle includes pickleweed (*Salicornia pacifica*) and saltgrass-dominated vegetation. Further details regarding the habitat model, including assumptions on which the model is based, are provided in Appendix 2.A, *Covered Species Accounts*. Factors considered in assessing the value of affected habitat for Suisun thistle and soft bird's-beak, to the extent that information is available, include the presence of known occurrences, the proximity to conservation lands, and overall patch size.

5.6.30.1 Adverse Effects

5.6.30.1.1 Permanent Habitat Loss, Conversion, and Fragmentation

Covered activities will result in the permanent loss of up to 73 acres[40] of modeled soft bird's-beak habitat (6% of the habitat in the Plan Area) and 73 acres of modeled Suisun thistle habitat (6% of the habitat in the Plan Area) (Table 5.6-2). Tidal natural communities restoration is the only covered activity resulting in permanent loss, conversion, or fragmentation of soft bird's-beak and Suisun thistle habitat. Covered activities will not result in the loss of soft bird's-beak or Suisun thistle occurrences (Table 5.6-9).

Tidal Natural Communities Restoration

Based on the hypothetical restoration footprint, tidal restoration will result in the removal of up to 73 acres of soft bird's-beak and Suisun thistle modeled habitat (primarily comprised of tidal brackish emergent wetland natural community). Tidal restoration in Suisun Marsh will involve the reintroduction of full tidal connection to managed wetlands or to tidally muted lands (i.e., lands with constraints on tidal flow and elevation, such as tide gates). Tidally muted lands do not experience the full range of tidal effects but over time develop tidal brackish emergent wetland vegetation. Restoring full tidal connectivity to previously tidally constrained land creates the potential to modify tidal elevations and flows such that previously suitable soft bird's-beak and Suisun thistle modeled habitat may be lost. Tidal restoration activities will not result in the loss of soft bird's-beak or Suisun thistle occurrences and are expected to benefit these two species by increasing the quantity and value of tidal brackish emergent wetland natural community.

5.6.30.1.2 Periodic Inundation

No periodic inundation effects will occur as a result of covered activities.

[40] Habitat loss acreage estimates are based on hypothetical footprints and models and anticipated take levels rather than detailed project-level design and represent the maximum allowed under the permit. Actual losses will be tracked through compliance monitoring to ensure that they do not exceed estimates.

5.6.30.1.3 Construction-Related Effects

Permanent, construction-related effects are described in Section 5.6.30.1.1, *Permanent Habitat Loss, Conversion, and Fragmentation*. Other construction-related effects on this species consist of construction-related injury or mortality and indirect effects. There will be no temporary habitat loss for these species. There are no direct construction-related effects expected for soft bird's–beak and Suisun thistle.

Construction-Related Injury or Mortality

Under *AMM11 Covered Plant Species*, construction activities will avoid direct injury or mortality to individual soft bird's-beak and Suisun thistle plants, as described in Appendix 3.C, *Avoidance and Minimization Measures*.

Indirect Construction-Related Effects

Disturbance outside the project footprint but within 250 feet of construction activities associated with tidal restoration could indirectly and temporarily affect 64 acres (5%) of soft bird's-beak and 66 acres (5%) of Suisun thistle modeled habitat (Table 5.6-6). Such effects may include growth inhibition, life-cycle changes (e.g., changes to normal flowering or dormancy patterns), and mortality resulting from fugitive dust and runoff (water, contaminants). Construction-related indirect effects will be minimized with implementation of *AMM2 Construction Best Management Practices and Monitoring*, as described in Appendix 3.C. In addition, traffic and construction and restoration activities that create temporary ground disturbances may introduce propagules of nonnative, invasive plants or cause existing populations of nonnative invasive plants to expand, potentially reducing habitat suitability for native plants. Adverse effects caused by nonnative plant introduction will be minimized as with implementation of AMM11.

5.6.30.1.4 Effects of Ongoing Activities

Habitat Enhancement and Management

Habitat enhancement and management activities will affect habitat for soft bird's-beak and Suisun thistle. Conducting these activities, such as the control of nonnative vegetation, to maintain and improve habitat functions of restored tidal aquatic habitats could result in mortality of soft bird's-beak and Suisun thistle, if they are present in work sites over the permit term. *CM11 Natural Communities Enhancement and Management* discusses guidelines and techniques used in invasive plant control to minimize impacts on species and habitat (Chapter 3, Section 3.4.11.2.3, *General Enhancement and Management Actions, Invasive Plant Control*). The range of habitat enhancement and management activities that will be implemented in restored soft bird's-beak and Suisun thistle habitat is expected to maintain and improve the functions of the habitat for these species over the permit term. No permanent direct effects or permanent or temporary indirect effects are expected for soft bird's-beak and Suisun thistle modeled habitat associated with habitat enhancement and management activities.

Recreation

Passive recreation in the reserve system, where that recreation is compatible with the biological goals and objectives, could result in disturbance of soft bird's-beak and Suisun thistle plants, if hikers or dogs illegally travel off trail. However, *AMM37 Recreation* (Appendix 3.C) limits trail placement to within 50 feet of occurrences to reduce risk of accidental trampling. AMM37 also requires trail construction to avoid all occurrences of soft bird's-beak and Suisun thistle. With recreation restrictions in place, as required under AMM37, recreation-related effects on soft bird's-beak and Suisun thistle expected to be minimal.

5.6.30.1.5 Other Indirect Effects

Salinity

Tidal restoration, water operations, and the use of salinity control gates to mimic a more natural water flow under the BDCP are expected to increase the salinity of water in Suisun Marsh (Appendix 5.C, *Flow, Passage, Salinity, and Turbidity*). Soft bird's-beak and Suisun thistle are brackish tidal marsh species and tolerant of saline environments. While the increase in salinities will likely increase the abundance of tidal brackish plant species and benefit soft bird's-beak and Suisun thistle, the outcome is uncertain. This uncertainty creates the same management needs as the possible desiccation of habitat (see *Tidal Damping*, below), which are aggressive control of nonnative (and native if need be), invasive species that limit seed dispersal and germination and thus colonization of newly created habitat; collection and storage of seed in case of catastrophic occurrence loss; and nursery stock that can be used, as needed, to aid the population in taking advantage of newly available habitat. Guidelines and techniques for the control of invasive plant species (including those known to be of particular concern, perennial pepperweed and nonnative annual grasses such as barbgrass and rabbitsfoot grass), seed banking, and conservation nursery practices[41] are discussed in Chapter 3, Section 3.4.11.2.4, *Aquatic and Emergent Wetland Natural Communities, Enhancement and Management Actions* and *Enhancement and Management Guidelines and Techniques*.

Tidal Damping

Tidal muting or damping is a reduction in tidal amplitude or elevation range (the distance between the highest and lowest tidal elevation). The potential effects of tidal damping on habitat are described for delta mudwort and Mason's lilaeopsis, in Section 5.6.26.1.5, *Other Indirect Effects*.

Overall, the effects of tidal damping are not well understood. Climate change is likely to attenuate the effects of tidal damping over time, as sea level rises. Furthermore, the restoration of tidal inundation is expected to create additional habitat and foster the establishment of additional stands or occurrences of soft bird's-beak and Suisun thistle, a benefit that is expected to contribute to the conservation of the species in the Plan Area.

5.6.30.1.6 Impact of Take on Species

Soft bird's-beak and Suisun thistle are endemic to California, with all range-wide occurrences entirely within the state. Soft bird's-beak is narrowly endemic to the San Francisco Bay region. There are 25 known, extant occurrences of soft bird's-beak range-wide, 12 of which (56%) are in the Plan Area (Table 5.6-9). Five of the 12 known occurrences in the Plan Area are located on existing conservations lands categorized as Type 1, and seven are located on existing conservation lands

[41] Seed collection, seed banking, conservation nursery practices, and the broadcasting of banked seed performed as part of the conservation strategy will be done with careful consideration of genetic consequences. See Chapter 3, Section 3.4.11.2.4, *Aquatic and Wetland Natural Communities, Enhancement and Management Guidelines and Techniques*, for a description of related guidelines and protocols.

categorized as Type 2, 3, or 4. All other occurrences are from the north San Francisco Bay region (Napa and Petaluma Marshes). There are four extant occurrences of Suisun thistle range-wide, all of which are located in Suisun Marsh in the Plan Area. This species is highly endemic, making it susceptible to changes in habitat.

Implementation of the BDCP will result in the removal of 73 acres of modeled habitat for soft bird's-beak and Suisun thistle, and, potentially, the desiccation and upland conversion of habitat as the result of tidal damping. A shift or decrease in distribution and abundance is also possible due to changes in water operations and salinity control gates. The uncertainty surrounding these indirect effects and the narrow endemism of Suisun thistle, in particular, create the potential for long-term, adverse effects on the species. However, the beneficial effects on the species, described below, are expected to offset potential adverse effects and contribute to the conservation of the species in the Plan Area.

5.6.30.2 Beneficial Effects

Assuming the protected tidal brackish emergent wetland natural community will provide suitable species habitat proportional to the amount of modeled habitat that currently exists within these natural communities in the Plan Area, zero acres of soft bird's-beak and Suisun thistle habitat will be protected. However, an estimated 1,500 acres of tidal brackish emergent wetland habitat will be restored (*CM3 Natural Communities Protection and Restoration*) (Table 5.6-8). Under Objective TBEWNC1.2, of at least 6,000 acres of restored or created tidal brackish emergent wetland, at least 1,500 acres will be distributed within middle and high marsh among the Western Suisun/Hill Slough Marsh Complex, the Suisun Slough/Cutoff Slough Marsh Complex, and the Nurse Slough/Denverton Marsh complex to contribute to total (existing and restored) acreage targets for each complex as specified in the Final Tidal Marsh Recovery Plan (U.S. Fish and Wildlife Service in prep.).

Some of the restoration will occur at Hill Slough Ecological Reserve and the ponded area at Rush Ranch, as per the Draft Tidal Marsh Recovery Plan (U.S. Fish and Wildlife Service 2010a). Conservation seed banking, as per the Draft Tidal Marsh Recovery Plan, will protect against extinction and provide material for conservation nursery operations. To ensure that a sufficient amount of the restored and protected tidal brackish emergent wetland natural community specifically benefits the soft bird's-beak and Suisun thistle, the Implementation Office will actively monitor and adaptively manage existing occurrences as well as any newly colonized occurrences on conservation lands (*CM4 Tidal Natural Communities Restoration*).

5.6.30.3 Net Effects

Assuming the restored and protected tidal brackish emergent wetland natural community will provide suitable species habitat proportional to the amount of modeled habitat that currently exists in these natural communities in the Plan Area, full implementation of the BDCP will result in an estimated net increase of 1,427 acres (116%) of soft bird's-beak habitat and an estimated net increase of 1,427 acres (122%) of habitat in conservation lands (Table 5.6-8). For Suisun thistle, tidal brackish emergent wetland restoration will result in an estimated net increase of 1,427 acres (111%) of available habitat and an estimated net increase of 1,427 acres (122%) of habitat on conservation lands (Table 5.6-8). Modeled habitat lost as a result of desiccation or shifts in salinity will be of high value, protected, and possibly occupied habitat. Restoration actions will focus on creating high-value marshes and sloughs with the necessary topographic heterogeneity to support vegetation consistent with historical conditions and the needs of soft bird's-beak and Suisun thistle.

Overall, the BDCP will provide a net benefit to the soft bird's-beak and Suisun thistle by restoring high-value brackish marsh habitat, preserving seed and growing nursery stock that is representative of current genetic diversity, and adaptively managing existing and newly created or restored occurrences that occur on public lands. Therefore, the BDCP will minimize and mitigate impacts, to the maximum extent practicable, and provide for the conservation and management of the soft bird's-beak and Suisun thistle in the Plan Area.

5.6.31 Vernal Pool Plants

This section describes the adverse, beneficial, and net effects of the covered activities on the vernal pool plant species, including alkali milk-vetch, legenere, Heckard's peppergrass, Boggs Lake hedge-hyssop, and dwarf downingia. The methods used to assess these effects are described in Section 5.2.8, *Effects Analysis for Wildlife and Plant Species*. The habitat model for vernal pool plants used two GIS layers: vernal pool complex, consisting of vernal pools and uplands that display characteristic vernal pool and swale visual signatures that have not been significantly affected by agricultural or development practices, and degraded vernal pool complex, consisting of low-value ephemeral habitat ranging from areas with vernal pool and swale visual signatures that display clear evidence of significant disturbance due to plowing, discing, or leveling to areas with clearly artificial basins such as shallow agricultural ditches, depressions in fallow fields, and areas of compacted soils in pastures. Further details regarding the habitat model, including assumptions on which the model is based, are provided in Appendix 2.A, *Covered Species Accounts.* Factors considered in assessing the value of affected habitat for the vernal pool plants, to the extent that information is available, include fragmentation, patch size, presence of other rare or covered species, disturbance, proximity to conservation lands, and connectivity with adjacent patches.

5.6.31.1 Adverse Effects

5.6.31.1.1 Permanent Habitat Loss, Conversion, and Fragmentation

Implementation of the BDCP is expected to result in permanent loss of 378 acres of vernal pool plant habitat (3% of modeled habitat in the Plan Area), all but 1 acre of which is low-value habitat (i.e., low density vernal pools) (Table 5.6-1). There will be no loss of alkali milk vetch, legenere, Boggs Lake hedge-hyssop, and dwarf downingia occurrences as a result of covered activities. One known Heckard's peppergrass occurrence may be affected.

Water Conveyance Facility Construction

This activity will result in the permanent removal and/or fragmentation of approximately 15 acres (less than 1%) of vernal pool plant modeled habitat (Table 5.6-2). All 15 acres of permanent habitat loss occur in Conservation Zone 8.

Tidal Natural Communities Restoration

Based on the hypothetical restoration footprint, this activity will result in the permanent removal of an estimated 372 acres[42] of vernal pool plant habitat (approximately 3% of habitat in the Plan Area), all but 1 acre of which is degraded vernal pool complex (i.e., areas with some signature of historical

[42] Habitat loss acreage estimates are based on hypothetical footprints and models and anticipated take levels rather than detailed project-level design and represent the maximum allowed under the permit. Actual losses will be tracked through compliance monitoring to ensure that they do not exceed estimates.

vernal pools but with evidence disturbance such as discing; see Table 5.6-2). Up to 1 acre of vernal pool complex (i.e., high-value, undisturbed habitat) will be permanently removed by this activity.

Degraded vernal pool complex within the hypothetical tidal restoration footprint includes lands in the Suisun Marsh ROA, along the eastern boundary of Conservation Zone 1, that are mapped as vernal pool complex because they flood seasonally and support typical vernal pool plants, but do not include topographic depressions that are characteristic of vernal pool crustacean habitat. This habitat occurs along the northern and eastern boundaries of Suisun Marsh and consists of small patches within or adjacent to conservation lands, but not within the core recovery area. Other low-value habitat in the hypothetical tidal restoration footprint includes a large patch of degraded vernal pool complex near Duck Slough, and small patches of degraded vernal pool complex south of Lindsey Slough.

Because the estimates of habitat loss resulting from tidal inundation are based on projections of where restoration may occur, actual effects are expected to be lower because sites will be selected and restoration projects designed to minimize or avoid effects on the covered vernal pool crustaceans. Tidal restoration projects will be designed to ensure that no more than 10 wetted acres of vernal pool or degraded vernal pool plant habitat are permanently lost as a result of covered activities.

The hypothetical tidal restoration footprint in Conservation Zone 1 overlaps with one occurrence of Heckard’s peppergrass in the Hass Slough area. While presumed extant, this occurrence is an observation from an 1891 Jepson collection that has not been verified in the field. Although this is a historical occurrence that may be extirpated, it is “presumed extant” (California Department of Fish and Wildlife 2013i). The collection record occurs within the hypothetical tidal restoration footprint. Despite the overlap between the hypothetical tidal restoration model and the Heckard’s peppergrass occurrence, occurrence loss is not expected (Table 5.6-9). Required surveys and avoidance protocols will be implemented during the project-level planning phase of each tidal restoration project and then implemented during construction. However, due to uncertainty, a no net loss approach allows for establishing one occurrence of Heckard’s peppergrass in the event that take is confirmed by field verification and the loss is unavoidable (Table 5.6-9). Actual effects will be tracked through compliance monitoring to ensure that they do not exceed maximum allowable take. See the avoidance and minimization measures described in Appendix 3.C, *Avoidance and Minimization Measures* for more detail.

5.6.31.1.2 Periodic Inundation

Yolo Bypass operations are the only covered activities expected to result in periodic inundation of vernal pool plant habitat.

Yolo Bypass Operations

Appendix 5.J, *Effects on Natural Communities, Wildlife, and Plants,* provides the method used to estimate periodic inundation effects in the Yolo Bypass. Based on this methodology, periodic inundation could affect vernal pool plants under the notch flow of 6,000 cfs (B) scenario only for up to 4 acres of vernal pool complex flooded.

Vernal pool plants are adapted to inundation and are known to vary in abundance and density depending upon various factors, inundation depths being just one. The increased depth, duration, and frequency of inundation in Yolo Bypass will almost assuredly affect germination timing and will, in some years, prohibit germination altogether. While increased depth, duration, and frequency of inundation will have some effect on year-to-year abundance and distribution, it is unlikely to cause permanent loss of any existing vernal pool plants.

5.6.31.1.3 Construction-Related Effects

Construction-related effects are described in Section 5.6.31.1.1, *Permanent Habitat Loss, Conversion, and Fragmentation*. Other construction-related effects on vernal pool plants consist of injury or mortality and indirect effects.

Construction-Related Injury or Mortality

Construction may cause injury or mortality to vernal pool plants by crushing individuals or disturbing the soil near occurrences; however, preconstruction surveys, construction monitoring, and other measures will be implemented to avoid and minimize injury or mortality of this species during construction, as described for AMM22 in Appendix 3.C, *Avoidance and Minimization Measures.*

Indirect Construction-Related Effects

Modeled habitat disturbance outside the project footprint but within 250 feet of the hypothetical footprint could indirectly and temporarily affect the habitat value of 176 acres of modeled vernal pool complex (1% of total habitat in the Plan Area) and 25 acres of modeled degraded vernal pool habitat (1% of total habitat in the Plan Area) (Table 5.6-6). However, restoration projects will be designed to ensure that no more than 10 wetted acres of vernal pool or degraded vernal pool complex will be indirectly affected by construction and restoration activities.

Indirect effects include growth inhibition, life cycle changes (e.g., changed to normal flowering or dormancy patterns), and mortality resulting from fugitive dust and runoff (water, contaminants) generated by construction activities. Construction-related indirect effects will be minimized with implementation of *AMM2 Construction Best Management Practices and Monitoring*, as described in Appendix 3.C. In addition, construction traffic and construction and restoration activities that create temporary ground disturbances could introduce propagules of nonnative invasive plant species or cause existing populations of nonnative invasive plant species to expand, potentially reducing habitat suitability for native plants. Adverse effects caused by nonnative plant introduction will be minimized with implementation of *AMM11 Covered Plant Species*.

5.6.31.1.4 Effects of Ongoing Activities

Facilities Operation and Maintenance

Ongoing operation and maintenance, and habitat enhancement and management activities are not expected to adversely affect the vernal pool plants.

5.6.31.1.5 Other Indirect Effects

No other known indirect effects on vernal pool plants will result from covered activities.

5.6.31.1.6 Impact of Take on Species

Alkali Milk-Vetch

Alkali milk-vetch is endemic to California, with all range-wide occurrences entirely within the state. There are 57 known, extant occurrences of alkali milk-vetch range-wide, 18 of which are presumed extant in the Plan Area (Table 5.6-9). Five if the 18 know occurrences located within the Plan Area are located on existing conservation lands (Type 1) and five are located on existing conservation lands (Type 2, 3, or 4). The Plan Area includes portions of the Jepson Prairie and Altamont Hills core recovery areas for this species.

Although none of the recorded occurrences overlap with areas anticipated to be affected, 1 acre of vernal pool complex with the potential to support this species could be affected by tidal natural communities restoration. Take of alkali milk-vetch as a result of BDCP implementation is not expected to adversely affect the long-term survival and conservation of this species for the following reasons.

- The lack of known occurrences in areas expected to be affected.
- The small percentage of vernal pool complex modeled habitat in the Plan Area that will be affected (less than 1%, or 1 of 8,547 acres).
- The high percentage (44%) of occurrences in the Plan Area that are currently protected.
- Implementation of avoidance and minimization measures described in Appendix 3.C.

Legenere

Legenere is endemic to California, with all range-wide occurrences entirely within the state. There are 71 extant occurrences of legenere range-wide, 7 of which are found in the Plan Area. The Plan Area includes portions of the Jepson Prairie Core Recovery Area for this species.

Six of these seven occurrences are on existing conservation lands (Type 1). No recorded occurrences will be affected by covered activities (Table 5.6-9). Take of legenere as a result of BDCP implementation is not expected to adversely affect the long-term survival and conservation of this species for the following reasons.

- The low proportion of known occurrences in the Plan Area (10%)
- The small percentage of vernal pool complex modeled habitat in the Plan Area that will be affected (less than 1%, or 1 of 8,547 acres).
- The lack of known occurrences in areas that will be affected.
- The high percentage (86%) of occurrences in the Plan Area that are currently protected.
- Implementation of avoidance and minimization measures described in Appendix 3.C.

Heckard's Peppergrass

Heckard's peppergrass is endemic to California, with all range-wide occurrences entirely within the state. The Plan Area includes 44% (five of fifteen) of the range-wide, extant occurrences, two of which are located on existing Type 1 conservation lands and two of which are located on existing Type 2, 3, or 4 conservation lands. One known Heckard's peppergrass occurrence may be affected. This occurrence is from an 1891 Jepson collection, has not been field-verified and may occur in the vicinity of Lindsey Slough. While loss of an occurrence is unlikely, one occurrence of Heckard's peppergrass may be established to achieve no net loss of occurrences in the case occurrence loss occurs (Table 5.6-9).

Take of Heckard's peppergrass as a result of BDCP implementation is not expected to adversely affect the long-term survival and conservation of this species for the following reasons.

- The high percentage (75%) of known occurrences in the Plan Area that are currently protected.
- The moderate percentage (33%) of occurrences in the Plan Area.

- The low percentage of vernal pool complex modeled habitat in the Plan Area that will be affected (less than 1%, or 1 of 8,547 acres).
- Implementation of avoidance and minimization measures described in Appendix 3.C.

Section 5.6.31.2, *Beneficial Effects,* one occurrence will be established and protected to achieve no net loss in the case of occurrence loss (Table 5.6-9).

Boggs Lake Hedge-Hyssop

Boggs Lake hedge-hyssop is almost entirely found in California; one known occurrence is found in Oregon. The Plan Area includes 1% (1 of 87) of the known, extant Boggs Lake hedge-hyssop occurrences in the state, with the one known occurrence in the Plan Area on existing conservation lands (Type 1) (Table 5.6-9). Based on the hypothetical footprint for tidal restoration, no known Boggs Lake hedge-hyssop occurrences will be affected, although portions of the 89 acres of vernal pool complex to be affected may be occupied by this species.

Take of Boggs Lake hedge-hyssop as a result of BDCP implementation is not expected to adversely affect the long-term survival and conservation of this species for the following reasons.

- The small proportion of this species' range and known occurrences present in the Plan Area.
- The small percentage of vernal pool complex modeled habitat in the Plan Area that will be affected (less than 1%, or 1 of 8,547 acres).
- Implementation of avoidance and minimization measures described in Appendix 3.C.

Dwarf Downingia

Within the United States, dwarf downingia is found only in California. It is also found in Chile. The Plan Area includes 10% (12 of 116) of the known, extant occurrences in the county, and 10 of the 12 known occurrences in the Plan Area are located on existing conservation lands (Type 1). Based on the hypothetical footprint for tidal restoration, no known dwarf downingia occurrences will be affected (Table 5.6-9), although portions of the 89 acres of vernal pool complex to be affected may be occupied by this species.

Take of dwarf downingia as a result of BDCP implementation is not expected to adversely affect the long-term survival and conservation of this species for the following reasons.

- The small proportion of this species' range and known occurrences present in the Plan Area.
- The small percentage of vernal pool complex modeled habitat in the Plan Area that will be affected (less than 1%, or 1 of 8,547 acres).
- The 67% protection of the occurrences in the Plan Area.
- Implementation of avoidance and minimization measures described in Appendix 3.C.

5.6.31.2 Beneficial Effects

Assuming the restored and protected alkali seasonal wetland complex wetland, degraded vernal pool complex, and vernal pool complex natural communities provide suitable vernal pool plant species habitat proportional to the amount of modeled habitat that currently exists in these natural communities in the Plan Area (5%, 21.2%, and 71.8% respectively), implementation of the BDCP will result in the protection of an estimated 8 acres of habitat consisting of these natural communities.

Based on the same assumptions, implementation of the BDCP will result in the restoration of an estimated 67 acres of vernal pool plant species habitat consisting of these natural communities. Additionally, the Plan requires protection of 600 acres of existing vernal pool complex in Conservation Zones 1, 8, and 11 (Objective VPNC1.1), primarily in vernal pool core recovery areas identified in the *Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon* (U.S. Fish and Wildlife Service 2005). Full implementation of the BDCP is therefore expected to result in an estimated 608 acres of protected habitat and 66 acres of restored habitat for vernal pool plant species (Table 5.6-7).

The protection and restoration will take place primarily in core recovery areas for the vernal pool plants as identified in the recovery plan (U.S. Fish and Wildlife Service 2005) and will increase the size and connectivity of vernal pool complex reserves in and adjacent to the Plan Area. The vernal pool reserve system will incorporate a range of inundation and soil characteristics in order to accommodate the varying needs of all the covered vernal pool plants species. These core recovery areas where protection and restoration will be focused have the highest concentrations of covered vernal pool occurrences in the Plan Area, and they also coincide with the conservation zones that include relatively large, unfragmented blocks of unprotected vernal pool complex adjacent to conservation lands. The Plan requires protection of two currently unprotected occurrences of alkali milk-vetch (Objective VPP1.1) and no net loss of Heckard's peppergrass in Conservation Zones 1, 8, or 11 within restoration sites or within the area of affected tidal range of restoration projects (Objective VPP1.2) (Table 5.6-9).

Additionally, the vernal pool complexes in the reserve system will be managed and enhanced (*CM11 Natural Communities Enhancement and Management*) to provide the appropriate ponding characteristics for supporting and sustaining the vernal pool crustaceans and to increase native biodiversity and reduce invasive plant species detrimental to vernal pool hydrology.

5.6.31.3 Net Effects

Full implementation of the BDCP will result in an estimated net decrease of 1 acre (less than 1%) of vernal pool plant habitat, and an estimated net increase of 658 acres (10%) of vernal pool plant habitat in conservation lands (Table 5.6-8).

The modeled habitat that may be lost as a result of tidal restoration in Cache Slough ROA (Conservation Zone 1) is of low value in that it consists of areas lacking topographic depressions or with disturbed, degraded vernal pool complex with a low density of vernal pools. The areas that will be conserved will consist of high-value vernal pool complex in core vernal pool recovery areas that will be interconnected and managed to sustain populations of covered vernal pool plants.

Overall, the BDCP will provide a substantial net benefit to the covered vernal pool plants through the increase in habitat value and protection. These protected areas will be managed and monitored to support the species. Therefore, the BDCP will minimize and mitigate impacts, to the maximum extent practicable, and provide for the conservation and management of the covered vernal pool plants in the Plan Area.

5.6.32 Covered Species Tables

Table 5.6-1. Maximum Allowable Habitat Loss for Covered Wildlife Species (acres)

Covered Wildlife Species	Total Existing Modeled Habitat in the Plan Area[b]	Maximum Allowable Habitat Loss by Covered Activity[a,b,c]															Maximum Allowable Habitat Loss		
		CM1 Water Facilities and Operation				CM2 Yolo Bypass Fisheries Enhancement		CM4 Tidal Natural Communities Restoration	CM5 Seasonally Inundated Floodplain Restoration		CM7 Riparian Natural Community Restoration		CM8 Grassland Natural Community Restoration	CM10 Nontidal Marsh Restoration	CM11 Natural Community Enhancement and Management	CM18 Conservation Hatcheries			
		Tunnel/Pipeline Facilities Construction				Fremont Weir and Yolo Bypass Improvements		Construction and Inundation[g]	Levee Construction		Riparian Restoration as Part of Tidal Natural Communities Restoration	Restoration within Restored Floodplain		Construction and Inundation	Construction of Recreational-Related Facilities	Construction			
		Permanent[d]	Permanent (Reusable Tunnel Material)[q]	Temporary (Borrow and Spoil)[d,e]	Temporary[d]	Permanent[f]	Temporary[f]	Permanent[g,h,i]	Permanent[j]	Temporary[j]	Permanent	Permanent[k]	Permanent[l]	Permanent[l]	Permanent	Permanent[l]	Permanent[p]	Temporary	Temporary (Borrow and Spoil)
Mammals																			
Riparian brush rabbit																			
Riparian habitat	2,909	3	0	0	1	0	0	19	43	35	0	0	0	0	0	0	65	36	0
Grassland habitat	3,103	124	0	0	54	0	0	18	26	20	0	0	0	0	0	0	168	74	0
Total	**6,012**	**127**	**0**	**0**	**55**	**0**	**0**	**37**	**69**	**55**	**0**	**0**	**0**	**0**	**0**	**0**	**233**	**110**	**0**
Riparian woodrat																			
Total	**2,166**	**0**	**0**	**0**	**0**	**0**	**0**	**10**	**41**	**33**	**0**	**0**	**0**	**0**	**0**	**0**	**51**	**33**	**0**
Salt marsh harvest mouse																			
Tidal brackish emergent wetland primary	3,641	0	0	0	0	0	0	67	0	0	0	0	0	0	0	0	67	0	0
Tidal brackish emergent wetland secondary	2,718	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upland secondary	749	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0	9	0	0
Managed wetland—wetland primary, low long-term conservation value	21,891	0	0	0	0	0	0	5,323	0	0	0	0	0	0	0	0	5323	0	0
Managed wetland—wetland secondary, low long-term conservation value	2,800	0	0	0	0	0	0	807	0	0	0	0	0	0	0	0	807	0	0
Managed wetland—upland, low long-term conservation value	3,787	0	0	0	0	0	0	762	0	0	0	0	0	0	0	0	762	0	0
Total	**35,586**	**0**	**0**	**0**	**0**	**0**	**0**	**6,968**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**6968**	**0**	**0**
San Joaquin kit fox																			
Breeding, foraging, and dispersal habitat	5,327	155	52	0	103	0	0	0	0	0	0	0	0	0	7.5	0	214.5	103	0
Total	**5,327**	**155**	**52**	**0**	**103**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**8**	**0**	**215**	**103**	**0**

Covered Wildlife Species	Total Existing Modeled Habitat in the Plan Area[b]	Maximum Allowable Habitat Loss by Covered Activity[a,b,c]															Maximum Allowable Habitat Loss		
		CM1 Water Facilities and Operation				CM2 Yolo Bypass Fisheries Enhancement		CM4 Tidal Natural Communities Restoration	CM5 Seasonally Inundated Floodplain Restoration		CM7 Riparian Natural Community Restoration		CM8 Grassland Natural Community Restoration	CM10 Nontidal Marsh Restoration	CM11 Natural Community Enhancement and Management	CM18 Conservation Hatcheries			
		Tunnel/Pipeline Facilities Construction				Fremont Weir and Yolo Bypass Improvements		Construction and Inundation[g]	Levee Construction		Riparian Restoration as Part of Tidal Natural Communities Restoration	Restoration within Restored Floodplain		Construction and Inundation	Construction of Recreational-Related Facilities	Construction			
		Permanent[d]	Permanent (Reusable Tunnel Material)[q]	Temporary (Borrow and Spoil)[d,e]	Temporary[d]	Permanent[f]	Temporary[f]	Permanent[g,h,i]	Permanent[j]	Temporary[j]	Permanent	Permanent[k]	Permanent[l]	Permanent[l]	Permanent	Permanent[l]	Permanent[p]	Temporary	Temporary (Borrow and Spoil)
Suisun shrew																			
Primary habitat	3,128	0	0	0	0	0	0	60	0	0	0	0	0	0	0	0	60	0	0
Secondary habitat	4,387	0	0	0	0	0	0	342	0	0	0	0	0	0	0	0	342[o]	0	0
Total	**7,515**	**0**	**0**	**0**	**0**	**0**	**0**	**402**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**402**	**0**	**0**
Birds																			
California black rail																			
Primary habitat	7,467	0	0	0	18	5	0	79	0	0	0	0	0	0	0	0	84	18	0
Secondary habitat	17,915	0	0	0	0	0	0	3,043	0	0	0	0	0	0	0	0	3,043	0	0
Total	**25,382**	**0**	**0**	**0**	**18**	**5**	**0**	**3,122**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**3,127**	**18**	**0**
California clapper rail[m]																			
Primary habitat	296	0	0	0	0	0	0	27	0	0	0	0	0	0	0	0	27	0	0
Secondary habitat	6,420	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	8	0	0
Total	**6,716**	**0**	**0**	**0**	**0**	**0**	**0**	**35**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**35**	**0**	**0**
Greater sandhill crane																			
Roosting and foraging—Permanent	7,340	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	8	0
Roosting and foraging—Temporary	16,522	0[n]	0	0	16	0	0	41	0	0	0	0	0	0	0	0	41	16	0
Foraging habitat	162,164	352	2,347	183	778	0	0	2,713	0	0	0	0	300	1,350	4	0	7066	778	183
Total	**186,026**	**352**	**2,347**	**183**	**802**	**0**	**0**	**2,754**	**0**	**0**	**0**	**0**	**300**	**1,350**	**4**	**0**	**7,107**	**802**	**183**
Least Bell's vireo																			
Total	**14,528**	**11**	**18**	**1**	**22**	**83**	**88**	**545**	**28**	**21**	**0**	**0**	**0**	**0**	**0**	**0**	**685**	**131**	**1**
Suisun song sparrow																			
Primary habitat	3,722	0	0	0	0	0	0	55	0	0	0	0	0	0	0	0	55	0	0
Secondary habitat	23,986	0	0	0	0	0	0	3,633	0	0	0	0	0	0	0	0	3,633	0	0
Total	**27,708**	**0**	**0**	**0**	**0**	**0**	**0**	**3,688**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**3,688**	**0**	**0**
Swainson's hawk																			
Foraging habitat	470,324	1,100	3,235	183	1,113	996	504	37,359	1,820	1,036	971	3,991	1,849	1,440	50	35	52,846	2653	183
Nesting habitat	9,796	8	10	0	18	79	54	295	38	31	0	0	0	0	0	0	430	103	0
Total	**480,120**	**1,108**	**3,245**	**183**	**1,131**	**1,075**	**558**	**37,654**	**1,858**	**1,067**	**971**	**3,991**	**1,849**	**1,440**	**50**	**35**	**53,276**	**2,756**	**183**

		Maximum Allowable Habitat Loss by Covered Activity[a,b,c]																
		CM1 Water Facilities and Operation				CM2 Yolo Bypass Fisheries Enhancement		CM4 Tidal Natural Communities Restoration	CM5 Seasonally Inundated Floodplain Restoration		CM7 Riparian Natural Community Restoration		CM8 Grassland Natural Community Restoration	CM10 Nontidal Marsh Restoration	CM11 Natural Community Enhancement and Management	CM18 Conservation Hatcheries			
		Tunnel/Pipeline Facilities Construction				Fremont Weir and Yolo Bypass Improvements		Construction and Inundation[g]	Levee Construction		Riparian Restoration as Part of Tidal Natural Communities Restoration	Restoration within Restored Floodplain		Construction and Inundation	Construction of Recreational-Related Facilities	Construction	Maximum Allowable Habitat Loss		
Covered Wildlife Species	Total Existing Modeled Habitat in the Plan Area[b]	Permanent[d]	Permanent (Reusable Tunnel Material)[q]	Temporary (Borrow and Spoil)[d,e]	Temporary[d]	Permanent[f]	Temporary[f]	Permanent[g,h,i]	Permanent[j]	Temporary[j]	Permanent	Permanent[k]	Permanent[l]	Permanent[l]	Permanent	Permanent[l]	Permanent[p]	Temporary	Temporary (Borrow and Spoil)
Tricolored blackbird																			
Breeding habitat—ag foraging	100,198	634	795	81	148	477	84	6,449	503	275	7	0	1,521	568	0	0	10954	507	81
Breeding habitat—foraging	58,181	161	52	0	114	105	155	1,750	47	30	11	0	0	0	43.5	35	2204.5	299	0
Breeding habitat—nesting	1,741	4	0	1	2	13	75	56	4	2	0	0	0	0	0	0	77	79	1
Nonbreeding habitat—foraging ag	194,251	203	2,124	0	575	0	54	17,205	652	367	953	3,991	210	945	0	0	26283	996	0
Nonbreeding habitat—roosting	28,066	7	12	0	20	8	0	1,633	1	1	0	0	0	0	0	0	1661	21	0
Nonbreeding habitat—foraging	34,308	48	197	0	47	0	0	1,331	3	3	0	0	0	0	6.5	0	1585.5	50	0
Total	**416,745**	**1,057**	**3,180**	**82**	**906**	**603**	**368**	**28,424**	**1,210**	**678**	**971**	**3,991**	**1,731**	**1,513**	**50**	**35**	**42,765**	**1,952**	**82**
Western burrowing owl																			
High-value habitat	149,783	340	541	0	351	882	245	9,929	142	83	11	0	362	159	0	35	12401	679	0
Low-value habitat	251,767	689	2,324	101	588	98	144	19,739	1,452	827	960	3,991	1,314	952	0	0	31519	1559	101
Total	**401,550**	**1,029**	**2,865**	**101**	**939**	**980**	**389**	**29,668**	**1,594**	**910**	**971**	**3,991**	**1,676**	**1,111**	**0**	**35**	**43,920**	**2,238**	**101**
Western yellow-billed cuckoo																			
Breeding habitat	1,970	3	6	0	1	26	5	110	6	5	0	0	0	0	0	0	151	11	0
Migratory habitat	10,425	4	10	0	18	57	83	310	16	11	0	0	0	0	0	0	397	112	0
Total	**12,395**	**7**	**16**	**0**	**19**	**83**	**88**	**420**	**22**	**16**	**0**	**0**	**0**	**0**	**0**	**0**	**548**	**123**	**0**
White-tailed kite																			
Breeding habitat	14,069	10	16	0	23	82	88	383	42	33	0	0	0	0	0	0	533	144	0
Foraging	500,365	1,100	3,239	183	1,112	1,008	516	41,625	1,706	968	971	3,991	1,849	1,440	50	35	57014	2596	183
Total	**514,434**	**1,110**	**3,255**	**183**	**1,135**	**1,090**	**604**	**42,008**	**1,748**	**1,001**	**971**	**3,991**	**1,849**	**1,440**	**50**	**35**	**57,547**	**2,740**	**183**
Yellow-breasted chat																			
Primary nesting and migratory habitat	8,178	7	10	0	6	9	58	182	23	15	0	0	0	0	0	0	231	79	0
Secondary nesting and migratory habitat	5,528	3	8	1	16	3	0	349	5	6	0	0	0	0	0	0	368	22	1
Suisun Marsh/upper Yolo Bypass nest and migratory habitat	841	0	0	0	0	71	29	14	0	0	0	0	0	0	0	0	85	29	0
Total	**14,547**	**10**	**18**	**1**	**22**	**83**	**87**	**545**	**28**	**21**	**0**	**0**	**0**	**0**	**0**	**0**	**684**	**130**	**1**

Covered Wildlife Species	Total Existing Modeled Habitat in the Plan Area[b]	Maximum Allowable Habitat Loss by Covered Activity[a,b,c]															Maximum Allowable Habitat Loss		
		CM1 Water Facilities and Operation				CM2 Yolo Bypass Fisheries Enhancement		CM4 Tidal Natural Communities Restoration	CM5 Seasonally Inundated Floodplain Restoration		CM7 Riparian Natural Community Restoration		CM8 Grassland Natural Community Restoration	CM10 Nontidal Marsh Restoration	CM11 Natural Community Enhancement and Management	CM18 Conservation Hatcheries			
		Tunnel/Pipeline Facilities Construction				Fremont Weir and Yolo Bypass Improvements		Construction and Inundation[g]	Levee Construction		Riparian Restoration as Part of Tidal Natural Communities Restoration	Restoration within Restored Floodplain		Construction and Inundation	Construction of Recreational-Related Facilities	Construction			
		Permanent[d]	Permanent (Reusable Tunnel Material)[q]	Temporary (Borrow and Spoil)[d,e]	Temporary[d]	Permanent[f]	Temporary[f]	Permanent[g,h,i]	Permanent[j]	Temporary[j]	Permanent	Permanent[k]	Permanent[l]	Permanent[l]	Permanent	Permanent[l]	Permanent[p]	Temporary	Temporary (Borrow and Spoil)
Reptiles																			
Giant garter snake																			
Aquatic—tidal	12,097	16	1	0	55	9	2	2	2	3	0	0	0	0	0	0	30	60	0
Aquatic—nontidal[s]	19,027	10	56	0	13	59	13	393	34	21	0	0	0	0	0	0	552	47	0
Upland—high	21,581	66	106	0	48	178	158	594	0	0	0	0	0	0	0	0	944	206	0
Upland—moderate	25,407	167	54	0	135	60	61	1,375	27	24	0	0	0	0	0	35	1718	220	0
Upland—low	5,683	14	4	0	5	1	0	154	20	18	0	0	0	0	0	0	193	23	0
Total	**83,795**	**273**	**221**	**0**	**256**	**307**	**234**	**2,518**	**83**	**66**	**0**	**0**	**0**	**0**	**0**	**35**	**3,437**	**556**	**0**
Aquatic breeding, foraging and movement (miles)	2,784	7	6	0	6	5	9	138	2	1	0	0	0	0	0	0	158	16	0
Western pond turtle																			
Aquatic habitat[j]	81,588	180	57	0	2,098	37	23	45	32	21	0	0	0	0	0	0	351	2142	0
Upland nesting and overwintering habitat	16,043	105	97	0	34	109	70	473	12	15	10	0	0	0	0	0	806	119	0
Upland nesting and overwintering habitat—NHD[t]	12,615	30	47	0	34	21	49	399	4	2	0	0	0	0	0	0	501	85	0
Total	**110,246**	**315**	**201**	**0**	**2,166**	**167**	**142**	**917**	**48**	**38**	**10**	**0**	**0**	**0**	**0**	**0**	**1,658**	**2,346**	**0**
Aquatic habitat linear (miles)—NHD[t]	1,418	3	6	0	3	1	3	106	2	1	0	0	0	0	0	0	118	7	0
Amphibians																			
California red-legged frog																			
Aquatic habitat	159	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Upland cover and dispersal habitat	7,766	6	0	0	0	0	0	0	0	0	0	0	0	0	24	0	30	0	0
Total	**7,925**	**7**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**24**	**0**	**31**	**0**	**0**
Aquatic habitat (miles)	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
California tiger salamander																			
Aquatic breeding habitat	7,845	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Terrestrial cover and aestivation	28,173	6	0	0	32	42	0	517	0	0	0	0	0	0	39.5	35	639.5	32	0
Total	**36,018**	**6**	**0**	**0**	**32**	**42**	**0**	**517**	**0**	**0**	**0**	**0**	**0**	**0**	**40**	**35**	**640**	**32**	**0**

Covered Wildlife Species	Total Existing Modeled Habitat in the Plan Area[b]	Maximum Allowable Habitat Loss by Covered Activity[a,b,c]															Maximum Allowable Habitat Loss		
		CM1 Water Facilities and Operation				CM2 Yolo Bypass Fisheries Enhancement		CM4 Tidal Natural Communities Restoration	CM5 Seasonally Inundated Floodplain Restoration		CM7 Riparian Natural Community Restoration		CM8 Grassland Natural Community Restoration	CM10 Nontidal Marsh Restoration	CM11 Natural Community Enhancement and Management	CM18 Conservation Hatcheries			
		Tunnel/Pipeline Facilities Construction				Fremont Weir and Yolo Bypass Improvements		Construction and Inundation[g]	Levee Construction		Riparian Restoration as Part of Tidal Natural Communities Restoration	Restoration within Restored Floodplain		Construction and Inundation	Construction of Recreational-Related Facilities	Construction			
		Permanent[d]	Permanent (Reusable Tunnel Material)[q]	Temporary (Borrow and Spoil)[d,e]	Temporary[d]	Permanent[f]	Temporary[f]	Permanent[g,h,i]	Permanent[j]	Temporary[j]	Permanent	Permanent[k]	Permanent[l]	Permanent[l]	Permanent	Permanent[l]	Permanent[p]	Temporary	Temporary (Borrow and Spoil)
Invertebrates																			
Valley elderberry longhorn beetle																			
Riparian vegetation	17,464	16	18	1	29	83	76	552	43	35	0	0	0	0	0	0	712	140	1
Nonriparian channels and grasslands	16,585	126	101	0	62	41	94	260	9	14	0	0	0	0	0	0	537	170	0
Total	**34,049**	**142**	**119**	**1**	**91**	**124**	**170**	**812**	**52**	**49**	**0**	**0**	**0**	**0**	**0**	**0**	**1,249**	**310**	**1**
California linderiella																			
Vernal pool complex	8,759	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0
Degraded vernal pool complex	2,713	7	0	0	0	0	0	52	0	0	0	0	0	0	0	0	59	0	0
Total	**11,472**	**15**	**0**	**0**	**0**	**0**	**0**	**52**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**67**	**0**	**0**
Conservancy fairy shrimp																			
Vernal pool complex	8,759	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0
Degraded vernal pool complex	2,713	7	0	0	0	0	0	52	0	0	0	0	0	0	0	0	59	0	0
Total	**11,472**	**15**	**0**	**0**	**0**	**0**	**0**	**52**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**67**	**0**	**0**
Longhorn fairy shrimp																			
Vernal pool complex	8,759	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0
Degraded vernal pool complex	2,713	7	0	0	0	0	0	52	0	0	0	0	0	0	0	0	59	0	0
Total	**11,472**	**15**	**0**	**0**	**0**	**0**	**0**	**52**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**67**	**0**	**0**
Midvalley fairy shrimp																			
Vernal pool complex	8,759	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0
Degraded vernal pool complex	2,713	7	0	0	0	0	0	52	0	0	0	0	0	0	0	0	59	0	0
Total	**11,472**	**15**	**0**	**0**	**0**	**0**	**0**	**52**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**67**	**0**	**0**
Vernal pool fairy shrimp																			
Vernal pool complex	8,759	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0
Degraded vernal pool complex	2,713	7	0	0	0	0	0	52	0	0	0	0	0	0	0	0	59	0	0
Total	**11,472**	**15**	**0**	**0**	**0**	**0**	**0**	**52**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**67**	**0**	**0**
Vernal pool tadpole shrimp																			
Vernal pool complex	8,759	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0
Degraded vernal pool complex	2,713	7	0	0	0	0	0	52	0	0	0	0	0	0	0	0	59	0	0
Total	**11,472**	**15**	**0**	**0**	**0**	**0**	**0**	**52**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**67**	**0**	**0**

Covered Wildlife Species	Total Existing Modeled Habitat in the Plan Area[b]	Maximum Allowable Habitat Loss by Covered Activity[a,b,c]																	
		CM1 Water Facilities and Operation				CM2 Yolo Bypass Fisheries Enhancement		CM4 Tidal Natural Communities Restoration	CM5 Seasonally Inundated Floodplain Restoration		CM7 Riparian Natural Community Restoration		CM8 Grassland Natural Community Restoration	CM10 Nontidal Marsh Restoration	CM11 Natural Community Enhancement and Management	CM18 Conservation Hatcheries			
		Tunnel/Pipeline Facilities Construction				Fremont Weir and Yolo Bypass Improvements		Construction and Inundation[g]	Levee Construction		Riparian Restoration as Part of Tidal Natural Communities Restoration	Restoration within Restored Floodplain		Construction and Inundation	Construction of Recreational-Related Facilities	Construction	Maximum Allowable Habitat Loss		
		Permanent[d]	Permanent (Reusable Tunnel Material)[q]	Temporary (Borrow and Spoil)[d,e]	Temporary[d]	Permanent[f]	Temporary[f]	Permanent[g,h,i]	Permanent[j]	Temporary[j]	Permanent	Permanent[k]	Permanent[l]	Permanent[l]	Permanent	Permanent[l]	Permanent[p]	Temporary	Temporary (Borrow and Spoil)

[a] The following covered activities and associated federal actions (listed here by the header/category as described in Chapter 4, *Covered Activities and Associated Federal Actions*) are assumed not to have footprint impacts on natural communities or species habitat: Operations and Maintenance of Existing SWP Facilities; Power Generation Water Use - Mirant Delta, LLC activities; Activities to Reduce Contaminants; Activities to Reduce Predators and Other Sources of Direct Mortality; Monitoring and Research Programs; Emergency Actions; CVP Operations and Maintenance; and Joint Federal and Non-federal Actions.

[b] Existing habitat and habitat loss are estimated using habitat models created from detailed vegetation mapping. See Appendix 2.A, *Covered Species Accounts*, for a complete description of species-specific mapping methods. Effects on species' habitat will be tracked during implementation through on-the-ground surveys performed by qualified biologists.

[c] See Table 5.J.1, *Quantitative Effects Analysis Methods and Assumptions*, in Appendix 5.J, *Effects on Natural Communities, Wildlife, and Plants*, for a description methods and assumptions relevant to estimating natural community loss by covered activity type and Table 5.J.3, *Key Assumptions Related to Tidal Restoration Effects on Covered Species Habitat*, for a list of assumptions used to determine permanent loss or conversion as a result of inundation caused by tidal restoration.

[d] Permanent and temporary effects assessed under CM1 are associated with construction of the following conveyance-related facilities: forebay, intake facilities, permanent access roads, shaft locations, and transmission lines. See Chapter 4, Section 4.2.1.1, *North Delta Diversions Construction and Operations*, for a complete description of all activities assessed under CM1.

[e] A borrow is a location from where construction material, such as sand or clay, will be taken. A spoil is an area where construction by-products, such as removed earth, will be placed and stored. A borrow/spoil is an area that will originally be used for borrow and later for spoil.

[f] Permanent and temporary effects assessed under CM2 include activities associated with Fremont Weir improvements, Putah Creek realignment activities, Lisbon weir and fish crossing improvements, and Sacramento Weir improvements.

[g] Inundation is tidal flooding of existing wetland habitat as a result of tidal restoration actions. Inundation can cause permanent loss of habitat from either the removal of habitat or the conversion of one habitat type to another. See Table 5.J.1, *Quantitative Effects Analysis Methods and Assumptions*, in Appendix 5.J, for a description of relevant assumptions. All construction is assumed to occur within the inundation footprint.

[h] Permanent loss calculations are based on hypothetical tidal restoration designs and include those areas modeled by ESAPWA (Appendix 3.B, *BDCP Tidal Habitat Evolution Assessment*) to be below extreme high water elevation. See Table 5.J.1 in Appendix 5.J, for methods and assumptions used to apply the hypothetical footprint to determine effects.

[i] Tidal restoration is expected to include riparian restoration where elevations are favorable. Permanent loss from riparian restoration was determined by non-GIS methods. See Table 5.J.1, in Appendix 5.J, for a complete list of methods and assumptions.

[j] Calculation of effects based on hypothetical floodplain restoration designs. See Table 5.J.1 in Appendix 5.J, for details.

[k] Based on restoration design assumptions described in Appendix 5.E, *Habitat Restoration*, and effects analysis assumptions detailed in Table 5.J.1 in Appendix 5.J.

[l] Permanent loss was determined based on non-GIS methods described in Table 5.J.1 in Appendix 5.J.

[m] Based on the hypothetical tidal restoration footprint, an estimated 4 acres of habitat will be lost or converted. However, to provide flexibility in implementation of tidal restoration projects, the take limit is set higher than the amount of loss estimated under the hypothetical footprint.

[n] *AMM30 Transmission Line Design and Alignment Guidelines* (Appendix 3.C, *Avoidance and Minimization Measures*) requires a reroute of the transmission line so it does not affect a roost site. This will reduce impacts on roosting and foraging habitat by 29 acres.

[o] Although the tidal restoration model results in some decreases in acreage of natural community loss between near-term and late long-term implementation periods due to tidal damping and sea level rise, for permitting purposes the maximum acreage of loss is shown for the late long-term period.

[p] Totals may not sum due to rounding.

[q] Reusable tunnel material is flexible, and the footprint used in the effects analysis is based on a worst-case scenario. The actual area to be affected by reusable tunnel material storage will likely be less than the estimated acreage.

[r] Loss reduced to zero. Although the temporary powerline footprint overlaps with 2 acres of alkali seasonal wetland complex and 16 acres of vernal pool complex in Conservation Zone 8, AMM30 requires that wetted acres of alkali seasonal wetlands and vernal pool complex be avoided during powerline installation (Appendix 3.C).

[s] Rice loss from *CM8 Grassland Natural Community Restoration* and *CM10 Nontidal Marsh Restoration* are not included in this analysis as rice conversion in Conservation Zone 2 will be avoided. This table will be updated for all other species in the next version.

[t] For western pond turtle NHD model types, a 35% habitat suitability correction factor was applied to existing modeled habitat and covered activity loss acreage as it was determined that, in the Plan Area, approximately 35% of all channels and ditches mapped in the NHD layer are likely suitable for western pond turtle. See Appendix 2.A, *Covered Species Accounts*, Section 2.A.29, for more details.

NHD = National Hydrologic Database; SWP = State Water Project; CVP = Central Valley Project.

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Table 5.6-2. Maximum Allowable Habitat Loss for Covered Plant Species (acres)

		Maximum Allowable Habitat Loss by Covered Activity[a,b,c]																
		CM1 Water Facilities and Operation				CM2 Yolo Bypass Fisheries Enhancement		CM4 Tidal Natural Communities Restoration	CM5 Seasonally Inundated Floodplain Restoration		CM7 Riparian Natural Community Restoration		CM10 Nontidal Marsh Restoration	CM8 Grassland Natural Community Restoration	CM18 Conservation Hatcheries			
	Total Existing	Tunnel/Pipeline Facilities Construction				Fremont Weir and Yolo Bypass Improvements		Construction and Inundation	Levee Construction		Riparian Restoration as Part of Tidal Natural Communities Restoration	Restoration within Restored Floodplain	Construction and Inundation		Construction	Maximum Allowable Habitat Loss		
Covered Plant Species	Modeled Habitat in the Plan Area[b]	Permanent[d]	Permanent (Reusable Tunnel Material)[p]	Temporary (Borrow and Spoil)[d,e]	Temporary[d]	Permanent[f]	Temporary[f]	Permanent[g,h,i]	Permanent[j]	Temporary[j]	Permanent	Permanent[k]	Permanent[g]	Permanent[l]	Permanent[l]	Permanent[q]	Temporary (Borrow and Spoil)	Temporary
Plants																		
Brittlescale[m]																		
Total	**451**	**0**	**0**	**0**	**0**	**0**	**0**	**20[u]**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**20**	**0**	**0**
Heartscale																		
Total	**6,451**	**0**	**0**	**0**	**0**	**0**	**0**	**306**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**306**	**0**	**0**
San Joaquin spearscale																		
Total	**14,477**	**23**	**30**	**0**	**29**	**56**	**0**	**622**	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**732**	**0**	**30**
Carquinez goldenbush[m]																		
Total	**1,346**	**0**	**0**	**0**	**0**	**0**	**0**	**50[u]**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**50**	**0**	**0**
Delta button celery																		
Total	**3,361**	**34**	**39**	**0**	**23**	**0**	**0**	**0**	**7**	**8**	**0**	**0**	**0**	**0**	**0**	**80**	**0**	**31**
Delta mudwort																		
Total	**6,081**	**12**	**3**	**0**	**15**	**3**	**2**	**6**	**1**	**2**	**0**	**0**	**0**	**0**	**0**	**25**	**0**	**19**
Mason's lilaeopsis																		
Total	**6,081**	**12**	**3**	**0**	**15**	**3**	**2**	**6**	**1**	**2**	**0**	**0**	**0**	**0**	**0**	**25**	**0**	**19**
Delta tule pea[n]																		
Total	**5,853**	**2**	**0**	**0**	**1**	**0**	**0**	**50[u]**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**52**	**0**	**1**
Suisun Marsh aster[n]																		
Total	**5,853**	**2**	**0**	**0**	**1**	**0**	**0**	**50[u]**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**52**	**0**	**1**
Side-flowering skullcap[o]																		
Total	**2,497**	**3**	**0**	**0**	**5**	**0**	**0**	**4**	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**8**	**0**	**6**
Slough thistle																		
Total	**1,834**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**50**	**6**	**0**	**0**	**0**	**0**	**0**	**55**	**0**	**6**
Soft bird's-beak																		
Total	**1,228**	**0**	**0**	**0**	**0**	**0**	**0**	**73**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**73**	**0**	**0**
Suisun thistle																		
Total	**1,281**	**0**	**0**	**0**	**0**	**0**	**0**	**73**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**73**	**0**	**0**

Covered Plant Species	Total Existing Modeled Habitat in the Plan Area[b]	Maximum Allowable Habitat Loss by Covered Activity[a,b,c]																
		CM1 Water Facilities and Operation				CM2 Yolo Bypass Fisheries Enhancement		CM4 Tidal Natural Communities Restoration	CM5 Seasonally Inundated Floodplain Restoration		CM7 Riparian Natural Community Restoration		CM10 Nontidal Marsh Restoration	CM8 Grassland Natural Community Restoration	CM18 Conservation Hatcheries			
		Tunnel/Pipeline Facilities Construction				Fremont Weir and Yolo Bypass Improvements		Construction and Inundation	Levee Construction		Riparian Restoration as Part of Tidal Natural Communities Restoration	Restoration within Restored Floodplain	Construction and Inundation		Construction	Maximum Allowable Habitat Loss		
		Permanent[d]	Permanent (Reusable Tunnel Material)[p]	Temporary (Borrow and Spoil)[d,e]	Temporary[d]	Permanent[f]	Temporary[f]	Permanent[g,h,i]	Permanent[j]	Temporary[j]	Permanent	Permanent[k]	Permanent[g]	Permanent[l]	Permanent[l]	Permanent[q]	Temporary (Borrow and Spoil)	Temporary
Vernal Pool Plants																		
Alkali milk-vetch																		
Vernal pool complex	8,709	8	0	0	0	0	0	1	0	0	0	0	0	0	0	9	0	0
Degraded vernal pool complex	2,576	7	0	0	0	0	0	51	0	0	0	0	0	0	0	58	0	0
Alkali seasonal wetland	188	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	**11,473**	**15**		**0**	**0**	**0**	**0**	**52**	**0**	**0**		**0**	**0**	**0**	**0**	**67**	**0**	**0**
Legenere																		
Vernal pool complex	8,709	8	0	0	0	0	0	1	0	0	0	0	0	0	0	9	0	0
Degraded vernal pool complex	2,576	7	0	0	0	0	0	51	0	0	0	0	0	0	0	58	0	0
Alkali seasonal wetland	188	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	**11,473**	**15**		**0**	**0**	**0**	**0**	**52**	**0**	**0**		**0**	**0**	**0**	**0**	**67**	**0**	**0**
Heckard's peppergrass																		
Vernal pool complex	8,709	8	0	0	0	0	0	1	0	0	0	0	0	0	0	9	0	0
Degraded vernal pool complex	2,576	7	0	0	0	0	0	51	0	0	0	0	0	0	0	58	0	0
Alkali seasonal wetland	188	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	**11,473**	**15**		**0**	**0**	**0**	**0**	**52**	**0**	**0**		**0**	**0**	**0**	**0**	**67**	**0**	**0**
Boggs Lake hedge-hyssop																		
Vernal pool complex	8,709	8	0	0	0	0	0	1	0	0	0	0	0	0	0	9	0	0
Degraded vernal pool complex	2,576	7	0	0	0	0	0	51	0	0	0	0	0	0	0	58	0	0
Alkali seasonal wetland	188	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	**11,473**	**15**		**0**	**0**	**0**	**0**	**52**	**0**	**0**		**0**	**0**	**0**	**0**	**67**	**0**	**0**
Dwarf downingia																		
Vernal pool complex	8,709	8	0	0	0	0	0	1	0	0	0	0	0	0	0	9	0	0
Degraded vernal pool complex	2,576	7	0	0	0	0	0	51	0	0	0	0	0	0	0	58	0	0
Alkali seasonal wetland	188	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	**11,473**	**15**		**0**	**0**	**0**	**0**	**52**	**0**	**0**		**0**	**0**	**0**	**0**	**67**	**0**	**0**

		Maximum Allowable Habitat Loss by Covered Activity[a,b,c]																
		CM1 Water Facilities and Operation				CM2 Yolo Bypass Fisheries Enhancement		CM4 Tidal Natural Communities Restoration	CM5 Seasonally Inundated Floodplain Restoration		CM7 Riparian Natural Community Restoration		CM10 Nontidal Marsh Restoration	CM8 Grassland Natural Community Restoration	CM18 Conservation Hatcheries			
	Total Existing	Tunnel/Pipeline Facilities Construction				Fremont Weir and Yolo Bypass Improvements		Construction and Inundation	Levee Construction		Riparian Restoration as Part of Tidal Natural Communities Restoration	Restoration within Restored Floodplain	Construction and Inundation		Construction	Maximum Allowable Habitat Loss		
Covered Plant Species	Modeled Habitat in the Plan Area[b]	Permanent[d]	Permanent (Reusable Tunnel Material)[p]	Temporary (Borrow and Spoil)[d,e]	Temporary[d]	Permanent[f]	Temporary[f]	Permanent[g,h,i]	Permanent[j]	Temporary[j]	Permanent	Permanent[k]	Permanent[g]	Permanent[l]	Permanent[l]	Permanent[q]	Temporary (Borrow and Spoil)	Temporary

[a] The following covered activities and associated federal actions (listed here by the header/category as described in Chapter 4, *Covered Activities and Associated Federal Actions*) are assumed not to have footprint impacts on natural communities or species habitat: Operations and Maintenance of Existing SWP Facilities; Power Generation Water Use - Mirant Delta, LLC activities; Activities to Reduce Contaminants; Activities to Reduce Predators and Other Sources of Direct Mortality; Monitoring and Research Programs; Emergency Actions; CVP Operations and Maintenance; and Joint Federal and Non-federal Actions.

[b] Existing habitat and habitat loss are estimated using habitat models created from detailed vegetation mapping. See Appendix 2.A, *Covered Species Accounts,* for a complete description of species-specific mapping methods. Effects on species' habitat will be tracked during implementation through on-the-ground surveys performed by qualified biologists.

[c] See Table 5.J.1, *Quantitative Effects Analysis Methods and Assumptions*, in Appendix 5.J *Effects on Natural Communities, Wildlife, and Plants,* for a description methods and assumptions relevant to estimating natural community loss by covered activity type and Table 5.J.3, *Key Assumptions Related to Tidal Restoration Effects on Covered Species Habitat*, for a list of assumptions used to determine permanent loss or conversion as a result of inundation caused by tidal restoration.

[d] Permanent and temporary effects assessed under CM1 are associated with construction of the following conveyance-related facilities: forebay, intake facilities, permanent access roads, shaft locations, and transmission lines. See Chapter 4, Section 4.2.1.1, *North Delta Diversions Construction and Operations*, for a complete description of all activities assessed under CM1.

[e] A borrow is a location from where construction material, such as sand or clay, will be taken. A spoil is an area where construction by-products, such as removed earth, will be placed and stored. A borrow/spoil is an area that will originally be used for borrow and later for spoil.

[f] Permanent and temporary effects assessed under CM2 include activities associated with Fremont Weir improvements, Putah Creek realignment activities, Lisbon weir and fish crossing improvements, and Sacramento Weir improvements.

[g] Inundation is tidal flooding of existing wetland habitat as a result of tidal restoration actions. Inundation can cause permanent loss of habitat from either the removal of habitat or the conversion of one habitat type to another. See Table 5.J.1, in Appendix 5.J, for a description of relevant assumptions. All construction is assumed to occur within the inundation footprint.

[h] Permanent loss calculations are based on hypothetical tidal restoration designs and include those areas modeled by ESAPWA (Appendix 3.B, *BDCP Tidal Habitat Evolution Assessment*) to be below extreme high water elevation. See Table 5.J.1, in Appendix 5.J, for methods and assumptions used to apply the hypothetical footprint to determine effects.

[i] Tidal restoration is expected to include riparian restoration where elevations are favorable. Permanent loss form riparian restoration was determined by non-GIS methods. See Table 5.J.1, in Appendix 5.J, for a complete list of methods and assumptions.

[j] Calculation of effects based on hypothetical floodplain restoration designs, see Table 5.J.1, in Appendix 5.J, for details.

[k] Based on restoration design assumptions described in Appendix 5.E, *Habitat Restoration*, and effects analysis assumptions detailed in Table 5.J.1, in Appendix 5.J.

[l] Permanent loss was determined based on non-GIS methods described in Table 5.J.1, in Appendix 5.J.

[m] Based on the hypothetical tidal restoration footprint, an estimated 4 acres of habitat will be lost or converted. However, to provide flexibility in implementation of tidal restoration projects, the take limit is set higher than the amount of loss estimated under the hypothetical footprint.

[n] Based on the hypothetical tidal restoration footprint, an estimated 2 acres of habitat will be lost or converted. However, to provide flexibility in implementation of tidal restoration projects, the take limit is set higher than the amount of loss estimated under the hypothetical footprint.

[o] Based on the hypothetical tidal restoration footprint, an estimated 4 acres of habitat will be lost or converted. However, to provide flexibility in implementation of tidal restoration projects, the take limit is set higher than the amount of loss estimated under the hypothetical footprint.

[p] Reusable tunnel material is flexible, and the footprint used in the effects analysis is based on a worst-case scenario. The actual area to be affected by reusable tunnel material storage will likely be less than the estimated acreage.

[q] Totals may not sum due to rounding.

[r] Although the tidal restoration model results in some decreases in acreage of natural community loss between near-term and late long-term implementation periods due to tidal damping and sea level rise, for permitting purposes the maximum acreage of loss is shown for the late long-term period.

[s] Loss reduced to zero. Although the temporary powerline footprint overlaps with 2 acres of alkali seasonal wetland complex and 16 acres of vernal pool complex in Conservation Zone 8, *AMM30 Transmission Line Design and Alignment Guidelines* requires that wetted acres of alkali seasonal wetlands and vernal pool complex be avoided during powerline installation (Appendix 3.C, *Avoidance and Minimization Measures*).

[t] Total permanent loss reduced from 372 acres (CM4) to 52 acres. This reduction is based on a 10-acre cap for total loss of wetted acres, assuming 15% density of vernal pools in the area affected. Acreage of vernal pool complex loss may be higher if actual vernal pool density is lower. The maximum acreage loss is based on loss of wetted acres, not total vernal pool complex acreage.

[u] To allow for flexibility in implementation and to address uncertainty related to the hypothetical restoration footprints, maximum loss from CM4 has been increased from 4 to 20 acres for brittlescale, 4 to 50 acres for Carquinez goldenbush, and from 1 to 50 acres for Delta tule pea and Suisun Marsh aster. Maximum loss from CM5 has been increased from 5 to 50 acres for slough thistle.

NHD = National Hydrologic Database; SWP = State Water Project; CVP = Central Valley Project.

Table 5.6-3. Periodic Effects on Wildlife

Resource	Total Existing Habitat in Plan Area (Acres)	Amount of Habitat Affected by Yolo Bypass Inundation at Variety of Flow Regimes[a] (acres)							Amount of Habitat Affected by Seasonally Inundated Floodplain
		1,000 cfs[b]	2,000 cfs[c]	3,000 cfs[d]	4,000 cfs[e]	5,000 cfs[f]	6,000 cfs (A)[g]	6,000 cfs (B)[h]	
Mammals									
Riparian brush rabbit									
Riparian habitat	2,909								264
Grassland habitat	3,103								423
Total	**6,011**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**687**
Riparian woodrat									
Total	**2,166**								**203**
Salt marsh harvest mouse									
Tidal brackish emergent wetland primary	3,641								0
Tidal brackish emergent wetland secondary	2,718								0
Upland secondary	749.0472								0
Managed wetland—wetland primary, low long-term conservation value	21,891								0
Managed wetland—wetland secondary, low long-term conservation value	2,800								0
Managed wetland—upland, low long-term conservation value	3,787								0
Total	**35,588**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
San Joaquin kit fox									
Total	**5,327**								**0**
Suisun shrew									
Primary habitat	3,128								0
Secondary habitat	4,387								0
Total	**7,515**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Birds									
California black rail[g]									
Primary habitat	7,467								0
Secondary habitat	17,915								6
Total	**25,382**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**6**
California clapper rail[g]									
Primary habitat	295.5694							9	0
Secondary habitat	6,420								0
Total	**6,716**	**0**	**0**	**0**	**0**	**0**	**0**	**9**	**0**
Greater sandhill crane									
Roosting and foraging—permanent	7,340								0
Roosting and foraging—temporary	16,522								0
Foraging	162,164								0
Total	**23,861**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Least Bell's vireo									
Total	**14,528**	**62**	**80**	**75**	**85**	**69**	**73**	**48**	**148**

Resource	Total Existing Habitat in Plan Area (Acres)	Amount of Habitat Affected by Yolo Bypass Inundation at Variety of Flow Regimes[a] (acres)							Amount of Habitat Affected by Seasonally Inundated Floodplain
		1,000 cfs[b]	2,000 cfs[c]	3,000 cfs[d]	4,000 cfs[e]	5,000 cfs[f]	6,000 cfs (A)[g]	6,000 cfs (B)[h]	
Suisun song sparrow[g]									
Primary habitat	3,722								0
Secondary habitat	23,986								0
Total	**27,707**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Swainson's hawk									
Foraging habitat	470,324	3,025	4,921	5,705	6,635	5,226	5,694	3,862	8,008
Nesting habitat	9,796	57	70	63	70	57	59	41	189
Total	**480,120**	**3,082**	**4,991**	**5,768**	**6,705**	**5,283**	**5,752**	**3,903**	**8,197**
Tricolored blackbird									
Breeding habitat—ag foraging	100,198	1,837	1,948	2,122	2,598	2,440	2,961	2,381	2,124
Breeding habitat—foraging	58,181	600	1,297	1,678	1,957	1,539	1,689	1,058	355
Breeding habitat—nesting	1,741	12	18	23	26	21	22	11	30
Nonbreeding habitat—foraging ag	194,251	42	64	128	177	186	191	156	2,506
Nonbreeding habitat—roosting	28,066	0	1	2	4	3	4	2	29
Nonbreeding Habitat—foraging	34,308	355	881	959	1,057	457	446	222	158
Total	**416,745**	**2,845**	**4,209**	**4,912**	**5,820**	**4,646**	**5,313**	**3,830**	**5,202**
Western burrowing owl									
High-value habitat	149,783	1,390	2,298	2,812	3,303	2,745	3,034	1,997	779
Low-value habitat	251,767	1,522	2,392	2,548	2,927	2,077	2,233	1,534	6,162
Total	**401,550**	**2,912**	**4,690**	**5,360**	**6,231**	**4,822**	**5,267**	**3,531**	**6,941**
Western Yellow-billed Cuckoo									
Breeding habitat	1,970	16	18	19	20	13	13	11	17
Migratory habitat	10,425	41	56	55	64	56	60	37	125
Total	**12,395**	**56**	**74**	**75**	**85**	**69**	**73**	**48**	**142**
White-tailed kite									
Breeding habitat	14,069	61	77	72	82	68	71	48	230
Foraging habitat	500,365	3,030	4,930	5,719	6,651	5,237	5,706	3,867	7,402
Total	**514,434**	**3,091**	**5,007**	**5,792**	**6,733**	**5,305**	**5,777**	**3,914**	**7,632**
Yellow-breasted chat									
Primary nesting and migratory habitat	8,178	21	30	32	38	32	34	19	92
Secondary nesting and migratory habitat	5,528	11	18	14	16	12	11	6	56
Suisun Marsh/upper Yolo Bypass nest and migratory habitat	841	30	32	29	32	25	28	23	0
Total	**14,547**	**62**	**80**	**75**	**85**	**69**	**73**	**48**	**148**

Resource	Total Existing Habitat in Plan Area (Acres)	Amount of Habitat Affected by Yolo Bypass Inundation at Variety of Flow Regimes[a] (acres)							Amount of Habitat Affected by Seasonally Inundated Floodplain
		1,000 cfs[b]	2,000 cfs[c]	3,000 cfs[d]	4,000 cfs[e]	5,000 cfs[f]	6,000 cfs (A)[g]	6,000 cfs (B)[h]	
Reptiles									
Giant garter snake									
Aquatic—tidal	12,097	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Aquatic—nontidal	19,027	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Upland—high	21,581	367	643	773	888	693	772	540	0
Upland—moderate	25,407	211	411	465	514	309	320	182	432
Upland—low	5,683	4	4						174
Total	**83,796**	**582**	**1,058**	**1,238**	**1,401**	**1,002**	**1,092**	**721**	**606**
Aquatic breeding, foraging and movement (miles)	2,784								21
Western pond turtle									
Aquatic habitat[i]	81,588	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Upland nesting and overwintering habitat	16,043	153	205	210	236	152	181	134	289
Upland nesting and overwintering habitat—NHD	12,615	130	310	452	562	542	589	419	42
Total	**110,245**	**283**	**515**	**662**	**798**	**694**	**769**	**554**	**331**
Aquatic habitat linear (miles) - NHD	1,418								9
									Amphibians
California red-legged frog									
Aquatic habitat	158.8594								0
Upland cover and dispersal habitat	7,766								0
Total	**7,925**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Aquatic habitat (miles)	29.91596								0
California tiger salamander									
Aquatic breeding habitat	7,845								0
Terrestrial cover and aestivation	28,173	191	435	564	639	501	544	275	0
Total	**36,018**	**191**	**435**	**564**	**639**	**501**	**544**	**275**	**0**
Invertebrates									
Valley elderberry longhorn beetle									
Riparian vegetation	17,464	59	74	72	80	66	69	44	266
Nonriparian channels and grasslands	16,585	103	181	214	244	174	200	125	287
Total	**34,048**	**161**	**256**	**286**	**325**	**240**	**269**	**169**	**553**
California linderiella									
Vernal pool complex	8,759					0	0	4	0
Degraded vernal pool complex	2,713								0
Total	**11,472**	**0**	**0**	**0**	**0**	**0**	**0**	**4**	**0**
Conservancy fairy shrimp									
Vernal pool complex	8,759					0	0	4	0
Degraded vernal pool complex	2,713								0
Total	**11,472**	**0**	**0**	**0**	**0**	**0**	**0**	**4**	**0**

Resource	Total Existing Habitat in Plan Area (Acres)	Amount of Habitat Affected by Yolo Bypass Inundation at Variety of Flow Regimes[a] (acres)							Amount of Habitat Affected by Seasonally Inundated Floodplain
		1,000 cfs[b]	2,000 cfs[c]	3,000 cfs[d]	4,000 cfs[e]	5,000 cfs[f]	6,000 cfs (A)[g]	6,000 cfs (B)[h]	
Longhorn fairy shrimp									
Vernal pool complex	8,759					0	0	4	0
Degraded vernal pool complex	2,713								0
Total	**11,472**	**0**	**0**	**0**	**0**	**0**	**0**	**4**	**0**
Midvalley fairy shrimp									
Vernal pool complex	8,759					0	0	4	0
Degraded vernal pool complex	2,713								0
Total	**11,472**	**0**	**0**	**0**	**0**	**0**	**0**	**4**	**0**
Vernal pool fairy shrimp									
Vernal pool complex	8,759					0	0	4	0
Degraded vernal pool complex	2,713								0
Total	**11,472**	**0**	**0**	**0**	**0**	**0**	**0**	**4**	**0**
Vernal pool tadpole shrimp									
Vernal pool complex	8,759					0	0	4	0
Degraded vernal pool complex	2,713								0
Total	**11,472**	**0**	**0**	**0**	**0**	**0**	**0**	**4**	**0**

[a] The columns provide effects comparisons for seven flow regimes. See Appendix 5.C, *Flow, Passage, Salinity, and Turbidity*, for description of methods.
[b] Notch flow = 1,000 cfs, existing flow = 2,170 cfs, and proposed flow =3,170 cfs.
[c] Notch flow = 2,000 cfs, existing flow = 2,647 cfs, and proposed flow = 4,647 cfs.
[d] Notch flow = 3,000 cfs, existing flow = 3,073 cfs, and proposed flow = 6, 073 cfs.
[e] Notch flow = 4,000 cfs, existing flow = 2,976 cfs, and proposed flow = 6,976 cfs.
[f] Notch flow = 5,000 cfs, existing flow = 4,393 cfs, and proposed flow = 9,343 cfs.
[g] Notch flow = 6,000 cfs, existing flow = 4,037 cfs, and proposed flow = 10,037 cfs.
[h] Notch flow = 6,000 cfs, existing flow = 6,289 cfs and proposed flow = 12,289 cfs.
cfs = cubic feet per second; NHD = National Hydrologic Database.
N/A = Existing, permanently aquatic habitat. Not affected by flooding.

Table 5.6-4. Periodic Effects on Plants

Resource	Total Existing Habitat in Plan Area	Amount of Habitat Affected by Yolo Bypass Inundation at Variety of Flow Regimes[a]							Amount of Habitat Affected by Seasonally Inundated Floodplain
		1,000 cfs[b]	2,000 cfs[c]	3,000 cfs[d]	4,000 cfs[e]	5,000 cfs[f]	6,000 cfs (A)[g]	6,000 cfs (B)[h]	
Plants									
Brittlescale									
Total									**0**
Heartscale									
Total		**37**	**76**	**80**	**96**	**75**	**84**	**68**	**0**
San Joaquin spearscale									
Total		**300**	**822**	**1,131**	**1,324**	**1,091**	**1,185**	**712**	**0**
Carquinez goldenbush									
Total									**0**
Delta button celery									
Total									**18**
Delta mudwort									
Total		**15**	**20**	**24**	**29**	**22**	**25**	**12**	**12**
Mason's lilaeopsis									
Total		**15**	**20**	**24**	**29**	**22**	**25**	**12**	**12**
Delta tule pea									
Total		**2**	**2**	**2**	**3**	**1**	**2**	**1**	**1**
Suisun Marsh aster									
Total		**2**	**2**	**2**	**3**	**1**	**2**	**1**	**1**
Side-flowering skullcap									
Total		**2**	**2**	**3**	**3**	**3**	**3**	**2**	**6**
Slough thistle									
Total									**6**
Soft bird's-beak[g]									
Total									**0**
Suisun thistle[g]									
Total									**0**
Vernal Pool Plants									
Alkali milk-vetch									
Degraded vernal pool									0
Vernal pool complex						0	0	4	0
Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**4**	**0**
Legenere									
Degraded vernal pool									0
Vernal pool complex						0	0	4	0
Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**4**	**0**

Resource	Total Existing Habitat in Plan Area	Amount of Habitat Affected by Yolo Bypass Inundation at Variety of Flow Regimes[a]							Amount of Habitat Affected by Seasonally Inundated Floodplain
		1,000 cfs[b]	2,000 cfs[c]	3,000 cfs[d]	4,000 cfs[e]	5,000 cfs[f]	6,000 cfs (A)[g]	6,000 cfs (B)[h]	
Heckard's peppergrass									
Degraded vernal pool									0
Vernal pool complex						0	0	4	0
Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**4**	**0**
Boggs Lake hedge-hyssop									
Degraded vernal pool									0
Vernal pool complex						0	0	4	0
Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**4**	**0**
Dwarf downingia									
Degraded vernal pool									0
Vernal pool complex						0	0	4	0
Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**4**	**0**

Blank cells denote that species does not have modeled habitat in Yolo Bypass in the Plan Area.
[a] The columns provide effects comparisons for seven flow regimes. See Appendix 5.C, *Flow, Passage, Salinity, and Turbidity*, for description of methods.
[b] notch flow = 1,000 cfs, existing flow = 2,170 cfs, and proposed flow =3,170 cfs.
[c] notch flow = 2,000 cfs, existing flow = 2,647 cfs, and proposed flow = 4,647 cfs.
[d] notch flow = 3,000 cfs, existing flow = 3,073 cfs, and proposed flow = 6, 073 cfs.
[e] notch flow = 4,000 cfs, existing flow = 2,976 cfs, and proposed flow = 6,976 cfs.
[f] notch flow = 5,000 cfs, existing flow = 4,393 cfs, and proposed flow = 9,343 cfs.
[g] notch flow = 6,000 cfs, existing flow = 4,037 cfs, and proposed flow = 10,037 cfs.
[h] notch flow = 6,000 cfs, existing flow = 6,289 cfs, and proposed flow = 12,289 cfs.
cfs = cubic feet per second.

Table 5.6-5. Indirect Effects on Wildlife

Covered Wildlife Species[a,b,c,d]	Total Existing Modeled Habitat in Plan Area (Acres)	Estimated Indirect Effects by Covered Activity[f]				Total Estimated Indirect Effects on Existing Modeled Habitat in the Plan Area	Indirect Effect Distances from Covered Activity
		CM1 Water Facilities and Operation	CM2 Yolo Bypass Fisheries Enhancement[e]	CM4 Tidal Natural Communities Restoration[e]	CM5 Seasonally Inundated Floodplain Restoration[e]		
		Construction	Construction	Construction	Construction		
		Temporary (Acres)	Temporary (Acres)	Temporary (Acres)	Temporary (Acres)	Temporary (Acres)	Feet
Mammals							
Riparian brush rabbit							
Riparian habitat	2,909	5	0	51	74	131	250
Grassland habitat	3,103	191	0	51	45	287	250
Total	**6,012**	**196**	**0**	**102**	**119**	**418**	**500**
Riparian woodrat							
Total	**2,166**	**0**	**0**	**18**	**63**	**81**	**250**
Salt marsh harvest mouse							
Tidal brackish emergent wetland primary	3,641	0	0	92	0	92	100
Tidal brackish emergent wetland secondary	2,718	0	0	60	0	60	100
Upland secondary	749	0	0	55	0	55	100
Managed wetland—wetland primary, low long-term conservation value	21,891	0	0	140	0	140	100
Managed wetland—wetland secondary, low long-term conservation value	2,800	0	0	45	0	45	100
Managed wetland—upland, low long-term conservation value	3,787	0	0	37	0	37	100
Total	**35,586**	**0**	**0**	**429**	**0**	**429**	**600**
San Joaquin kit fox							
Breeding, foraging, and dispersal habitat	5,327	182	0	0	0	182	250
Total	**5,327**	**182**	**0**	**0**	**0**	**182**	**250**
Suisun shrew							
Primary habitat	3,128	0	0	83	0	83	100
Secondary habitat	4,387	0	0	84	0	84	100
Total	**7,515**	**0**	**0**	**167**	**0**	**167**	**200**
Birds							
California black rail							
Primary habitat	7,467	126	5	364	0	495	500
Secondary habitat	17,915	3	0	428	0	431	500
Total	**25,382**	**129**	**5**	**792**	**0**	**926**	**1,000**
California clapper rail							
Primary habitat	296	0	0	19	0	19	500
Secondary habitat	6,420	0	0	523	0	523	500
Total	**6,716**	**0**	**0**	**542**	**0**	**542**	**1,000**
Greater sandhill crane							
Roosting and foraging—permanent	7,340	362	0	0	0	362	1,300
Roosting and foraging—temporary	16,522	975	0	174	0	1149	1,300

Covered Wildlife Species[a,b,c,d]	Total Existing Modeled Habitat in Plan Area (Acres)	Estimated Indirect Effects by Covered Activity[f] CM1 Water Facilities and Operation Construction Temporary (Acres)	CM2 Yolo Bypass Fisheries Enhancement[e] Construction Temporary (Acres)	CM4 Tidal Natural Communities Restoration[e] Construction Temporary (Acres)	CM5 Seasonally Inundated Floodplain Restoration[e] Construction Temporary (Acres)	Total Estimated Indirect Effects on Existing Modeled Habitat in the Plan Area Temporary (Acres)	Indirect Effect Distances from Covered Activity Feet
Foraging habitat	162,164	8,218	0	1,825	0	10043	1,300
Total	**186,026**	**9,555**	**0**	**1,999**	**0**	**11,554**	**3,900**
Least Bell's vireo							
Total	**14,528**	**237**	**244**	**619**	**88**	**1,188**	**500**
Suisun song sparrow							
Primary habitat	3,722	0	0	287	0	287	500
Secondary habitat	23,986	0	0	584	0	584	500
Total	**27,708**	**0**	**0**	**871**	**0**	**871**	**1,000**
Swainson's hawk							
Foraging habitat	470,324	6,954	2,275	6,013	5,132	20,374	0
Nesting habitat	9,796	172	255	361	100	888	600
Total	**480,120**	**7,126**	**2,530**	**6,374**	**5,232**	**21,262**	**600**
Tricolored blackbird							
Breeding habitat—ag foraging	100,198	824	1,612	1,152	1,874	5,462	0
Breeding habitat—foraging	58,181	777	931	2,389	296	4,393	0
Breeding habitat—nesting	1,741	43	89	43	57	232	1,300
Nonbreeding habitat—foraging ag	194,251	7,597	38	2,856	2,089	12,580	0
Nonbreeding habitat—roosting	28,066	422	49	1,214	35	1,720	
Nonbreeding habitat—foraging	34,308	824	0	1,324	13	2,161	0
Total	**416,745**	**10,487**	**2,719**	**8,978**	**4,365**	**26,549**	**1,300**
Western burrowing owl							
High-value habitat	149,783	1,330	1,202	3,040	235	5,807	500
Low-value habitat	251,767	3,688	512	1,632	3,621	9,453	500
Total	**401,550**	**5,018**	**1,714**	**4,672**	**3,865**	**15,260**	**1,000**
Western yellow-billed cuckoo							
Breeding habitat	1,970	49	24	98	30	201	500
Migratory habitat	10,425	152	220	398	43	813	500
Total	**12,395**	**201**	**244**	**496**	**73**	**1,014**	**1,000**
White-tailed kite							
Breeding habitat	14,069	228	269	543	119	1,159	600
Foraging	500,365	6,981	2,297	6,477	4,731	20,486	0
Total	**514,434**	**7,209**	**2,566**	**7,020**	**4,850**	**21,645**	**600**
Yellow-breasted chat							
Primary nesting and migratory habitat	8,178	124	80	388	72	664	500
Secondary nesting and migratory habitat	5,528	107	5	172	16	300	500
Suisun Marsh/upper Yolo Bypass nest and migratory habitat	841	0	160	74	0	234	500

		Estimated Indirect Effects by Covered Activity[f]					
		CM1 Water Facilities and Operation	CM2 Yolo Bypass Fisheries Enhancement[e]	CM4 Tidal Natural Communities Restoration[e]	CM5 Seasonally Inundated Floodplain Restoration[e]	Total Estimated Indirect Effects on Existing Modeled Habitat in the Plan Area	Indirect Effect Distances from Covered Activity
		Construction	Construction	Construction	Construction		
Covered Wildlife Species[a,b,c,d]	**Total Existing Modeled Habitat in Plan Area (Acres)**	**Temporary (Acres)**	**Temporary (Acres)**	**Temporary (Acres)**	**Temporary (Acres)**	**Temporary (Acres)**	**Feet**
Total	**14,547**	**231**	**245**	**634**	**88**	**1,198**	**1,500**
Reptiles							
Giant garter snake							
Aquatic—tidal	12,097	184	13	219	14	430	200
Aquatic—nontidal	19,027	87	133	103	23	346	200
Upland—high	21,581	277	242	372	0	891	200
Upland—moderate	25,407	427	125	773	54	1,379	200
Upland—low	5,683	79	1	150	52	282	200
Total	**83,795**	**1,054**	**514**	**1,617**	**143**	**3,328**	**1,000**
Aquatic breeding, foraging and movement (miles)	2,784	26	11	33	4	74	
Western pond turtle							
Aquatic habitat[j]	81,588	697	150	1,856	74	2,777	200
Upland nesting and overwintering habitat	16,043	275	115	331	31	752	200
Upland nesting and overwintering habitat-NHD	12,615	106	37	243	15	401	200
Total	**110,246**	**1,078**	**302**	**2,430**	**120**	**3,930**	**600**
Aquatic habitat linear (miles)—NHD	1,418	12	1	14	7	34	
Amphibians							
California red-legged frog							
Aquatic habitat	159	4	0	0	0	4	500
Upland cover and dispersal habitat	7,766	60	0	0	0	60	500
Total	**7,925**	**64**	**0**	**0**	**0**	**64**	**1,000**
Aquatic habitat (miles)	30	0	0	0	0	0	
California tiger salamander							
Aquatic breeding habitat	7,845	0	0	201	0	201	500
Terrestrial cover and aestivation habitat	28,173	85	30	659	0	774	500
Total	**36,018**	**85**	**30**	**860**	**0**	**975**	**1,000**
Invertebrates							
Valley elderberry longhorn beetle							
Riparian vegetation	17,464	88	56	125	33	302	100
Nonriparian channels and grasslands	16,585	175	85	261	12	532	100
Total	**34,049**	**263**	**141**	**386**	**44**	**834**	**200**
California linderiella							
Vernal pool complex	8,759	40	0	89	0	129	250
Degraded vernal pool complex	2,713	1	0	45	0	46	250
Total	**11,472**	**41**	**0**	**134**	**0**	**175**	**500**

Covered Wildlife Species[a,b,c,d]	Total Existing Modeled Habitat in Plan Area (Acres)	Estimated Indirect Effects by Covered Activity[f]				Total Estimated Indirect Effects on Existing Modeled Habitat in the Plan Area	Indirect Effect Distances from Covered Activity
		CM1 Water Facilities and Operation	CM2 Yolo Bypass Fisheries Enhancement[e]	CM4 Tidal Natural Communities Restoration[e]	CM5 Seasonally Inundated Floodplain Restoration[e]		
		Construction	Construction	Construction	Construction		
		Temporary (Acres)	Temporary (Acres)	Temporary (Acres)	Temporary (Acres)	Temporary (Acres)	Feet
Conservancy fairy shrimp							
Vernal pool complex	8,759	8	0	90	0	98	250
Degraded vernal pool complex	2,713	2	0	45	0	47	250
Total	**11,472**	**10**	**0**	**135**	**0**	**145**	**500**
Longhorn fairy shrimp							
Vernal pool complex	8,759	40	0	89	0	129	250
Degraded vernal pool complex	2,713	1	0	45	0	46	250
Total	**11,472**	**41**	**0**	**134**	**0**	**175**	**500**
Midvalley fairy shrimp							
Vernal pool complex	8,759	40	0	89	0	129	250
Degraded vernal pool complex	2,713	1	0	45	0	46	250
Total	**11,472**	**41**	**0**	**134**	**0**	**175**	**500**
Vernal pool fairy shrimp							
Vernal pool complex	8,759	40	0	89	0	129	250
Degraded vernal pool complex	2,713	1	0	45	0	46	250
Total	**11,472**	**41**	**0**	**134**	**0**	**175**	**500**
Vernal pool tadpole shrimp							
Vernal pool complex	8,759	40	0	89	0	129	250
Degraded vernal pool complex	2,713	1	0	45	0	46	250
Total	**11,472**	**41**	**0**	**134**	**0**	**175**	**500**

[a] Indirect effects are quantifiable by assuming a disturbance distance within which a species might reasonably experience indirect effects of covered activities. Indirect effects include audible or visual disturbance that may result in altered species behavior or avoidance of usually occupied habitat. Indirect effects also include environmental degradation such as the collection of dust and debris or the temporary decrease in ambient water quality. Temporary indirect effects are those that are associated with construction and will end when construction is complete. Permanent indirect effects are primarily audible effects associated with the continued operation of water intake and pump facilities.

[b] Disturbance effect was calculated by buffering known and hypothetical impact footprints (detailed in Section 5.2, *Methods*) by the distances listed in Table 5.J-4, *Indirect Effect Distances from Covered Activity, Wildlife*, and Table 5.J-5, *Indirect Effect Distances from Covered Activity, Plants*, in Appendix 5.J, *Effects on Natural Communities, Wildlife, and Plants.*

[c] Nontidal marsh, grassland, and vernal pool restoration and conservation fish hatchery construction do not have known or hypothetical footprints with which to calculate indirect effects on covered species' habitat. Temporary and permanent indirect effects for these covered activities are discussed qualitatively where relevant.

[d] All habitat values are in acres unless otherwise indicated.

[e] Riparian planting associated with tidal marsh and floodplain restoration, and periodic inundation associated with Yolo Bypass operations, are assumed to have no indirect effects.

[f] The following covered activities and associated federal actions (listed here by the header/category as described in Chapter 4, *Covered Activities and Associated Federal Actions*) are assumed not to have significant disturbance effects on species habitat: Operations and Maintenance of Existing SWP Facilities; Power Generation Water Use - Mirant Delta, LLC activities; Activities to Reduce Contaminants; Activities to Reduce Predators and Other Sources of Direct Mortality; Monitoring and Research Programs; Emergency Actions; CVP Operations and Maintenance; and Joint Federal and Non-federal Actions.

NHD = National Hydrologic Database; SWP= State Water Project; CVP = Central Valley Project.

Table 5.6-6. Indirect Effects on Plants (acres)

Covered Plant Species[a,b,c,d]	Total Existing Modeled Habitat in Plan Area	Estimated Indirect Effects by Covered Activity[f]				Total Estimated Indirect Effects on Existing Modeled Habitat in the Plan Area	Indirect Effect Distances from Covered Activity
		CM1 Water Facilities and Operation	CM2 Yolo Bypass Fisheries Enhancement[e]	CM4 Tidal Natural Communities Restoration[e]	CM5 Seasonally Inundated Floodplain Restoration[e]		
		Construction	Construction	Construction	Construction		
		Temporary	Temporary	Temporary	Temporary	Temporary	
Plants							
Brittlescale							
Total	**451**	**0**	**0**	**3**	**0**	**3**	**250**
Heartscale							
Total	**6,451**	**0**	**0**	**193**	**0**	**193**	**250**
San Joaquin spearscale							
Total	**14,477**	**58**	**48**	**129**	**1**	**236**	**250**
Carquinez goldenbush							
Total	**1,346**	**0**	**0**	**9**	**0**	**9**	**0**
Delta button celery							
Total	**3,361**	**97**	**0**	**0**	**26**	**123**	**0**
Delta mudwort							
Total	**6,081**	**93**	**10**	**261**	**11**	**375**	**0**
Mason's lilaeopsis							
Total	**6,081**	**93**	**10**	**261**	**11**	**375**	**0**
Delta tule pea							
Total	**5,853**	**5**	**0**	**420**	**1**	**426**	**0**
Suisun Marsh aster							
Total	**5,853**	**5**	**0**	**420**	**1**	**426**	**0**
Side-flowering skullcap							
Total	**2,497**	**32**	**1**	**80**	**1**	**114**	0
Slough thistle							
Total	**1,834**	**0**	**0**	**0**	**25**	**25**	**0**
Soft bird's-beak							
Total	**1,228**	**0**	**0**	**64**	**0**	**64**	**0**
Suisun thistle							
Total	**1,281**	**0**	**0**	**66**	**0**	**66**	**0**
Vernal Pool Plants							
Alkali milk-vetch							
Vernal pool complex	8,709	32	0	117	0	149	250
Degraded vernal pool complex	2,576	1	0	18	0	19	250
Alkali seasonal wetland	188	8	0	0	0	8	250
Total	**11,473**	**41**	**0**	**135**	**0**	**176**	**750**

Covered Plant Species[a,b,c,d]	Total Existing Modeled Habitat in Plan Area	Estimated Indirect Effects by Covered Activity[f]				Total Estimated Indirect Effects on Existing Modeled Habitat in the Plan Area	Indirect Effect Distances from Covered Activity
		CM1 Water Facilities and Operation	CM2 Yolo Bypass Fisheries Enhancement[e]	CM4 Tidal Natural Communities Restoration[e]	CM5 Seasonally Inundated Floodplain Restoration[e]		
		Construction	Construction	Construction	Construction		
		Temporary	Temporary	Temporary	Temporary	Temporary	
Legenere							
Vernal pool complex	8,709	32	0	117	0	149	250
Degraded vernal pool complex	2,576	1	0	18	0	19	250
Alkali seasonal wetland	188	8	0	0	0	8	250
Total	**11,473**	**41**	**0**	**135**	**0**	**176**	**750**
Heckard's peppergrass							
Vernal pool complex	8,709	32	0	117	0	149	250
Degraded vernal pool complex	2,576	1	0	18	0	19	250
Alkali seasonal wetland	188	8	0	0	0	8	250
Total	**11,473**	**41**	**0**	**135**	**0**	**176**	**750**
Boggs Lake hedge-hyssop							
Vernal pool complex	8,709	32	0	117	0	149	250
Degraded vernal pool complex	2,576	1	0	18	0	19	250
Alkali seasonal wetland	188	8	0	0	0	8	250
Total	**11,473**	**41**	**0**	**135**	**0**	**176**	**750**
Dwarf downingia							
Vernal pool complex	8,709	32	0	117	0	149	250
Degraded vernal pool complex	2,576	1	0	18	0	19	250
Alkali seasonal wetland	188	8	0	0	0	8	250
Total	**11,473**	**41**	**0**	**135**	**0**	**176**	**750**

[a] Indirect effects are quantifiable by assuming a disturbance distance within which a species might reasonably experience indirect effects of covered activities. Indirect effects include audible or visual disturbance that may result in altered species behavior or avoidance of usually occupied habitat. Indirect effects also include environmental degradation such as the collection of dust and debris or the temporary decrease in ambient water quality. Temporary indirect effects are those that are associated with construction and will end when construction is complete. Permanent indirect effects are primarily audible effects associated with the continued operation of water intake and pump facilities.

[b] Disturbance effect was calculated by buffering known and hypothetical impact footprints (detailed in Section 5.2, *Methods*) by the distances listed in Table 5.J-4, *Indirect Effect Distances from Covered Activity, Wildlife*, and Table 5.J-5, *Indirect Effect Distances from Covered Activity, Plants*, Appendix 5.J, *Effects on Natural Communities, Wildlife, and Plants.*

[c] Nontidal marsh, grassland, and vernal pool restoration and conservation fish hatchery construction do not have known or hypothetical footprints with which to calculate indirect effects on covered species' habitat. Temporary and permanent indirect effects for these covered activities are discussed qualitatively when relevant.

[d] All habitat values are in acres unless otherwise indicated.

[e] Riparian planting associated with tidal marsh and floodplain restoration, and periodic inundation associated with Yolo Bypass operations, are assumed to have no indirect effects.

[f] The following covered activities and associated federal actions (listed here by the header/category as described in Chapter 4, *Covered Activities and Associated Federal Actions*) are assumed not to have significant disturbance effects on species habitat: Operations and Maintenance of Existing SWP Facilities; Power Generation Water Use - Mirant Delta, LLC activities; Activities to Reduce Contaminants; Activities to Reduce Predators and Other Sources of Direct Mortality; Monitoring and Research Programs; Emergency Actions; CVP Operations and Maintenance; and Joint Federal and Non-federal Actions.

Table 5.6-7. Net Effects of Full BDCP Implementation on Wildlife

								Net Effect of Full BDCP Implementation					
	Existing Condition		Habitat Loss[c]			BDCP Conservation		Total Expected Modeled Habitat			Total Expected Modeled Habitat Protection		
Covered Wildlife Species	Total Extent in Plan Area (Acres)[a]	Protected (Acres)[b]	Permanent (Acres)	Temporary (Borrow and Spoil) (Acres)[d]	Permanent Protected (Acres)[b]	Expected Restoration (Acres)[e]	Expected Protection (Acres)[e]	Total Extent in Plan Area (Acres)	Net Change in Total Extent in Plan Area (Acres)[p]	Percent Change in Total Extent over Existing	Total Protected in the Plan Area (Acres)	Net Change in Extent Protected (Acres)	Percent Change in Extent of Protected over Existing
Mammals													
Riparian brush rabbit													
Riparian habitat	2,909	137	65	0	1	800	200	3,644	735	25%	1,136	999	729%
Grassland habitat	3,103	394	168	0	106	79	317	3,014	-89	-3%	684	290	74%
Total	**6,012**	**531**	**233**	**0**	**107**	**879**	**517**	**6,658**	**646**	**11%**	**1,820**	**1,289**	**243%**
Riparian woodrat													
Habitat	2,166	100	51	0	0	300	90	2,415	249	11%	490	390	390%
Total	**2,166**	**100**	**51**	**0**	**0**	**300**	**90**	**2,415**	**249**	**0**	**490**	**390**	**390%**
Salt marsh harvest mouse													
Tidal brackish emergent wetland primary	3,641	3,529	67	0	67	1,500	0	5,074	1,433	39%	4,962	1,433	41%
Tidal brackish emergent wetland secondary	2,718	2,716	0	0	0	4,500	0	7,218	4,500	166%	7,216	4,500	166%
Upland secondary	749	636	9[h]	0	3	46	50	786	37	5%	729	93	15%
Managed wetland—wetland primary, low long-term conservation value	21,891	21,875	5,323	0	5,323	0	1,500	16,568	-5,323	-24%	18,052	-3,823	-17%
Managed wetland—wetland secondary, low long-term conservation value	2,800	2,800	807	0	807	0	0	1,993	-807	-29%	1,993	-807	-29%
Managed wetland—upland, low long-term conservation value	3,787	3,776	762	0	762	0	0	3,025	-762	-20%	3,014	-762	-20%
Total	**35,586**	**35,332**	**6,968**	**0**	**6,962**	**6,046**	**1,550**	**34,664**	**-922**	**-3%**	**35,966**	**634**	**2%**
San Joaquin kit fox			**0**	**0**	**0**								
Breeding, foraging, and dispersal habitat	5,327	1,073	214	0	127	132	1,011	5,245	-82	-2%	2,089	1,016	95%
Total	**5,327**	**1,073**	**214**	**0**	**127**	**132**	**1,011**	**5,245**	**-82**	**-2%**	**2,089**	**1,016**	**95%**
Suisun shrew													
Primary habitat	3,128	3,004	60	0	60	1,500	1	4,568	1,440	46%	4,445	1,441	48%
Secondary habitat	4,387	4,313	342[h]	0	327	4,506	231	8,551	4,164	95%	8,723	4,410	102%
Total	**7,515**	**7,317**	**402**	**0**	**387**	**6,006**	**232**	**13,119**	**5,604**	**75%**	**13,168**	**5,851**	**80%**
Birds													
California black rail													
Primary habitat	7,467	4,584	83	0	77	3,579	0	10,963	3,496	47%	8,086	3,502	76%
Secondary habitat	17,915	16,810	3,043[h]	0	2,964	12,115	275	26,987	9,072	51%	26,236	9,426	56%
Total	**25,382**	**21,394**	**3,126**	**0**	**3,041**	**15,694**	**275**	**37,950**	**12,568**	**50%**	**34,322**	**12,928**	**60%**
California clapper rail[f]													
Primary habitat	296	178	27	0	27	1,500	0	1,769	1,473	498%	1,651	1,473	828%
Secondary habitat	6,420	5,942	8[h]	0	5	4,500	0	10,912	4,492	70%	10,437	4,495	76%
Total	**6,716**	**6,120**	**35**	**0**	**32**	**6,000**	**0**	**12,681**	**5,965**	**89%**	**12,088**	**5,968**	**98%**

Covered Wildlife Species	Existing Condition: Total Extent in Plan Area (Acres)[a]	Existing Condition: Protected (Acres)[b]	Habitat Loss[c]: Permanent (Acres)	Habitat Loss[c]: Temporary (Borrow and Spoil) (Acres)[d]	Habitat Loss[c]: Permanent Protected (Acres)[b]	BDCP Conservation: Expected Restoration (Acres)[e]	BDCP Conservation: Expected Protection (Acres)[e]	Net Effect of Full BDCP Implementation — Total Expected Modeled Habitat: Total Extent in Plan Area (Acres)	Net Change in Total Extent in Plan Area (Acres)[p]	Percent Change in Total Extent over Existing	Net Effect of Full BDCP Implementation — Total Expected Modeled Habitat Protection: Total Protected in the Plan Area (Acres)	Net Change in Extent Protected (Acres)	Percent Change in Extent of Protected over Existing
Greater sandhill crane													
Roosting and foraging - Permanent	7,340	6,291	0	0	0	575		7,915	575	8%	6,866	575	9%
Roosting and foraging - Temporary	16,522	1,414	41[g]	0	25	0	0	16,105	-41	0%	1,389	-25	-2%
Foraging	162,164	35,301	7,065	183	3,676	0	7,300	154,916	-7,248	-4%	38,925	3,624	10%
Total	**186,026**	**43,006**	**7,065**	**183**	**3,701**	**575**	**7,300**	**178,936**	**-6,714**	**-4%**	**47,180**	**4,174**	**10%**
Least Bell's vireo													
Migratory and breeding	14,528	5,093	685	1	539	1,000	593	14,842	314	2%	6,147	1,054	21%
Total	**14,528**	**5,093**	**685**	**1**	**539**	**1,000**	**593**	**14,842**	**314**	**2%**	**6,147**	**1,054**	**21%**
Suisun song sparrow													
Primary habitat	3,722	3,485	55	0	55	1,500	0	5,167	1,445	39%	4,930	1,445	41%
Secondary habitat	23,986	23,082	3,633[h]	0	3,535	4,500	384	24,853	867	4%	24,431	1,349	6%
Total	**27,708**	**26,567**	**3,688**	**0**	**3,590**	**6,000**	**384**	**30,020**	**2,312**	**8%**	**29,361**	**2,794**	**11%**
Swainson's hawk													
Foraging habitat	470,324	96,757	52,845	183	10,867	2,000	54,627	419,296	-51,028	-11%	142,517	45,760	47%
Nesting habitat	9,796	3,320	430	0	333	2,613	392	11,979	2,183	22%	5,992	2,672	80%
Total	**480,120**	**100,077**	**53,275**	**183**	**11,200**	**4,613**	**55,019**	**431,275**	**-48,845**	**-10%**	**148,509**	**48,432**	**48%**
Tricolored blackbird													
Breeding habitat—ag foraging	100,198	16,563	10,954	81	1,116	0	11,050	89,163	-11,035	-11%	26,497	9,934	60%
Breeding habitat—foraging	58,181	27,227	2,204	0	1,626	1,651	5,311	57,628	-553	-1%	32,563	5,336	20%
Breeding habitat—nesting	1,741	587	77	1	9	539	115	2,202	461	26%	1,232	645	110%
Nonbreeding habitat—foraging ag	194,251	30,960	26,282	0	4,196	0	26,300	167,969	-26,282	-14%	53,064	22,104	71%
Nonbreeding habitat—roosting	28,066	21,121	1,662	0	1,632	27,868	1,290	54,272	26,206	93%	48,647	27,526	130%
Nonbreeding Habitat—Foraging	34,308	8,815	1,586	0	1,204	943	3,500	33,665	-643	-2%	12,054	3,239	37%
Total	**416,745**	**105,273**	**42,766**	**82**	**9,783**	**31,001**	**47,566**	**404,898**	**-11,847**	**-3%**	**174,057**	**68,784**	**65%**
Western burrowing owl													
High-value habitat	149,783	52,500	12,450	0	4,924	1,642	8,589	138,975	-10,808	-7%	57,807	5,307	10%
Low-value habitat	251,767	34,845	31,519	101	4,628	3	25,177	220,150	-31,617	-13%	55,397	20,552	59%
Total	**401,550**	**87,345**	**43,969**	**101**	**9,552**	**1,645**	**33,766**	**359,125**	**-42,425**	**-11%**	**113,204**	**25,859**	**30%**
Western yellow-billed cuckoo													
Breeding habitat	1,970	944	150	0	88	500	82	2,320	350	18%	1,438	494	52%
Migratory habitat	10,425	3,255	397	0	333	2,897	435	12,925	2,500	24%	6,254	2,999	92%
Total	**12,395**	**4,199**	**547**	**0**	**421**	**3,397**	**517**	**15,245**	**2,850**	**23%**	**7,692**	**3,493**	**83%**
White-tailed kite													
Breeding habitat	14,069	4,793	533	0	405	3,800	570	17,336	3,267	23%	8,758	3,965	83%
Foraging	500,365	126,079	57,015	183	16,531	2,050	49,875	445,217	-55,148	-11%	161,473	35,394	28%
Total	**514,434**	**130,872**	**57,548**	**183**	**16,936**	**5,850**	**50,445**	**462,553**	**-51,881**	**-10%**	**170,231**	**39,359**	**30%**

Covered Wildlife Species	Existing Condition		Habitat Loss[c]			BDCP Conservation		Net Effect of Full BDCP Implementation					
								Total Expected Modeled Habitat			Total Expected Modeled Habitat Protection		
	Total Extent in Plan Area (Acres)[a]	Protected (Acres)[b]	Permanent (Acres)	Temporary (Borrow and Spoil) (Acres)[d]	Permanent Protected (Acres)[b]	Expected Restoration (Acres)[e]	Expected Protection (Acres)[e]	Total Extent in Plan Area (Acres)	Net Change in Total Extent in Plan Area (Acres)[p]	Percent Change in Total Extent over Existing	Total Protected in the Plan Area (Acres)	Net Change in Extent Protected (Acres)	Percent Change in Extent of Protected over Existing
Yellow-breasted chat													
Primary nesting and migratory habitat	8,178	2,556	232	0	161	1,000	341	8,946	768	9%	3,736	1,180	46%
Secondary nesting and migratory habitat	5,528	1,879	367	1	301	1,538	231	6,698	1,170	21%	3,347	1,468	78%
Suisun Marsh/Upper Yolo Bypass nest and migratory habitat	841	677	85	0	77	145	22	901	60	7%	767	90	13%
Total	**14,547**	**5,112**	**684**	**1**	**539**	**2,683**	**594**	**16,545**	**1,998**	**14%**	**7,850**	**2,738**	**54%**
Reptiles													
Giant garter snake													
Aquatic—tidal	12,097	3,905	28	0	18	1,250[i]	0	13,319	1,222	10%	5,137	1,232	32%
Aquatic—nontidal	19,027	7,474	553	0	204	2,200[j]	1,547	20,674	1,647	9%	11,017	3,543	47%
Upland—high	21,581	8,404	944	0	546	721[k]	948	21,358	-223	-1%	9,527	1.123	13%
Upland—moderate	25,407	8,663	1,718	0	932	259	1,238	23,948	-1,459	-6%	9,228	565	7%
Upland—low	5,683	1,029	193	0	142	0	0	5,490	-193	-3%	887	-142	-14%
Total	**83,795**	**29,475**	**3,436**	**0**	**1,842**	**4,430**	**3,733**	**84,789**	**994**	**1%**	**336,255**	**306,780**	**1041%**
Aquatic breeding, foraging and movement (miles)	2,784	566	156	0	51		281[l]	2,628	-156	-6%	796	230	41%
Western pond turtle													
Aquatic habitat[j]	81,588	40,776	351	0	262	29,739	1,278	110,976	29,388	36%	71,531	30,755	75%
Upland nesting and overwintering habitat	16,043	6,374	805	0	557	480	1,448	15,718	-325	-2%	7,745	1,371	22%
Upland nesting and overwintering habitat—NHD[m]	4,415	1,607	175	0	121	329	1,241	4,569	154	3%	5,972	2,060	128%
Total	**102,046**	**48,757**	**1,331**	**0**	**940**	**30,548**	**3,967**	**131,874**	**29,217**	**29%**	**85,248**	**34,185**	**70%**
Aquatic habitat linear (miles)—NHD[m]	496	113	41	0	13		44[n]	455	-41	-8%	144	31	27%
Amphibians													
California red-legged frog													
Aquatic habitat	159	14	1	0	0	16	3	174	15	9%	33	19	136%
Upland cover and dispersal habitat	7,766	1,774	30	0	5	352	1,047	8,088	322	4%	3,168	1,394	79%
Total	**7,925**	**1,788**	**31**	**0**	**5**	**368**	**1,050**	**8,262**	**337**	**4%**	**3,201**	**1,413**	**79%**
Aquatic habitat (miles)	30	4	0	0	0			30	0	0%	4	0	0%
California tiger salamander													
Aquatic breeding habitat	7,845	5,048	0	0	0	43	600	7,888	43	1%	5,691	643	13%
Terrestrial Cover and Aestivation	28,173	9,973	639	0	48	644	5,150	28,178	5	0%	15,719	5,746	58%
Total	**36,018**	**15,021**	**639**	**0**	**48**	**687**	**5,750**	**36,066**	**48**	**0%**	**21,410**	**6,389**	**43%**
Invertebrates													
Valley elderberry longhorn beetle													
Riparian vegetation	17,464	5,412	712	1	531	4,857	729	21,608	4,144	24%	10,467	5,055	93%
Non-riparian channels and grasslands	16,585	4,703	538	0	235	0	1,634	16,047	-538	-3%	6,102	1,399	30%
Total	**34,049**	**10,115**	**1,250**	**1**	**766**	**4,857**	**2,363**	**37,655**	**3,606**	**11%**	**16,569**	**6,454**	**64%**
California linderiella													
Vernal pool complex	8,759	5,424	8	0	8	51	608	8,802	43	0%	6,075	651	12%
Degraded vernal pool complex	2,713	887	59[o]	0	9	0	0	2,654	-59	-2%	878	-9	-1%
Total	**11,472**	**6,311**	**67**	**0**	**17**	**51**	**608**	**11,456**	**-16**	**0%**	**6,953**	**642**	**10%**

								Net Effect of Full BDCP Implementation					
	Existing Condition		Habitat Loss[c]			BDCP Conservation		Total Expected Modeled Habitat			Total Expected Modeled Habitat Protection		
Covered Wildlife Species	Total Extent in Plan Area (Acres)[a]	Protected (Acres)[b]	Permanent (Acres)	Temporary (Borrow and Spoil) (Acres)[d]	Permanent Protected (Acres)[b]	Expected Restoration (Acres)[e]	Expected Protection (Acres)[e]	Total Extent in Plan Area (Acres)	Net Change in Total Extent in Plan Area (Acres)[p]	Percent Change in Total Extent over Existing	Total Protected in the Plan Area (Acres)	Net Change in Extent Protected (Acres)	Percent Change in Extent of Protected over Existing
Conservancy fairy shrimp													
Vernal pool complex	8,759	5,424	8	0	8	51	608	8,802	43	0%	6,075	651	12%
Degraded vernal pool complex	2,713	887	59[o]	0	9	0	0	2,654	-59	-2%	878	-9	-1%
Total	**11,472**	**6,311**	**67**	**0**	**17**	**51**	**608**	**11,456**	**-16**	**0%**	**6,953**	**642**	**10%**
Longhorn fairy shrimp													
Vernal pool complex	8,759	5,424	8	0	8	51	608	8,802	43	0%	6,075	651	12%
Degraded vernal pool complex	2,713	887	59[o]	0	9	0	0	2,654	-59	-2%	878	-9	-1%
Total	**11,472**	**6,311**	**67**	**0**	**17**	**51**	**608**	**11,456**	**-16**	**0%**	**6,953**	**642**	**10%**
Midvalley fairy shrimp													
Vernal pool complex	8,759	5,424	8	0	8	51	608	8,802	43	0%	6,075	651	12%
Degraded vernal pool complex	2,713	887	59[o]	0	9	0	0	2,654	-59	-2%	878	-9	-1%
Total	**11,472**	**6,311**	**67**	**0**	**17**	**51**	**608**	**11,456**	**-16**	**0%**	**6,953**	**642**	**10%**
Vernal pool fairy shrimp													
Vernal pool complex	8,759	5,424	8	0	8	51	608	8,802	43	0%	6,075	651	12%
Degraded vernal pool complex	2,713	887	59[o]	0	9	0	0	2,654	-59	-2%	878	-9	-1%
Total	**11,472**	**6,311**	**67**	**0**	**17**	**51**	**608**	**11,456**	**-16**	**0%**	**6,953**	**642**	**10%**
Vernal pool tadpole shrimp													
Vernal pool complex	8,759	5,424	8	0	8	51	608	8,802	43	0%	6,075	651	12%
Degraded vernal pool complex	2,713	887	59[o]	0	9	0	0	2,654	-59	-2%	878	-9	-1%
Total	**11,472**	**6,311**	**67**	**0**	**17**	**51**	**608**	**11,456**	**-16**	**0%**	**6,953**	**642**	**10%**

								Net Effect of Full BDCP Implementation					
	Existing Condition		**Habitat Loss[c]**			**BDCP Conservation**		**Total Expected Modeled Habitat**			**Total Expected Modeled Habitat Protection**		
Covered Wildlife Species	**Total Extent in Plan Area (Acres)[a]**	**Protected (Acres)[b]**	**Permanent (Acres)**	**Temporary (Borrow and Spoil) (Acres)[d]**	**Permanent Protected (Acres)[b]**	**Expected Restoration (Acres)[e]**	**Expected Protection (Acres)[e]**	**Total Extent in Plan Area (Acres)**	**Net Change in Total Extent in Plan Area (Acres)[p]**	**Percent Change in Total Extent over Existing**	**Total Protected in the Plan Area (Acres)**	**Net Change in Extent Protected (Acres)**	**Percent Change in Extent of Protected over Existing**

[a] Existing habitat and habitat loss are estimated using habitat models created from detailed vegetation mapping. See Appendix 2.A, *Covered Species Accounts*, for a complete description of species-specific mapping methods. Effects on species' habitat will be tracked during implementation through on-the-ground surveys performed by qualified biologists.

[b] Known conservation lands were categorized into four types. See Chapter 3, Section 3.2.4.2.2, *Existing Conservation Lands*, for definitions of conservation land types.

[c] See Appendix 5.J, *Effects on Natural Communities, Wildlife, and Plants*, for relevant methods and assumptions applied to determine habitat loss.

[d] A borrow is a location from where construction material, such as sand or clay, will be taken. A spoil is an area where construction by-products, such as removed earth, will be placed and stored. A borrow/spoil is an area that will originally be used for borrow and later for spoil.

[e] See Appendix 5.J, Attachment 5J.B, *Natural Community Restoration and Protection Contributing to Covered Species Conservation*, for a description of methods used to determine total conservation.

[f] Based on the hypothetical tidal restoration footprint, an estimated 4 acres of habitat will be lost or converted. However, to provide flexibility in implementation of tidal restoration projects, the take limit is set higher than the amount of loss estimated under the hypothetical footprint.

[g] *AMM30 Transmission Line Design and Alignment Guidelines* requires a reroute of the powerline, so it does not affect a roost site (Appendix 3.C, *Avoidance and Minimization Measures*). This will reduce impacts on roosting and foraging habitat by 29 acres.

[h] Although the tidal restoration model results in some decreases in acreage of natural community loss between near-term and late long-term implementation periods due to tidal damping and sea level rise, for permitting purposes the maximum acreage of loss is shown for the late long-term period.

[I] Of the 4,240 acres of rice land or equivalent-value habitat, the proportional methods approach assumes 750 + 500 acre muted tidal.

[j] Of the 4,240 acres of rice land or equivalent-value habitat, the proportional methods approach assumes approximately 1,250 acres of muted tidal, 1,000 as nontidal restoration, 1,000 as rice, and 1,000 as upland. In addition to the 1,000 acres nontidal under "rice land or equivalent," the objectives call for 1,200 acres of nontidal marsh.

[k] Of the 400 acres of protected or restored grassland, assume 200 acres protected and 200 restored. Additionally, under the "rice land or equivalent," assume 1,000 acres grassland, half of which is protected and half restored: 200 + 500.

[l] Protection of linear habitat for giant garter snake was estimated based on the total length of linear habitat in cultivated lands multiplied by the fraction of cultivated lands in the Plan Area to be protected.

[m] For western pond turtle NHD model types, a 35% habitat suitability correction factor was applied to existing modeled habitat and covered activity loss acreage as it was determined that, in the Plan Area, approximately 35% of all channels and ditches mapped in the NHD layer are likely suitable for western pond turtle. See Appendix 2.A, *Covered Species Accounts*, Section 2.A.29, for more details.

[n] Protection of linear habitat for western pond turtle was estimated based on the total length of linear habitat in cultivated lands and managed wetlands multiplied by the fraction of cultivated lands and managed wetlands in the Plan Area to be protected. In addition, a 35% habitat suitability correction factor was applied, as approximately 35% of canals and ditches in the NHD layer are considered suitable (see Appendix 2.A, *Covered Species Accounts*, Section 2.A.29, for more details).

[o] Permanent loss reduced from 372 acres (CM4) to 59 acres. This reduction is based on a 10-acre cap for loss of wetted acres, assuming 15% density of vernal pools in the area affected. Acreage of vernal pool complex loss may be higher if actual vernal pool density is lower. The maximum acreage loss is based on loss of wetted acres, not total vernal pool complex acreage.

[p] Temporary borrow and spoil impacts are included, because they are considered permanent for the purposes of assessing net effects.

Table 5.6-8. Net Effects of Full BDCP Implementation on Plants

Covered Plant Species	Existing Condition		Habitat Loss			BDCP Conservation		Net Effect of Full BDCP Implementation: Total Expected Modeled Habitat			Net Effect of Full BDCP Implementation: Total Expected Modeled Habitat Protection		
	Total Extent in Plan Area (Acres)[a]	Protected (Acres)[b]	Permanent (Acres)[c]	Temporary (Borrow and Spoil) (Acres)[c,d]	Permanent Loss from Protected Areas (Acres)[c,d]	Restoration (Acres)[e]	Protection (Acres)[e]	Total Extent in Plan Area (Acres)	Net Change in Total Extent (Acres)[l]	Percent Change in Total Extent over Existing	Total Protected in the Plan Area (Acres)	Net Change in Extent Protected (Acres)	Percent Change in Extent Protected over Existing
Plants													
Brittlescale[f]													
Total	**451**	**142**	**20**	**0**	**0**	**5**	**75**	**436**	**-15**	**-3%**	**222**	**80**	**56%**
Heartscale													
Total	**6,451**	**3,415**	**306**	**0**	**4**	**107**	**75**	**6,252**	**-199**	**-3%**	**3,593**	**178**	**5%**
San Joaquin spearscale													
Total	**14,477**	**8,365**	**731**	**0**	**127**	**259**	**1,070**	**14,005**	**-472**	**-3%**	**9,567**	**1202**	**14%**
Carquinez goldenbush[f]													
Total	**1,346**	**695**	**4**	**0**	**0**	**18**	**86**	**1,360**	**14**	**1%**	**799**	**104**	**15%**
Delta button celery													
Total	**3,361**	**483**	**79**	**0**	**29**	**257**	**213**	**3,539**	**178**	**5%**	**924**	**441**	**91%**
Delta mudwort													
Total	**6,081**	**2,105**	**25**	**0**	**11**	**2,587**	**0[i]**	**8,643**	**2,562**	**42%**	**4,681**	**2576**	**122%**
Mason's lilaeopsis													
Total	**6,081**	**2,105**	**25**	**0**	**11**	**2,587**	**0[i]**	**8,643**	**2,562**	**42%**	**4,681**	**2576**	**122%**
Delta tule pea[g]													
Total	**5,853**	**5,399**	**3**	**0**	**1**	**3,792**	**0[i]**	**9,642**	**3,789**	**65%**	**9,190**	**3791**	**70%**
Suisun Marsh aster[g]													
Total	**5,853**	**5,399**	**3**	**0**	**1**	**3,792**	**0[i]**	**9,642**	**3,789**	**65%**	**9,190**	**3791**	**70%**
Side-flowering skullcap[h]													
Total	**2,497**	**670**	**8**	**0**	**2**	**695**	**0[i]**	**3,184**	**687**	**28%**	**1363**	**693**	**103%**
Slough thistle													
Total	**1,834**	**371**	**5**	**0**	**0**	**214**	**750**	**2,043**	**209**	**11%**	**1335**	**964**	**260%**
Soft bird's-beak													
Total	**1,228**	**1,165**	**73**	**0**	**73**	**1500**	**0**	**2,655**	**1,427**	**116%**	**2,592**	**1,427**	**122%**
Suisun thistle													
Total	**1,281**	**1,169**	**73**	**0**	**73**	**1500**	**0**	**2,708**	**1,427**	**111%**	**2,596**	**1,427**	**122%**
Vernal Pool Plants													
Alkali milk-vetch													
Vernal pool complex[j,k]	8,896	5,558	9	0	9	52	608	8,939	43	0%	6,209	651	12%
Degraded vernal pool complex	2,576	753	58[m]	0	7	14	0						
Total	**11,472**	**6,311**	**67**	**0**	**16**	**66**	**608**	**11,471**	**-1**	**0%**	**6,969**	**658**	**10%**
Legenere													
Vernal pool complex[j,k]	8,896	5,558	9	0	9	52	608	8,939	43	0%	6,209	651	12%
Degraded vernal pool complex	2,576	753	58[m]	0	7	14	0						
Total	**11,472**	**6,311**	**67**	**0**	**16**	**66**	**608**	**11,471**	**-1**	**0%**	**6,969**	**658**	**10%**

Covered Plant Species	Existing Condition		Habitat Loss			BDCP Conservation		Net Effect of Full BDCP Implementation					
								Total Expected Modeled Habitat			Total Expected Modeled Habitat Protection		
	Total Extent in Plan Area (Acres)[a]	Protected (Acres)[b]	Permanent (Acres)[c]	Temporary (Borrow and Spoil) (Acres)[c,d]	Permanent Loss from Protected Areas (Acres)[c,d]	Restoration (Acres)[e]	Protection (Acres)[e]	Total Extent in Plan Area (Acres)	Net Change in Total Extent (Acres)[l]	Percent Change in Total Extent over Existing	Total Protected in the Plan Area (Acres)	Net Change in Extent Protected (Acres)	Percent Change in Extent Protected over Existing
Heckard's peppergrass													
Vernal pool complex[j,k]	8,896	5,558	9	0	9	52	608	8,939	43	0%	6,209	651	12%
Degraded vernal pool complex	2,576	753	58[m]	0	7	14	0						
Total	**11,472**	**6,311**	**67**	**0**	**16**	**66**	**608**	**11,471**	**-1**	**0%**	**6,969**	**658**	**10%**
Boggs Lake hedge-hyssop													
Vernal pool complex[j,k]	8,896	5,558	9	0	9	52	608	8,939	43	0%	6,209	651	12%
Degraded vernal pool complex	2,576	753	58[m]	0	7	14	0						
Total	**11,472**	**6,311**	**67**	**0**	**16**	**66**	**608**	**11,471**	**-1**	**0%**	**6,969**	**658**	**10%**
Dwarf downingia													
Vernal pool complex[j,k]	8,896	5,558	9	0	9	52	608	8,939	43	0%	6,209	651	12%
Degraded vernal pool complex	2,576	753	58[m]	0	7	14	0						
Total	**11,472**	**6,311**	**67**	**0**	**16**	**66**	**608**	**11,471**	**-1**	**0%**	**6,969**	**658**	**10%**

[a] Existing habitat and habitat loss are estimated using habitat models created from detailed vegetation mapping. See Appendix 2.A, *Covered Species Accounts*, for a complete description of species-specific mapping methods. Effects on species' habitat will be tracked during implementation through on-the-ground surveys performed by qualified biologists.

[b] Known conservation lands were categorized into four types. See Chapter 3, Section 3.2.4.2.2, *Existing Conservation Lands*, for definitions of conservation land types.

[c] See Appendix 5.J, *Effects on Natural Communities, Wildlife, and Plants*, for relevant methods and assumptions applied to determine habitat loss.

[d] A borrow is a location from where construction material, such as sand or clay, will be taken. A spoil is an area where construction by-products, such as removed earth, will be placed and stored. A borrow/spoil is an area that will originally be used for borrow and later for spoil.

[e] See Appendix 5.J, Attachment 5J.B, *Natural Community Restoration and Protection Contributing to Covered Species Conservation*, for a description of methods used to determine total conservation.

[f] Based on the hypothetical tidal restoration footprint, an estimated 4 acres of habitat will be lost or converted. However, to provide flexibility in implementation of tidal restoration projects, the take limit is set higher than the amount of loss estimated under the hypothetical footprint.

[g] Based on the hypothetical tidal restoration footprint, an estimated 3 acres of habitat will be lost or converted. However, to provide flexibility in implementation of tidal restoration projects, the take limit is set higher than the amount of loss estimated under the hypothetical footprint.

[h] Based on the hypothetical tidal restoration footprint, an estimated 7 acres of habitat will be lost or converted. However, to provide flexibility in implementation of tidal restoration projects, the take limit is set higher than the amount of loss estimated under the hypothetical footprint.

[I] Riparian protection unlikely to overlap with range.

[j] Alkali seasonal wetland acreage was combined with vernal pool complex acreage.

[k] The vernal pool model completely overlaps with the vernal pool crustaceans model; therefore, all 600 acres of vernal pool restoration are expected to benefit vernal pool plants species.

[l] Temporary borrow and spoil impacts are included, because they are considered permanent for the purposes of assessing net effects.

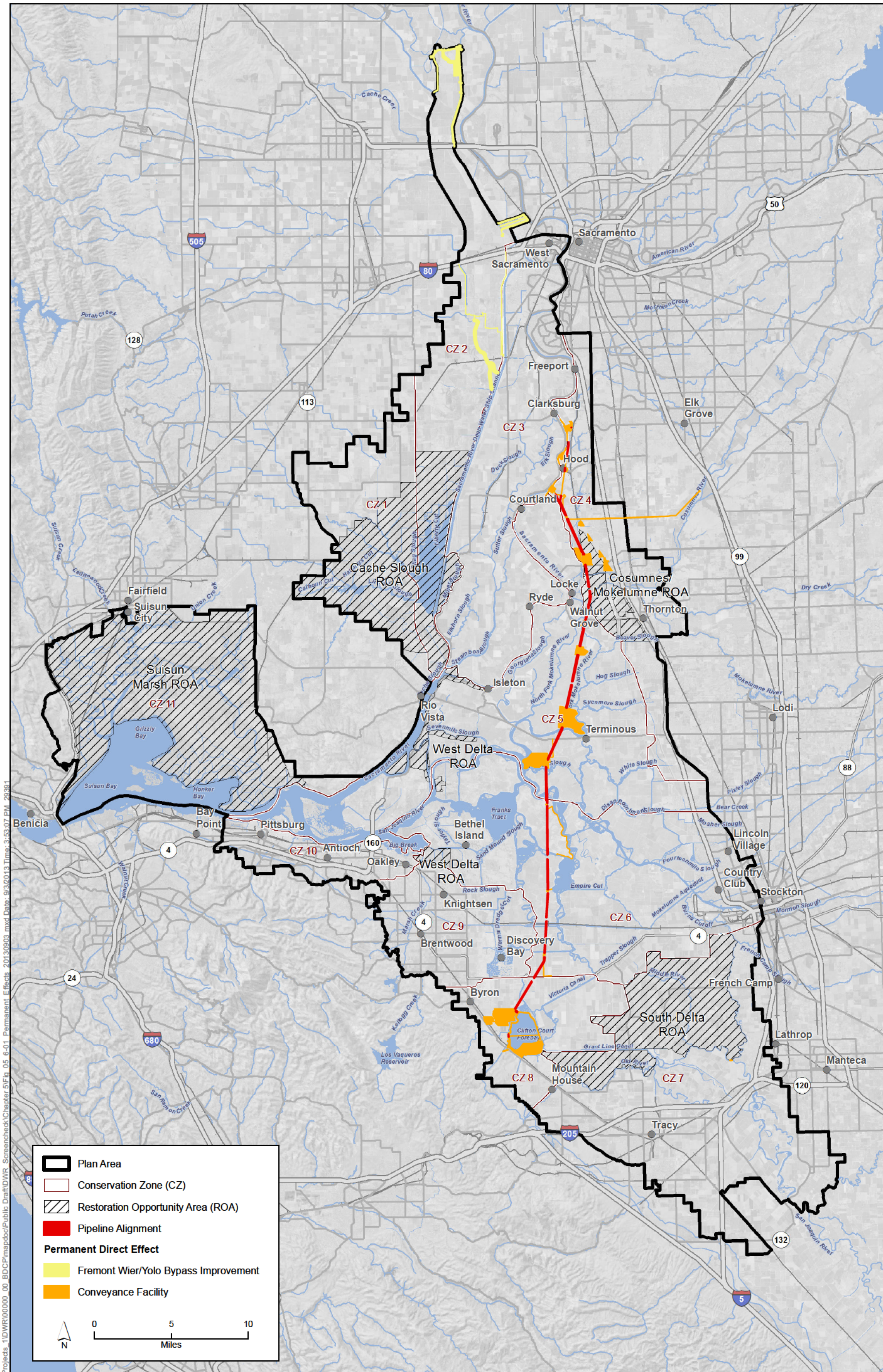
[m] Permanent loss reduced from 372 acres (CM4) to 58 acres. This reduction is based on a 10-acre cap for loss of wetted acres, assuming 15% density of vernal pools in the area affected. Acreage of vernal pool complex loss may be higher if actual vernal pool density is lower. The maximum acreage loss is based on loss of wetted acres, not total vernal pool complex acreage.

NHD = National Hydrologic Database.

Table 5.6-9. Covered Plant Species: Extant Occurrences, Maximum Allowable Loss, and Conservation

Resource	Existing Condition (Number of Occurrences)[a, b]				Adverse Effect on Occurrences	Outcome with Full Implementation of the BDCP		
	In California	In Plan Area	Protected in Type 1 Conservation Lands[i]	Protected in Type 2, 3, or 4 Conservation Lands[j]	Maximum Allowable Loss	Protected/ Established by BDCP	New Total in Type 1 Conservation Lands	Percent Increase in Protected Occurrences
Plants								
Brittlescale	62	7	3[k]	2	0	0	3	0%
Heartscale	57	8	2	1	0	0	2	0%
San Joaquin spearscale	107	19	4	3	0	2	6	50%
Carquinez goldenbush	14	10	1	5	0	3	4	300%
Delta button celery[c]	26	2[c]	0	0	0[p]	2	2	NA++[d]
Delta mudwort	58	58	4	11	0[e]	0	4	0%
Mason's lilaeopsis	196	181	12	41	0[l]	0	12	0%
Delta tule pea	133	106	8	51	0[m]	0	8	0%
Suisun Marsh aster	174	164	14	49	0[n]	0	14	0%
Side-flowering skullcap	12	12	10	0	0[o]	0	10	0%
Slough thistle	19	2[f]	0	0	0[q]	2	2	NA++[d]
Soft bird's-beak	25	12	5	7	0[r]	0	5	0%
Suisun thistle	4	4	3	1	0	2	5	67%
Vernal Pool Plants								
Alkali milk-vetch	57	18	5	5	0	2	7	40%
Legenere	71	7	6	0	0	0	6	–
Heckard's peppergrass	15	5	2	2	1[g]	1[h]	4	–
Boggs Lake hedge-hyssop	87	1	1	0	0	0	1	–
Dwarf downingia	116	12	10	0	0	0	8	–

[a] A plant occurrence is defined by the California Natural Diversity Database (CNDDB) as any population or group of nearby populations located more than 0.25 mile from any other population. Plant occurrences include CNDDB data and results of 2009–2011 field surveys for the Delta Habitat Conveyance and Conservation Program. Some of these data are pending entry into the CNDDB and are counted here consistent with the CNDDB occurrence definition.
[b] Includes "presumed extant" and "possibly extirpated" occurrences as defined by CNDDB.
[c] While there are no presumed extant occurrences of delta button celery in the Plan Area, this species is covered because two possibly extirpated occurrences are found in the Plan Area, and modeled habitat exists.
[d] ++ refers to an increase from zero occurrences within existing conservation lands. This value cannot be calculated as a percentage.
[e] Three occurrences of delta mudwort overlap with the hypothetical tidal restoration footprint. While the loss of an occurrence with more than 10 individuals is not allowed, up to 5% of an occurrence with 10 or more individuals may be lost due to direct or indirect effects (e.g., construction or tidal damping). Loss of individuals will be offset through replacement of occupied habitat at a ratio of 1:1 to achieve no net loss of occupied habitat. The Implementation Office will ensure no net loss through pre- and postconstruction and monitoring. See *AMM11 Covered Plant Species* (Appendix 3.C, *Avoidance and Minimization Measures*) for more details.
[f] This occurrence near the San Joaquin River Club has not been seen since 1974 but is presumed to be extant; a second occurrence northeast of Lathrop Bridge has not been seen since 1933 and is possibly extirpated (California Department of Fish and Wildlife 2013h).
[g] This occurrence (CNDDB Element Occurrence number 7) is an observation from an 1891 Jepson collection that has not been verified in the field. Although this is an historical occurrence with potential to be extirpated, it is "presumed extant" (California Department of Fish and Game 2013h). The collection record-occurs within the hypothetical tidal restoration footprint. While tidal restoration is not expected to result in take, because the status is undetermined, if found and taken, a new occurrence will be established to maintain no net loss of the species in the Plan Area.
[h] The protection or establishment of one Heckard's peppergrass occurrence will only be necessary if take is confirmed by field verification.
[i] Based on the best available information, occurrence overlaps wholly or significantly with Type 1 conservation lands such that the occurrence can be considered "conserved" with no further conservation opportunity.
[j] Based on the best available information, occurrence overlaps wholly or significantly with Type 2, 3, and 4 conservation lands. While these occurrences have some level of protection, management actions may not include enhancement and management of covered plants and additional conservation opportunities may exist.
[k] Occurrence near Jepson Prairie (ICF occurrence 979) is not considered completely protected.
[l] Portions of 22 of the 181 Mason's lilaeopsis occurrences in the Plan Area overlap with the conveyance facility footprint (CM1) or hypothetical tidal restoration footprint (CM4). While the loss of an occurrence with more than 10 individuals is not allowed, up to 5% of an occurrence with 10 or more individuals may be lost due to direct or indirect effects (e.g., construction or tidal damping). Loss of individual plants will be offset through replacement of occupied habitat at a ratio of 1:1 to achieve no net loss of occupied habitat. The Implementation Office will ensure no net loss through pre- and postconstruction and monitoring. See *AMM11 Covered Plant Species* (Appendix 3.C) for more details.
[m] Portions of 28 of the 106 Delta tule pea occurrences in the Plan Area overlap with the conveyance facility footprint (CM1) or hypothetical tidal restoration footprint (CM4). While the loss of an occurrence with more than 10 individuals is not allowed, up to 5% of an occurrence with 10 or more individuals may be lost due to direct or indirect effects (e.g., construction or tidal damping). Loss of individual plants will be offset through replacement of occupied habitat at a ratio of 1:1 to achieve no net loss of occupied habitat. The Implementation Office will ensure no net loss through pre- and postconstruction and monitoring. See *AMM11 Covered Plant Species* (Appendix 3.C) for more details.
[n] Portions of 29 of the 164 Suisun Marsh aster occurrences in the Plan Area overlap with the conveyance facility footprint (CM1) or hypothetical tidal restoration footprint (CM4). While the loss of an occurrence with more than 10 individuals is not allowed, up to 5% of an occurrence with 10 or more individuals may be lost due to direct or indirect effects (e.g., construction or tidal damping). Loss of individual plants will be offset through replacement of occupied habitat at a ratio of 1:1 to achieve no net loss of occupied habitat. The Implementation Office will ensure no net loss through pre- and postconstruction and monitoring. See *AMM11 Covered Plant Species* (Appendix 3.C) for more details.
[o] Two of the 12 side-flowering skullcap occurrences in the Plan Area overlap with the conveyance facility footprint (CM1) or hypothetical tidal restoration footprint (CM4). While the loss of an occurrence with more than 10 individuals is not allowed, up to 5% of an occurrence with 10 or more individuals may be lost due to direct or indirect effects (e.g., construction or tidal damping). Loss of individual plants will be offset through replacement of occupied habitat at a ratio of 1:1 to achieve no net loss of occupied habitat. The Implementation Office will ensure no net loss through pre- and postconstruction and monitoring. See *AMM11 Covered Plant Species* (Appendix 3.C) for more details.
[p] One occurrence of delta button celery overlaps with the hypothetical floodplain restoration footprint. While this occurrence is possibly extirpated, *AMM11 Covered Plant Species* (Appendix 3.C) requires strict avoidance of occupied habitat so no occupied habitat will be lost.
[q] Both Plan Area occurrences of slough thistle overlap with the hypothetical floodplain restoration footprint. *AMM11 Covered Plant Species* (Appendix 3.C) requires strict avoidance of occupied habitat so no occupied habitat will be lost.
[r] Seven occurrences of soft bird's-beak overlap with the hypothetical tidal restoration footprint (CM4). While the loss of an occurrence with more than 10 individuals is not allowed, up to 5% of an occurrence with 10 or more individuals may be lost due to direct or indirect effects (e.g., construction or tidal damping). Loss of individual plants will be offset through replacement of occupied habitat at a ratio of 1:1 to achieve no net loss of occupied habitat. The Implementation Office will ensure no net loss through pre- and postconstruction monitoring. See *AMM11 Covered Plant Species* (Appendix 3.C) for more details.



GIS Data Source: Conservation Zones, SAIC 2012; Constrcutability (Rev 2c), DWR 2013; Restoration Opportunity Area, SAIC 2011.

Figure 5.6-1
Covered Activities Resulting in Permanent Effects

5.7 References

5.7.1 Literature Cited

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5.7.2 Personal Communications

Burau, J. U.S. Geological Survey. Unpublished report in preparation. Hydrodynamic/Transport Conceptual Model, Delta Regional Ecosystem Restoration Implementation Plan.

Breault, A. Waterfowl and Habitat Biologist, Canadian Wildlife Service, Delta BC, March 2012—presentation to the Pacific Flyway Study Committee.

Hansen, Eric. Hansen Biological Consulting. June 4, 2009—Telephone conversation.

Hansen, Eric. Hansen Biological Consulting. August 30, 2013—Email regarding the effects of duration of inundation on giant garter snake overwintering.

Israel, Josh. Fisheries Biologist, U.S. Bureau of Reclamation. February 20, 2012—Telephone communication with Rick Wilder discussing flow correlates of white sturgeon year class strength, possible mechanisms for relationships, and previous analyses to determine correlations and reporting of them.

Ivey, G. L. Wildlife biologist and greater sandhill crane specialist. International Crane Foundation. August 25, 2013—Email to Heather White.

Kirkland, Marianne. California Department of Water Resources. November 13, 2012—Personal communication.

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Llaban, Angela. Environmental Scientist. California Department of Water Resources, West Sacramento, CA. February 8, 2012—Email to Marin Greenwood, Aquatic Ecologist, ICF International. Excel spreadsheet with estimates of incidental take of winter-run Chinook salmon at the South Delta export facilities (1993–2011).

Meese, R. J. Staff Research Associate, Department of Environmental Science and Policy (SEP) and Information Center for the Environment (ICE), University of California, Davis. December 20, 2011—GIS data transfer, in Access database format, detailing known, historic breeding colony sites in or near the Plan Area that had not yet been entered into ICE.

Miller, B. J. Consulting Engineer. October 5, 2011—Emails to Marianne Guerin, Associate, Research Management Associates, with Excel data analysis estimating entrainment.

Nobriga, M. L., Fish Biologist, U.S. Fish and Wildlife Service. April 16, 2010—Telephone conversation with L. Wise, Senior Consultant, Cardno-Entrix, to discuss his comments on early analyses for the delta and longfin smelt effects analysis.

Patterson, Laura. California Department of Water Resources. January 2012—Personal communication.

Rosenfield, J. A. April 16, 2010—Telephone conversation with L. Wise, Senior Consultant, Cardno-Entrix, to discuss his comments on early analyses for the delta and longfin smelt effects analysis.

Schwall, Lt. L. Game Warden, California Department of Fish and Game, Sacramento, California. August 15, 2007—Conversation with Rick Wilder about sturgeon poaching in the Delta.

Sommer, T., Senior environmental scientist. California Department of Water Resources. June 28 and 29, 2010—Telephone conversations with S. Unger, owner, Waterwise Consulting, about splittail spawning timing and conditions.