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NORTH CENTRAL REGION OFFICE
PO BOX 942836
SACRAMENTO, CA 94236
(916) 376-9600

California Department of Water Resources (DWR) Web site:
http://www.water.ca.gov.

For information on DWR and DWR projects,

please contact the Regional Coordinators at:
DWR-RC@water.ca.gov.

Contents

Sacramento-San Joaquin Delta D-9
Current State of the Region D-9
Purpose of Overlay Area D-9
Statewide Significance of the Delta D-9
Water Governance D-11
Unique Characteristics D-16
Unique Challenges/Drivers of Change D-26
Regional Resource Management Conditions D-33
Environmental Water D-33
Ecosystem Restoration D-34
Water Supplies D-36
Water Uses Within the Delta D-40
Water Uses Outside the Delta D-42
Water Quality D-46
Flood Management D-53
Resource Planning in the Delta D-59
Delta Plan D-59
Bay Delta Conservation Plan D-61
Bay-Delta Water Quality Control Plan Update D-62
Triennial Review of the Water Quality Control Plan for the Sacramento River and San Joaquin River Basins D-63
Strategic Workplan for Activities in the San Francisco Bay/Sacramento-San Joaquin Delta Estuary D-63
Ecosystem Restoration Program D-63
Quantifiable Biological Objectives and Flow Criteria for Aquatic and Terrestrial Species of Concern Dependent on the Delta D-64
Central Valley Flood Protection Plan D-64
Delta Risk Management Strategy D-65
Integrated Regional Water Management Plans D-65
Environmental Stewardship D-67
Resource Management Strategies D-72
References D-75
References Cited D-75
Personal Communications D-80
Additional References D-80

Tables

Table D-1 Agencies with Responsibilities in the Delta and Suisun Marsh D-14
Table D-2 Laws, Directives, and Orders Affecting CVP and SWP Operations D-45

Table D-3 Summary of Community Drinking Water Systems in the Sacramento-San Joaquin Delta Region that Rely on One or More Contaminated Groundwater Wells that Exceed a Primary Drinking Water Standard D-51
Table D-4 Summary of Contaminants Affecting Community Drinking Water Systems in the Sacramento-San Joaquin Delta Region D-52
Table D-5 Sacramento-San Joaquin Delta Area Exposures within the 100-Year and 500-Year Floodplains D-56
Table D-6 Completion for IRWM Plans D-68
Table D-7 Resource Management Strategies and Delta Actions D-73

Figures

Figure D-1 Sacramento-San Joaquin Delta and Suisun Marsh D-10
Figure D-2 Sacramento-San Joaquin Delta Watershed D-12
Figure D-3 County Boundaries and General Land Use D-20
Figure D-4 Land Subsidence in the Delta D-24
Figure D-5 DWR Hydrologic and Western Region Climate Center Climate Regions D-32
Figure D-6 Historical Diversions from within the Delta D-37
Figure D-7 Historical Diversions before the Delta D-38
Figure D-8 Delta Water Balance for Years 1998, 2000, and 2001 ..... D-39
Figure D-9 Location of State Water Project and Central Valley Project Facilities in the Delta-Suisun Area D-44
Figure D-10 Statewide Flood Hazard Exposure Summary for the Sacramento-San Joaquin Delta Region 100-year Floodplain D-57
Figure D-11 Statewide Flood Hazard Exposure Summary for the Sacramento-San Joaquin Delta Region 500-year Floodplain D-58
Figure D-12 Regional Acceptance Process IRWM Regions, Sacramento-San Joaquin Delta D-66

Acronyms and Abbreviations Used in This Report

µg/L	micrograms per liter
AB	Assembly Bill
af	acre-feet
BCDC	San Francisco Bay Conservation and Development Commission
BDCP	Bay Delta Conservation Plan
Cal EMA	California Emergency Management Agency
CALFED	Former agency comprised of State and federal agencies with the mission of improving California's water supply and the ecological health of the San Francisco Bay/Sacramento-San Joaquin Delta
CCC	Contra Costa Canal
CCF	Clifton Court Forebay
cfs	cubic feet per second
CO_2	carbon dioxide
cm/yr.	centimeters per year
CVFFP	Central Valley Flood Protection Plan
CVFPB	Central Valley Flood Protection Board
CVP	Central Valley Project
CVRWQCB	Central Valley Regional Water Quality Control Board
CV-SALTS	Central Valley Salinity Alternatives for Long-Term Sustainability
CWC	California Water Code
DCC	Delta Cross Channel
DDT	dichlorodiphenyltrichloroethane
Delta Conservancy	Sacramento-San Joaquin Delta Conservancy
DFW	California Department of Fish and Wildlife
DMC	Delta Mendota Canal
DO	dissolved oxygen
DPC	Delta Protection Commission

DRMS	Delta Risk Management Strategy
DSC	Delta Stewardship Council
DWR	California Department of Water Resources
DWSC	Stockton Deep Water Ship Channel
EC	electrical conductivity
EIS/EIR	environmental impact statement/environmental impact report
EPA	U.S. Environmental Protection Agency
ERP	Ecosystem Restoration Program
FEMA	Federal Emergency Management Agency
FRPA	Fish Restoration Program Agreement
GHG	greenhouse gas
HCP	habitat conservation plan
HMP	State Hazard Mitigation Plan
IEP	Interagency Ecological Program
IRWM	integrated regional water management
IWM	integrated water management
ITP	Department of Fish and Wildlife Longfin Smelt Incidental Take Permit
maf	million acre-feet
MOU	memorandum of understanding
NBA	North Bay Aqueduct
NCCP	natural community conservation plan
NDWA	North Delta Water Agency
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
OMR	Old and Middle River
PCB	polychlorinated biphenyl
POD	pelagic organism decline
ROD	record of decision

RWQCB	regional water quality control board
SB	Senate Bill
SFBRWQCB	San Francisco Bay Regional Water Quality Control Board
SFMP	State Flood Management Plan
SMPA	Suisun Marsh Preservation Act
SPFC	State Plan of Flood Control
SMPP	Suisun Marsh Protection Plan
SMSCG	Suisun Marsh Salinity Control Gates
SPFC	State Plan of Flood Control
SRCD	Suisun Resource Conservation District
SWP	State Water Project
SWRCB	State Water Resource Control Board
TMDL	total maximum daily load
UFMP	urban forest management plan
USACE	U.S. Army Corps of Engineers
VAMP	Vernalis Adaptive Management Program
WRCC	Western Regional Climate Center

Sacramento-San Joaquin Delta. The Delta is an unique estuary covering more than 1,300 square miles, with the major land use being agriculture. The area is also valued for its scenic and recreational resources and supports several fisheries. The Delta is the source of water for export through the State Water Project and the federal Central Valley Project to regions in the south.

Sacramento-San Joaquin Delta

Current State of the Region

Purpose of Overlay Area

Some areas of the state with common water issues or interests cross the boundaries from one hydrologic region to another. To acknowledge this, the California Department of Water Resources (DWR) developed the concept of "overlay areas" and first described overlay areas in California Water Plan Update 2005. The purpose of the overlay areas is to collect and provide information that will better enable planners and decision-makers to address issues in areas of special interest where both of the following criteria apply: (1) the area is of statewide significance — meaning that water management strategies and actions taken in one area affect much of the remainder of the state — and (2) common water management conditions exist in the area — meaning that issues and integrated planning opportunities span more than one of the 10 hydrologic regions. The two overlay areas of special interest are the Sacramento-San Joaquin Delta (Delta) and Mountain Counties.

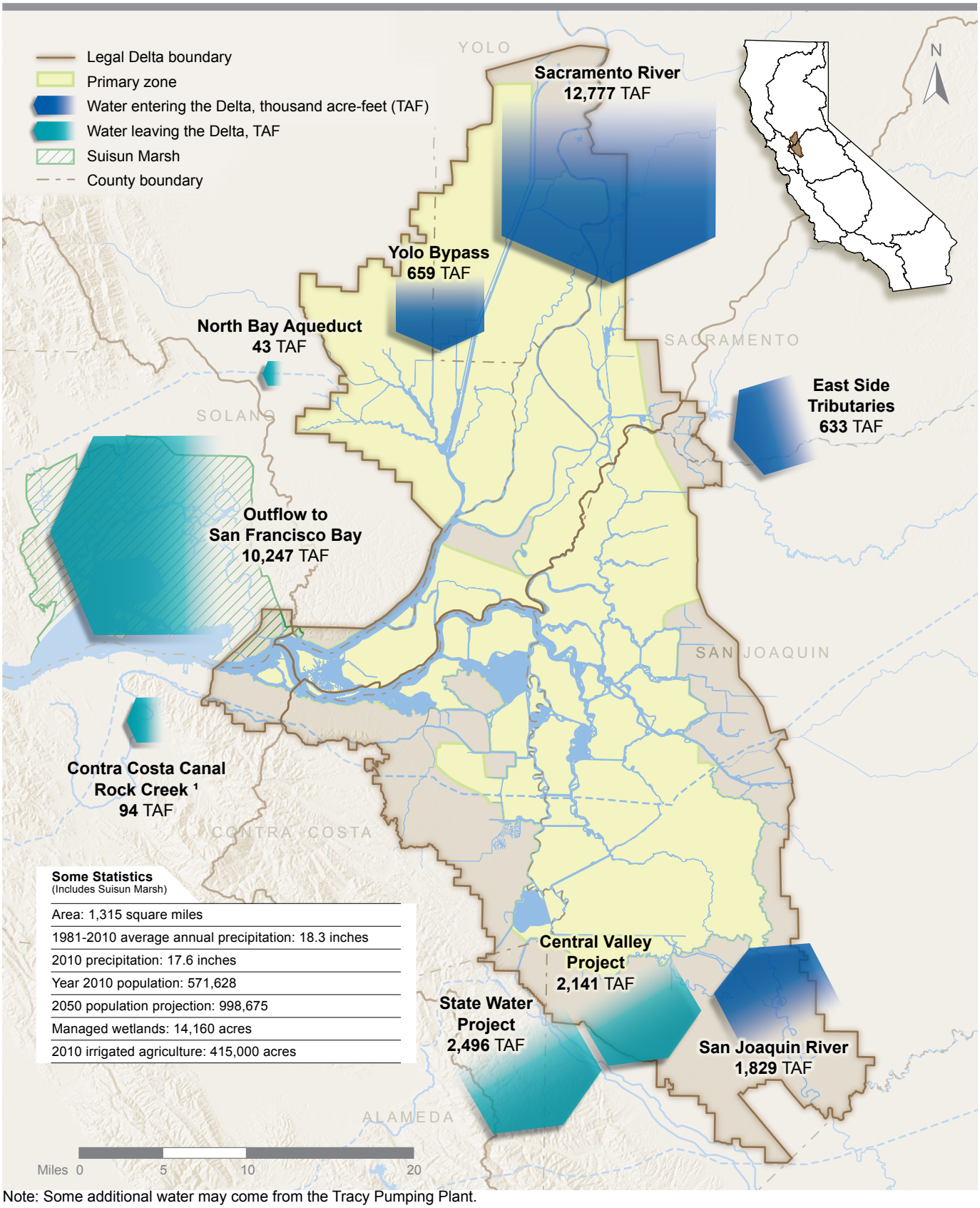
For Update 2005, the Delta and Suisun Marsh were included as an overlay area because of its common characteristics, environmental significance, and the important role it has in the State's water systems. The Delta and Suisun Marsh encompasses about 840,000 acres of tidal influenced land near the confluence of the Sacramento and San Joaquin rivers; and occupies portions of the Sacramento, San Joaquin, and San Francisco hydrologic regions. The geographic extent of the Delta overlay coincides with the statutory Delta boundary that defines the Legal Delta (California Water Code [CWC] Section 12220) and the Suisun Marsh as defined in California Public Resources Code Section 29101.

Statewide Significance of the Delta

The Delta and Suisun Marsh are at the confluence of the Sacramento River and San Joaquin River basins, which drain about 40 percent of California. Collectively they cover about 1,315 square miles (Figure D-1) in portions of six California counties and are part of the largest estuary on the West Coast of the United States. Covering only about 1 percent of California's area, the Delta contributes much more to the state than one might expect from its size.

The Delta serves as a hub for California's two largest water systems in the state, the federal Central Valley Project (CVP) and the State Water Project (SWP). A large part of the state is dependent upon water exported from the Delta to meet much of its agricultural and urban needs. Approximately two-thirds of the state's population live and work in urban areas that receive at least some of their water supply from the Delta. About 3 million acres of agricultural land are irrigated with exported water. In addition to providing water for farms, homes, and industry, water exported from the Delta provides significant water supplies to California's vital wetlands. Water from the Delta's watershed is also used within various areas upstream of the Delta and exported to areas around the state without going through the Delta.

Figure D-1 Sacramento-San Joaquin Delta and Suisun Marsh



Note: Some additional water may come from the Tracy Pumping Plant.

The Delta watershed covers 40 percent of the state (Figure D-2). Many of California's major rivers converge on the Delta as tributaries of the Sacramento, the state's largest river, or the San Joaquin River. Entering the Delta separately are the Cosumnes, Mokelumne, and Calaveras rivers, the Yolo Bypass, and numerous smaller creeks and sloughs. The Sacramento River is the single outlet to Suisun Bay. For more on these rivers, see other Volume 2 reports for the Sacramento River and San Joaquin River hydrologic regions.

The Delta region is also important to the state because of its vital transportation and water conveyance facilities, ecosystem functions, and wide range of recreational opportunities. The Delta contains highways, railroads and shipping routes, natural gas storage and transmission facilities, electric transmission pathways, and gasoline product distribution pipelines. Eighty percent of the state's commercial fishery species live in or migrate through the Delta (California Natural Resources Agency, California Department of Water Resources, U.S. Bureau of Reclamation 2013). In addition, the Delta provides world renowned boating, hunting, fishing, and nature viewing opportunities, with 12 million user-days annually (Delta Protection Commission 2012).

Water Governance

More than 200 public agencies — federal, State, regional, and local — claim partial responsibility for governance, planning, facilities, or resource protections that utilize and safeguard the Delta and Suisun Marsh ecosystem. These diverse public agencies, and the legal requirements that guide them, form a complicated patchwork of governance with a complex history. Table D-1 is a partial listing of the more than 200 local, State, and federal agencies that have some jurisdiction and authority in governing water in and through the Delta.

In 2006, Governor Schwarzenegger's Executive Order S-17-06 created the Delta Vision Task Force to create a vision to repair the ecological damage to the Delta. The task force declared that the Delta problems could not be solved in isolation. The problems were inextricably linked to statewide water supply, habitat, and flood management programs, and that stronger governance and accountability were a must. In response, the Delta Reform Act was crafted and passed by the Legislature.

Senate Bill X7 1 — Delta Reform Act

In 2009, the Legislature passed a series of water-related measures that included the Delta Reform Act (Senate Bill X7 1). The act established the coequal goals of a more reliable water supply for California and protecting, restoring, and enhancing the Delta ecosystem as overarching State policy and required that the coequal goals be achieved in a manner that protects and enhances the unique cultural, recreational, natural resource, and agricultural values of the Delta as an evolving place. Furthermore, the act notably required that Californians reduce their reliance on the Delta.

A new governance structure was created by the Delta Reform Act. It created the Delta Stewardship Council and Sacramento-San Joaquin Delta Conservancy and reshaped the Delta Protection Commission. The Legislature intended these three agencies to fulfill different, yet interrelated and complementary, roles in the protection and enhancement of the Delta. Additionally, a new Delta Watermaster position was created at the State Water Resources Control Board (SWRCB).

Figure D-2 Sacramento-San Joaquin Delta Watershed

Delta Stewardship Council

The Delta Stewardship Council (DSC) is required to develop a comprehensive, legally enforceable direction for how the State manages important water and environmental resources in the Delta through the adoption of the Delta Plan. The DSC also ensures implementation of the Delta Plan through coordination and oversight of State and local agencies proposing to fund, carry out, and approve Delta-related activities. The Delta Reform Act also established the Delta Science Program within the DSC to ensure the appropriate use of science in Delta decision-making.

Sacramento-San Joaquin Delta Conservancy

The Sacramento-San Joaquin Delta Conservancy was established to act as a primary state agency to implement ecosystem restoration in the Delta and support efforts that advance environmental protection and the economic well- being of Delta residents. The Delta Conservancy is also directed to support efforts that protect, conserve, and restore the region's physical, agricultural, cultural, historical, and living resources. The Delta Conservancy's service area is the statutory Delta and Suisun Marsh.

Delta Protection Commission

The Delta Protection Commission, originally established by the Delta Protection Act of 1992 and reshaped by the 2009 legislation, is responsible for developing a long-term resource management plan for land uses within the primary zone of the Delta and is required by the Delta Reform Act to develop an economic sustainability plan for the Delta. The Delta Protection Commission's goal is to ensure orderly, balanced conservation and development of Delta land resources and improved flood protection.

Delta Watermaster

The Delta Watermaster position was created to oversee the day-to-day administration of water rights, enforcement activities, and reports on water right activities regarding diversions in the Delta.

CALFED

In 1994, 25 State and federal agencies came together with the mission of improving California's water supply and the ecological health of the San Francisco Bay/Sacramento-San Joaquin Delta. The Delta's importance to the economic stability of California and the nation led to the drafting in 2000 of a 30-year plan for its management and restoration. Implementation of the plan was ultimately pledged by these agencies with expertise to manage the complex program. This plan, set forth in a programmatic Record of Decision (ROD), laid out a science-based planning process through which the participating agencies were able to make and implement better, more informed decisions and actions on future projects and programs. The science-based planning process included an Independent Science Board, known as the CALFED Independent Science Board, made up of distinguished experts (scientists and engineers) with a range of multidisciplinary expertise.

Table D-1 Agencies with Responsibilities in the Delta and Suisun Marsh

Federal	
U.S. Bureau of Reclamation	Owns and operates the Central Valley Project, which, among other activities, pumps water through and out of the Delta.
U.S. Army Corps of Engineers	Involved with both federal and non-federal partners in assessing channel navigation, ecosystem, and flood risk management projects in the Delta. Works cooperatively with its non-federal partners regarding the regulation, maintenance, and improvement of project levees in the Delta.
U.S. Fish and Wildlife Service	Develops plans for the conservation and recovery of fish and wildlife resources and addresses the variable needs of fish and wildlife pursuant to the Endangered Species Act.
National Marine Fisheries Service	Develops plans for the conservation and recovery of salmonids in the Delta pursuant to the Endangered Species Act
U.S. Environmental Protection Agency	Responsible for protection and restoration of water quality in the Delta, pursuant to the Clean Water Act (CWA), which regulates the discharge of pollutants into waterways and sets standards for water quality. Oversees implementation of CWA programs and policies delegated to the State.
Other federal agencies	Various roles or responsibilities in the Delta relevant to the agency's concern (for example, U.S. Department of Agriculture, Natural Resources Conservation Service, and others).
State	
Delta Stewardship Council	Established in 2009 by the Delta Reform Act to further the achievement of the coequal goals through the development and implementation of a legally enforceable Delta Plan.
Delta Conservancy	Established by the Delta Reform Act to serve as a primary State agency to implement ecosystem restoration in the Delta and support efforts that advance environmental protection and economic well being of Delta residents.
Delta Protection Commission	Prepares a long-term resource management plan for land uses within the primary zone of the Delta and is required by the Delta Reform Act to develop an economic sustainability plan for the Delta.
Office of the Delta Watermaster	Created in 2009 by the Delta Reform Act to oversee day-to-day administration of water rights, enforcement activities, and reports on water right activities regarding diversions in the Delta.
California Department of Fish and Wildlife	Fish and wildlife protection, including issuance of permits and actions to restore habitats.

State	
California Department of Water Resources	Owns and operates the State Water Project, has emergency response and flood planning responsibilities, holds water quality/supply contracts with Delta water agencies, and coordinates overall statewide water planning.
State Water Resources Control Board	Responsible for developing and implementing the Bay-Delta Water Quality Control Plan to establish water quality objectives, including flow objectives, to ensure reasonable protection of beneficial uses in the Bay-Delta. Responsible for establishing, implementing, and enforcing water right requirements to ensure the proper allocation and efficient use of water in and out of the Delta, including the role of the Delta Watermaster. With regional boards, responsible for developing and implementing other water quality standards and control plans consistent with State and federal laws to reasonably protect aquatic beneficial uses.
Central Valley Flood Protection Board	Plans flood control along the Sacramento and San Joaquin rivers and their tributaries in cooperation with the U.S. Army Corps of Engineers.
California Natural Resources Agency	In coordination with a group of local water agencies, environmental and conservation organizations, State and federal agencies, and other interest groups, developing the Bay Delta Conservation Plan.
Other state agencies	Have various roles or responsibilities in the Delta relevant to the agency's concern (for example, Department of Food and Agriculture, Department of Transportation, State Parks, Boating and Waterways, State Lands Commission, California Environmental Management Agency, and others).
Local	
Hundreds of local reclamation districts, resource conservation districts, water districts, city and county governments, and other special districts.	

Source: Modified from Table 2-1 in the Final Draft Delta Plan (Delta Stewardship Council 2012).

Two years later, the California Bay-Delta Authority was created to oversee the program's implementation; and Congress adopted the plan in 2004. Signatories to the CALFED Framework agreed to work together to formulate water quality standards, coordinate operations of the SWP and CVP and work toward long-term solutions to problems in the Delta. In 2005, Governor Schwarzenegger called for an independent review to help CALFED refocus and revitalize — dealing with emerging crisis and issues in the Delta, which resulted in a 10-year Action Plan that outlined the new way CALFED was to work. The independent review also brought forth a new Strategic Planning Division that directed CALFED to integrate better with the end of Stage 1 efforts with the Governor's Delta Vision initiative.

Delta Vision

Executive Order S-17-06, directed a chosen committee to "develop a durable vision for sustainable management of the Delta" with the goal of "managing the Delta over the long term to restore and maintain identified functions and values that are determined to be important to the environmental quality of the Delta and the economic and social wellbeing of the people of the state." The Delta Vision committee members created a vision for the Delta and for California that included 12 integrated and linked recommendations:

1. The Delta ecosystem and a reliable water supply for California are the primary, coequal goals for sustainable management of the Delta.
2. The California Delta is a unique and valued area.
3. The Delta ecosystem must function as an integral part of a healthy estuary.
4. California's water supply is limited and must be managed with significantly higher efficiency.
5. The principles of "reasonable use" and "public trust" are particularly important and applicable to the Delta.
6. The goals of conservation, efficiency, and sustainable use must drive California water policies.
7. A revitalized Delta ecosystem will require reduced diversions at critical times.
8. New facilities for conveyance and storage are needed to better manage California's water resources for both the estuary and exports.
9. Major, strategic investments in the Delta must strengthen selected levees, improve floodplain management, and improve water circulation and quality.
10. It is essential to have an independent body with authority to achieve the coequal goals of ecosystem revitalization and adequate water supply for California.
11. Inappropriate urbanization of the Delta should be discouraged.
12. Institutions and policies for the Delta should be designed for resiliency and adaptation.

Unique Characteristics

The Delta is a unique place distinguished by its geography, legacy communities, a rural and agricultural setting, vibrant natural resources, and a mix of economic activities. The Legislature finds that the maintenance of an adequate water supply in the Delta sufficient to maintain and expand agriculture, industry, urban, and recreational development in the Delta area is necessary to the peace, health, safety, and welfare of the people of the State (CWC Section 12201). The Legislature has found that the Delta's uniqueness is particularly characterized by its hundreds of miles of meandering waterways and the many islands adjacent to them; and has described the Delta's highly productive agriculture, recreational assets, fisheries, and wildlife as invaluable resources (CWC Section 12981(b)). The Delta Plan (Delta Stewardship Council 2013) recognizes the following values that make the Delta a distinctive and special place:

- The Delta's geography of low-lying islands and tracts shaped by sloughs, shipping channels, and rivers, tidal influences, levees, and other water controls is unique among California landscapes.
- The Delta retains a rural heritage, characterized by farms and small towns linked by navigable waterways and winding country roads.
- The Delta's agricultural economy is vital to the region and to the state.
- The Delta is a region where maritime ports, commercial agriculture, and expanding cities coexist with a unique native ecosystem that is home to many species of wildlife and fish.
- The Delta is a place of ethnic tradition, legacy communities, and family farms.
- The Delta provides opportunities for recreation and tourism because of its unique geography, mix of opportunities, and rich natural resources.

Levee System

Without the levees, Delta land could not be used as it is today for highly productive farming, homes, and conveyance of fresh water to support other areas of the state. Delta levees provide a wide array of local, statewide, and nationwide benefits. Virtually all assets and attributes of the Delta, including many benefits that accrue to the state at large, are dependent upon the Delta levee system for flood protection. Levees protect land areas near and below sea level and provide a network of channels that direct movement of water across the Delta. California has significant interest in the benefits provided by the Delta and protected by the Delta levees.

Levees for Delta islands and tracts hold significant state interest due to protection provided to:

- Human life and public health.
- Personal property.
- Businesses.
- Significant wetlands, both natural and those created by waterfowl-friendly agricultural practices within the Pacific Flyway.
- Highways and railroads.
- Water supply aqueducts and pumping plants.
- River corridors that provide fish and wildlife migration and for conveyance of flood flows (Sacramento, Mokelumne, Cosumnes, and San Joaquin rivers).
- Transmission lines (electric and petroleum).
- Navigation and deep-water shipping.
- Water and wastewater treatment plants.
- Natural gas storage, production, and transmission.
- Water quality and water supply.
- Western islands that help repel salinity.
- Export water supply conveyance.
- Agriculture.
- Recreation.

- Cultural, historical, and aesthetic assets.
- Meandering waterways.

Some of these benefits are protected by Delta levees acting individually to prevent direct damage from flooding. Other benefits are protected by the levees functioning together to preserve the network of channels and land areas. Damage and interruption of service from critical infrastructure protected by some Delta levees can affect the state's economy and public health and welfare (California Department of Water Resources 2012).

In the Legal Delta, there are 980 miles of permanently maintained levees (Delta Protection Commission 2012). Of this total, 380 miles are project levees constructed or improved by the U.S. Army Corps of Engineers (USACE); 63 miles are urban non-project levees; and the remaining 537 miles are non-urban, non-project levees that are maintained and enhanced primarily by the local reclamation districts. Of those 537 miles, 470 miles are "lowland" levees, which protect lands below sea level (Delta Protection Commission 2012). Lowland levees are critical to protecting water quality, the conveyance of water through the Delta, and protecting and enhancing the Delta as a place, whereas project and urban levees are fundamentally flood control levees.

Project levees are those levees that are part of the federal-State flood protection system in the Sacramento-San Joaquin Valley. These are levees of federally authorized projects for which the State has provided assurances of cooperation to the federal government and are considered part of the State Plan of Flood Control (SPFC). The SPFC represents a portion of the Central Valley flood management system for which the State has special responsibilities, as defined in the CWC Section 9110(f). The SPFC Descriptive Document (California Department of Water Resources 2010a) provides a detailed inventory and description of the levees, weirs, bypass channels, pumps, dams, and other structures included in the SPFC.

Constructed facilities in the Delta area include the extensive system of levees that provides flood protection to the 70 major islands and tracts, as well as improved channels, gates, and control structures that serve multiple purposes, including water supply conveyance, salinity control, and fisheries protection. An island-by-island list of project and non-project levees, as well as some of the major water facilities is available in the *California's Flood Future Report* (California Department of Water Resources and U.S. Army Corps of Engineers 2013).

Ecosystem

The Delta is a floodplain estuary that connects river to ocean and land to water. Floodplain estuaries are among the most productive ecosystems on the planet. The high productivity associated with floodplain estuaries is driven by the intimate relationship between land and water. However, compared to other estuaries, the Delta has very low levels of primary productivity in both the Suisun Marsh and the Delta.

Historically, the Delta consisted of hundreds of miles of tidally influenced sloughs and channels and hundreds of thousands of acres of marsh and overflow land. There were three primary landscapes within the Delta of the past: tidal freshwater wetlands interwoven with tidal channels dominated the Central Delta, flood basins bordered by broad riparian forests on the natural levees of the Sacramento River in the North Delta, and the three distributary branches of the

San Joaquin River that supported a broad floodplain that gradually merged with tidal wetlands in the South Delta (Whipple et al. 2012). At one time, the Delta supported hundreds of species, including the grizzly bear, tule elk, and gray wolf. As land reclamation took place and levees were built, the ecosystem changed. More than 90 percent of the wetlands were converted to farms and more recently to urban uses. The grizzly bear and gray wolf no longer reside in the Delta, but a population of tule elk has been established in the Suisun Marsh. The numbers of birds using the Delta have declined as well due to land reclamation, although changes in cropping patterns have allowed populations of some species to increase. Currently, the Delta and Suisun Marsh support more than 55 known fish species and more than 750 plant and wildlife species. Of these species, approximately 100 wildlife species, 140 plant species, and 13 taxonomic units of fish are considered special-status species and are afforded some form of legal or regulatory protection (Delta Stewardship Council 2012).

The Suisun Marsh is the largest contiguous brackish water marsh remaining on the West Coast of North America and is a critical part of the Bay Delta estuary ecosystem. The marsh encompasses more than 10 percent of California's remaining natural wetlands and serves as the resting and feeding ground for resident waterfowl and thousands of birds migrating on the Pacific Flyway, a major north-south route for migratory birds. The marsh also serves as a critical link for anadromous fish and is thought to be an important nursery for fish.

Land Use

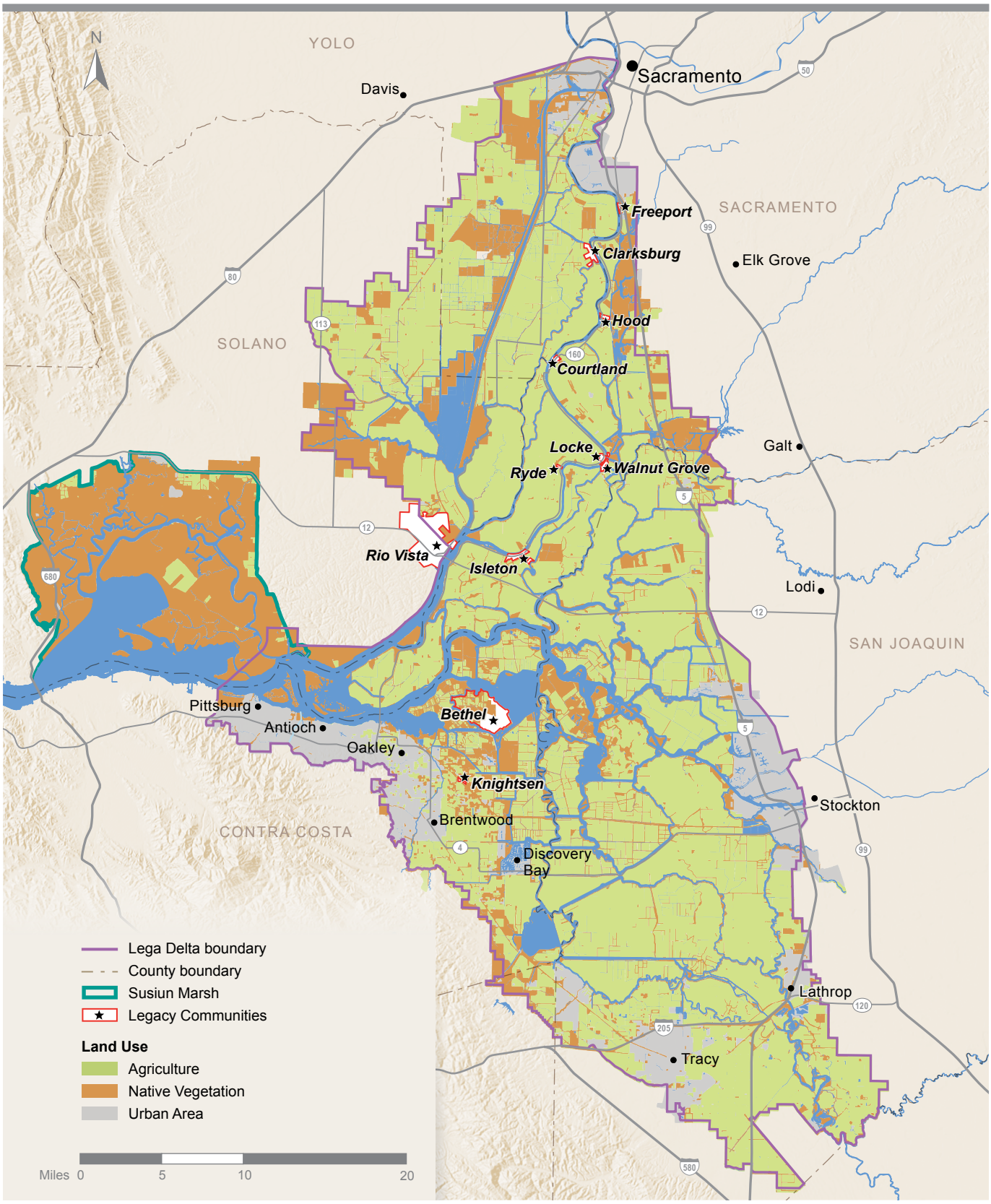
As noted previously, the Delta is made up of six counties: Alameda, Contra Costa, Sacramento, San Joaquin, Solano, and Yolo. The Delta area, which includes the Legal Delta and the Suisun Marsh, totals approximately 1,315 square miles or about 840,000 acres (URS Corporation and Jack R. Benjamin & Associates 2008). Figure D-3 shows the county boundaries and the general land use in the Delta and Suisun Marsh.

Before 1850, the Delta was essentially a broad expanse of water-based habitat and natural channels. The Delta was a water highway between San Francisco and Sacramento and the Gold Country. The fastest and most direct means of travel between Sacramento and San Francisco was by ferryboat. Large-scale reclamation of the Delta for agriculture began in 1868, and by 1900 most of the lands with mineral-organic soils around the Delta's exterior were reclaimed. The final period of Delta reclamation occurred between 1900 and 1920 on lands in the Delta's interior. The result of these reclamation efforts is largely what is seen as the Delta today — approximately 700 miles of meandering waterways and 980 miles of levees protecting more than 538,000 acres of farmland, homes, and other structures (URS Corporation and Jack R. Benjamin & Associates 2008).

Today, the Delta is dominated by highly productive agricultural land. The main crops grown in the Delta are corn, alfalfa, pasture, tomatoes, and grapes. Historically, asparagus, corn, pasture, alfalfa, and sugar beets were the dominant crops. In addition to changes in crops, the amount of urban and natural protected lands has increased in the Delta, but agricultural lands have decreased.

The Delta was given a legal boundary (CWC Section 12220) in 1959 with the passage of the Delta Protection Act (see Figure D-1). Anticipating the potential effects of urban development on the Delta, the original act was refined in 1992 to provide Primary and Secondary zones within the previously defined Legal Delta and the development of a resource management plan for land uses

Figure D-3 County Boundaries and General Land Use



within the Primary Zone. The Primary Zone (about two-thirds of the Delta area) was intended to remain relatively free from urban and suburban encroachment to protect agriculture, wildlife habitat, and recreation uses. Urban development in the Secondary Zone (the remaining one-third) was intended to include an appropriate buffer zone to prevent impacts on the lands in the Primary Zone.

The Delta Reform Act of 2009 (SB X7 1) directs the Delta Protection Commission to prepare and submit to the Legislature recommendations regarding the potential expansion of or change to the Primary Zone of the Delta. The Primary Zone Study was completed in 2010, but the Delta Protection Commission has not submitted any recommendations for changes to the Primary and/or Secondary zones to the Legislature.

The Delta Protection Commission updated the 1995 Resource Management Plan in 2010. Several policies and recommendations in the Land Use and Resource Management Plan for the Primary Zone of the Delta are applicable to the California Water Plan. These include:

- Water Policy 1. "State, federal and local agencies shall be strongly encouraged to preserve and protect the water quality of the Delta both for in-stream purposes and for human use and consumption."
- Water Policy 2. "Ensure that Delta water rights and water contracts are respected and protected, including area of origin water rights and riparian water rights."

There has been significant population growth within the Legal Delta since 1990, almost entirely attributable to the expanding urban areas contained within the Secondary Zone. Specifically, the Secondary Zone contains an estimated 560,000 residents according to the *2010 Decennial Census*, up from about 360,000 in 1990, a 56 percent increase (the state as a whole increased by 25 percent during this period). In contrast, the Census reports roughly 12,000 residents living in the Primary Zone in 2010, about the same number as 20 years ago. Currently, the population within the Primary Delta represents about 2 percent of the Legal Delta's total; and this proportion appears to be shrinking (Delta Protection Commission 2012).

The Primary Zone encompasses about 67 percent of the Legal Delta's total land area. It is a highly rural and sparsely populated area surrounded by relatively fast-growing urban areas in or adjacent to the Secondary Zone. A variety of interrelated factors are preventing growth in the Secondary Zone from spreading to the Primary Zone, most notably regulatory prohibitions, lack of public infrastructure, and economic feasibility. The relatively fast growth in the Secondary Zone is largely attributable to its role in accommodating spillover growth from large, land-constrained urban centers in the San Francisco, Sacramento, and Stockton metropolitan areas.

The Delta's economy, like its population, is primarily urban and service oriented. However, the Delta Reform Act of 2009 and the Delta Protection Act of 1992 are primarily concerned with the natural resources of the Delta and the economic activity sustained by those resources such as agriculture and outdoor recreation. In addition, the resources of the Delta support significant water, energy, and transportation infrastructure that serves the Delta, regional and state economies, and an important commercial and recreational salmon fishery throughout the state.

The Stockton and Sacramento Deep Water Ship Channels were constructed in 1933 and 1963, respectively. Recent volume was 0.7 million and 2.9 million metric tons in Sacramento and Stockton, respectively. The Port of Sacramento has seen an average decline in tonnage since 1994. This is related to reductions in agricultural and forestry shipments, which were the

mainstay of operations at the port. Cargo levels through the Port of Stockton have continued to grow; and in 2005, Stockton became the fourth busiest port in California, after Los Angeles, Long Beach, and Oakland. Both ports are currently investigating the use of barges to move goods between California's coastal ports and the Central Valley.

Agriculture

Agriculture is among the qualities that define the Delta as a place. Creating farmland was the purpose for the Delta's initial reclamation and for the maintenance of its levees and water controls. Agriculture benefits from the Delta's productive soils, special climate, and abundant water. Close to 80 percent of all farmland in the Delta is classified as Prime Farmland, the California Farmland Mapping and Monitoring Program's highest designated tier (Delta Protection Commission 2012). Because of the fertile peat soils and the moderating marine influence, Delta agriculture's per-acre yields are almost 50 percent higher than the state's average (Trott 2007).

The main crops grown in the Delta are corn, alfalfa, tomatoes, wheat, and wine grapes. In 2009 the total value of Delta crops was approximately $702 million. When related value-added manufacturing such as wineries, canneries, and dairy products are included, the statewide impact of Delta agriculture is 25,125 jobs, $2.135 billion in value added, and $5.372 billion in economic output (Delta Protection Commission 2012).

In addition to the economic value of agricultural lands, some lands provide rich seasonal wildlife habitat. Thousands of acres of agricultural lands are flooded after harvest and provide feeding and resting areas for resident and migratory birds and other wildlife. This practice of seasonal flooding helps maximize the wildlife values of agricultural areas and lessen opportunities for agricultural pests.

While agriculture is the primary land use in the Delta, the total area of agricultural lands in the combined Delta and Suisun Marsh area has declined from about 549,420 acres in 1984 to 460,450 acres in 2008 (Delta Stewardship Council 2012). The continued viability of agriculture in the Delta will require the protection of sufficient farmland and fresh water to support commercially viable operations and provide ways for agriculture to coexist with habitat restoration.

The Williamson Act was enacted in 1965 to help lessen the impacts of rapidly spiraling land values and property taxes, and to ensure that California would continue to benefit from a long-term supply of agricultural and open space land. In the 48 years since, the act has been primarily used by local governments to preserve agricultural land in California. However, the act also provides options for non-agricultural open space contracts per Government Code Section 51205. Cities and counties have the authority to include open space, habitat, and recreation as primary uses in agricultural preserves and to provide for those uses in their Williamson Act contracts. In the Delta, relatively few, if any, agricultural preserves currently provide for exclusive open space contracts to be set up.

Recreation

Recreation is an integral part of the Delta, complementing its multiple resources and contributing to the economic vitality and livability of the region. Residents of nearby areas visit virtually every

day, generating a total of roughly 12 million visitor-days of use annually and a direct economic impact of more than a quarter of a billion dollars in spending (Delta Protection Commission 2012). The region's mix of land and water offers diverse recreation experiences and facilities including fishing, boating, bird-watching, other nature activities, hunting, enjoying restaurants, campgrounds, picnic areas, and visiting historical towns and buildings.

The California Department of Parks and Recreation prepared a *Recreation Proposal for the Sacramento-San Joaquin Delta and Suisun Marsh* in May 2011, which recommends enhancing California State Parks and other State agencies' properties and programs to create a network of recreation areas in the Delta and encourages improvement of public access along the shorelines of growing Delta communities. It recommends providing recreation improvements in new water management and habitat restoration projects where these are consistent with the projects' purpose. Future prospects for Delta recreation and tourism will be strongly influenced by decisions about the Delta ecosystem, water quality, levee improvements, and governance including land use and environmental standards. The Bay Delta Conservation Plan (BDCP), Delta water quality plans, levee investments, and other decisions yet to be made can all significantly affect recreation and tourism.

Legacy Communities

The Delta Reform Act of 2009 (SB X7 1) identifies the Delta's legacy communities as Bethel Island, Clarksburg, Courtland, Freeport, Hood, Isleton, Knightsen, Rio Vista, Ryde, Locke, and Walnut Grove. Each community has its own character. Bethel Island is a recreation destination. Clarksburg and Courtland are centers for wine and pear production. Freeport and Hood were transportation centers with river landings and rail spurs to move goods. Locke and Walnut Grove had large Asian populations who worked at packing sheds and surrounding local farms. Ryde is known for its landmark hotel, and Isleton is known for festivals and visitor-serving businesses. Rio Vista is the largest community, and Knightsen is a small community known for several nearby horse ranches. All the legacy communities except Isleton and Bethel Island are in the Delta's Primary Zone.

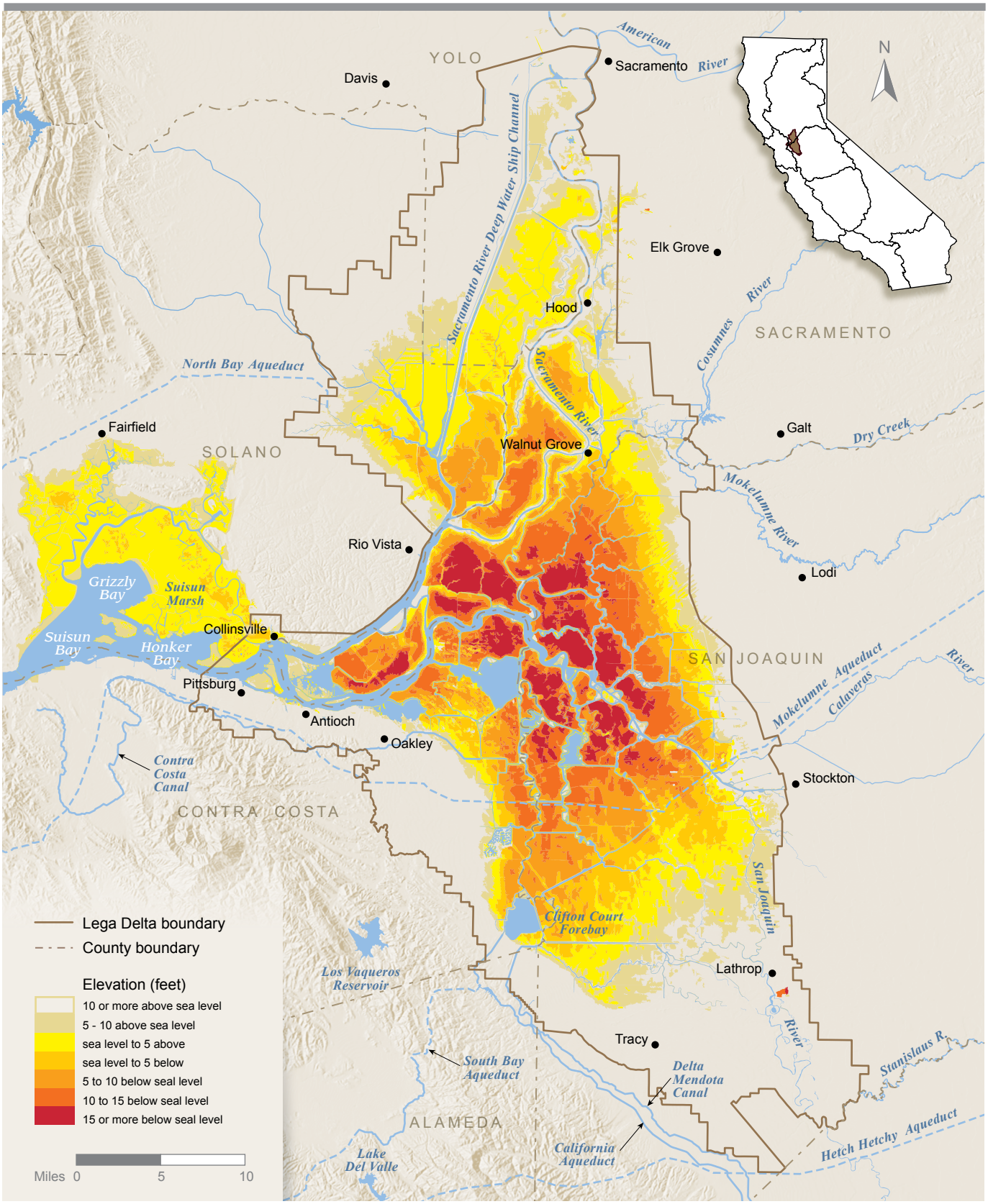
Subsidence

The reclamation of Delta islands and their cultivation for agriculture initiated a process of land subsidence, mostly due to oxidation of peat soils, but also from wind erosion. Drainage and cultivation dried the saturated peat, reducing its volume by approximately 50 percent (Mount and Twiss 2005). Early cultivation practices also included burning, which further reduced the volume of the soil and altered its structure. Over time, long-term oxidation reduced about 2.6 billion to 3.3 billion cubic yards of these peaty soils to small particles and gases (Delta Stewardship Council 2013). As a result, most of the central Delta today is below sea level, with some islands commonly 12 to 15 feet below sea level (Figure D-4). Although subsidence has slowed in some areas, other regions of the Delta continue to lose soil to oxidation and wind erosion at a rate of 5 to 15 tons per acre per year (Delta Stewardship Council 2013). It is projected that some areas of the Delta could subside an additional 2 to 4 feet by 2050 (Deverel and Leighton 2010).

Re-established, non-tidal wetlands with managed hydrology can produce significant increases in land-surface elevations, which can help to improve levee stability and

Sherman Island. Recreation is a valuable asset in the Delta.

Figure D-4 Land Subsidence in the Delta



protect subsided islands from future flooding. DWR and U.S. Geological Survey Cooperative Water Program funded a study investigating the subsidence reversal potential of two, 3-hectare, permanently flooded, impounded wetlands re-established on a deeply subsided field on Twitchell Island. The purpose of this project was to determine if re-establishing wetlands in the Delta could re-create the anaerobic environment where the Delta peat formed in order to reverse subsidence. Results show land-surface elevations increased by an average of 4 centimeters per year in both wetlands from 1997 to 2006; however, the rates at different sites in the wetlands ranged from –0.5 to +9.2 centimeters per year (cm/yr.) (Miller et al. 2008).

There has been some success in managing subsidence by creating ponds and planting them with tules, which were supplemented by cattails and other marsh vegetation, causing organic material to accumulate. This process has the potential to provide benefits through carbon sequestration. The Economic Sustainability Plan (Delta Protection Commission 2012) also mentions the potential use of subsidence-reversal agriculture in the Delta.

Suisun Marsh

Historically, the Suisun Marsh consisted of 68,000 acres of tidally inundated islands separated by sloughs. Diking of Suisun Bay, primarily for livestock grazing, began around the mid-1860s. Shortly thereafter the first duck clubs were established around the marsh ponds. By the early 1900s, livestock grazing was giving way to other agricultural activities. Eventually, increasing salinity and land subsidence caused agricultural activities to fail and be replaced by duck clubs. Levees originally constructed for farming are now an integral part of the infrastructure of the duck clubs.

The Suisun Soil Conservation District was formed in 1963, later named the Suisun Resource Conservation District (SRCD). The SRCD is a special district that represents private landowners in the Suisun Marsh on a variety of issues at federal, State, and local levels. The goals of SRCD are to achieve water supply of adequate quality to promote preferred waterfowl habitat and retain wetland resource values through appropriate management practices.

In 1974, the Legislature passed the Nejedly-Bagley-Z'berg Suisun Marsh Preservation Act (SMPA). SMPA directed the San Francisco Bay Conservation and Development Commission (BCDC), and the California Department of Fish and Wildlife (DFW) to prepare the Suisun Marsh Protection Plan. (The California Department of Fish and Wildlife was formerly called the California Department of Fish and Game.) The Suisun Marsh Protection Plan (SMPP), developed in 1976, includes a Primary Management Area (see Figure D-1) encompassing 89,000 acres and a Secondary Management Area that includes approximately 22,500 acres of significant buffer lands. The SMPP calls for the preservation of Suisun Marsh, preservation of waterfowl habitat, improvement to water distribution and levee systems, and encouragement of agriculture that is consistent with wildlife and waterfowl, such as grazing. The BCDC has land use and development permitting authority in the Primary Management Area. The SRCD has primary local responsibility for water management on privately owned lands in the marsh.

In 2000, the CALFED Record of Decision (ROD) was signed, which included the Ecosystem Restoration Program (ERP) calling for the restoration of 5,000 to 7,000 acres of tidal wetlands and the enhancement of 40,000 to 50,000 acres of managed wetlands. In 2011, the Suisun Marsh Habitat Management, Preservation, and Restoration Plan was completed. This plan seeks to balance the needs of the CALFED ROD, the SMPA, and other plans by protecting and enhancing

land uses, existing waterfowl and wildlife values, endangered species, and State and federal water project supply quality.

Currently, 90 percent of the wetlands in the Suisun Marsh are diked and managed as food, cover, and nesting habitat for thousands of birds migrating on the Pacific Flyway and resident waterfowl (Suisun Resource Conservation District 1998). The Suisun Marsh provides habitat for more than 221 bird species, 45 mammalian species, 16 reptile and amphibian species, and more than 40 fish species (U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service, and California Department of Fish and Game. 2010). The tidal habitat in the marsh provides rearing areas for juvenile salmon, thus supporting the state's commercial salmon fishery. The marsh levee system, which comprises approximately 200 miles of levees, contributes toward managing salinity in the Delta.

The balance of the Suisun Marsh is privately owned, with 158 individual waterfowl hunting clubs and numerous upland parcels for cattle grazing. DFW owns nearly 15,300 acres of managed and tidal wetlands. Urban encroachment has not occurred within the marsh, but conflicts and pressures are occurring with the increasing urbanization and industrialization up to the edges of the Suisun Marsh Secondary Management Area.

Tribal

SB 18 (Chapter 905, Statutes of 2004) requires cities and counties to consult with Native American tribes during the adoption or amendment of local general plans or specific plans. A contact list of appropriate tribes and representatives within a region is maintained by the Native American Heritage Commission. The following is a list of the tribes with historical or cultural ties to the Delta region, according to the commission:

- California Valley Miwok Tribe.
- Cortina Band of Indians.
- Ione Band of Miwok Indians.
- North Valley Yokuts Tribe.
- Rumsey Indian Rancheria of Wintun.
- Shingle Springs Band of Miwok Indians.
- The Ohlone Indian Tribe.
- United Auburn Indian Community of the Auburn Rancheria.
- Wilton Rancheria.

Unique Challenges/Drivers of Change

Suisun Marsh. The Suisun Marsh is managed to protect and restore the functions of the estuary ecosystem.

The Delta and Suisun Marsh ecosystem, as a large component of the San Francisco Estuary, was once one of the most biologically productive and diverse ecosystems on the West Coast, supporting a wide array of native plant and wildlife species and providing important habitat for many migratory species. The Delta ecosystem is now in peril. As a result of human activity to reclaim farmland, protect areas from flood, and provide water for agriculture and communities, discharge of wastes from agriculture, industry, and urban areas, and the introduction of harmful invasive species, the Delta has been modified in ways that adversely influence ecosystem function and compromise its ability to support

a healthy ecosystem. These changes not only affect the species that live there, but also the ecosystem services that benefit humans, such as improved water quality, agricultural productivity, healthy commercial and sport fisheries, flood protection, and recreation.

One example of the decline of the Delta ecosystem is the pelagic organism decline. Abundance indices calculated by the Interagency Ecological Program through 2007 suggest marked declines in four pelagic fishes in the upper San Francisco Estuary (the Delta and Suisun Bay). These fishes include delta smelt, which is listed under State and federal Endangered Species acts as endangered and threatened, respectively, and the longfin smelt protected under California's Endangered Species law as a threatened species. Although the numbers had historically fluctuated, this steep and lasting dropoff signaled an ecological crisis.

There are many factors and actions that have stressed the Delta ecosystem and collectively are termed "stressors." The Delta Independent Science Board (which replaced the CALFED Independent Science Board) categorized these stressors into broad groups to assist in evaluating management options. These categories include current stressors, legacy stressors, globally determined stressors, and anticipated stressors. The current stressors in the Delta identified in the Delta Plan are altered Delta flow, habitat degradation and loss, impaired water quality, non-native species, and hatcheries and harvest management (Delta Stewardship Council 2013). Additionally, the Delta faces other unique challenges that will influence efforts to address the declining ecosystem, such as the need for water supply reliability, flood risk, and climate change.

Altered Delta Flows

Native species are adapted to the seasonal, inter-annual, and spatial variability of the historical flow pattern and the functions that come with it. Flow interacts with land to create physical habitats and connections where species find food, refuge, and reproduction space. Through a variety of mechanisms, native species can survive, grow, and reproduce better when flows occur in more natural historical patterns.

Present-day Delta flows are very different from historical, natural flows. Water flows have been altered by water supply and flood control structures and draining of floodplains, wetlands, and groundwater basins. Current flow management regulations provide some protection for ecological functions and native species, but the current Delta flow regime is generally harmful to many native aquatic species while encouraging non-native aquatic species (State Water Resources Control Board 2010b).

Habitat Degradation and Loss

Much of the original habitat for the Delta's native fish, wildlife, and plants has been urbanized or converted to agriculture over the last 160 years (Healey et al. 2008; Moyle et al. 2010; Baxter et al. 2010). The current Delta ecosystem continues to be productive, but its habitat types and conditions support a much different mix of species than the historical Delta, and many of the currently thriving species are non-native. Inadequate habitat for native species that reside in and migrate through the Delta is an important current ecosystem stressor that is affected by and interacts with many other stressors.

Impaired Water Quality

The location, extent, and dynamics of the freshwater-saltwater interface in the Bay Delta is an important factor in the distribution and abundance of many fish, invertebrate, and plant species, and is largely determined by the amount of fresh water flowing from the Delta west into Suisun Bay. The Delta ecosystem is also affected by a variety of pollutants discharged into Delta and tributary waters. Pollutants of concern affecting Delta biological species and ecosystem processes include nutrients, pesticides, mercury, selenium, and other persistent bioaccumulative toxic substances. More detail on how these constituents affect the Delta can be found under the Water Quality section.

Non-native Species

Non-native species in the Delta create a wide range of stresses on native species. They have altered food webs and habitats, they compete with native species for resources, and they prey directly upon native species. Non-native species have been introduced into the Delta over time via watercraft, fishing gear, live bait, intentionally (either legally or illegally) introduced for recreational or other purposes, or released from aquariums into the environment (California Department of Fish and Game 2011).

Introduced species now dominate all habitats in the Delta. Among the introduced species of the Delta, the most visible is the aquatic weed *Egeria densa*, which often fills low-velocity channels in the central and southern Delta and reduces water turbidity. Two clams from Asia dominate the benthos of the Delta: the Asian clam, *Corbicula fluminea*, is most abundant in fresh water; and the overbite clam, *Corbula amurensis*, is abundant in brackish-to-saline water. Striped bass and largemouth bass, both deliberate introductions, are not only among the most abundant fish of pelagic and nearshore habitats, they are also predatory and probably have a negative effect on native species.

Another invasive species, water hyacinth, *Eichhornia crassipes*, showed up in California more than 100 years ago. Water hyacinth was first reported in California in 1904 in a Yolo County slough. There were increased reports of water hyacinth in the Delta region during the 1970s. By 1981, water hyacinth covered 1,000 acres of the Delta and 150 of the 700 miles of waterways (California Department of Boating and Waterway 2009). Water hyacinth can rapidly dominate a waterway, impede drainage, foul water pumps, and block irrigation channels. It changes water quality and displaces native vegetation used for food or shelter.

Impacts of Hatcheries and Harvest Management

Hatcheries can introduce diseases to wild fish populations and alter their genetic makeup, thus affecting their ability to perform in the wild. Inappropriate or insufficient fishing regulations and practices also can have wide-ranging effects, from overfishing that reduces genetic diversity to food web and ecological changes.

Water Supply Reliability

Over the past several decades, increasing demand for the Delta's resources have increased the conflict between the needs of water users and efforts to sustain the estuary's aquatic ecosystem

and support recovery of State and federally listed fish. These conflicts have led to a crisis regarding the ability to protect Delta fisheries, maintain water quality, and meet the needs of both in-Delta and export area agricultural and municipal water users. This situation has resulted in the need to address these competing beneficial uses and sustainability concerns.

Delta export reliability hinges on first satisfying water quality requirements for native Delta fish and the criteria for in-Delta flow and water quality standards. The in-Delta water quality conditions will fluctuate with seawater intrusion, the quality and quantity of river and small stream inflows, in-Delta water management operations, and export pumping operations. Required inflows to the in-Delta ecosystem will also depend on the health of indigenous species and invasive species management actions.

Existing Delta conveyance does not provide long-term reliability to meet current and projected needs. Conveyance through the Delta in times of drought is especially challenging considering the various demands from agriculture, municipalities, and environmental needs. To improve through-Delta conveyance water supply reliability and provide greater operational flexibility, improvements to existing facilities in the form of updating aging infrastructure, upgrading existing capacities, adding redundancy to the system, and constructing additional facilities may be needed.

The major issues pertaining to reliability of water supply transferred through the Delta include the following items.

- The health of the Delta ecosystem is paramount in consideration of water-related activities within the Delta. Continuing declines in some native species populations migrating through or living in the Delta, such as salmon and delta smelt, highlight the increasing influence of the Delta ecosystem on water supply reliability. Any activity proposed for Delta conveyance will need to consider the restoration and preservation of native habitat to benefit pelagic organisms and other native species.
- The integrity of Delta levees is continually undermined by such elements as storm events creating floods and seawater surges, island subsidence, natural levee erosion, poor quality peat soils used to build the original levees, seismic activity, burrowing animals, and sea level rise. These vulnerabilities call into question the long-term sustainability of using the Delta as a conveyance corridor.
- Maintaining water quality within the Delta for both drinking water and for native species habitat will be a challenge. Constituents of concern include, but are not limited to, salinity, bromide, chloride, organic carbon, nutrients, pathogens, dissolved oxygen, temperature, and turbidity. Control of water quality in a tidal estuary with seasonal and yearly fluctuating hydrology will require well understood and fully inclusive strategies. As water quality requirements can vary and at times conflict among users, the challenge will be to agree upon the implementation strategy.
- Maintenance of in-Delta projects for beneficial uses such as recreational boating and swimming, sport-fishing, shipping, and agriculture, industrial, and drinking water supply will be an ongoing management challenge as political and fiscal climates evolve and resources for competing priorities become scarcer.

Measures to ensure long-term water supply reliability will need to consider many challenges, including the health of the Delta ecosystem, levee maintenance policies, protection of infrastructure in the Delta that is of statewide importance, and water quality for all users. (See

section Resource Planning in the Delta for more information on the Bay Delta Conservation Plan.)

Flood Risk

Land reclamation in the Delta began in the 1850s by construction of levees, resulting in today's complex labyrinth of islands and waterways that are protected from flooding by these levees. Many of the Delta levees were initially constructed more than a century ago using primitive materials and equipment and without the benefit of today's engineering standards although many miles of levees have since been improved to modern standards. Levee failures occur as a result of large runoff events, extreme high tides, wind-generated waves, earthquakes, land subsidence, sea level rise, or burrowing activities. The consequent flooding of a Delta island can increase the risk of levee failures on adjacent islands.

From a flooding viewpoint, at least 75 percent of the Delta area, more than 78 percent of its cropland, and over 210,000 people are exposed to a 500-year flood event (California Department of Water Resources and U.S. Army Corps of Engineers 2013). In addition, a catastrophic-level failure in the Sacramento-San Joaquin Delta would endanger a major source of water supply for 27 million California residents and approximately 3 million irrigated acres of farmland (Delta Stewardship Council 2013).

Major issues related to flood management facing the Delta are the impacts of climate change, sea level rise, subsidence, levee maintenance and certification, and impacts of development. Major floods occur regularly in the Delta area. Some urban and small-stream flooding occurs in every large storm. Floods during winter storms that cause high water surface elevations and have strong winds have been a common cause of levee failures in the Delta. For example, the flows of the Sacramento River at Rio Vista during winter and early spring are often 30 times greater than the typical late-summer flows. In any season, a combination of high tides, high winds, and high water can increase the risk of flooding. High water in the Delta can overtop levees, as well as increase the hydrostatic pressure on levees and their foundations, which causes instability and increases the risk of failure due to through-levee and/or under-levee seepage.

Climate Change

For more than two decades, the State and federal government have been preparing for climate changes effects on natural and built systems with a strong emphasis on water supply. Climate change is already impacting many resource sectors in California including public health, water, agriculture, biodiversity, transportation, and energy infrastructure (U.S. Global Change Research Program 2009; California Natural Resources Agency 2009). Climate model simulations based on the Intergovernmental Panel on Climate Change's 21st Century Climate Scenarios, project increasing temperatures in California with greater increases in the summer (Intergovernmental Panel on Climate Change 2013). Projected changes in annual precipitation patterns in California will result in changes to surface runoff timing, volume, and type (Cayan 2008). Recently developed computer downscaling techniques (model simulations that refine computer projects to a scale smaller than global models) indicate that California flood risks from warm-wet atmospheric river-type storms may increase beyond those that we have known historically, mostly in the form of occasional more-extreme-than-historical storm seasons (Dettinger 2011).

Currently, enough data exist to warrant the importance of contingency plans, mitigation (reduction) of greenhouse gas (GHG) emissions, and incorporating adaptation strategies, methodologies, and infrastructure improvements that benefit the region at present and into the future. While the State is taking aggressive action to mitigate climate change through GHG reduction and other measures (California Air Resources Board 2008) global impacts from carbon dioxide and other GHGs that are already in the atmosphere will continue to impact climate through the rest of the century (Intergovernmental Panel on Climate Change 2013).

Resilience to an uncertain future can be achieved by implementing adaptation measures sooner rather than later. Because of the economic, geographical, and biological diversity of the state, vulnerabilities and risks due to current and future anticipated changes are best assessed on a regional basis. Many resources are available to assist water managers and others in evaluating their region-specific vulnerabilities and identifying appropriate adaptive actions (U.S. Environmental Protection Agency and California Department of Water Resources 2011; California Emergency Management Agency and California Natural Resources Agency 2012). The most comprehensive report to date on climate change observations, impacts, and projections for the southwestern United States, including California, is the *Assessment of Climate Change in the Southwest United States* (Garfin et al. 2013).

Observations

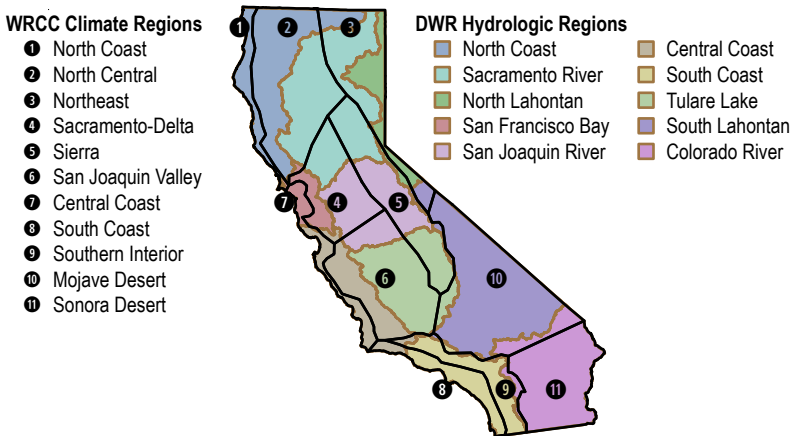
Climate change impacts observed in California in the past 100 years include an increase in average temperatures of approximately one degree Fahrenheit statewide. Regionally specific temperature data were retrieved from the Western Regional Climate Center (WRCC) (2013). The WRCC acts as a repository of historical climate data and information. Air temperature records for the past century were summarized by the WRCC into distinct climate regions (Abatzoglou et al. 2009). While DWR's hydrologic regions do not correspond directly to WRCC's climate regions, the Delta overlay lies within the WRCC Sacramento-Delta region (Figure D-5). Mean temperatures in the WRCC Sacramento-Delta region have increased about 1.5 to 2.4 °F (0.9 to 1.3 °C), with minimum values increasing more than maximums (2.1 to 3.1 °F [1.2 to 1.7 °C] and 0.8 to 2.0 °F [0.4 to 1.1 °C]), respectively.

In the 20th century, tide gages and satellite altimetry show that global mean sea level has risen about 7 inches (California Department of Water Resources 2008). The change in mean sea level at the San Francisco tide gage, the nation's oldest continually operating tidal observation station, is consistent with the global average of 7 inches. However, when the current rate is adjusted for vertical land motion and atmospheric pressure the relative mean sea level is increasing at a rate of 0.04 +/- 0.06 in yr-1 (1.02 +/- 1.73 mm yr-1) south of Cape Mendocino, which is lower than the current rate of global mean sea level rise (National Research Council 2012).

Projections and Impacts

While historical data is a measured indicator of how the climate is changing, it can't project what future conditions may be like under different GHG emission scenarios. Current climate science uses modeling methods to simulate and develop future climate projections. A recent study by Scripps Institution of Oceanography uses the most sophisticated methodology to date and indicates that by mid-century (2060-2069) temperatures will be 3.4 to 4.9 °F (1.9 to 2.7 °C) higher across the state than they were from 1985 to 1994 (Pierce et al. 2012). For the Delta region, the study projects that annual temperatures will increase by approximately

Figure D-5 DWR Hydrologic and Western Region Climate Center Climate Regions



Note: The Western Region Climate Center (WRCC) divides California into 11 separate climate regions, and generates historic temperature time-series and trends for these regions (http://www.wrcc.dri.edu/monitor/cal-mon/frames_version.html). DWR maintains 10 hydrologic regions, with the Delta and Mountain Counties being overlays of other DWR hydrologic regions. Each DWR hydrologic region spans one or more of the WRCC climate regions.

4.1 °F (2.3 °C), with a 3.1 °F (1.7 °C) increase in winter temperatures and a 5.2 °F (2.9 °C) in summer temperatures. Climate projections for the Delta region from Cal-Adapt indicate that the temperatures between 1990 and 2100 will increase by as much as 6 to 7 °F (3.3 to 3.9 °C) in the winter and by 7 to 9 °F (3.9 to 5 °C) in the summer (California Emergency Management Agency and California Natural Resources Agency 2012).

Changes in precipitation across California due to climate change could result in changes in type of precipitation (rain or snow) in a given area, in timing or total amount, and in surface runoff timing and volume. Most climate model precipitation projections for the state anticipate drier conditions in Southern California, with heavier and warmer winter precipitation in Northern California. More intense wet and dry periods are anticipated which could lead to flooding in some years and drought in others. Extreme precipitation events are projected to increase with climate change (Dettinger 2011). Since there is less scientific detail on localized precipitation changes, there exists a need to adapt to this uncertainty at the regional level (Qian et al. 2010). In addition, mean sea levels are projected to rise about 12 inches by 2050 and as much as 67 inches by 2100 (National Research Council 2012). Lying at the confluence of two major rivers, the Delta region is particularly vulnerable to the impacts of these changes.

The major rivers draining into the Delta region originate in the Cascade Range to the north and the Sierra Nevada to the east and are fed primarily by snowmelt. Winter air temperatures in these mountain ranges are projected to increase by 4 to 8 °F by 2100 (California Emergency Management Agency and California Natural Resources Agency 2012). The Sierra Nevada snowpack is projected to continue to decline as warmer temperatures raise the elevation of snow levels, reduce spring snowmelt, and increase winter runoff. DWR projects that the Sierra Nevada will experience a 25 to 40 percent reduction of snowpack from its historical average by 2050 (California Department of Water Resources 2008). Increasing temperatures may also increase net evaporation from reservoirs by 15 to 37 percent (Medellin-Azuara et al. 2009; California Natural Resources Agency 2009). The higher winter runoff may contribute to increase stress on Delta levees and shorten seasonal inundation of floodplains. Lower flows in the summer and fall could increase water temperatures, reduce water quality, and result in greater salinity intrusion. Environmental water supplies could also need to be retained in reservoirs for managing instream flows to maintain habitat for endangered fish species and to meet water quality standards. Climate

change is likely to further constrain the management of those endangered species and the State's ability to provide water for other uses (Cayan 2008; Hayhoe et al. 2004). Combined, these changes could contribute to biodiversity shifts, loss of agricultural productivity, and additional pumping restrictions in the Delta region.

Precipitation is also expected to become more variable with more extreme wet and dry conditions. Larger storm events in the Delta would put additional stress on the levees and contribute to more frequent levee failures. Levee failures can result in the direct loss of life and property and also disrupt important services or transportation corridors. They can also result in salinity intrusion — reducing agricultural productivity in the region — and disrupt SWP and CVP operations. Longer periods of drought could impact the region as well. Lower flows into the Delta would contribute to increased water temperatures, greater salinity intrusion, and reduced water quality putting greater stress on the ecosystem — reducing agricultural productivity and impacting SWP and CVP operations.

In addition to these changes, land surfaces in the Delta are subsiding, increasing the region's vulnerability to sea level rise. Additional sea level rise would increase the amount of land vulnerable to a 100-year flood event, though the amount varies throughout the region (for the most recent sea level rise projections for California, see Figure 3-22 in Volume 1, Chapter 3). Models project that 14 percent of the acreage in Solano County would be more vulnerable to a 100-year flood event; however, that number increases to 40 percent in Contra Costa County and up to 59 percent in Sacramento County (California Emergency Management Agency and California Natural Resources Agency 2012). In addition to higher flood risk due to storm events, rising sea levels would inundate low lying areas and increase salinity intrusion into the Delta. The potential impacts to the region include an increase in the risk of levee failure, loss of agricultural land and productivity, loss of wetlands, reduced water quality due to salinity intrusion, contamination of groundwater supplies, more water dedicated to meeting water quality standards, biodiversity shifts, increased vulnerability to invasive species, and changes to SWP and CVP operations.

The Delta region is economically dependent on the thriving agricultural industry, which could be affected by a more variable hydrologic regime, salinity intrusion, increased levels of pests and disease, increased evapotranspiration, and other indirect effects of rising temperatures. In some instances, a longer growing season would be beneficial, but productivity of some crops may decline. Climate change impacts in neighboring agricultural regions could also have indirect impacts on agriculture in the Delta region.

Regional Resource Management Conditions

Environmental Water

A diverse set of conditions in the Delta helped shape a unique ecosystem from which hundreds of aquatic species, many endemic to the system, evolved. Alterations to this system from the activities of reclaiming and maintaining the Delta for agriculture, urban areas, transportation corridors and utilities, and managing the Delta as a water conveyance and supply system continue to challenge management of the system for the benefit of the ecosystem.

Since development within the Delta began, operation and management of the water conveyance and supply system has continually evolved. History suggests that many of the management adjustments and changes that have been made over the years within the Delta have fallen short in addressing the environmental or water quality concerns these actions were designed to resolve.

Requirements of SWRCB and the biological opinions for endangered species largely determine requirements for water quality, flow, and CVP/SWP project operations in the Delta and Suisun Marsh. On occasion, the SWRCB requirements are superseded by requirements set by other agencies such as the U.S. Fish and Wildlife Service (USFWS). For example, in their middle 1990s *Delta Smelt/Sacramento Splittail Biological Opinions*, the USFWS set CVP/SWP operational criteria, which were ultimately folded into the SWRCB's decision D-1641; and the requirements in D-1641 address standards for fish and wildlife protection, municipal and industrial water quality, agricultural water quality, and Suisun Marsh salinity. Further, requirements outlined in contractual agreements, such as those between DWR and the North Delta Water Agency, play a role in Delta water quality, flow, and CVP/SWP project operations.

The SWP and the CVP coordinate project operations to maintain the standards established by D-1641 and the biological opinions by releasing water from upstream reservoirs for in-Delta as well as Delta outflow requirements, curtailing export pumping at the SWP Banks and CVP Tracy pumping plants during specified time periods, and meeting salinity standards in the Suisun Marsh. A sampling of requirements imposed on project operations are further described in the subsequent Project Operations section.

Ecosystem Restoration

This section describes the major plans approved and in development and the major programs related to ecosystem restoration in the Delta and Suisun Marsh.

Ecosystem Restoration Program Conservation Strategy for Restoration of the Delta Ecological Management Zone and the Sacramento and San Joaquin Valley Regions

The DFW Conservation Strategy describes future restoration priorities and actions of the Delta and the Sacramento Valley and the San Joaquin Valley regions. It further provides the conceptual framework and process that will guide the refinement, evaluation, prioritization, implementation, monitoring, and review of ERP actions. The Conservation Strategy can be found at http://www.dfg.ca.gov/erp/reports_docs.asp.

Suisun Marsh Habitat Management, Preservation, and Restoration Plan

The Suisun Marsh Habitat Management, Preservation, and Restoration Plan is a comprehensive plan designed to address the various conflicts regarding use of marsh resources. The focus is on achieving an acceptable multi-stakeholder approach to restoring 5,000 to 7,000 acres of tidal wetlands and the management of managed wetlands and their functions that are consistent with the CALFED program, the Suisun Marsh Preservation Agreement, applicable species recovery plans, and other interagency goals. The plan is at http://www.dfg.ca.gov/delta/suisunmarsh/.

Fish Restoration Program Agreement

The Fish Restoration Program Agreement (FRPA) between DFW and DWR was signed on October 18, 2010. FRPA addresses specific habitat restoration requirements of the USFWS and the National Marine Fisheries Service (NMFS) biological opinions for SWP and CVP operations. FRPA is also intended to address the habitat requirements of the DFW Longfin Smelt Incidental Take Permit for SWP Delta operations. The primary objective of the FRPA program is to implement the fish habitat restoration requirements and related actions of the biological opinions and the incidental take permit in the Delta, Suisun Marsh, and Yolo Bypass. It is focused on 8,000 acres of intertidal and associated subtidal habitat to benefit delta smelt, including 800 acres of mesohaline habitat to benefit longfin smelt, and a number of related actions for salmonids. The implementation plan for FRPA is at http://www.water.ca.gov/environmentalservices/frpa.

Bay Delta Conservation Plan

The BDCP is a planning process intended to result in the issuance of permits from DFW under the Natural Community Conservation Planning Act and from the USFWS and the NMFS pursuant to Section 10 of the federal Endangered Species Act. The BDCP proposes to contribute to the restoration of the health of the Delta's ecological systems by contributing to a more natural flow pattern than existing conditions in the Delta and by implementing a comprehensive restoration program. As currently proposed, the BDCP seeks to restore and protect approximately 145,000 acres of aquatic and terrestrial habitat over its 50-year term (California Department of Water Resources 2013). More information on the BDCP is at http://baydeltaconservationplan.com/Home.

Local Habitat Conservation Plans and Natural Community Conservation Plans

Several locally sponsored habitat conservation plans (HCPs) and natural community conservation plans (NCCP) are in place or under development in the Delta. These plans propose to allow for economic activities in the Delta to continue while minimizing and mitigating the impact of authorized incidental take of the endangered or rare species that the plans cover and to conserve these species and their habitats. Completed plans in the Delta include the San Joaquin HCP and East Contra Costa HCP/NCCP. Still being developed are the Yolo County HCP/NCCP, South Sacramento HCP, and Solano Multispecies HCP.

Sacramento-San Joaquin Delta Conservancy

In 2009, the Legislature established the Delta Conservancy to act as a primary State agency to implement ecosystem restoration in the Delta and to support efforts that advance environmental protection and the economic well-being of Delta residents. The Delta Conservancy Strategic Plan was adopted in June 2012. More information on the Delta Conservancy is at http://www.deltaconservancy.ca.gov/.

Delta Levees Special Flood Control Projects

DWR's Delta Levees Special Flood Control Projects program provides funding to local agencies in the Delta for habitat projects linked to flood management improvements. Similarly, the

2012 Central Valley Flood Protection Plan proposes new or enhanced flood bypasses, levee setbacks, and fish passage improvements that provide both flood risk reduction and habitat. More information on the Delta Levees Special Flood Control Projects program is at http://www.water.ca.gov/floodsafe/fessro/levees/special_projects/special_projects.

Water Supplies

In an average water year like 2000, the largest source of water was the Sacramento River, which transported a little more than 21 million acre-feet into the Delta. Additional flows from the San Joaquin River and eastside tributaries such as the Mokelumne and Cosumnes rivers contributed just over 3.9 million acre-feet, with precipitation directly on the Delta adding about another million acre-feet. Freshwater flows in the Delta are typically much smaller than those caused by tidal flows. In addition to precipitation-derived runoff, Pacific Ocean tides move into and out of the Delta twice a day. Tidal rise and fall varies with location, from less than a foot in the eastern Delta to more than 5 feet in the western Delta.

A sizable amount of water from the Delta's watershed is diverted upstream and used before it reaches the Delta as Figures D-5 and D-6 illustrate. Figure D-6 depicts historical diversions from the Delta. Figure D-7 shows historical diversions before the Delta, in-Delta uses, and exports and outflows to the ocean.

In-Delta Uses, and Exports from the Delta, Plus Outflows

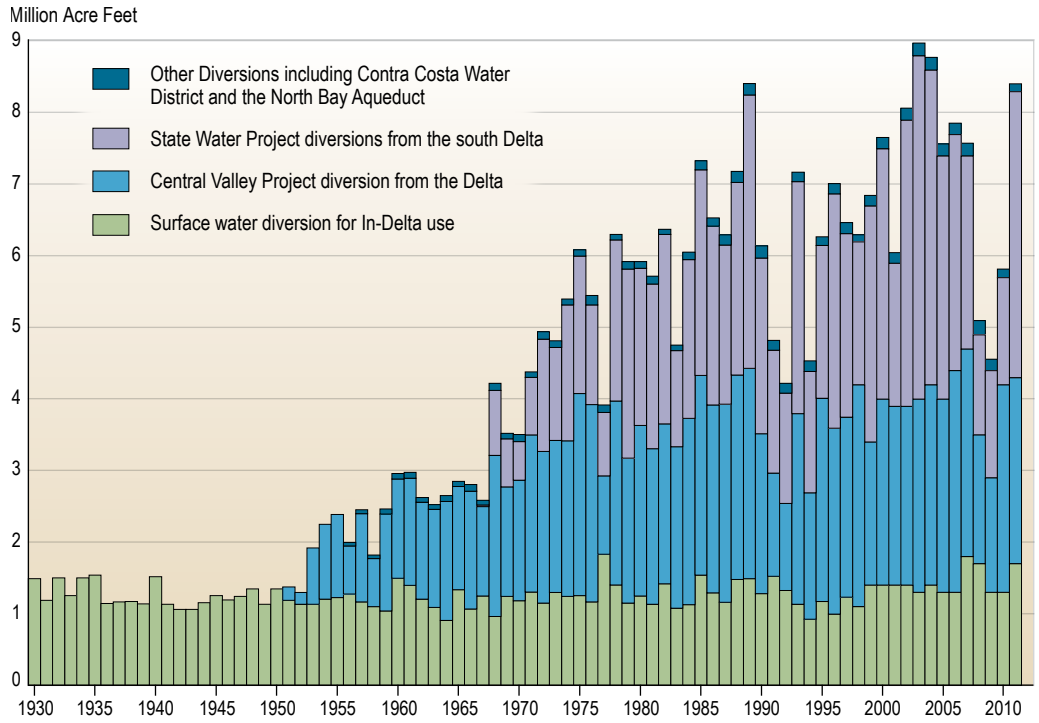
The Suisun Marsh is a brackish marsh. Salinities vary seasonally with higher salinities in the summer and fall, and lower salinities in the winter and spring. There is always an east-to-west salinity gradient in the Suisun Marsh. During periods of local rainfall, numerous creeks provide freshwater inflow to the northern areas of the marsh, seasonally decreasing the salinities of these regions. These creeks are Denverton, Union, Laural, Ledgewood, Suisun, Green Valley, Jameson Canyon, and American Canyon.

Groundwater supplies in the Primary Zone of the Delta are continually recharged due to flows in Delta channels and the soft, absorbent soils of Delta islands. The water table is relatively shallow. A number of groundwater basins/subbasins touch on the Secondary Zone including the Sacramento Valley/Solano Subbasin, San Joaquin Valley/Eastern San Joaquin and Tracy subbasins, and the Suisun-Fairfield Valley Basin. Groundwater levels in most basins have declined as a result of agricultural and urban development and in some cases, as a result of the use of groundwater to compensate for transfer of surface waters to other regions. The Eastern San Joaquin Subbasin has been characterized as being severely overdrafted with significant depressions east of Stockton and Lodi. Groundwater levels fluctuate with droughts, development, delivery of surface waters to the region, and periods of wet years.

Water Balance

A water balance is a good way to get an overview of the major flows into and out of the Delta. Three recent years 1998 (wet year), 2000 (average year), and 2001 (dry year) demonstrate typical fluctuations in Delta inflows/outflows. Figure D-8 shows Delta inflows/outflows for years 1998, 2000, and 2001. During these years, the water system was generally operated under the same

Figure D-6 Historical Diversions from within the Delta



Note: Data from 1930-1997 comes from the *Delta Vision Blue Ribbon Task Force 2008 Final Report* and data from 1998-2010 comes from DWR water portfolio and dayflow numbers.

rules as today. Some observations that can be made by looking at these three types of water years are:

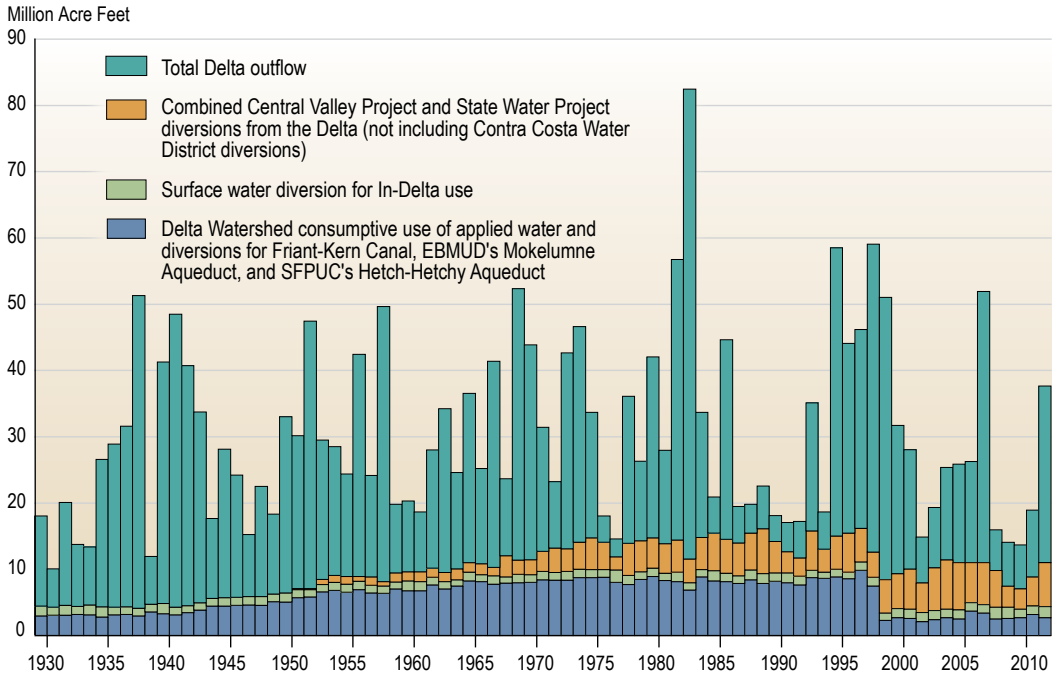
- In-Delta consumptive use is similar most years.
- Water export quantities show more variability, but still are in a relatively narrow range.
- The widest variability from year to year occurs in the outflow from the Delta. Net outflow to the bay/ocean in a wet year can be many times more than the outflow during a dry year.
- Water diversions and exports are a larger portion of the Delta inflow during a dry year.

The historical records show even larger flow ranges than represented in Figure D-8. For example, during water year 1983 (October 1982 through September 1983), more than 60 million acre-feet (maf) of water passed through the Delta to the San Francisco Bay (see Figure D-7). By comparison, during water year 1977, which was one of the most severe drought years on record, only about 5 maf passed through the Delta to the San Francisco Bay (see Figure D-7).

Water Rights

Riparian water rights are entitlements to water that are held by owners of land bordering natural flows of water. A landowner has a right to divert a portion of the flow for reasonable and beneficial use on their land within the same watershed. Natural flows do not include return flows

Figure D-7 Historical Diversions before the Delta



Trends in Destinations and Uses

Period	Average Annual Total (MAF)	Outflow	in-Delta	Exports	Delta Watershed
1930 to 1949	25.80	81%	5%	0%	14%
1990 to 2005	31.71	67%	4%	4%	24%
1950 to 1969	34.34	51%	5%	15%	29%
1970 to 1989	32.85	48%	4%	17%	31%

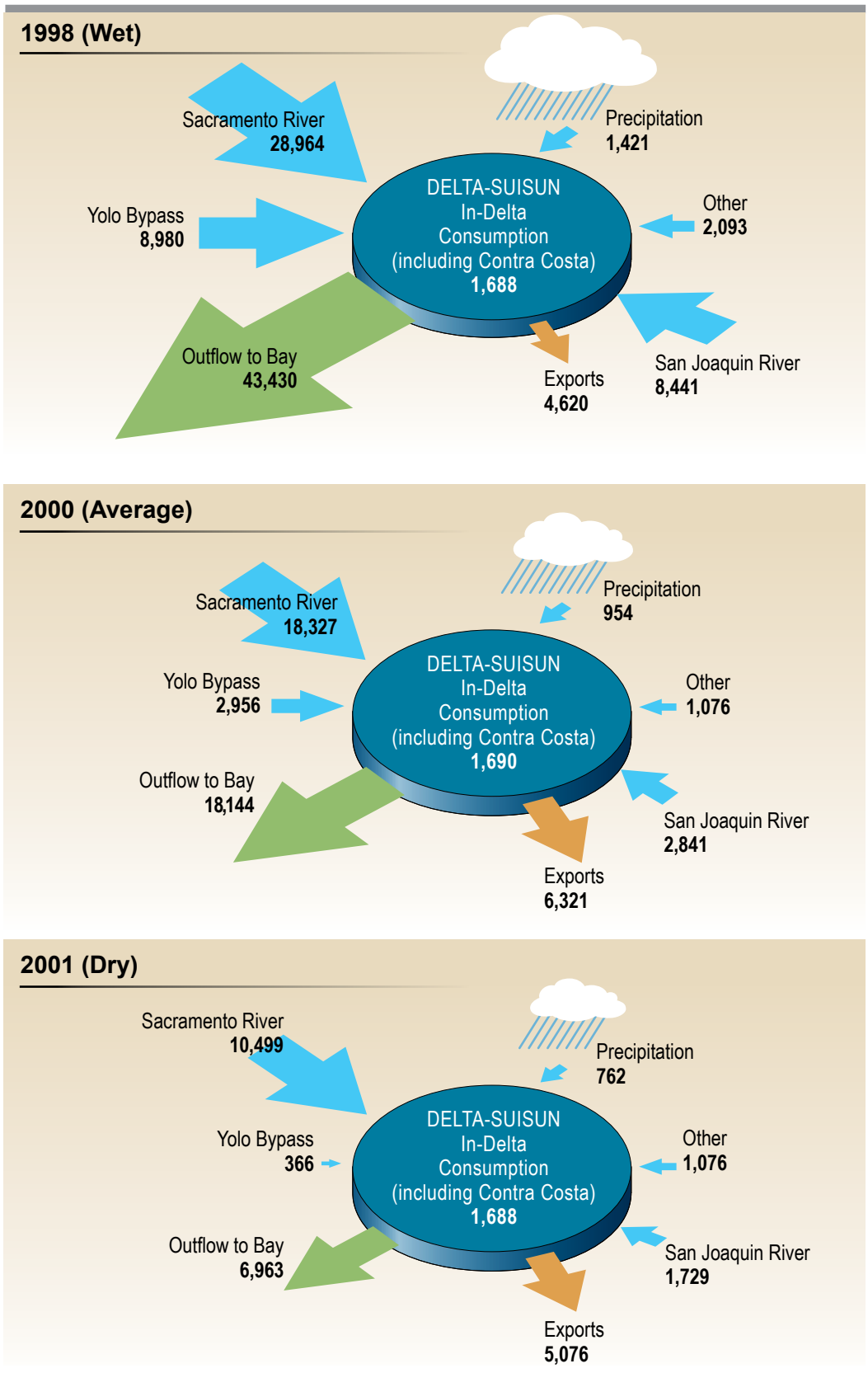
Note: Data from 1930-1997 comes from the *Delta Vision Blue Ribbon Task Force 2008 Final Report* and data from 1998-2010 comes from DWR water portfolio and dayflow numbers.

from use of groundwater, water stored and later released (e.g., by the SWP or the CVP for Delta export), or water diverted from another watershed.

Appropriative rights are held in the form of conditional permits or licenses from the SWRCB. Appropriative rights can be applied to both riparian and non-riparian lands provided the riparian rights on a given stream are satisfied first. Additionally, whether an appropriative right was initiated before or after 1914 affects the priority and legal history of the right and thus the regulation of the right.

A body of water rights law includes the area of origin, county of origin, watershed of origin, and Delta protection statutes. These laws were developed to retain the priority to subsequent appropriative uses within an area, county, or watershed, as against out-of-basin permitted appropriations. Specifically, they were enacted to protect local water users from appropriations by the CVP and SWP for use in areas outside the area of origin or the areas immediately adjacent to the areas of origin. Thus, area of origin statutes consist of a priority right to satisfy current

Figure D-8 **Delta Water Balance for Years 1998, 2000, and 2001**



Source: Status and Trends of Delta Suisun Services. DWR 2007.

uses, as well as a prospective priority right to satisfy future beneficial uses within a specifically identified geographic area.

The Delta Protection Act (1959) incorporates the area of origin protection to the Delta. Specifically, the act declares as a policy of the State "that no person, corporation or public or private agency or the State or the United States should divert water from the channels of the Sacramento-San Joaquin Delta to which the users within said Delta are entitled."

Contract Rights

The SWRCB authorizes and regulates diversion and export of water from the Delta by the SWP and CVP. The SWRCB first issued water rights permits to the U.S. Bureau of Reclamation for the operation of the CVP in 1958 (Water Rights Decision 893) and to DWR for operation of the SWP in 1967 (D-1275 and D-1291). Entitlements to these surface water supplies can be obtained through contracting with the SWP and the CVP. The CVP and SWP contractors have contractual rights as specified in the contracts. DWR has also entered into water supply contracts with water agencies in the Delta such as the North Delta Water Agency (NDWA). The NDWA contract provides assurances that users within the NDWA boundary have the right to divert water of a suitable quality to meet the reasonable and beneficial uses for agricultural, municipal, and industrial purposes.

Groundwater Rights

In most areas of California, overlying landowners may extract percolating groundwater and put it to beneficial use without approval from the SWRCB or a court. California does not have a permit process for regulating groundwater use. In several basins, however, groundwater use is subject to regulation in accordance with court decrees adjudicating the groundwater rights within the basins.

The California Supreme Court decided in the 1903 case *Katz v. Walkinshaw* that the "reasonable use" provision that governs other types of water rights also applies to groundwater. Prior to this time, the English system of unregulated groundwater pumping had dominated, but it proved to be inappropriate to California's semiarid climate. The Supreme Court case established the concept of overlying rights, in which the rights of others with land overlying the aquifer must be taken into account. Later court decisions established that groundwater may be appropriated for use outside the basin, although appropriator's rights are subordinate to those with overlying rights. A general overview of groundwater rights in California is on the SWRCB Web site at http://www.waterboards.ca.gov/waterrights/board_info/water_rights_process.shtml.

Water Uses Within the Delta

Surface Water

Water use in the Delta region is mostly agricultural. Irrigation water is taken directly from the channels and sloughs through approximately 1,800 diversions, which together divert up to 5,000 cubic feet per second (cfs) during peak summer months. Though the primary water users in the Delta are individual farming operations, formal institutions have been established to manage Delta water. For instance, in November 1965, DWR and the U.S. Bureau of Reclamation reached

agreement with some Delta interests on the quality of agricultural water to be maintained by the SWP and the CVP at various locations in the Delta. There was, however, no legal entity to sign the related contracts. As a result, the Legislature created the Delta Water Agency. This agency was replaced with three separate agencies in 1973 — the NDWA, the Central Delta Water Agency, and the South Delta Water Agency. Contra Costa Water District, East Contra Costa Irrigation District, Byron-Bethany Irrigation District, the City of Antioch, and various industrial corporations are the remaining local water users within the Delta.

Most Delta farms use water under riparian and appropriative water rights, and drainage water from the islands is pumped back into the Delta waterways. In 2000, Delta agriculture used about 1.3 million acre-feet of water to irrigate about 476,000 acres of crops (Tully and Young 2007). Agricultural production in the Delta requires an intricate and inter-connected system of levees and the irrigation and drainage infrastructure to maintain the current dry and fertile condition of the reclaimed island lands. Reclamation district and private canals and ditches function as both water supply and drainage conveyance facilities on Delta islands. Canals and ditches are typically kept at low water levels during the drainage season to convey localized drainage and stormwater to be pumped out by the reclamation districts. During the crop-growing season, water is diverted from the river tributaries into the same ditches and canals for irrigation and reused throughout each interconnected system. The practice of reusing irrigation drainage water for subsequent irrigation is not currently constrained because the quality of agricultural drainage and supply water are both relatively good.

Agricultural water supply in the Delta relies heavily on irrigation because there is high rainfall during the winter and low rainfall during the majority of the growing season. Delta groundwater levels vary seasonally and are highly influenced by seasonal precipitation, drainage, soil texture and profiles, proximity to tributaries, and open water and surface water levels. Surface water levels in the Delta are determined by the Delta inflows, tides, local diversions, and CVP/SWP water export operations and deliveries. High water tables and poor drainage, which result in excessive seepage, can limit crop selection options, lead to crop loss or damage, contribute to pest infestations (e.g., fungus and mildews), and changes in soil conditions.

Drain tiles to control groundwater depth and to move drain water are installed for most permanent crops and some open ground throughout the Delta to prevent the oversaturation of soils. The water table elevation must remain below the crop root zone to maximize growth and yield as well as minimize root rotting from oversaturation.

In general, irrigation water is diverted directly from Delta waterways and transported to farmlands via irrigation and drainage canals and in some cases directly into field furrows. Although Delta farmers use groundwater for irrigation, the ability to divert directly from adjacent and nearby water sources, makes its use less dominant compared to other agricultural regions in the state. Agricultural surface water diversion intakes and pumping operations depend on sufficient water surface levels to keep the intakes submerged, which has been a problem in the South Delta where temporary control structures are currently installed annually to raise surface water elevations. Energy requirements for pumping and therefore agricultural water costs in the Delta are also affected by surface water elevations. A small fraction of in-Delta residential water is provided through community public water systems, such as the Contra Costa Water District. The remaining portion of water in the Delta is either used by the various forms of evapotranspiration or contributes to Delta outflow, which provides wildlife habitat and salinity control benefits. Recreation water uses do not have a large effect on the Delta water balance, but are still important in the Delta.

Most Suisun Marsh managed wetlands begin flooding in the fall around October 1 in preparation for the fall migration of waterfowl. At the end of waterfowl season, water manipulation for habitat development may continue through July. Typically, the water remaining in the wetlands is drained in June or July to allow vegetative growth and to perform routine maintenance activities, such as repair of water control structures and levee maintenance, during the summer work season.

Power generation plants at Antioch and Pittsburg are cooled with water diverted from the Delta. Combined, the two power plants' pumps can divert 3,240 cfs. The SWP's North Bay Aqueduct (NBA) and the CVP's Contra Costa Canal deliver water to Bay Area cities. In 2010, the SWP diverted about 43,000 acre-feet into the NBA; and Contra Costa Water District withdrew about 94,000 acre-feet.

Groundwater

Within the Delta's Primary Zone, residential water is generally drawn through private wells. Little is known about groundwater use from the basins within the Delta's Secondary Zone with the exception of the East San Joaquin Subbasin. Various estimates place groundwater use in the East San Joaquin Subbasin at 730,000 to 800,000 acre-feet per year. The CALFED Programmatic Environmental Impact Statement/Environmental Impact Report (EIS/EIR) (2000) estimated that average annual groundwater withdrawals range from 100,000 to 150,000 acre-feet in upland areas of the Delta.

Recycled Water

According to the 2009 Municipal Wastewater Recycling Survey, compiled by the SWRCB, 9,115 acre-feet per year are being recycled in the Delta. Most of the recycled water was used for agricultural irrigation or for wetlands and natural systems (State Water Resources Control Board 2011a). State policy (State Water Resources Control Board 2009) encourages increased use of recycled water, but recognizes the potential of recycled water to contribute to exceeding or threatening to exceed water quality objectives due to salt and nutrients. Therefore, the policy requires stakeholders to work together to develop salt and nutrient management plans. The Central Valley Salinity Alternatives for Long-Term Sustainability (CV-SALTS) is a strategic initiative to address problems with salinity and nitrates in the surface waters and groundwaters of the Central Valley.

Water Uses Outside the Delta

About half the state's runoff, which originates in the Sierra Nevada, flows through the Delta watershed. Many diversions in the Delta watershed occur in the upper watershed. On average, approximately 31 percent of the flow from the Delta watershed is diverted before it ever reaches the Delta (California Natural Resource Agency 2010). Some of the water diverted from the Delta tributaries is returned to the tributaries through wastewater effluent and agricultural return flows, albeit at a degraded quality.

Diversions from the Delta, first by the CVP in the 1950s and then by the SWP starting in the 1960s, have steadily increased over the years. The SWP provides water primarily to urban areas, but also supplies some water for agricultural uses, including the Kern County Water Agency. The

SWP has contracts to deliver 4.2 million acre-feet annually. The CVP has contracts to deliver 3.1 million af annually from the Delta. The projects generally are not able to deliver their full contract amounts because the projects are also operated for Delta water quality requirements and fish protections, especially during times of drought. In recent years, on average, the projects together have exported about 5 million af annually.

Project Operations

The CVP Delta facilities include the Contra Costa Canal (CCC), the C.W. "Bill" Jones Pumping Plant, the Tracy Fish Collection Facility, the Delta-Mendota Canal (DMC), and the Delta Cross Channel (DCC). The CCC and DMC convey water from the Delta to Contra Costa County and the DMC and San Luis service areas. The DCC is a controlled diversion channel between the Sacramento River and Snodgrass Slough. The C.W. "Bill" Jones Pumping Plant's diversion capacity is about 4,600 cfs.

The SWP facilities in the Delta include the NBA, Clifton Court Forebay (CCF), John E. Skinner Fish Facility, the Harvey O. Banks Pumping Plant, the Suisun Marsh Salinity Control Gates (SMSCG), several Suisun Marsh distribution systems (Roaring River and Morrow Island) and up to four temporary barriers in the South Delta. The NBA conveys water to Napa and Solano counties, and its maximum pumping capacity is 175 cfs. The CCF, Skinner Fish Facility, and Banks Pumping Plant divert and convey water to SWP service areas south of the Delta including the South Bay. Daily diversions into the CCF are governed by an agreement with the USACE (Public Notice 5820A). While the pumping capacity of Banks Pumping Plant is 10,500 cfs, the current permitted average daily diversion at CCF is 6,680 cfs. The SMSCG are operated to meet marsh water quality standards. The Suisun Marsh water distribution systems are designed to provide lower salinity water to public and privately managed wetlands and to discharge drainage water. Figure D-9 shows the locations of SWP and facilities.

As noted in the Environmental Water section, the operations of the SWP/CVP are subject to many State and federal laws, agreements, biological opinions, contract requirements, flood operations, etc. that are designed to protect water quality, water supplies, wetlands, anadromous and native fisheries, migratory birds, threatened and endangered species, and to prevent flooding, etc. Table D-2 (Laws, Directives, and Orders Affecting CVP and SWP Operations) lists several of these operational criteria and provides a summary description. An overview of several key actions is provided below:

- **Coordinated Operations Agreement.** The CVP and SWP release previously stored water into the Delta where they redivert the stored water and also divert natural flow to users mainly south and west of the Delta. The CVP and SWP use the Delta as a common conveyance facility. Reservoir releases and Delta exports must be coordinated to ensure that each project achieves its share of water supplies and bears it share of obligations to protect resources.
- **Suisun Marsh Preservation Agreement.** The SWRCB's D-1485 directed the CVP and SWP to develop a plan to protect Suisun Marsh resources. An agreement was signed in 1987 with the goal to mitigate the effects of the CVP and SWP operations and other upstream diversions on water quality in the marsh.
- **Endangered Fish Species Biological Opinions.** The general decline of several fish species, the delta smelt and spring-run and winter-run salmon in particular, generated much concern resulting in a series of biological opinions from the National Oceanic and Atmospheric Administration (NOAA) Fisheries and the USFWS. These opinions ultimately established

Figure D-9 Location of State Water Project and Central Valley Project Facilities in the Delta-Suisun Area

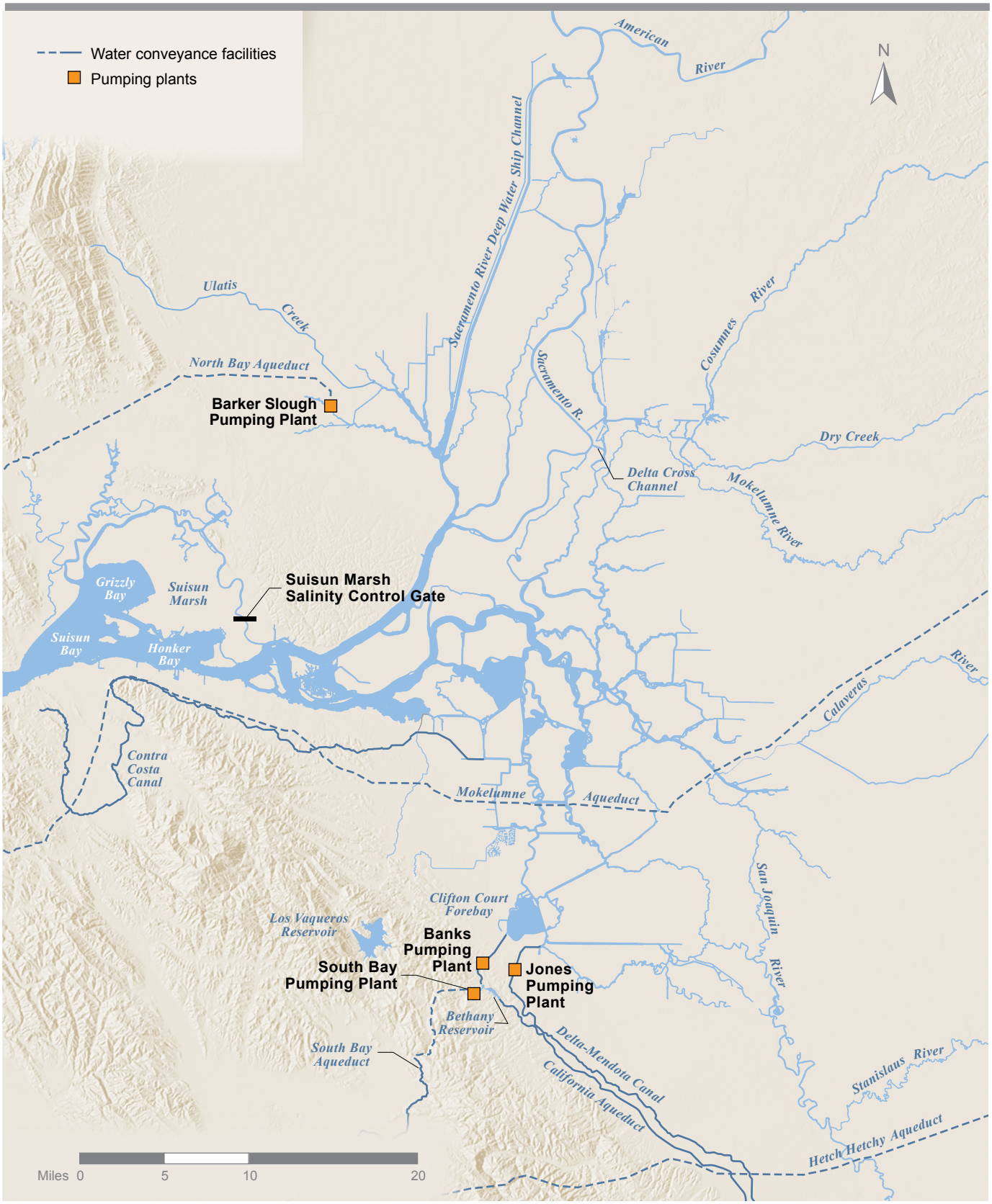


Table D-2 Laws, Directives, and Orders Affecting CVP and SWP Operations

Laws, Directives, and Orders	Year	Description
Delta Protection Act	1959	Ensures water is available for in-Delta beneficial uses
North Delta Water Agency	1981	Contract that ensures there will be suitable water in the Northern Delta for agriculture and other beneficial uses.
Coordinated Operating Agreement	1986	Agreement between the State and feds to determine the respective water supplies of the CVP and SWP while allowing for a negotiated sharing of Delta excess outflows and the satisfaction of in-basin obligations between the projects
SWRCB Orders 90-5, 91-1	1990, 1991	Modified Reclamation water rights to incorporate temperature control objectives in the Upper Sacramento River
NMFS BO for Winter-run Chinook Salmon	1992, 1993, 1995, 2009	Established operation to protect winter-run and provided for "incidental taking"
CVPIA	1992	Mandated changes to the CVP particularly for the protection, restoration and enhancement of fish and wildlife
FWS BO for Delta Smelt and Sacramento Splittail	1993, 1994, 1995, 2008	Established operational criteria to protect Delta Smelt
Bay-Delta Plan Accord and SWRCB Order WR 95-06	1994, 1995	Agreement and associated SWRCB order to provide for the operations of the CVP and SWP to protect Bay-Delta water quality. Also provided for development of a new Bay-Delta operating agreement (being pursued through CALFED)
Monterey Agreement	1995	Agreement between DWR and SWP contractors to manage contractor operations
SWRCB Revised Water Right Decision 1641	2000	Revised order to provide for operations of the CVP and SWP to protect Delta water quality
CALFED ROD	2000	Presented a long-term plan and strategy designed to fix the Bay-Delta
CVPIA ROD	2001	Implemented provisions of CVPIA including allocating 800,000 acre-feet of CVP yield for environmental purposes
NMFS BO for Spring-run Chinook Salmon and Steelhead	2001, 2002, 2004, 2009	Established criteria for operations to protect spring-run Chinook salmon and steelhead
SWRCB Order 2006-0006	2006	Draft Cease and Desist Order against DWR and U.S. Bureau of Reclamation

Source: Table entries in part are excerpts from Table 1-1 of the June 2004 CVP-OCAP, available at http://www.usbr.gov/mp/cvo/ocapBA.html.

Notes:

BO = biological opinion
CVP = Central Valley Project
CVPIA = Central Valley Project Improvement Act
FWS = U.S. Fish and Wildlife Service
NMFS = National Marine Fisheries Service
SWP = State Water Project
SWRCB = State Water Resources Control Board
ROD = Record of Decision

requirements to be met by the SWP and CVP to protect these species. These included requirements for Delta inflow and outflow, DCC gate closure, and reduced export pumping. Many of these fish protection requirements were incorporated into the 1995 water quality control plan below. New biological opinions issued in 2008 and 2009 modified some existing requirements such as additional DCC gate closures and slightly different Old and Middle River (OMR) flow targets (to protect delta smelt) and added others, including a fall X2 (habitat protection outflow) requirement in certain water year types.

- **1995 Water Quality Control Plan and Decision 1641.** The 1995 Water Quality Control Plan for the Sacramento-San Joaquin Delta Estuary (commonly referred to as the Bay-Delta Plan) incorporated several changes recommended by the U.S. Environmental Protection Agency (EPA), NOAA Fisheries, and USFWS to the objectives for salinity and endangered species protection. Decision 1641, established in 1999, implements the objectives in the 1995 Bay-Delta Plan, and imposes flow and water quality objectives to assure protection of beneficial uses in the Delta. In essence, the requirements in D-1641 address standards for fish and wildlife protection, municipal and industrial water quality, agricultural water quality, and Suisun Marsh salinity. The decision added new provisions for X2, export/inflow ratio, and the Vernalis Adaptive Management Program (VAMP). Changes in the water rights of the CVP, SWP, and other were instituted with the goal of meeting the new standards. The SWRCB also granted conditional changes to the point of diversion for the CVP and SWP, in the southern Delta, with D-1641 and approved a petition to change places and purposes of use in the CVP. The 2006 Bay-Delta Plan, which is currently in effect, superseded the 1995 plan.
- **North Delta Water Agency (NDWA).** In 1981, DWR and NDWA executed a contract that ensures that there will be suitable water available in the northern Delta for agriculture and other beneficial uses. Further, a 1998 memorandum of understanding provides that DWR is responsible for any obligation imposed on NDWA to provide water to meet Bay Delta flow objectives so long as the 1981 contract remains in effect.
- **Delta Protection Act and Area of Origin Statutes.** See the discussion under the Water Supplies section above.

Water Quality

The Delta lies within two regional water boards: the Central Valley Regional Water Quality Control Board (CVRWQCB) and the San Francisco Bay Regional Water Quality Control Board (SFBRWQCB). Both regional water boards have adopted water quality control plans that establish water quality objectives for the Delta based on the identified beneficial uses of Delta waters. The beneficial uses identified in the Water Quality Control Plan for the San Francisco Bay Basin (San Francisco Bay Regional Water Quality Control Board 2011) and the Water Quality Control Plan for the Sacramento River and San Joaquin River Basins (Central Valley Regional Water Quality Control Board 2011) include:

- Municipal and domestic supply.
- Industrial service supply.
- Industrial process supply.
- Agricultural supply.
- Groundwater recharge.
- Navigation.
- Water contact recreation.

- Non-contact water recreation.
- Shellfish harvesting.
- Commercial and sport fishing.
- Warm freshwater habitat.
- Cold freshwater habitat.
- Migration of aquatic organisms.
- Spawning, reproduction, and/or early development.
- Estuarine habitat.
- Wildlife habitat.
- Rare, threatened, or endangered species.

SWRCB adopted the Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (2006 Bay-Delta Plan) (State Water Resources Control Board 2006), which supersedes the regional board basin plans to the extent of any conflict. The SWRCB has responsibility over water rights and recognizing that flow affects water quality, the SWRCB adopted the 2006 Bay-Delta Plan to establish water quality objectives for the constituents that are most associated with flows in the Delta such as chloride, electrical conductivity, temperature and dissolved oxygen.

Surface Water Quality

Generally, water quality in the Delta is affected by hydrologic conditions. The north part of the Delta, which is dominated by Sacramento River water, generally has better water quality than the south part of the Delta, which is dominated by San Joaquin River water and ocean tides. Land use, dredging, diversions, and point-source and non-point-source inputs of pollutants also influence Delta water quality. In addition to water quality challenges from nutrients and salinity, Delta waters do not meet the water quality standards for certain constituents and thus are considered impaired.

Delta water quality is impaired due to:

- Pesticides (chlorpyrifos, diazinon, group A pesticides, dichlorodiphenyltrichloroethane [DDT], chlordane, dieldrin, diuron).
- Mercury.
- Polychlorinated biphenyls (PCBs).
- Invasive species.

Localized impairments have been identified for:

- Pyrethroids in Morrison Creek.
- Electrical conductivity in the southern portion of the Delta.
- Low dissolved oxygen in the vicinity of Stockton and the South Delta.
- Pathogens in the vicinity of Stockton and in Marsh Creek.
- Selenium in the West Delta (State Water Resources Control Board 2010a).

Pesticides causing impairment of the Delta are human-made chemicals used to control pests, insects, and undesirable vegetation in urban and agricultural landscapes. A fraction of the applied pesticides can enter Delta waterways during rainfall or irrigation events when residual pesticides migrate in stormwater runoff or irrigation return water or migrate with sediment carried in stormwater runoff or irrigation return water and cause unintended toxicity to aquatic life.

High levels of mercury in fish are of concern to people and wildlife that eat Delta fish. Sources of inorganic mercury in the Delta include tributary inflows from upstream watersheds, atmospheric deposition, urban runoff, dredging activities, and municipal and industrial wastewater. Sources of inorganic mercury in the watersheds upstream of the Delta include gold and mercury mine sites, legacy mercury in the stream channel sediments, geothermal springs, atmospheric deposition, urban runoff, and municipal and industrial wastewater (Central Valley Regional Water Quality Control Board 2010).

PCBs have been classified as probable human carcinogens, and the primary exposure is through consumption of PCBs-contaminated fish. Manufacture and distribution of materials containing detectable PCBs have been banned, but large quantities of PCBs remain in use. PCBs have been introduced to the environment through land disposal, accidental spills and leaks, incineration of PCBs or other organic material in the presence of chlorine, pesticide applications, surface coatings such as paints and caulks, and wastewater discharge. In the San Francisco Bay, large quantities of PCBs are present in the water column and sediment (San Francisco Bay Regional Water Quality Control Board 2008).

Low dissolved oxygen concentrations may act as a barrier to upstream spawning migration of Chinook salmon and may stress and kill other resident aquatic organisms. The Stockton Deep Water Ship Channel (DWSC) is a portion of the San Joaquin River that has been dredged by the USACE to allow for the navigation of ocean going cargo vessels between San Francisco Bay and the Port of Stockton. Three main factors contribute to the dissolved oxygen impairment of the DWSC:

- Loads of oxygen-demanding substances such as algae from upstream sources that react by numerous chemical, biological, and physical mechanisms to remove dissolved oxygen from the water column in the DWSC.
- DWSC geometry impacts various mechanisms that add or remove dissolved oxygen from the water column, such that net oxygen demand exerted in the DWSC is increased.
- Reduced flow through the DWSC impacts mechanisms that add or remove dissolved oxygen from the water column, such that net oxygen demand in the DWSC is increased (Central Valley Regional Water Quality Control Board 2005).

Other dissolved oxygen impairments in the vicinity of Stockton and the south Delta are most likely due to excess loadings of oxygen demanding substances.

Pathogens and fecal coliforms are a human health concern for drinking water and recreational uses. These bacteria may be introduced to a water body from many sources including faulty sewer and septic systems, urban runoff, animal wastes, and land use runoff from both developed and undeveloped systems (U.S. Environmental Protection Agency 2001).

Selenium has been identified as a potential bioaccumulation concern in white sturgeon, and probably green sturgeon, in San Francisco Bay and the West Delta. Selenium mainly originates

from natural sources although these sources are often concentrated and redistributed by anthropogenic activities such as agricultural management practices. Fossil fuels, such as coal and crude oil, are also naturally enriched with selenium. Thus, refining and cracking of crude oil, combustion of fossil fuels and solid wastes, microbial activity, and industrial processes also release selenium to the atmosphere and surface waters. The main sources of selenium to the north San Francisco Bay and the west Delta are industrial and municipal discharges including petroleum refineries, urban and non-urban runoff, erosion and sediment transport within the north San Francisco Bay, flow from Central Valley watersheds through the Delta, and atmospheric deposition (San Francisco Bay Regional Water Quality Control Board 2011).

Nutrients

Plant nutrients of concern in water are primarily nitrogen and phosphorus compounds including ammonia, ammonium, nitrite, nitrate, and phosphate. Excessive amounts (over fertilization) or altered proportions of these nutrients in streams, rivers, lakes, estuaries, or the coastal ocean can have detrimental effects on ecosystems. Die-offs of algae that deplete oxygen and cause fish kills are a well-known example, but even less obvious effects of nutrients can have important impacts on aquatic ecosystems. Changes in the types of algae that form the base of the aquatic food web including growth of toxic algae have been linked to excessive amounts or altered ratios of plant nutrients. Ratios of nutrients in Delta waters are thought to be a primary driver in the composition of aquatic food webs in the Bay Delta (Glibert 2010). The effect of ammonium on food webs in the Delta remains an open question, and much active research and healthy scientific debate continue.

San Francisco Bay has long been recognized as a nutrient enriched estuary. Nonetheless, dissolved oxygen concentrations found in the bay's subtidal habitats are much higher and phytoplankton biomass and productivity are substantially lower than would be expected in an estuary with such high nutrient enrichment. This implies that eutrophication is controlled by processes other than straightforward nutrient limitation of primary production. The published literature suggests that phytoplankton growth and accumulation are largely controlled by a combination of factors, including strong tidal mixing, light limitation due to high turbidity, and grazing pressure by clams (Cloern and Jassby 2012).

There is a growing body of evidence that suggests the historical resilience of San Francisco Bay to the harmful effects of nutrient enrichment is weakening. Since the late 1990s, regions of the bay have experienced significant increases in phytoplankton biomass (30 – 105 percent from Suisun to South Bay) and declines in dissolved oxygen concentrations (2 percent and 4 percent in Suisun Bay and South Bay, respectively. In addition, an unprecedented autumn phytoplankton bloom in October 1999, and increased frequency of cyanobacteria and dinoflagellate (the 2004 red tide event) blooms occurring in the North Bay, further signal changes in the estuary. The Delta has experienced blooms of harmful algal species (e.g., *Microcystis aeruginosa*) that produce toxins that can impact human health and wildlife.

Salinity

Salinity enters the Delta from the tides and from return flows from agricultural lands, principally in the San Joaquin Valley. Prior to the construction of today's water supply and flood control facilities, salinity levels were lower in the winter and spring and higher in the summer and fall. Delta salinity levels are currently mandated by water quality control regulations. Some evidence

indicates the current (less variable) salinity regime may favor invasive species to the detriment of native species. Small amounts of salt in urban supplies can negatively affect consumer perception and acceptance of tap water. Slightly higher salinities decrease crop yields. Increasing salinity in both agricultural and urban water decreases how the water can be used and, at too high a level, can make the water unusable. While the ecosystem may benefit from more variability in the salinity, the water diversions for agricultural and urban uses rely upon a more constant low level salinity.

Central Valley Salinity Alternatives for Long-Term Sustainability

In the Central Valley, which contains almost the entire Delta, the CVRWQCB and the SWRCB are working with a stakeholder coalition and are developing a comprehensive salinity and nutrient management plan for the Central Valley. CV-SALTS is a strategic initiative to address problems with salinity and nitrates in the surface waters and groundwater of the Central Valley. The long-term plan developed under CV-SALTS will identify and implement future management measures aimed at the regulation of major sources of salt. As this issue impacts all users (stakeholders) of water within the Delta, it is important that all stakeholders participate in CV-SALTS to be part of the development and have input on the implementation of salt and nitrate management within the Delta area. In the Central Valley, the only acceptable process to develop the salt and nutrient management plans that are required under State policy is through CV-SALTS (State Water Resources Control Board 2009).

Drinking Water Quality

In general, drinking water systems in the Delta region deliver water to their customers that meet federal and State drinking water standards. Recently, the Regional Water Boards completed a statewide assessment of community water systems that rely on contaminated groundwater. This report identified 21 community drinking water systems in the Delta region that rely on at least one contaminated groundwater well as a source of supply (Table D-3). Arsenic is the most prevalent groundwater contaminant affecting community drinking water wells in the region (Table D-4). The majority of the affected systems are small water systems which often need financial assistance to construct a water treatment plant or alternate solution to meet drinking water standards.

The Delta provides drinking water to more than 25 million people in the Southern California, Central Coast, and San Francisco Bay regions; and several million people obtain their water supply from the tributaries of the Delta. The tributaries of the Sacramento and San Joaquin rivers that originate in the Cascade Range and Sierra Nevada generally have high quality water. However, as the tributaries flow into lower elevations, they are affected by urban, industrial, and agricultural land uses, natural processes, and a highly managed water supply system.

The CVRWQCB has also been working with a workgroup made up of interested stakeholders — including federal and State agencies, drinking water agencies, and wastewater, municipal stormwater, and agricultural interests — to develop a drinking water policy to help protect drinking water supplies. These efforts resulted in a *Drinking Water Policy for Surface Waters of the Delta and its Upstream Tributaries* that was adopted by the CVRWQCB (2013). The policy includes narrative water quality objectives for the pathogens *Cryptosporidium* and *Giardia*, along with implementation provisions, and clarification that the narrative water quality objective for chemical constituents includes drinking water constituents of concern. The workgroup evaluated

Table D-3 Summary of Community Drinking Water Systems in the Sacramento-San Joaquin Delta Region that Rely on One or More Contaminated Groundwater Wells that Exceed a Primary Drinking Water Standard

Community Drinking Water Systems and Groundwater Wells Grouped by Water System Population	Number of Affected Community Drinking Water Systems	Number of Affected Community Drinking Water Wells
Small System (≤ 3,300)	18	23
Medium System (3,301 - 10,000)	1	2
Large System (≥ 10,000)	2	2
Total	21	27

Source: *Communities That Rely on a Contaminated Groundwater Source for Drinking Water.* State Water Resources Control Board 2013.

land use changes and potential control measures that could be expected to occur in the next 20 years. The workgroup concluded that organic carbon would not increase at drinking water intakes based on the cumulative effect of several factors that included reduction in agricultural lands and increasing regulations, as well as increased urbanization. While pathogens were not specifically modeled in this effort, current monitoring indicates that the new narrative water quality objective is being met. Additional information is available at http:www.waterboards.ca.gov/centralvalley/water_issues/drinking_water_policy/index.shtml.

Groundwater Quality

Groundwater quality in the Delta area is generally good with the following contaminants:

- Arsenic (State Water Resources Control Board 2012; U.S. Geological Survey 2010, 2011).
- Localized contamination has been identified.
- Organic compounds (State Water Resources Control Board 2012).
- Nitrates (State Water Resources Control Board 2012).
- Hexavalent chromium (State Water Resources Control Board 2011b).

The primary source of arsenic in groundwater in the Delta is minerals eroded from the volcanic and granitic rocks of the Sierra Nevada. Geochemical conditions in and near the Delta are conducive to arsenic dissolution.

Chromium is a metal found in natural deposits of ores containing other elements, mostly as chrome-iron ore. It is also widely present in soil and plants. Recent sampling of drinking water throughout California suggests that hexavalent chromium may occur naturally in groundwater at many locations. Chromium may also enter the environment from human uses. Chromium is used in metal alloys such as stainless steel protective coatings on metal, magnetic tapes, and pigments for paints, cement, paper, rubber, composition floor covering, etc. Elevated levels (above the detection limit of 1 µg/L) of hexavalent chromium have been detected in many active

Table D-4 Summary of Contaminants Affecting Community Drinking Water Systems in the Sacramento-San Joaquin Delta Region

Principal Contaminant (PC)	Community Drinking Water Systems where PC exceeds the Primary Maximum Contaminant Level (MCL)	Number of Community Drinking Water Wells where PC exceeds the Primary Maximum Contaminant Level MCL
Arsenic	17	22
Nitrate	2	2
Gross alpha particle activity	1	2
Fluoride	1	1
Uranium	1	1

Source: *Communities That Rely on a Contaminated Groundwater Source for Drinking Water.* State Water Resources Control Board 2013

and standby public supply wells along the west or valley floor portion of the Central Valley (State Water Resources Control Board 2011b).

Suisun Marsh Water Quality

The Suisun Marsh water quality is impaired due to:

- Low dissolved oxygen/organic enrichment.
- Mercury.
- Nutrients.

Acute drops in dissolved oxygen (DO) concentrations in Suisun Marsh have been observed regularly in the fall. Some of these low DO events have caused documented fish kills. The recurring DO problems are linked to seasonal operations of ponds and wetlands managed for waterfowl hunting. For most of the year, duck club ponds are drained and occasionally flooded to promote the growth of plants that are the favored food of waterfowl. Vegetation manipulation, in conjunction with flooding of these areas for hunting, periodically results in discharges of anoxic black water from the diked marshes. The discharges, laden with decaying plant matter, can cause severe DO depletion.

The duck pond discharges are also rich in nutrients and organic carbon that further stimulate microbial activity and establish conditions that promote methylation of mercury. Methylmercury, one of the most toxic forms of mercury, enters the aquatic food web and can accumulate to levels of concern in fish and wildlife at the top of the aquatic food chain. The concerns related to mercury apply broadly in the marsh (other than associated with duck pond discharges) in that concentrations of methylmercury in fish found in Suisun Marsh and the Delta exceed levels that may be harmful to human health. Also, increased methylmercury production is a significant concern for planned tidal wetland restoration projects. Suisun Marsh is also listed for nutrient

impairment, and the conditions in the larger slough channels within the marsh that connect to Suisun Bay currently reflect similar conditions of low primary productivity observed in Suisun Bay. There is little available information regarding other potential impacts of nutrients in the marsh, such as nuisance algal blooms.

SFBRWQCB is working on a multi-pollutant total maximum daily load to address these water quality impairments in Suisun Marsh.

Flood Management

California's water resource development has resulted in a complex, fragmented, and intertwined physical and governmental infrastructure. Although primary responsibility might be assigned to a specific local entity, aggregate responsibilities for flood management are spread among more than 200 agencies in the Delta area with many different governance structures. A list of these agencies can be found in *California's Flood Future Report* (California Department of Water Resources and U.S. Army Corps of Engineers 2013). These governmental entities are collectively responsible for operating and maintaining water management facilities, as well as maintaining and upgrading levees that protect lands and assets in the Delta area. Agency roles and responsibilities can be limited by how the agency was formed, which might include enabling legislation, a charter, a memorandum of understanding with other agencies, or facility ownership.

Central Valley Flood Protection Board

The Central Valley Flood Protection Board (CVFPB), created in 1911 as the Reclamation Board, is the State agency charged with overseeing flood management in California's Central Valley. The CVFPB works with the USACE, DWR, other federal and State agencies, and local maintaining agencies in approving funding and projects to continuously improve and expand the Central Valley flood management system. Voter-approved Propositions 84 and 1E of 2006 provided the funding to begin and, in many cases complete larger, more significant flood system improvement projects.

Central Valley Flood Protection Plan

SB 5 (2008), Flood Management, required DWR and CVFPB to prepare and adopt a Central Valley Flood Protection Plan by 2012. The CVFPP was adopted in June 2012. SB 5 also requires cities and counties in the Sacramento-San Joaquin Valley to amend general plans, within 24 months of June 2012, to contain feasible implementation measures designed to carry out the goals, policies, and objectives to reduce the risk of flood damage, based on data and analysis contained in the CVFPP. Each county shall develop flood emergency plans in collaboration with cities within its jurisdiction. Within 36 months of June 2012, cities and counties of the Sacramento-San Joaquin Valley are required to amend zoning ordinances to be consistent with the amended general plans. By 2015, these cities or counties will be prohibited from entering into a development agreement, approving any permit, entitlement, or subdivision map unless an urban level of flood protection is provided in urban and urbanizing areas or until the Federal Emergency Management Agency (FEMA)-standard of flood protection is provided in non-urbanized areas. The urban level of flood protection is defined as protection against flooding that has a 1-in-200 chance of occurring in any given year.

Delta Levees Subventions Program

The Delta Levees Subventions Program was authorized in 1973 and reimburses local levee maintaining agencies in the Legal Delta for a portion of their levee maintenance costs. Following the historic floods of 1986, the Subventions Program was expanded, and a second program, Special Flood Control Projects (also called Special Projects Program), was added in 1988 to provide State support for major levee repair and reconstruction work in the eight western Delta islands that are considered critical to maintaining water supply. The 1988 changes (SB 34) required that expenditures result in "no net long-term loss of habitat," a new mandate that was expanded in 1996 (Assembly Bill 360) to require that program expenditures result in "net habitat improvement" in addition to "no net loss." While subsequent amendments to the program expanded the Special Projects Program to the entire Delta rather than only the western islands, the focus of both Subventions and Special Projects has been on non-project levees, though the programs can support work on project levees in the Delta's Primary Zone.

Other Flood Related Laws and Plans

A number of laws regarding flood risk and land use planning were enacted in 2007. These laws establish a comprehensive approach to improving flood management by addressing system deficiencies, improving flood risk information, and encouraging links between land use planning and flood management. Many of the requirements set down by these laws are only applicable within the Central Valley. A list of the legislation is provided below and a summary of each is available in the *California's Flood Future Report* (California Department of Water Resources and U.S. Army Corps of Engineers 2013):

- AB 156 (2007) Flood Control.
- AB 70 (2007) Flood Liability.
- AB 162 (2007) General Plans.

CWC Sections 85020(g), 85225, and 85305-85309 have special significance to flood management activities in the Delta and are summarized in *California's Flood Future Report* (California Department of Water Resources and U.S. Army Corps of Engineers 2013).

A number of proposed regulatory policies in the Delta Plan (Delta Stewardship Council 2013) require covered actions to file for consistency with the Delta Plan policies, prioritize State investments in Delta levees and risk reduction, require flood protection for residential development in rural areas, protect floodways and floodplains, as well as expand floodplains and riparian habitats in levee projects.

Risk Characterization

Common flood types in the Delta include stormwater, slow-rise, and coastal flooding. Other possible flood types include tsunami and engineered structure failure. Throughout the Delta, levees were originally constructed from material dredged from adjacent channels, which have been improved in various places since then to hold back river and tidal waters. These levees are subject to damage from rodents, piping, and possibly from foundation movement. These effects could lead to sudden failure at any time since many Delta levees hold back water throughout the year. Most of the area's precipitation falls from December through March. Monthly rainfall can

come within a single 24-hour period during winter storms. Winter storms bring both high inflows and windy conditions. In combination with annual and daily high tides, this could cause waves to wash over and damage Delta levees, potentially leading to failure. When an island floods, the fetch (the distance along open water or land over which the wind blows or the distance waves can traverse unobstructed) is increased to the full width of the island. The waves could cause extensive damage to unprotected interior levee slopes.

Historic Floods

Major floods occur regularly in the Delta. Some urban and small-stream flooding occurs in every large storm. Floods during winter storms that cause high water surface elevations and have strong winds have been a common cause of levee failures in the Delta. For example, the flows of the Sacramento River at Rio Vista during winter and early spring are often 30 times the typical late-summer flows. High water in the Delta can overtop levees, as well as increase the hydrostatic pressure on levees and their foundations, causing instability and increasing the risk of failure due to through-levee and/or under-levee seepage.

Delta levee failures have caused 165 inundations of islands and tracts since 1900 (URS Corporation and Jack R. Benjamin & Associates 2008). Tides and water-level surges due to low atmospheric pressure will contribute to high water levels at times, which may or may not coincide with periods of high Delta inflow caused by floods. Some inflow floods will have high contributions from the Mokelumne, Cosumnes, San Joaquin, or other smaller tributaries. Other contributions will be primarily from the Sacramento River. In addition, isolated sunny-day levee failures (like that on the Upper Jones Tract in June 2004) will occur. These failures could be caused by burrowing activities that compromise the integrity of the levees.

Floods have been recorded in Central Valley for more than 175 years. The most notable flood in the 19th century was the Great Flood of 1861-1862. Central Valley floods of 1907 and 1909 revised flood management plans of the time and led to development of the San Joaquin River flood management system. Additionally, the flood of 1986-1987 resulted in legislation to improve the Delta Levees Program.

Flood Exposure

Flood exposure in the Delta is widespread throughout the whole region. The Legislature recognized that the Delta is a critically important natural resource for California and the nation. Flood exposure identifies who and what is impacted by flooding. Flood exposure provides a limited representation of detailed flood risk. Two levels of flood events are commonly used to characterize flooding:

- 100-year flood is a shorthand expression for a flood that has a 1-in-100 probability of occurring in any given year. This can also be expressed as the 1 percent annual chance of, or 1 percent annual chance flood.
- 500-year flood has a 1-in-500 (or 0.2 percent) probability of occurring in any given year.

In the Delta, nearly half the resident population and $18 billion in assets are exposed to the 500-year flood event. Table D-5 provides a snapshot of people, structures, crops, and infrastructure and sensitive species exposed to flooding in the area. Figures D-10 and D-11 show the exposure

Table D-5 Sacramento-San Joaquin Delta Area Exposures within the 100-Year and 500-Year Floodplains

Segment Exposed	1% (100-year) Floodplain	0.2% (500-year) Floodplain
Population, % total exposed	59,300, 13%	218,100, 47%
Structure and Content Value	$6.1 billion	$18.0 billion
Crop Value	$683 million	$1.0 billion
Tribal Lands (acres)	0	0
Essential Facilities (count)	20	92
High Potential-Loss Facilities (count)	19	47
Lifeline Utilities (count)	4	13
Transportation Facilities (count)	134	251
Department of Defense Facilities (count)	2	2
State and Federal Threatened, Endangered, Listed, and Rare Plants[a]	46	46
State and Federal Threatened, Endangered, Listed, and Rare Animals[a]	61	64

Source: *California's Flood Future Report.* Statewide Flood Management Planning (SFMP) Final November 2013.

Note:

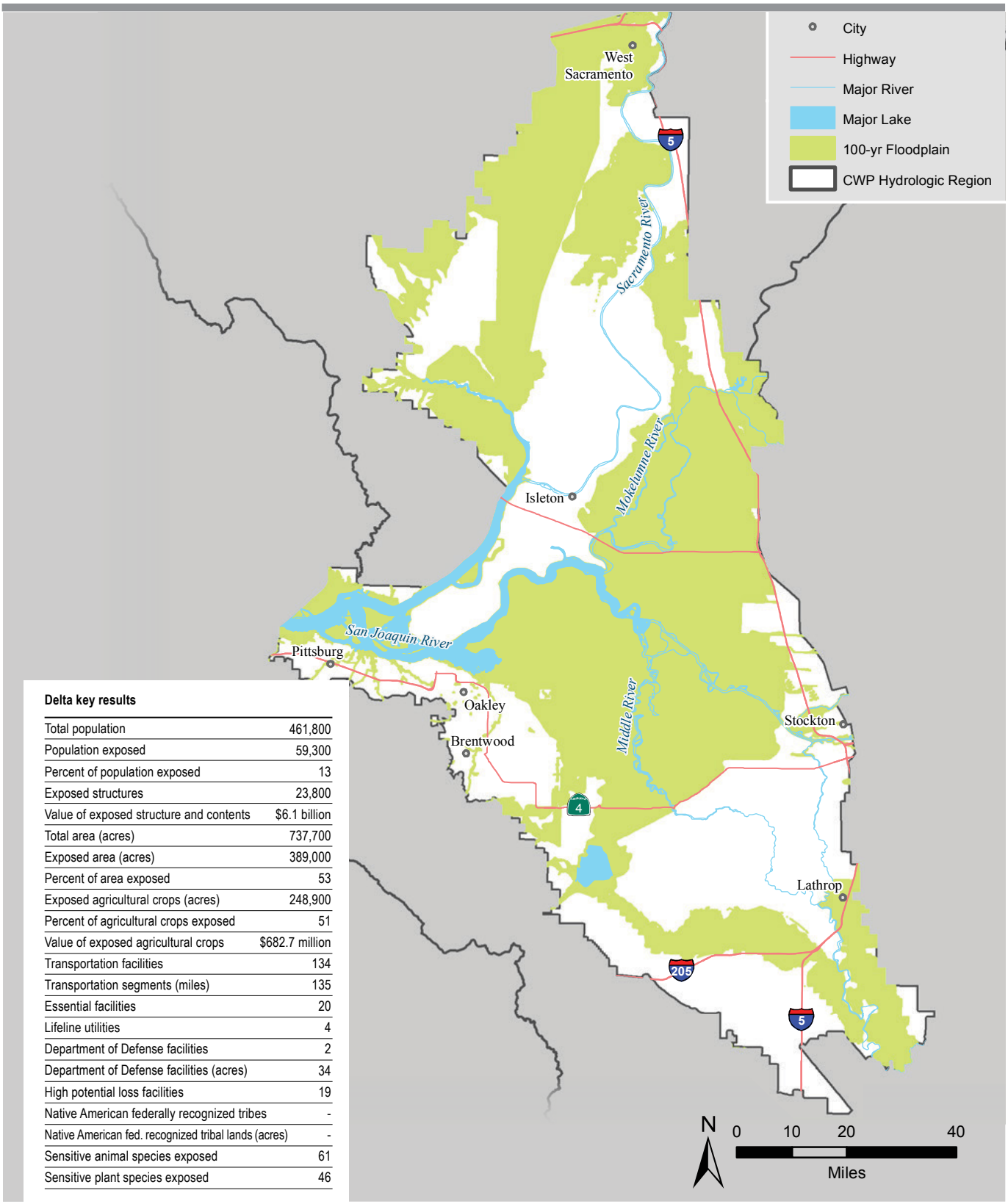
[a] Many Sensitive Species have multiple occurrences throughout the state and some have very large geographic footprints that may overlap more than one analysis region. As a result, a single Sensitive Species could be counted in more than one analysis region. Because of this, the reported statewide totals will be less than the sum of the individual analyses regions.

to flood hazard in the Delta area. More than 100 threatened, endangered, listed, or rare plant and animal species exposed to flood hazards are distributed throughout the Delta.

Levee Performance and Risk Studies

Different levees in the Delta were built to different standards. There are 380 miles of project levees that are maintained by local reclamation districts with oversight and inspection from the State in conformance with federal levee policies. These levees were built to standards that generally exceed the Public Law 84-99 federal standard. Urban levees, 63 miles of which are non-project levees, must meet the 200-year flood protection standards, as defined in the Central Valley Flood Protection Act of 2008, by 2025. DWR is developing criteria for these urban levees that will generally be more stringent than the current criteria for project levees. The remaining 537 miles are non-urban, non-project levees. DWR and the Sacramento District of the USACE set geometric standards for the crown height and width and for slopes of agricultural levees (non-project levees). The State Hazard Mitigation Plan (HMP) standard was viewed as an intermediate standard with the long-term goal of upgrading to the higher federal standard of PL 84-99. The original goal was September 10, 1991, as a deadline for qualifying levees to be eligible for federal disaster assistance; but actual practice allowed for federal aid where sufficient progress

Figure D-10 **Statewide Flood Hazard Exposure Summary for the Sacramento-San Joaquin Delta Region 100-year Floodplain**

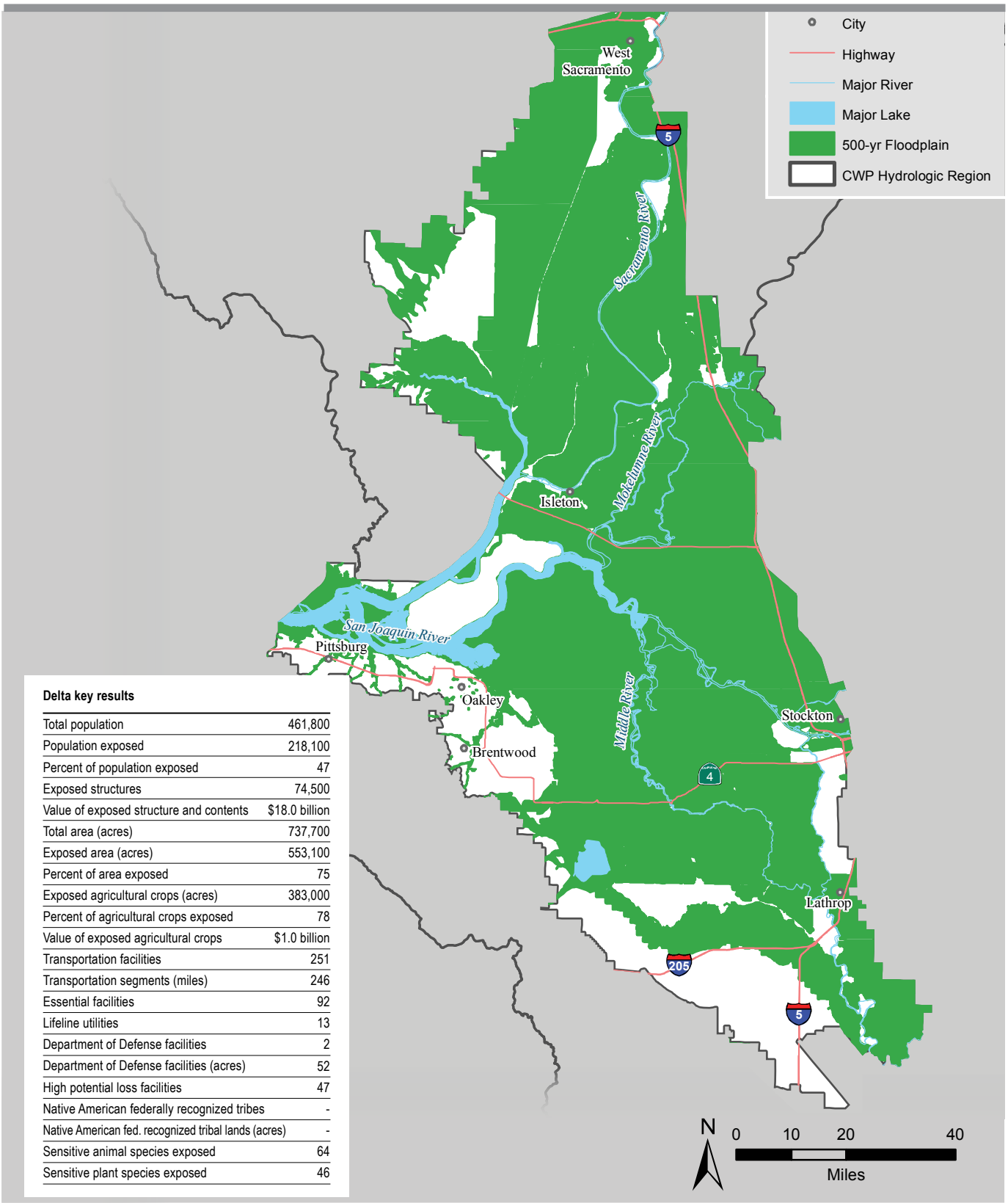


Delta key results

Total population	461,800
Population exposed	59,300
Percent of population exposed	13
Exposed structures	23,800
Value of exposed structure and contents	$6.1 billion
Total area (acres)	737,700
Exposed area (acres)	389,000
Percent of area exposed	53
Exposed agricultural crops (acres)	248,900
Percent of agricultural crops exposed	51
Value of exposed agricultural crops	$682.7 million
Transportation facilities	134
Transportation segments (miles)	135
Essential facilities	20
Lifeline utilities	4
Department of Defense facilities	2
Department of Defense facilities (acres)	34
High potential loss facilities	19
Native American federally recognized tribes	-
Native American fed. recognized tribal lands (acres)	-
Sensitive animal species exposed	61
Sensitive plant species exposed	46

Source: California's Flood Future Report 2013.

Figure D-11 Statewide Flood Hazard Exposure Summary for the Sacramento-San Joaquin Delta Region 500-year Floodplain



Delta key results

Total population	461,800
Population exposed	218,100
Percent of population exposed	47
Exposed structures	74,500
Value of exposed structure and contents	$18.0 billion
Total area (acres)	737,700
Exposed area (acres)	553,100
Percent of area exposed	75
Exposed agricultural crops (acres)	383,000
Percent of agricultural crops exposed	78
Value of exposed agricultural crops	$1.0 billion
Transportation facilities	251
Transportation segments (miles)	246
Essential facilities	92
Lifeline utilities	13
Department of Defense facilities	2
Department of Defense facilities (acres)	52
High potential loss facilities	47
Native American federally recognized tribes	-
Native American fed. recognized tribal lands (acres)	-
Sensitive animal species exposed	64
Sensitive plant species exposed	46

Source: California's Flood Future Report 2013.

was being made in meeting the criteria. In 2006, FEMA made it a rigid requirement for levees to at least meet the HMP criteria at the time of a disaster to qualify for federal aid. In 2010, FEMA and California Emergency Management Agency (Cal EMA) modified their memorandum of understanding to clarify the criteria and again allow federal aid for levees not meeting the HMP standard if certain criteria including demonstrated progress for levee upgrades were met (Federal Emergency Management Agency 2010). In December 2012, FEMA terminated the MOU, stating it was vague and failed to adequately address both current levee standards and FEMA's Public Assistance Policy. As of 2013, FEMA and Cal EMA are discussing how to resolve the issue. Without the MOU, the eligibility of Delta levees for FEMA recovery and flood-fighting assistance remains unclear. In the meantime, it appears that FEMA will use its national policy that covers FEMA assistance (Federal Emergency Management Agency 2011), especially when levees don't meet PL 84-99 standards.

Most non-project Delta levees satisfy HMP standards, and about 47 percent met the PL 84-99 as of February 2007 based on data from DWR. Today that number is most likely higher due to additional work completed with Proposition IE funds.

Delta levee improvements performed since the late 1970s have gradually strengthened many miles of levees, making them less vulnerable. The Sacramento and San Joaquin River Flood Control projects that were completed in the 1960s strengthened project levees. Upstream dams constructed in the 1950s and 1960s attenuated moderate flood flows. When funds currently slated for levees have been expended, more than $698 million will have been invested in improvements to Delta levees since 1973 (Delta Protection Commission 2012).

Evaluations of levees for individual Delta islands and tracts are used to plan local levee repairs and upgrades periodically. In addition, several Delta-wide studies of levees have considered the vulnerability of Delta levees to potential failure. Each of these studies highlighted the relatively high chance of continued Delta levee failures. The reclamation districts have been funded individually by DWR to produce five-year plans for upgrading their levees.

In the Delta area, 31 local flood management projects or planned improvements have been identified. These projects represent a subset of the work that needs to be completed in the Delta. A list of the local flood management projects can be found in *California's Flood Future Report* (California Department of Water Resources and U.S. Army Corps of Engineers 2013).

The local projects identified during DWR's Statewide Flood Management Planning Program information gathering have costs totaling approximately $1.2 billion. Eight of the local planned projects use an integrated water management project approach with a flood management component. Examples of local integrated water management (IWM) projects include the Dutch Slough Tidal Marsh Restoration, the Budisilich Fish Passage Improvements, and the Lower San Joaquin River Flood Bypass.

Resource Planning in the Delta

Delta Plan

The primary responsibility of the DSC is to develop, adopt, and implement a legally enforceable, comprehensive, long-term management plan for the Delta and Suisun Marsh called the Delta

Plan. This will achieve the coequal goals of providing a more reliable water supply for California and protecting, restoring, and enhancing the Delta ecosystem in a manner that protects and enhances the unique cultural, recreational, natural resource, and agricultural values of the Delta as an evolving place. The Delta Plan was adopted by the DSC on May 16, 2013.

The Delta Plan builds on work by DWR, DFW, and the SWRCB. Collectively, its required policies and numerous recommendations:

- Reduce reliance on water from the Delta by requiring those who take water from the Delta, transfer water through the Delta, or use water in the Delta to describe and certify that they are using all feasible options to use water efficiently and to develop additional local and regional water supplies.
- Identify ways to improve statewide water supply reliability throughout California by calling for State investments in improved local and regional supplies and water use efficiency. The plan also calls for improved Delta conveyance and expansion of groundwater and surface storage.
- Protect, restore, and enhance the Delta ecosystem by designating six high priority locations in the Delta and Suisun Marsh to recover endangered species, rebuild salmon runs, and enhance habitat for wildlife. The plan also prioritizes actions to reduce pollution, ensure improved water quality, and limit invasive species, while moving to establish a more natural pattern of water flows in the Delta.
- Protect the uniqueness of the Delta by preserving rural lands for agriculture and habitat use, and require that new residential, commercial, or industrial development is located in areas currently designated for urban use.
- Reduce risks to people, property, and State interests in the Delta by prohibiting encroachment on floodways and floodplains, requiring a minimum level of flood protection for new residential development of five or more parcels, and committing to develop priorities for State investment in Delta flood protection by 2015.
- Integrate governmental actions and the best available science through regulatory policies and non-binding recommendations.
- Call for swift and successful completion of the Bay Delta Conservation Plan, which seeks to modernize the existing water conveyance system, and improve the health of the estuary. If the BDCP meets the requirements of law it will be incorporated into the Delta Plan.

As a long-term management plan, the Delta Plan will be updated every five years. It includes 73 non-regulatory recommendations to be considered by other agencies, the Legislature, or the governor. The Delta Plan presents a view of the diversity of the water supply system and its components, including demands for water and how water is currently used, together with the need for an improved Delta ecosystem. The planning time frame is 2100, using monitoring and adjusting of decisions (adaptive management), informed by the best available science.

Some elements of the Delta Plan will have regulatory effects. Any plan, project, or program that meets certain criteria will be subject to regulations included in the Delta Plan; and the project proponents must certify consistency with the Delta Plan. There are 14 regulations in the Delta Plan that took effect on September 1, 2013. The policies are as follows:

- G P1: Detailed Findings to Establish Consistency with the Delta Plan.
- WR P1: Reduce Reliance on the Delta through Improved Regional Water Self Reliance.

- WR P2: Transparency in Water Contracting.
- ER P1: Delta Flow Objectives.
- ER P2: Restore Habitats at Appropriate Elevations.
- ER P3: Protect Opportunities to Restore Habitat.
- ER P4: Expand Floodplains and Riparian Habitats in Levee Projects.
- ER P5: Avoid Introductions of and Habitat Improvements for Invasive Non-native Species.
- DP P1: Locate New Urban Development Wisely.
- DP P2: Respect Local Land Use When Siting Water or Flood Facilities or Restoring Habitats.
- RR P1: Prioritization of State Investments in Delta Levees and Risk Reduction.
- RR P2: Require Flood Protection for Residential Development in Rural Areas.
- RR P3: Protect Floodways.
- RR P4: Floodplain Protection.

Bay Delta Conservation Plan

The Bay Delta Conservation Plan is a HCP/NCCP intended to make significant contributions to the recovery of priority fish and wildlife species while securing reliable water supplies from the Delta for human use. The BDCP is planned to be implemented over a 50-year timeframe according to an adaptive management program. The parties seeking permits pursuant to the BDCP include DWR, U.S. Bureau of Reclamation, Metropolitan Water District of Southern California, the Kern County Water Agency, the Santa Clara Valley Water District, Zone 7 Water Agency, Westlands Water District, and the State and Federal Water Contractors Agency (California Department of Water Resources 2013). The goal of these parties is to formulate a plan that could ultimately be approved by the USFWS and the NMFS as an HCP under the provisions of Endangered Species Act section 10(a)(1)(B) and as an NCCP by DFW under Fish and Game Code Sections 2800 et seq. and/or the California Endangered Species Act Sections 2050 et seq. If the BDCP is approved and permitted and meets specific requirements in CWC Section 85320(e), it would become part of the Delta Plan. The DSC has a potential appellate role regarding the inclusion of BDCP in the Delta Plan.

The BDCP contains conservation measures intended to protect, restore, enhance, and manage physical habitat to expand the extent and quality of intertidal, floodplain, and other habitats across defined conservation zones. It also contains measures to reduce the effect of various stressors on covered species, such as toxic contaminants, non-native predators, illegal harvest, and non-project water diversions. In addition to meeting the conservation needs of priority species, the BDCP aims to contribute to improving exported water supply reliability by modifying Delta conveyance facilities to create a more natural flow pattern in the Delta to benefit fish species. This is intended to allow for water exports when hydrologic conditions result in the availability of sufficient water, to be consistent with the requirements of State and federal law and the terms and conditions of SWP and CVP water delivery contracts and other existing applicable agreements.

The BDCP process is considering a range of options for conveying water through or around the Delta; however, the preferred alternative is the dual conveyance system:

- Through-Delta Conveyance: Continue to divert water in southern Delta at existing or modified intakes/diversions for SWP and CVP operation.

- Isolated Conveyance: Divert water from the Sacramento River at new North Delta intakes/ diversions and convey the water to the existing SWP and CVP pumping plants through a pipeline/tunnel.
- Dual Conveyance: Combine through-Delta conveyance and isolated conveyance to allow operation flexibility.

While the BDCP intends to provide ecological benefits to the Delta and statewide benefits of a more reliable water supply, there are impacts to the Delta community from the BDCP. The Administrative Draft Environmental Impact Report/Environmental Impact Statement (EIR/EIS) of the BDCP identified the following negative impacts for the Delta (California Department of Water Resources 2013)

- Permanent loss of substantial amounts of important farmland.
- Long-term reduction in recreation opportunities.
- Permanent regional economic effects in the Delta.
- Increases in long-term average bromide concentrations at Barker Slough, Staten Island, and Emmaton on the Sacramento River.
- Substantially increased chloride concentrations in the Delta such that the frequency of exceeding the 150 mg/L Bay-Delta Water Quality Control Plan objective would approximately double.
- Increases in long-term average electrical conductivity levels that would occur in Suisun Marsh could further degrade existing electrical conductivity (EC) levels and thus contribute additionally to adverse effects on the fish and wildlife beneficial uses.

The BDCP process is ongoing. The BDCP Draft EIR/EIS was released on December 9, 2013. The 120-day public review and comment period is effective December 13, 2013 through April 14, 2014 and was extended to July 29, 2014.

Bay-Delta Water Quality Control Plan Update

The SWRCB's Bay-Delta Water Quality Control Plan (aka Bay-Delta Plan identifies beneficial uses of the Bay Delta, water quality objectives for the reasonable protection of those beneficial uses, and a program of implementation for achieving the water quality objectives including control of salinity caused by saltwater intrusion, municipal discharges, and agricultural drainage, and water projects operations.

The SWRCB is in the process of a phased review and update of the 2006 Bay-Delta Plan. This will include review of potential modifications to current objectives included in the 2006 Bay-Delta Plan, the potential establishment of new objectives, and modifications to the program of implementation for those objectives. It will also include potential changes to the monitoring and special studies program included in the 2006 Bay-Delta Plan. The water quality control planning process will not include amendments to water rights and other measures to implement a revised Bay-Delta Plan. A separate environmental impact report will be prepared for these actions In addition, a separate substitute environmental document is being prepared to address updates to the water quality objectives for the protection of southern Delta agricultural beneficial uses, San Joaquin River flow objectives for the protection of fish and wildlife beneficial uses, and the program of implementation for those objectives.

Triennial Review of the Water Quality Control Plan for the Sacramento River and San Joaquin River Basins

To meet requirements of the federal Clean Water Act section 303(c) and CWC Section 13240, the CVRWQCB reviews the water quality standards contained in the Water Quality Control Plan for the Sacramento River and San Joaquin River Basins every three years. The basin plan is the foundation for the RWQCB's water quality regulatory programs. It designates beneficial uses for both surface water and groundwater bodies in the Central Valley, establishes water quality objectives to protect those beneficial uses, contains implementation plans that describe the actions necessary to achieve water quality objectives, and describes the surveillance and monitoring activities needed to determine regulatory compliance and assess the health of the basins' water resources.

Strategic Workplan for Activities in the San Francisco Bay/Sacramento-San Joaquin Delta Estuary

The CVRWQCB, SFBRWQCB, and SWRCB adopted a Strategic Workplan for Activities in the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (Strategic Workplan) in July 2008 (State Water Resources Control Board 2008). The Strategic Workplan was written in response to two SWRCB resolutions describing the actions they will complete to protect the beneficial uses of water in the Bay Delta estuary. The workplan activities are divided into nine broad categories:

- Water quality and contaminant control.
- Comprehensive Delta monitoring program.
- Southern Delta salinity and San Joaquin River flow objectives.
- Suisun Marsh objectives.
- Comprehensive review of the 2006 Bay-Delta Plan, water rights, and other requirements to protect fish and wildlife beneficial uses and the public trust.
- Methods of diversion of the SWP and CVP.
- Water rights compliance, enforcement, and other activities to ensure adequate flows to meet water quality objectives.
- Water use efficiency for urban and agricultural water users.
- Other actions.

Ecosystem Restoration Program

The Ecosystem Restoration Program (ERP) is a multi-agency effort aimed at improving and increasing aquatic and terrestrial habitats and ecological function in the Delta and its tributaries. Principal participants overseeing ERP are the DFW, the USFWS, and the NMFS, collectively known as the ERP Implementing Agencies. The program's primary role is to provide funding and management for projects throughout the Delta, Sacramento Valley, and San Joaquin Valley. Current work in the Delta includes, but is not limited to, habitat restoration (including riparian, upland, floodplain, shallow water, and marsh habitat), fish screens and fish passage, ecosystem water quality, non-native invasive species, historical ecology, and food web productivity. Various documents and reports related to these issues are at: http://www.dfg.ca.gov/ERP/reports_docs.asp.

Implementation of the 30-Year CALFED Program ROD was divided into two stages, stage 1 (2000-2007) and stage 2 (2008-2030). The stage 1 plan for ecosystem restoration was developed for implementation during the first seven years of the program. Stage 1 ERP implementation is complete and included research, restoration, and monitoring activities. The ERP is developing a conservation strategy to guide stage 2 implementation. The conservation strategy describes the ecosystem restoration goals and conservation priorities that will be utilized by the ERP Implementing Agencies. Portions of the conservation strategy are being incorporated into the Delta Plan, including a description of and rationale for habitat types targeted for restoration, suggested actions for management of non-native invasive species, and an elevation map to help guide habitat restoration priorities in the Delta. Additionally, ERP staff coordinated with the Delta Science Program to ensure that the ERP adaptive management framework, as revised for the ERP conservation strategy, aligns with the adaptive management framework in the Delta Plan.

The ERP coordinates with other programs and activities within the Delta including Delta Conservancy, Central Valley Project Improvement Act/Anadromous Fish Restoration Program, Fish Restoration Program Agreement, FloodSAFE California Initiative, BDCP, Fish Passage Improvement Program, Delta Vision Foundation, State Wildlife Action Plan, California Water Quality Monitoring Council, and the CVRWQCB.

Quantifiable Biological Objectives and Flow Criteria for Aquatic and Terrestrial Species of Concern Dependent on the Delta

The DFW is required by CWC Section 85084.5 to develop quantifiable biological objectives and flow criteria for species of concern dependent on the Delta. The report, *Quantifiable Biological Objectives and Flow Criteria for Aquatic and Terrestrial Species of Concern Dependent on the Delta* contains the recommendations, rationale, and justification for biological objectives to protect aquatic and terrestrial species of concern that are dependent on the Delta, and flow criteria that would benefit aquatic species of concern (California Department of Fish and Game 2010). This was submitted to the SWRCB in November 2010. The report is at http://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=25987.

Central Valley Flood Protection Plan

The Central Valley Flood Protection Act of 2008 directed DWR to prepare the CVFPP, a flood management planning effort that addresses flood risks and ecosystem restoration opportunities in an integrated manner while concurrently improving ecosystem functions, operations and maintenance practices, and institutional support for flood management. The CVFPP specifically proposes a systemwide approach to flood management for the areas currently protected by facilities of the SPFC. Under this approach, California will prioritize investments in flood risk reduction projects and programs that incorporate ecosystem restoration and multi-benefit projects. The CVFPP was adopted by the Central Valley Flood Control Board on June 29, 2012. It is expected that the CVFPP will be updated every five years thereafter.

The CVFPP proposes a systemwide approach to address the following issues:

- Physical improvements in the Sacramento and San Joaquin River basins.
- Urban flood protection.
- Small community flood protection.

- Rural/Agricultural area flood protection.
- System improvements.
- Non-SPFC levees.
- Ecosystem restoration opportunities.
- Climate change considerations.

The geographic scope of the CVFPP includes only the portions of the Delta covered by the SPFC. Approximately two-thirds of Delta levees are not addressed in the CVFPP. Portions of the central Delta are not part of the State's FloodSAFE Regional Flood Management Plans.

Delta Risk Management Strategy

The Delta Risk Management Strategy (DRMS) is expected to lead to development of strategies to manage the risk of Delta Area levee failure and to improve management of State funding supporting Delta area levee maintenance and improvement (California Department of Water Resources 2014). DWR directed the study, which was sponsored by DWR, DFW, and USACE, guided by 20 subject experts from federal, State, local, and private organizations and performed by about 30 consultants in appropriate fields. The DRMS is in two phases. Phase 1, completed in 2007, identified three risks to Delta area levees (earthquake, high water, and levee and foundation deterioration) and evaluated the consequences in terms of cost, water quality effects, ecosystem effects, and public health and safety. Phase 1 concluded that the annual probability of an island being flooded is less than one percent to more than seven percent, depending on the location. Phase 2 evaluated long-term risk-reduction options for Delta area levees and describes a discrete set of actions that can be taken to reduce the risks and consequences of levee failure. The final Phase 2 report was released in June 2011.

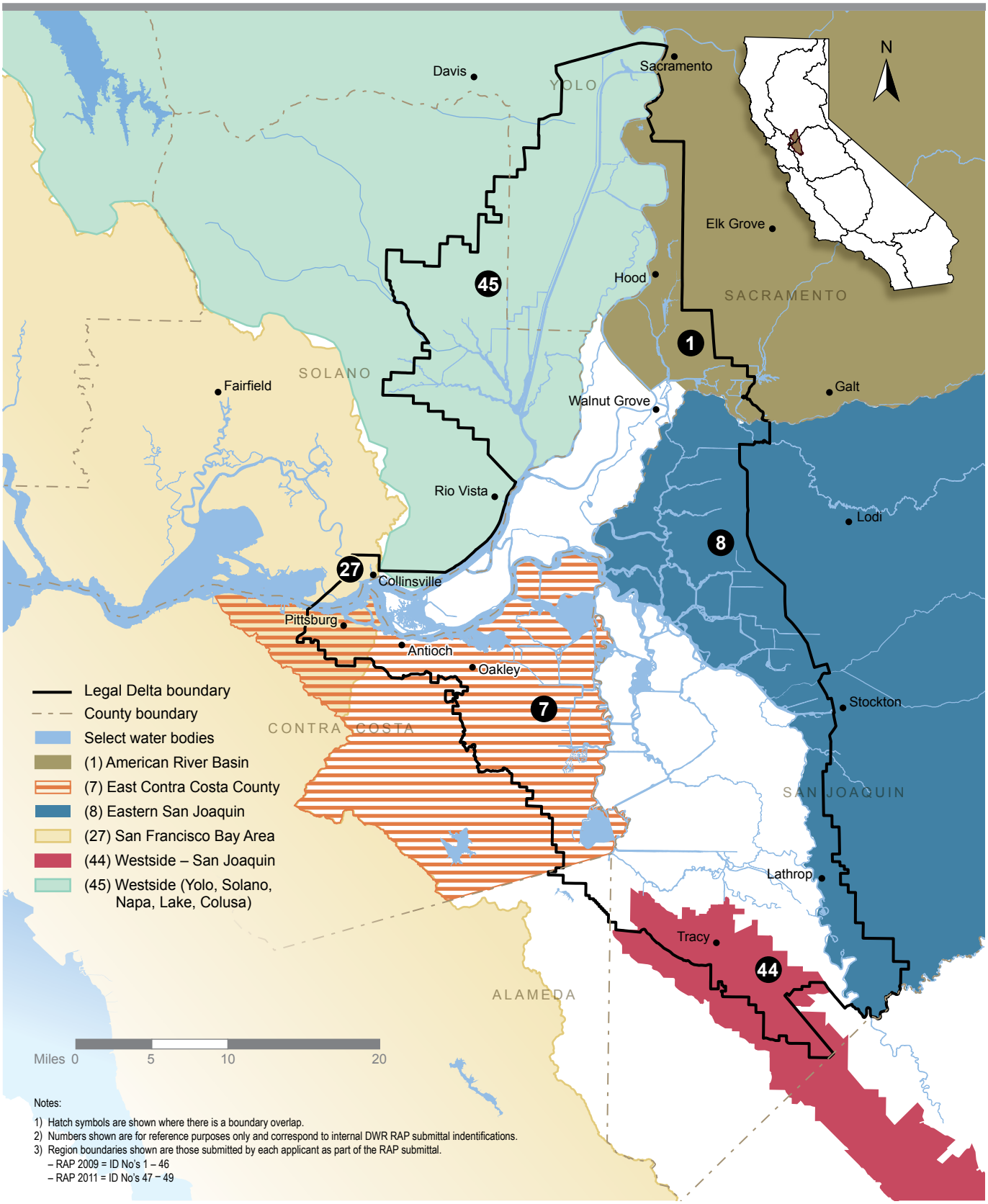
Integrated Regional Water Management Plans

The Integrated Regional Water Management (IRWM) Planning Act, signed by the Governor as part of SB 1 in 2008 (CWC Section 10530 et seq.), provides a general definition of an IRWM plan as well as guidance to DWR as to what IRWM program guidelines must contain. All IRWM plans must discuss whether they contribute to the attainment of one or more of the objectives of the former CALFED Bay-Delta Program. The regional acceptance process is a component of the IRWM Program Guidelines and is used to evaluate and accept an IRWM region into the IRWM grant program. Acceptance and approval is required before any region can submit an application for IRWM grant funds. Approval has been awarded to the six IRWM regions that touch on the Delta: American River Basin, East Contra Costa County, Eastern San Joaquin, San Francisco Bay Area, Westside-San Joaquin, and Westside-Yolo/Solano/Napa/Lake/Colusa (Figure D-12).

The Delta region is engaged in IRWM planning through multiple planning regions that empower stakeholders to develop integrated solutions and diversified water management portfolios collaboratively to meet regional water management challenges. The IRWM efforts serve a vital role, in combination with local and statewide planning, to provide for sustainable water use, water quality, and environmental functions.

Integrated water management principals are being applied more frequently in flood management planning. An example of an IWM approach in the Delta area is the Lower San Joaquin River

Figure D-12 Regional Acceptance Process IRWM Regions, Sacramento-San Joaquin Delta



Notes:

1) Hatch symbols are shown where there is a boundary overlap.
2) Numbers shown are for reference purposes only and correspond to internal DWR RAP submittal indentifications.
3) Region boundaries shown are those submitted by each applicant as part of the RAP submittal.
   – RAP 2009 = ID No's 1 – 46
   – RAP 2011 = ID No's 47 – 49

Flood Bypass project, which will increase flood conveyance capacity through a constrained reach of the San Joaquin River floodway by acquiring easements and fee title to expand the Paradise Cut Bypass. The project will also provide floodplain and riparian habitat for sensitive species including riparian brush rabbit, giant garter snake, Sacramento splittail, and juvenile Chinook salmon. The project would reduce flood stage in main stem San Joaquin River between Vernalis and Stockton and reduce the likelihood of levee failure on the San Joaquin River in the Lathrop, Manteca, and Stockton areas.

Although the Delta region includes part of six IRWM plans, none are written specifically for the Delta region. Some, like the American River Basin Plan, do not mention the Delta by name, but acknowledge that water supply goals and objectives are consistent with the larger statewide goals and objectives outlined by the CALFED Program. The Westside-Yolo/Solano/Napa/Lake Colusa IRWM Plan includes goals and objectives that focus on reducing the Westside Region's dependence on the Delta. Actions include foundational efforts such as monitoring water quality or subsidence, mercury remediation in the Cache Creek system and Yolo Bypass, Clarksburg levee improvement, and Sutter Slough erosion control.

Three other Delta-related issues most common in these IRWM plans are levee system improvement, new or enlarged surface storage, and upstream ecosystem restoration. Land use, and its accompanying water use, is another aspect explored in the IRWM plans. In many cases, the IRWM plans consider land use and changes in water use as potentially affecting both quality and flow to the Delta.

Table D-6 lists IRWM Plan updates completed at the dates shown.

Environmental Stewardship

Climate Change Adaptation

Climate change has the potential to impact the region, which the state depends upon for its economic and environmental benefits. These changes would increase the vulnerability of natural and built systems in the region. Impacts to natural systems will challenge aquatic and terrestrial species with diminished water quantity and quality, and shifting ecoregions. Built systems would be impacted by changing hydrology and runoff timing, loss of natural snowpack storage, making the region more dependent on surface storage in reservoirs and groundwater sources. Increased future water demand for both natural and built systems may be particularly challenging with less natural storage and less overall supply.

Water managers and local agencies must work together to determine the appropriate planning approach for their operations and communities. While climate change adds another layer of uncertainty to water planning, it does not fundamentally alter the way water managers already address uncertainty (U.S. Environmental Protection Agency and California Department of Water Resources 2011). However, stationarity (the idea that natural systems fluctuate within an unchanging environment of variability) can no longer be assumed so new approaches will likely be required (Milly et al. 2008).

The IRWM planning framework allows water managers to address climate change on a smaller, more regional scale. Climate change is now a required component of all IRWM plans (California

Table D-6 Completion for IRWM Plans

IRWM Region	Completion Date
American River Basin IRWM Plan	2013
East Contra Costa County IRWM Plan	2012
Eastern San Joaquin IRWM Plan	2013
San Francisco Bay IRWM Plan	2013
Westside – Yolo/Solano/Napa/Lake/Colusa IRWM Plan	2013
Westside – San Joaquin	2006

Department of Water Resources 2010b, 2012). IRWM regions must identify and prioritize their specific vulnerabilities, and identify adaptation strategies that are most appropriate. Planning and adaptation strategies that address the vulnerabilities should be proactive and flexible, starting with proven strategies that will benefit the region today, and adding new strategies that will be resilient to the uncertainty of climate change. Other planning efforts in the region that are addressing the potential impacts of climate change include the Delta Plan, the BDCP, the CVFPP, and the ERP.

However, local agencies, as well as federal and State agencies, face the challenge of interpreting climate change data and determining which methods and approaches are appropriate for their planning needs. The *Climate Change Handbook for Regional Water Planning* (U.S. Environmental Protection Agency and California Department of Water Resources 2011) provides an analytical framework for incorporating climate change impacts into a regional and watershed planning process and considers adaptation to climate change. This handbook provides guidance for assessing the vulnerabilities of California's watersheds and regions to climate change impacts and prioritizing these vulnerabilities.

The State of California has developed additional online tools and resources to assist resource managers and local agencies in adapting to climate change. These tools and resources include the following:

- *Safeguarding California: Reducing Climate Risk, An Update to the 2009 California Climate Adaptation Strategy, Public Draft* (California Natural Resources Agency 2013): http://resources.ca.gov/climate_adaptation/docs/Safeguarding_California_Public_Draft_Dec-10.pdf.
- *California Climate Adaptation Planning Guide* – (California Emergency Management Agency and California Natural Resources Agency (2012) at: http://resources.ca.gov/climate_adaptation/local_government/adaptation_policy_guide.html.
- Cal-Adapt Web site at: http://cal-adapt.org.
- Urban Forest Management Plan (UFMP) Toolkit – sponsored by the California Department of Forestry and Fire Protection at: http://ufmptoolkit.com.
- California Climate Change portal at: http://www.climatechange.ca.gov.
- DWR Climate Change Web site at: http://www.water.ca.gov/climatechange/resources.cfm.

- The Governor's Office of Planning and Research Web site at: http://www.opr.ca.gov/m_climatechange.php.

In addition, many of the resource management strategies found in Volume 3 not only assist in meeting water management objectives, but also provide benefits for adapting to climate change. These include:

- Chapter 2, "Agricultural Water Use Efficiency."
- Chapter 4, "Flood Management."
- Chapter 5, "Conveyance — Delta."
- Chapter 7, "System Reoperation."
- Chapter 13, "Surface Storage — CALFED."
- Chapter 17, "Matching Water Quality to Use."
- Chapter 18, "Pollution Prevention."
- Chapter 21, "Agricultural Land Stewardship."
- Chapter 22, "Ecosystem Restoration."
- Chapter 24. "Land Use Planning and Management."
- Chapter 27, "Watershed Management."

The myriad of resources and choices available to water managers can seem overwhelming. However, managers can implement many proven strategies to prepare for climate change in the Delta region, regardless of the magnitude of future warming. These strategies often provide multiple benefits. For example, wetland restoration not only provides habitat for at-risk species, but can help improve water quality, attenuate waves associated with storm surges, and sequester carbon. Other adaptation measures include setback levees, reinforcing or armoring of levees, floodplain restoration, riparian restoration, especially at the toe of levees, and subsidence reversal.

Water managers need to consider both the natural and built environments as they plan for the future. Stewardship of natural areas and protection of biodiversity are critical for maintaining ecosystems, which can benefit humans via carbon sequestration, pollution remediation, and flood risk reduction. Increased collaboration between water managers, land use planners, and ecosystem managers can identify common goals and actions that are needed to achieve resilience to climate change and other stressors. While both adaptation and mitigation are needed to manage climate change risks and often are complementary, unintended consequences may arise if efforts are not coordinated (California Natural Resources Agency 2009).

Climate Change Mitigation

Energy intensity in this overlay region is evaluated in the Sacramento, San Joaquin, and San Francisco regional reports.

Ecosystem Services

A pilot project of IRWM that includes enhancement of biological diversity among its goals is presented below. One of the aims of the pilot project is to recognize the economic value of

the goods and services that nature provides and to incorporate that value into natural resource management decisions. Such recognition includes development of ways to measure the economic value of those services. This can be important information for water managers who normally see only the costs of ecosystem protection and restoration, but not the benefits, in their budgets. The services considered in this project are carbon sequestration for GHG mitigation, land subsidence reversal, and wildlife.

This project constitutes on-the-ground efforts to advance several of the objectives in the implementation plan of Update 2009. In particular, it aims to expand environmental stewardship (objective 5), practice integrated flood management (objective 6), and manage a sustainable California Delta (objective 7).

The project goes beyond most watershed management efforts by laying the foundation for establishment of markets to buy and sell units of nature's services; that is, mechanisms for beneficiaries to pay for goods and services they receive. This requires some sort of assessment of the monetary value of the benefits. The desired end product is to put payments in the hands of producers — resource managers — as an incentive to keep them producing.

Carbon Capture Farming in the Delta Pilot Project

The Delta is a critical natural resource, an important agricultural region, and a major hub for California's water supply. Over the past century, agricultural practices in the Delta have caused the loss of more than 2 million acre-feet of peat soils, causing land to subside down to 20 feet or more below sea level on several islands in the west and central Delta (Mount and Twiss 2005). Current agricultural practices continue to remove these soils and, as part of that loss, emit about 5 million tons of carbon dioxide annually — about one percent of California's total emissions (Merrill et al. 2010). Peat soil can generate unusually large amounts of GHGs because it is a natural storehouse of enormous amounts of carbon.

Land subsidence contributes to the risk of failure of the levees that protect the islands (California Department of Water Resources 1986, 1989). The levees protect farmland and maintain a supply of water to 25 million people and 3 million acres of irrigated farmland outside the Delta. Land subsidence increases the hydraulic stress on levees, making them leakier and more likely to fail, and increases the volume of water that could be taken up by an island in the event of a levee break (Mount and Twiss 2005). In turn, a levee break could allow a pulse of brackish or salt water to invade the Delta and compromise water quality for most uses.

Subsidence reversal should reduce the cost of maintenance of levees on subsided islands and provide better protection for a vast array of infrastructure including roads, railroads, bridges, airports, ferries, electricity transmission lines, natural gas pipelines, oil and gas production fields, marinas, aqueducts, and towns. Two land management options, referred to as carbon capture wetland farms and low carbon agriculture, could reduce soil loss and GHG emissions, reduce the many risks associated with land subsidence, and provide habitat benefits to the Delta ecosystem (Merrill et al. 2010).

Carbon capture wetland farms are constructed wetlands operated to maximize retention of atmospheric carbon, mainly in the soil, and minimize the release of other GHGs. Native tule wetlands, in particular, can capture and store carbon at very high rates and, in doing so, build soil that significantly and continuously reverses subsidence (Merrill et al. 2010).

Low carbon agriculture refers to farming practices that reduce GHG emissions and rates of ongoing land subsidence. They could be applied to conventional crops or in combination with tule wetland farms. These practices could include increasing groundwater levels during the growing and fallow seasons, winter flooding, reduced tillage, soil nutrient management that does not rely on nitrogen-based synthetic fertilizer, and conversion to rice production.

Research on tule wetlands in the Delta shows that a combination of increases in carbon sequestration and prevented soil carbon loss could reduce greenhouse gas emissions by 10 to 35 metric tons of CO_2 equivalents per year (Merrill et al. 2010). The reductions could continue to accrue over a period of 50 to 100 years or so, depending on initial subsided land elevations. Studies in the Delta have shown that land elevations increased by an average of 4 cm/yr. from accumulation of material from wetlands (Miller et al. 2008). Subsidence reversal from this accretion would directly improve levee stability through reduced hydrostatic pressure. Restoring wetland habitats could also benefit native wildlife, including waterfowl, the threatened giant garter snake, and many other species.

Wetland water management calls for maintaining saturated conditions in more of the soil profile for a greater amount of time than in conventional farming. This prolonged soil saturation reduces decomposition rates of plant material and GHG emissions that result from the decomposition.

A pilot project on Twitchell Island, conducted by U.S. Geological Survey and DWR, provided much of the foundational science about carbon budgets on Delta islands. Originally this was a study of the potential for subsidence reversal. The project directly measured GHG fluxes in tule wetlands and adjacent control sites, which were conventionally managed cornfields. Overall effects on GHG storage and release were driven both by carbon capture in the wetlands and by large GHG emissions from cornfields. That is, the conversion of annual cropland to wetlands both sequestered a large amount of carbon dioxide and prevented the GHG emissions caused by plowing, drying, and fertilizing peat soil.

Growers of tule wetlands could earn revenue from the sale of carbon credits. AB 32, the Global Warming Solutions Act, mandates large reductions in GHG emissions in California. One likely method to reduce emissions is through a market in carbon offset credits. Economic models are under development to project break-even costs for replacing conventional farmland with wetlands. Preliminary findings are that carbon capture wetlands might become financially viable when carbon prices reach about $20 per metric ton. This break-even price excludes unknown or highly variable factors, such as land acquisition and costs of verification of GHG credits.

The potential for carbon-capture wetlands and other low-carbon farming methods to provide so many benefits — wildlife habitat, flood protection and public safety, reliable water quality and supply, GHG mitigation, jobs and income for farmers — has attracted attention from several quarters. A comprehensive study performed jointly by The Nature Conservancy, Environmental Defense Fund, Wetlands and Water Resources, Inc., and Stillwater Sciences titled *Greenhouse Gas Reduction and Environmental Benefits in the Sacramento-San Joaquin Delta: Advancing Carbon-capture Wetland Farms and Exploring Potential for Low Carbon Agriculture* (Merrill et al. 2010) concluded that the benefits of carbon capture wetland farming are established well enough to prompt the next step, farm-scale demonstration projects. These would involve technical studies to develop protocols to measure carbon offsets, including GHG fluxes and overall carbon budgets. Studies also would address potential adverse impacts, including contamination from mercury and dissolved organic carbon and the need for mosquito control.

DWR has formed a partnership with The Nature Conservancy and Environmental Defense Fund to locate and fund a larger, 200- to 400-acre site in the Delta for feasibility testing at the farm scale. A demonstration project could examine both the costs and GHG emissions from a menu of management practices, including winter flooding, low-carbon agriculture, rice production, tule farms, and wetlands designed for waterfowl and waterfowl hunters. Potential partners include Metropolitan Water District, Irvine Ranch Water District, Sacramento Municipal Utility District, Pacific Gas and Electric Company, and the Delta Conservancy.

Meanwhile, DWR has established a 305-acre project to grow tules on Sherman Island to measure carbon budgets and enhance habitat features. Enhancements include provision of open water without tules preferred by waterfowl, islands for bird nesting, and introduction of fish for mosquito control. DWR also has constructed a 300-acre rice research project on Twitchell Island to study subsidence reversal, carbon sequestration, effects on methylmercury and certain agricultural chemicals, and economic feasibility.

Resource Management Strategies

Resources management strategies are detailed in Volume 3 of Update 2013. A number of these strategies will be useful in improving the management of water for use within the Delta as well as tackling other challenges. Table D-7 lists the resource management strategies that appear applicable in the Delta based on regional studies. Several efforts under way may potentially implement a number of these resource management strategies.

Table D-7 Resource Management Strategies and Delta Actions

Resource Management Strategies	Delta Plan	BDCP	CVFPP	Suisun Marsh Plan	Strategic Workplan	IRWM
REDUCE WATER DEMAND						
Agricultural Water Use Efficiency	X				X	X
Urban Water Use Efficiency	X				X	X
IMPROVE OPERATIONAL EFFICIENCY AND TRANSFERS						
Conveyance Delta	X	X			X	
Conveyance Regional/Local	X	X		X	X	X
System Reoperation	X	X		X	X	X
Water Transfers	X	X			X	X
INCREASED WATER SUPPLY						
Conjunctive Management and Groundwater Storage	X	X	X		X	X
Desalination – Brackish and Seawater	X					X
Precipitation Enhancement						
Recycled Municipal Water	X				X	X
Surface Storage – CALFED	X		X			X
Surface Storage – Regional/Local	X		X			X
IMPROVE WATER QUALITY						
Drinking Water Treatment and Distribution	X				X	X
Groundwater/Aquifer Remediation	X					X
Matching Water Quality to Use					X	X
Pollution Prevention	X			X	X	X
Salt and Salinity Management	X	X		X	X	X
Urban Stormwater Runoff Management	X				X	X
PRACTICE RESOURCE STEWARDSHIP						
Agricultural Lands Stewardship	X	X	X	X		X
Economic Incentives - Loans, Grants, and Water Pricing	X		X		X	X
Ecosystem Restoration	X	X	X	X	X	X
Forest Management						X
Land Use Planning and Management	X		X	X	X	X
Recharge Area Protection	X		X		X	X

Resource Management Strategies	Delta Plan	BDCP	CVFPP	Suisun Marsh Plan	Strategic Workplan	IRWM
Water-Dependent Recreation	X			X	X	X
Watershed Management	X				X	X
IMPROVE FLOOD MANAGEMENT						
Flood Management	X		X	X		X
OTHER STRATEGIES						
Sediment Management	X	X	X	X	X	
Outreach and Education		X	X			
Water-Dependent Cultural Resources				X		

Notes:

BDCP = Bay Delta Conservation Plan

CVFPP = Central Valley Flood Protection Plan

IRWMP = Integrated Regional Water Management Plan

References

References Cited

Abatzoglou JT, Redmond KT, and Edwards LM. 2009. "Classification of Regional Climate Variability in the State of California." Journal of Applied Meteorology and Climatology. 48: 1527-1541. Viewed online at: http://journals.ametsoc.org/doi/pdf/10.1175/2009JAMC2062.1.

Baxter R, Breuer R, Brown L, Conrad L, Feyrer F, Fong S, Gehrts K, Grimaldo L, Herbold B, Hrodey P, et al. 2010. *Interagency Ecological Program 2010 Pelagic Organism Decline Work Plan and Synthesis of Results*. Sacramento (CA): Interagency Ecological Program for the San Francisco Estuary. 259 pp. Viewed online at: http://www.water.ca.gov/iep/docs/FinalPOD2010Workplan12610.pdf.

Bay Conservation and Development Commission. 2011. *Living with a Rising Bay: Vulnerability and Adaptation in San Francisco Bay and on its Shoreline*. San Francisco (CA): San Francisco Bay Conservation and Development Commission. 187 pp. Viewed online at: http://www.bcdc.ca.gov/BPA/LivingWithRisingBay.pdf.

CALFED Bay Delta Program. *Final Programmatic Environmental Impact Statement/Environmental Impact Report*. Sacramento (CA): CALFED Bay Delta Program. 31 pp. Viewed online at: http://www.water.ca.gov/cvfmp/docs/Appendix_D_CALFED%20EIS-R%20Executive%20Summary.pdf.

California Air Resources Board. 2008. *Climate Change Scoping Plan: A Framework for Change. Sacramento (CA): California Air Resources Board*. 152 pp. Viewed online at: http://www.arb.ca.gov/cc/scopingplan/document/adopted_scoping_plan.pdf.

California Department of Boating and Waterways. 2009. *Water Hyacinth Control Program. Final Programmatic Environmental Impact Report*. Sacramento (CA): California Department of Boating and Waterways. 14 pp. Viewed online at: http://www.dbw.ca.gov/PDF/WHCP_Final/PEIR_Vol2/01-TOC.pdf.

California Department of Fish and Game. 2010. *Quantifiable Biological Objectives and Flow Criteria for Aquatic and Terrestrial Species of Concern Dependent on the Delta*. Sacramento (CA): California Department of Fish and Game. State Water Resources Control Board. 162 pp. Viewed online at: http://deltacouncil.ca.gov/docs/2010-11-23/final-quantifiable-biological-objectives-and-flow-criteria-aquatic-and-terrestrial-s.

___. 2011. *Conservation Strategy for Restoration of the Sacramento-San Joaquin Delta Ecological Management Zone and the Sacramento and San Joaquin Valley Regions, Draft*. Sacramento (CA): California Department of Fish and Game. 341 pp. Viewed online at: http://www.dfg.ca.gov/ERP/reports_docs.asp.

California Department of Parks and Recreation. 2011. *Recreation Proposal for the Sacramento-San Joaquin Delta and Suisun Marsh*. Sacramento (CA): California Department of Parks and Recreation. 40 pp. Viewed online at: http://www.parks.ca.gov/pages/795/files/delta%20rec%20proposal_08_02_11.pdf.

California Department of Water Resources. 1982. *Delta Levees Investigation, Bulletin 192-82*. Sacramento (CA): California Department of Water Resources. California Natural Resources Agency. 236 pp. Viewed online at: http://www.water.ca.gov/waterdatalibrary/docs/historic/Bulletins/Bulletin_192/Bulletin_192__1982.pdf.

___. 1986. *Delta Subsidence Investigation Progress Report*. Sacramento (CA): California Department of Water Resources. California Natural Resources Agency. 1-53 pp. Viewed online at: http://www.deltarevision.com/2011/historic-timeline/historic_maps/1986_delta_subsidence.pdf.

___. 1989. *Delta Subsidence Investigation Progress Report*. Sacramento (CA): California Department of Water Resources. California Natural Resources Agency. 1-6 pp. Viewed online at: http://searchworks.stanford.edu/view/2466556.

___. 2008. *Managing an Uncertain Future: Climate Change Adaptation Strategies for California's Water*. Sacramento (CA): California Department of Water Resources. California Natural Resources Agency. 34 pp. Viewed online at: http://www.water.ca.gov/climatechange/docs/ClimateChangeWhitePaper.pdf.

___. 2009. *Bulletin 160-09 California Water Plan Update 2009: Colorado River Hydrological Region Report*. Sacramento (CA): California Department of Water Resources. California Natural Resources Agency. 58 pp. Viewed online at: http://www.waterplan.water.ca.gov/docs/cwpu2009/0310final/v3_coloradoriver_cwp2009.pdf.

___. 2010a. *Central Valley Flood Planning Program, Draft State Plan of Flood Control Descriptive Document*. Sacramento (CA): California Department of Water Resources. California Natural Resources Agency. 42 pp. Viewed online at: http://www.water.ca.gov/cvfmp/docs/DRAFT_SPFC_Descriptive_Doc_Ch1-2_20100126.pdf.

___. 2010b. *Proposition 84 & Proposition 1E Integrated Regional Water Management Guidelines*. Sacramento (CA): California Department of Water Resources. California Natural Resources Agency. 81 pp. Viewed online at: http://www.rwah2o.org/rwa/files/IRWMP%20GL%20Final%20072010.pdf.

___. 2011. *2012 Central Valley Flood Planning Program, Public Draft*. Sacramento (CA): California Department of Water Resources. California Natural Resources Agency. 162 pp. Viewed online at: http://www.water.ca.gov/cvfmp/docs/2012_CVFPP_FullDocumentLowRes_20111230.pdf.

___. 2012. *Background/Reference Memorandum: Delta Region, Integrated Flood Management, Key Considerations and Statewide Implications*. Sacramento (CA): California Department of Water Resources. California Natural Resources Agency. 80 pp. Viewed online at: http://www.water.ca.gov/floodsafe/fessro/docs/announce_background.pdf.

___. 2013. *Bay Delta Conservation Plan*. [Public Draft]. Sacramento (CA): California Department of Water Resources. California Natural Resources Agency. Prepared by ICF International. Viewed online at: http://baydeltaconservationplan.com/PublicReview/PublicReviewDraftBDCP.aspx.

___. 2014. "Delta Risk Management Strategy." Flood and Safety. [Web site]. Sacramento (CA): California Department of Water Resources. California Natural Resources Agency. Viewed online at: http://www.water.ca.gov/floodsafe/fessro/levees/drms/.

California Department of Water Resources and U.S. Army Corps of Engineers. 2013. *California's Flood Future: Recommendations for Managing the State's Flood Risk*. Sacramento (CA): California Department of Water Resources. California Natural Resources Agency. U.S. Army Corps of Engineers. Viewed online at: http://www.water.ca.gov/sfmp/resources.cfm#highlights.

California Emergency Management Agency and California Natural Resources Agency. 2012. *California Adaptation Planning Guide*. [4 Documents]. Sacramento (CA): California Emergency Management Agency and California Natural Resources Agency. 336 pp. Viewed online at: http://resources.ca.gov/climate_adaptation/local_government/adaptation_planning_guide.html.

California Natural Resources Agency. 2009. *2009 California Climate Adaptation Strategy*. Sacramento (CA): California Natural Resources Agency. 200 pp. Viewed online at: http://resources.ca.gov/climate_adaptation/docs/Statewide_Adaptation_Strategy.pdf.

___. 2010. *Bay Delta Conservation Plan: Highlights of the BDCP*. Sacramento (CA): California Natural Resources Agency. 61 pp. Viewed online at: http://baydeltaconservationplan.com/Libraries/Dynamic_Document_Library/Draft_BDCP_Highlights_12-9-13.sflb.ashx.

___. 2013. *Safeguarding California: Reducing Climate Risk. An Update to the 2009 California Climate Adaptation Strategy (Public Draft)*. Sacramento (CA): California Natural Resources Agency. 289 pp. Viewed online at: http://resources.ca.gov/climate_adaptation/docs/Safeguarding_California_Public_Draft_Dec-10.pdf.

California Natural Resources Agency, California Department of Water Resources, U.S. Bureau of Reclamation. 2013. *Bay Delta Conservation Plan, Public Review Draft*. Sacramento (CA): California Natural Resources Agency, California Department of Water Resources, U.S. Bureau of Reclamation. Viewed online at: http://baydeltaconservationplan.com/PublicReview.aspx.

Cayan DR, Maurer EP, Dettinger MD, Tyree M, and Hayhoe K. 2008. "Climate Change Scenarios for the California Region." Climatic Change. 87(1): 21-42 pp. Viewed online at: http://tenaya.ucsd.edu/~dettinge/cccc08_scenarios.pdf.

Central Valley Regional Water Quality Control Board. 2005. *Amendments to the Water Quality Control Plan for the Sacramento River and San Joaquin River Basins for the Control Program for Factors Contributing to the Dissolved Oxygen Impairment in the Stockton Deep Water Ship Channel*. Sacramento (CA): Central Valley Regional Water Quality Control Board. 104 pp. Viewed online at: http://www.waterboards.ca.gov/centralvalley/water_issues/tmdl/central_valley_projects/san_joaquin_oxygen/final_staff_report/do_tmdl_final_draft.pdf.

___. 2010. *Amendments to the Water Quality Control Plan for the Sacramento River and San Joaquin River Basins for the Control of Methylmercury and Total Mercury in the Sacramento-San Joaquin Delta Estuary*. Sacramento (CA): Central Valley Regional Water Quality Control Board. 44 pp. Viewed online at: http://www.waterboards.ca.gov/centralvalley/water_issues/tmdl/central_valley_projects/delta_hg/index.shtml.

___. 2011. *Water Quality Control Plan for the California Regional Water Quality Control Board Central Valley Region*. Sacramento (CA): Central Valley Regional Water Quality Control Board. 148 pp. Viewed online at: http://www.waterboards.ca.gov/rwqcb5/water_issues/basin_plans/sacsjr.pdf.

___. 2013. *Drinking Water Policy for Surface Waters of the Delta and its Upstream Tributaries*. Sacramento (CA): Central Valley Regional Water Quality Control Board. Viewed online at: http://www.waterboards.ca.gov/rwqcb5/water_issues/drinking_water_policy/.

Cloern JE and Jassby AD. 2012. "Drivers of change in estuarine-coastal ecosystems: discoveries form four decades of study in San Francisco Bay." [Journal]. Reviews of Geophysics 50: 1-33 pp. Viewed online at: http://www.restorethedelta.org/wp-content/uploads/2012/11/CloernJassbyDriversofChange.pdf.

Delta Protection Commission. 2012. *Economic Sustainability Plan for the Sacramento-San Joaquin Delta*. Sacramento (CA): Delta Protection Commission. 14 pp. Viewed online at: http://www.delta.ca.gov/Final_ESP_Jan_2012.htm.

Delta Stewardship Council. 2012. *The Delta Plan, Chapter 1*. Sacramento (CA): Delta Stewardship Council. 22 pp. Viewed online at: http://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/bd_prcss_faq.shtml.

___. 2013. *The Delta Plan*. Sacramento (CA): Delta Stewardship Council. 374 pp. Viewed online at: http://deltacouncil.ca.gov/sites/default/files/documents/files/DeltaPlan_2013_CHAPTERS_COMBINED.pdf.

Dettinger M. 2011. "Climate Change, Atmospheric Rivers, and Floods in California - A Multimodal Analysis of Storm Frequency and Magnitude Changes." Journal of the American Water Resources Association 47: 514-523 pp. Viewed online at: http://tenaya.ucsd.edu/~dettinge/md_jawra2011.pdf.

Deverel S and Leighton D. 2010. "Historic, Recent, and Future Subsidence, Sacramento-San Joaquin Delta, California, USA." San Francisco Estuary and Watershed Science. 8(2). Viewed online at: http://www.escholarship.org/uc/item/7xd4x0xw.

Federal Emergency Management Agency. 2011. *FEMA Recovery Policy RP9524.3, Rehabilitation and Assistance for Levees and other Flood Control Works*. Washington D.C.: Federal Emergency Management Agency. 5 pp. Viewed online at: https://www.fema.gov/pdf/government/grant/pa/9524_3.pdf.

Federal Emergency Management Agency and California Emergency Management Agency. 2010. *Memorandum of Understanding between the State of California Emergency Management Agency and the U.S. Department of Homeland Security's Federal Emergency Management Agency, Regarding Criteria for Public Assistance Eligibility for Reclamation Districts in the Sacramento/San Joaquin Delta*. Washington D.C.: Federal Management Agency and California Emergency management Agency. Viewed online at: http://www.fema.gov/media-library-data/20130726-1854-25045-3755/california_sacramento_san_joaquin_delta___planning_and_preparing_1_.txt.

Glibert PM. 2010. "Long-term changes in nutrient loading and stoichiometry and their relationships with changes in the food web and dominant pelagic fish species in the San Francisco Estuary, California." Reviews in Fisheries Science. 18: 211-232 pp. Viewed online at: http://www.umces.edu/sites/default/files/pdfs/hpl_glibert_delta_smelt.pdf.

Grafin G, Jardine A, Merideth R, Black M, and LeRoy S. 2013. "Assessment of Climate Change in the Southwest United States: A Report Prepared for the National Climate Assessment." Washington D.C.: Island Press. 531 pp. Viewed online at: http://swccar.org/sites/all/themes/files/SW-NCA-color-FINALweb.pdf.

Hayhoe K, Cayan D, Field CB, Frumhoff PC, Maurer EP, et al. 2004. "Emissions Pathways, Climate Change, and Impacts on California." Proceedings of the National Academy of Science. 101(34): 12422-12427 pp. Viewed online at: http://www.pnas.org/content/101/34/12422.full.pdf+html.

Healey MC, Dettinger MD, and Norgaard RB. 2008. "The State of Bay-Delta Science, 2008." Sacramento (CA): CALFED Science Program. 174 pp. Viewed online at: http://www.science.calwater.ca.gov/pdf/publications/sbds/sbds_final_update_122408.pdf.

Intergovernmental Panel on Climate Change. 2013. *Climate Change 2013: The Physical Science Basis*. Geneva (Switzerland). 2216 pp. Viewed online at: http://www.climatechange2013.org/images/uploads/WGIAR5_WGI-12Doc2b_FinalDraft_All.pdf.

Medellin-Azuara J, Connel CR, Madani K, Lund JR, and Howitt RE. 2009. *Water Management Adaptation with Climate Change*. Sacramento (CA): California Climate Change Center. 34 pp. Viewed online at: http://www.energy.ca.gov/2009publications/CEC-500-2009-049/CEC-500-2009-049-F.PDF.

Merrill A, Siegel S, Morris B, Ferguson A, Young G, et al. 2010. *Greenhouse Gas Reduction and Environmental Benefits in the Sacramento-San Joaquin Delta: Advancing Carbon Capture Wetland Farms and Exploring Potential for Low Carbon Agriculture*. Sacramento (CA): Project by: The Nature Conservancy, Environmental Defense Fund, Wetlands and Water Resources, Inc., and Stillwater Sciences. 292 pp. Viewed online at: http://www.stillwatersci.com/resources/2010merrilletal_deltacarbon.pdf.

Miller RL, Fram MS, Fujii R, Wheeler G. 2008. "Subsidence reversal in a re-established wetland in the Sacramento-San Joaquin Delta, California, USA." San Francisco Estuary and Watershed Science. 6(1): Article 1. Viewed online at: http://escholarship.org/uc/item/5j76502x#page-1.

Milly PCD, Betancourt J, Falkenmark M, Hirish RM, Kundzewicz ZW, Letternmainer DP, and Stouffer RJ. 2008. "Stationarity is Dead: Whither Water Management?" Science. 319: 573-574 pp. [Journal.] Viewed online at: http://wwwpaztcn.wr.usgs.gov/julio_pdf/milly_et_al.pdf.

Mount J and Twiss R. 2005. "Subsidence, sea level rise, seismicity in the Sacramento-San Joaquin Delta." San Francisco Estuary and Watershed Science. 3(1): Article 5. Viewed online at: http://escholarship.org/uc/item/4k44725p.

Moyle PB, Bennett WA, Fleenor WE, Lund JR. 2010. "Habitat variability and complexity in the upper San Francisco Estuary." San Francisco Estuary and Watershed Science. 8(3):1-24 pp. Viewed online at: https://watershed.ucdavis.edu/library/habitat-variability-and-complexity-upper-san-francisco-estuary?destination=node/101.

National Research Council. 2012. *Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future*. Washington D.C.: The National Academies Press. 201 pp. http://www.nap.edu/catalog.php?record_id=13389.

Pierce DW, Das T, Cayan DR, Maurer EP, Miller NL, Bao Y, Nanamitsu M, Yoshimura K, Snyder MA, Sloan LC, Franco G, and Tyree M. 2012. "Probabilistic Estimates of Future Changes in California Temperature and Precipitation Using Statistical and Dynamical Downscaling." Climate Dynamics. 40 (3-4): 839-856 pp. [Journal.] Viewed online at: http://link.springer.com/article/10.1007%2Fs00382-012-1337-9.

Quian Y, Ghan SJ, Leung R. 2010. "Downscaling Hydroclimatic Changes Over the Western US Based on CAM Subgrid Scheme and WRF Regional Climate Simulations." California Energy Commission. International Journal of Climatology. 30(30): 675-693 pp. [Journal.] Viewed online at: http://onlinelibrary.wiley.com/doi/10.1002/joc.1928/abstract.

San Francisco Bay Regional Water Quality Control Board. 2008. *Amending the Water Quality Control Plan for the San Francisco Bay Region to Establish a Total Maximum Daily Load and Implementation Plan for PCBs in the San Francisco Bay*. Oakland (CA): San Francisco Bay Regional Water Quality Control Board. Viewed online at: http://www.waterboards.ca.gov/sanfranciscobay/water_issues/programs/TMDLs/sfbaypcbstmdl.shtml.

___. 2011. *Water Quality Control Plan for the San Francisco Bay Basin*. Oakland (CA): San Francisco Bay Regional Water Quality Control Board. 7 pp. Viewed online at: http://www.waterboards.ca.gov/rwqcb2/water_issues/programs/planningtmdls/basinplan/web/docs/bp_ch1withcover.pdf.

State Water Resources Control Board. 2006. *Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary*. Sacramento (CA): State Water Resources Control Board. 60 pp. Viewed online at: http://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/wq_control_plans/2006wqcp/docs/2006_plan_final.pdf.

___. 2008. *Strategic Workplan for Activities in the San Francisco Bay/Sacramento-San Joaquin Delta Estuary*. Sacramento (CA): State Water Resources Control Board. 97 pp. Viewed online at: http://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/strategic_plan/docs/baydelta_workplan_final.pdf.

___. 2009. *Recycled Water Policy*. Sacramento (CA): State Water Resources Control Board. 14 pp. Viewed online at: http://www.waterboards.ca.gov/water_issues/programs/water_recycling_policy/docs/recycledwaterpolicy_approved.pdf.

___. 2010a. I*ntegrated Report (Clean Water Act Section 303(d) List/305(b) Report)*. Sacramento (CA): State Water Resources Control Board. 25 pp. Viewed online at: http://www.waterboards.ca.gov/water_issues/programs/tmdl/records/state_board/2010/ref3640.pdf.

___. 2010b. *Development of Flow Criteria for the Sacramento-San Joaquin Delta Ecosystem*. Sacramento (CA): State Water Resources Control Board. Viewed online at: http://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/index.shtml.

___. 2011a. *Municipal Wastewater Recycling Survey*. Sacramento (CA): State Water Resources Control Board. Viewed online at: http://www.waterboards.ca.gov/water_issues/programs/grants_loans/water_recycling/munirec.shtml.

___. 2011b. *Groundwater Information Sheet*. Hexavalent Chromium. Sacramento (CA): State Water Resources Control Board. Viewed online at: http://www.swrcb.ca.gov/water_issues/programs/gama/coc.shtml.

___. 2012. *Communities that Rely on Contaminated Groundwater: Report to the Legislature*. Sacramento (CA): State Water Resources Control Board. 245 pp. Viewed online at: http://www.waterboards.ca.gov/water_issues/programs/gama/ab2222/docs/cmntes_rely_gw.pdf.

___. 2013. *Communities that Rely on Contaminated Groundwater Sources for Drinking Water*. Sacramento (CA): State Water Resources Control Board. 181 pp. Viewed online at: http://www.waterboards.ca.gov/water_issues/programs/gama/ab2222/docs/ab2222.pdf.

Suisun Resource Conservation District. 1998. *Individual Ownership Adaptive Management Habitat Plan*. Sacramento (CA): Suisun Resource Conservation District. California Department of Water Resources. 92 pp. Viewed online at: http://www.suisunrcd.org/documents/Adaptive_Habitat_Management_Plan.pdf.

Trott K. 2007. *Context Memorandum: Agriculture in the Delta Iteration 2*. Sacramento (CA): Delta Vision. 37 pp. Viewed online at: http://deltavision.ca.gov/context_memos/Agriculture/Agriculture_Iteration2.pdf.

Tully and Young. 2007. *Water Supply and Water Quality*. Sacramento (CA): Delta Vision Blue Ribbon Task Force. Viewed online at: http://www.waterplan.water.ca.gov/docs/cwpu2009/0310final/v4c05a02_cwp2009.pdf.

United States Bureau of Reclamation, U.S. Fish and Wildlife Service, and California Department of Fish and Game. 2010. *Suisun Marsh Habitat Management, Preservation, and Restoration Plan*. Draft Environmental Impact Statement/Environmental Impact Report. Sacramento (CA): U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service, California Department of Fish and Game. Viewed online at: http://www.usbr.gov/mp/nepa/nepa_projdetails.cfm?Project_ID=781.

United States Environmental Protection Agency. 2001. *Protocol for Developing Pathogen TMDLS*. Washington D.C.: U.S. Environmental Protection Agency. 134 pp. Viewed online at: http://www.epa.gov/owow/tmdl/pathogen_all.pdf.

United States Environmental Protection Agency and California Department of Water Resources. 2011. *Climate Change Handbook for Regional Water Planning*. Sacramento (CA): United States Environmental Protection Agency and California Department of Water Resources. 246 pp. Viewed online at: http://www.water.ca.gov/climatechange/docs/Climate_Change_Handbook_Regional_Water_Planning.pdf.

United States Geological Survey. 2010. *Groundwater Quality in the Northern San Joaquin Valley, California*. Reston (VA): U.S. Geological Survey. State Water Resources Control Board. 138 pp. Viewed online at: http://www.waterboards.ca.gov/water_issues/programs/gama/docs/nsjv_dsr.pdf.

___. 2011. *Groundwater Quality in the Southern Sacramento Valley, California*. Reston (VA): U.S. Geological Survey. State Water Resources Control Board. 4 pp. Viewed online at: http://www.waterboards.ca.gov/water_issues/programs/gama/docs/sosac_fs.pdf.

United States Global Change Research Program. 2009. *Global Climate Change Impacts in the United States*. Cambridge (NY): U.S. Global Change Research Program. National Oceanic and Atmospheric Administration. 196 pp. Viewed online at: http://nca2009.globalchange.gov/.

URS Corporation and Jack R. Benjamin & Associates. 2008. *Delta Risk Management Strategy (DRMS) Phase 1*. Sacramento (CA): URS Corporation and Jack R. Benjamin & Associates. Prepared for California Department of Water Resources. 32 pp. Viewed online at: http://www.water.ca.gov/floodsafe/fessro/levees/drms/docs/drms_execsum_ph1_final_low.pdf.

Western Region Climate Center. 2013. "Climate Variability in the State of California." Journal of Applied Meteorology and Climatology. 48: 1527-1541 pp. Viewed online at: http://www.wrcc.dri.edu/.

Whipple AA, Grossinger RM, Rankin D, Stanford B, Askevold RA. 2012. *Sacramento-San Joaquin Delta Historical Ecology Investigation: Exploring Pattern and Process*. Richmond (CA): Prepared for the California Department of Fish and Game and Ecosystem Restoration Program. 225 pp. Viewed online at: http://www.sfei.org/sites/default/files/Delta_HistoricalEcologyStudy_SFEI_ASC_2012_lowres.pdf.

Personal Communications

Davis-Fadtke, Kristal. Delta Conservancy. November 26, 2013. An e-mail communication with Melinda Terry, Executive Director, California Central Valley Flood Control Association regarding water use for Delta Agriculture.

Additional References

California Air Resources Board. 2013. *Climate Change Scoping Plan: First Update (Public Draft)*. Sacramento (CA): Air Resources Board. 123 pp. Viewed online at: http://www.arb.ca.gov/cc/scopingplan/2013_update/discussion_draft.pdf.

California Climate Action Team. 2010. *State of California Sea-Level Rise Interim Guidance Document, Appendix A*. Sacramento (CA): California Climate Action Team. 13 pp. Viewed online at: http://www.opc.ca.gov/webmaster/ftp/pdf/docs/2013_SLR_Guidance_Update_FINAL1.pdf.

___. 2013. *State of California Sea-Level Rise Guidance Document: March 2013 Update*. Sacramento (CA): California Action Team. 13 pp. Viewed online at: http://scc.ca.gov/files/2013/04/2013_SLR_Guidance_Update_FINAL.pdf.

California Department of Water Resources. 2006. *Progress on Incorporating Climate Change into Management of California's Water Resources*. Sacramento (CA): California Department of Water Resources. Natural Resources Agency. 339 pp. Viewed online at: http://baydeltaoffice.water.ca.gov/climatechange/DWRClimateChangeJuly06.pdf.

___. 2012. *Proposition 84 & Proposition 1E Integrated Regional Water Management Guidelines*. Sacramento (CA): California Department of Water Resources. Natural Resources Agency. 88 pp. Viewed online at: http://www.water.ca.gov/irwm/grants/docs/Guidelines/GL_2012_FINAL.pdf.

California Emergency Management Agency and California Natural Resources Agency. 2012. *California Adaptation Planning Guide: Understanding Regional Characteristics*. Sacramento (CA): California Emergency Management Agency and California Natural Resources Agency. 114 pp. Viewed online at: http://resources.ca.gov/climate_adaptation/docs/APG_Understanding_Regional_Characteristics.pdf.

___. 2012. *California Adaptation Planning Guide: Identifying Adaptation Strategies*. Sacramento (CA): California Emergency Management Agency and California Natural Resources Agency. 68 pp. Viewed online at: http://resources.ca.gov/climate_adaptation/docs/APG_Identifying_Adaptation_Strategies.pdf.

California Energy Commission. 2006. *Refining Estimates of Water-Related Energy Use in California*. Sacramento (CA): California Energy Commission. 95 pp. Viewed online at: http://www.energy.ca.gov/2006publications/CEC-500-2006-118/CEC-500-2006-118.PDF.

___. 2013. "Cal-Adapt." [Web site]. Sacramento (CA): California Energy Commission. Viewed online at: http://cal-adapt.org/.

___. 2013. *Integrated Energy Policy Report*. Sacramento (CA): California Energy Commission. 322 pp. Viewed online at: http://www.energy.ca.gov/2013publications/CEC-100-2013-001/CEC-100-2013-001-LCF.pdf.

___. 2013. "Hydroelectric Power in California." [Web site]. Sacramento (CA): California Energy Commission. Viewed online at: http://www.energy.ca.gov/hydroelectric/.

California Natural Resources Agency. 2013. *Safeguarding California: Reducing Climate Risk. An Update to the 2009 California Climate Adaptation Strategy (Public Draft)*. Sacramento (CA): California Natural Resources Agency. 289 pp. Viewed online at: http://resources.ca.gov/climate_adaptation/docs/Safeguarding_California_Public_Draft_Dec-10.pdf.

California Public Utilities Commission. 2010. *Embedded Energy in Water Studies, Studies 1, 2, and 3*. Sacramento (CA): California Public Utilities Commission. Prepared by GEI Consultants and Navigant Consulting, Inc. Viewed online at: http://www.cpuc.ca.gov/PUC/energy/Energy+Efficiency/EM+and+V/Embedded+Energy+in+Water+Studies1_and_2.htm.

Central Valley Regional Water Quality Control Board. 2012. *Delta Water Quality – Effects of Ambient Ammonia Concentrations*. Sacramento (CA): Central Valley Regional Water Quality Control Board. Viewed online at: http://www.waterboards.ca.gov/centralvalley/water_issues/delta_water_quality/ambient_ammonia_concentrations/index.shtml.

Cohen AN, and Carlton JT. 1998. "Accelerating invasion rate in a highly invaded estuary." Science. 279(5350): 555-558 pp. Viewed online at: http://www.sciencemag.org/content/279/5350/555.

Das T, Dettinger MD, Cayan DR, and Hidalgo GH. 2011. "Potential Increase in Floods in California's Sierra Nevada under Future Climate Projections." Climatic Change. 109(1): 71-94 pp. Viewed online at: http://tenaya.ucsd.edu/~dettinge/das_climchg_floods.pdf.

EGrid. 2012. *Version 1.0 Year 2009 GHG Annual Output Emission Rates*. Washington D.C.: United States Environmental Protection Agency. 1 pp. Viewed online at: http://www.epa.gov/cleanenergy/documents/egridzips/eGRID2012V1_0_year09_GHGOutputrates.pdf.

Grafin G, Jardine A, Merideth R, Black M, and LeRoy S. 2013. "Assessment of Climate Change in the Southwest United States: A Report Prepared for the National Climate Assessment." Washington D.C.: Island Press. 531 pp. Viewed online at: http://swccar.org/sites/all/themes/files/SW-NCA-color-FINALweb.pdf.

Hanak E, and Lund JR. 2011. "Adapting California's Water Management to Climate Change." Climatic Change [Published online]. [Journal]. 28 pp. Viewed online at: http://www.waterlawsymposium.com/sites/default/files/Hanak&Lund_climatic_change.pdf.

Hayhoe K, Cayan D, Field CB, Frumhoff PC, Maurer EP, et al. 2004. "Emissions Pathways, Climate Change, and Impacts on California." Proceedings of the National Academy of Science. 101(34): 12422-12427 pp. Viewed online at: http://www.pnas.org/content/101/34/12422.full.pdf+html.

Intergovernmental Panel on Climate Change. 2007. *Climate Change 2007 - Synthesis Report*. Geneva (Switzerland). 104 pp. Viewed online at: http://www.ipcc.ch/publications_and_data/ar4/syr/en/contents.html.

Jack R. Benjamin & Associates (JBA). 2005. *Preliminary Seismic Risk Analysis Associated with Levee Failures in the Sacramento-San Joaquin Delta*. Sacramento (CA): Prepared for California Bay-Delta Authroity and California Department of Water Resources. 50 pp. Viewed online at: http://www.water.ca.gov/floodmgmt/dsmo/sab/drmsp/docs/Delta_Seismic_Risk_Report.pdf.

Jackson L, Haden VR, Wheeler SM, Hollander AD, Perman J, O'Green T, Mehta VK, Clark V, Williams J, and Trupp A. 2012. *Vulnerability and Adaptation to Climate Change in California Agriculture*. Sacramento (CA): California Energy Commission. 113 pp. Viewed online at: http://www.energy.ca.gov/2012publications/CEC-500-2012-031/CEC-500-2012-031.pdf.

Janetos A, Hansen L, Inouye D, Kelly BP, Meyerson L, Peterson B, and Shaw R. 2008. *The Effects of Climate Change on Agriculture, Land Resources, Water Resources, and Biodiversity in the United States: Biodiversity*. Washington D.C.: U.S. Climate Change Science Program. 252 pp. Viewed online at: http://www.usda.gov/oce/climate_change/SAP4_3/CCSPFinalReport.pdf.

Knowles N, Dettinger M, Cayan D. 2007. *Trends in Snowfall versus Rainfall for the Western United States, 1949-2001*. Sacramento (CA): California Energy Commission, Public Interest Energy Research Program. 39 pp. Viewed online at: http://water.usgs.gov/nrp/proj.bib/Publications/2007/knowles_dettinger_etal_2007.pdf.

Lenihan JM, Bachelet D, Drapek R, Neilson RP. 2006. *The Response of Vegetation Distribution, Ecosystem Productivity, and Fire in California to Future Climate Scenarios Simulated by the MC1 Dynamic Vegetation Model*. Sacramento (CA): California Climate Change Center, California Energy Commission. 25 pp. Viewed online at: http://www.energy.ca.gov/2005publications/CEC-500-2005-191/CEC-500-2005-191-SF.PDF.

Moser S, Franco G, Pittiglio S, Chou W, and Cayan D. 2008. *The Future is Now: An Update on Climate Change Science Impacts and Response Options for California*. Sacramento (CA): California Energy Commission 114 pp. Viewed online at: http://www.energy.ca.gov/2008publications/CEC-500-2008-071/CEC-500-2008-071.PDF.

Public Policy Institute of California. 2008. *Comparing Futures for the Sacramento-San Joaquin Delta: Technical Appendix B, "Levee Decisions and Sustainability for the Delta."* Sacramento (CA): Public Policy Institute of California. 49 pp. Viewed online at: http://www.ppic.org/content/pubs/other/708ehr_appendixb.pdf.

San Francisco Bay Regional Water Quality Control Board. 2011. *Total Maximum Daily Load Selenium in North San Francisco Bay, Preliminary Project Report*. Oakland (CA): San Francisco Bay Regional Water Quality Control Board. 109 pp. Viewed online at: http://www.waterboards.ca.gov/sanfranciscobay/water_issues/programs/TMDLs/seleniumtmdl.shtml.

Van Vuuren DP, Edmonds J, Kainuma M, Riahi K, Thomson A, Hibbard K, et al. 2011. "The Reprentative Concentration Pathways: An Overview." Climatic Change 109(1-2): 5-31 pp. Viewed online at: http://link.springer.com/article/10.1007%2Fs10584-011-0148-z#.

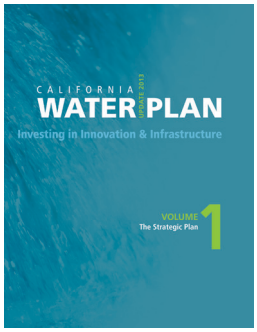
Westerling AL, Bryant BP, Preisler HK, Hidalgo HG, Das T, and Shrestha SR. 2009. *Climate Change, Growth, and California Wildfire*. Sacramento (CA): California Climate Change Center. 43 pp. Viewed online at: http://www.energy.ca.gov/2009publications/CEC-500-2009-046/CEC-500-2009-046-D.PDF.

Wilkinson RC. 2000. *Methodology for Analysis of the Energy Intensity of California's Water Systems and an Assessment of Multiple Potential Benefits through Integrated Water-Energy Efficiency Measures*. Sacramento (CA): California Institute for Energy Efficiency. 89 pp. Viewed online at: http://large.stanford.edu/courses/2012/ph240/spearrin1/docs/wilkinson.pdf.

Yun, Q, Ghan SJ, Leung LR. 2010. "Downscaling Hydroclimatic Changes over the Western US based on CAM Subgrid Scheme and WRF Regional Climate Simulations." International Journal of Climatology 30(5) 675-693 pp. Viewed online at: http://onlinelibrary.wiley.com/doi/10.1002/joc.1928/abstract.

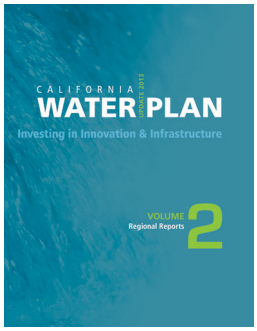
Navigating Water Plan Update 2013

Update 2013 includes a wide range of information, from a detailed description of California's current and potential future conditions to a "Roadmap For Action" intended to achieve desired benefits and outcomes. The plan is organized in five volumes — the three volumes outlined below; Volume 4, *Reference Guide*; and Volume 5, *Technical Guide*.



VOLUME 1, The Strategic Plan

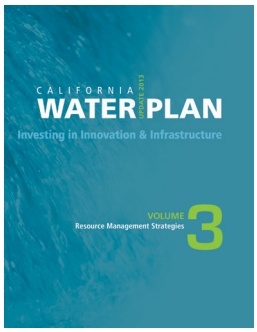
- Call to action, new features for Update 2013, progress toward implementation.
- Update 2013 themes.
- Comprehensive picture of current water, flood, and environmental conditions.
- Strengthening government alignment and water governance.
- Planning (data, analysis, and public outreach) in the face of uncertainty.
- Framework for financing the California Water Plan.
- Roadmap for Action — Vision, mission, goals, principles, objectives, and actions.



VOLUME 2, Regional Reports

- State of the region — watersheds, groundwater aquifers, ecosystems, floods, climate, demographics, land use, water supplies and uses, governance.
- Current relationships with other regions and states.
- Accomplishments and challenges.
- Looking to the future — future water demands, resource management strategies, climate change adaptation.

VOLUME 3, Resource Management Strategies



Integrated Water Management Toolbox,
30+ management strategies to:

- Reduce water demand.
- Increase water supply.
- Improve water quality.
- Practice resource stewardship.
- Improve flood management.
- Recognize people's relationship to water.

All five volumes are available for viewing and downloading at DWR's Update 2013 Web site: http://www.waterplan.water.ca.gov/cwpu2013/final/ or http://www.waterplan.water.ca.gov/cwpu2013/final/index.cfm.

If you need the publication in alternate form, contact the Public Affairs Office, Graphic Services Branch, at (916) 653-1074.

Integrated water management *is a comprehensive and collaborative approach for managing water to concurrently achieve social, environmental, and economic objectives. In the California Water Plan, these objectives are focused toward improving public safety, fostering environmental stewardship, and supporting economic stability. This integrated approach delivers higher value for investments by considering all interests, providing multiple benefits, and working across jurisdictional boundaries at the appropriate geographic scale. Examples of multiple benefits include improved water quality, better flood management, restored and enhanced ecosystems, and more reliable water supplies.*

Edmund G. Brown Jr.
Governor
State of California

John Laird
Secretary for Natural Resources
Natural Resources Agency

Mark Cowin
Director
Department of Water Resources

October 2014