## Chapter 6

# Surface Water Quality

## 6.1 Introduction

This chapter describes Surface Water Quality in the study area; and potential changes that could occur as a result of implementing the alternatives evaluated in this Environmental Impact Statement (EIS). Implementation of the alternatives could affect these resources through potential changes in operation of the Central Valley Project (CVP) and State Water Project (SWP) and ecosystem restoration.

## 6.2 Regulatory Environment and Compliance Requirements

Potential actions that could be implemented under the alternatives evaluated in this EIS could affect surface water resources impacted by changes in the operations of CVP or SWP reservoirs and in the vicinity of and lands served by CVP and SWP water supplies. Actions located on public agency lands; or implemented, funded, or approved by Federal and state agencies would need to be compliant with appropriate Federal and state agency policies and regulations, as summarized in Chapter 4, Approach to Environmental Analyses.

Several of the Federal and state laws and regulations that provide quantitative criteria to determine compliance also are summarized in this subsection of this chapter to provide context for information provided in the remaining sections of this chapter.

### 6.2.1 Federal Water Pollution Control Act Amendments of 1972 (Clean Water Act)

The Federal Water Pollution Control Act Amendments of 1972, also known as the Clean Water Act (CWA), established the institutional structure for the U.S. Environmental Protection Agency (USEPA) to regulate discharges of pollutants into the waters of the United States, establish water quality standards, conduct planning studies, and provide funding for specific grant projects. The CWA was further amended through the CWA of 1977 and the Water Quality Act of 1987. The California State Water Resources Control Board (SWRCB) has been designated by the USEPA to develop and enforce water quality objectives and implementation plans in California, as described below under State Policies and Regulations.

The California RWQCBs have adopted, and the SWRCB has approved, water quality control plans (basin plans) for each watershed basin in the State. The basin plans designate the beneficial uses of waters within each watershed basin, and water quality objectives designed to protect those uses pursuant to

Section 303 of the CWA. The beneficial uses together with the water quality objectives that are contained in the basin plans constitute State water quality standards.

Under the CWA section 303(d), the USEPA identifies and ranks water bodies for which existing pollution controls are insufficient to attain or maintain water quality standards based upon information prepared by all states, territories, and authorized Indian tribes (referred to collectively as "states" in the CWA). This list of impaired waters for each state comprises the state's 303(d) list. Each state must establish priority rankings and develop Total Maximum Daily Load (TMDL) values for all impaired waters. TMDLs calculate the greatest pollutant load that a water body can receive and still meet water quality standards and designated beneficial uses.

Section 305(b) of the CWA requires every state to submit a biennial water quality assessment of all state waters. These state-wide reports serve as the basis for USEPA's national Water Quality Inventory Report to Congress. Each water body is assessed regarding its ability to support the most common beneficial uses: aquatic life, drinking water supply, fish consumption, non-contact recreation, shell fishing, and swimming; also known as core beneficial uses (SWRCB 2010a).The USEPA requires states to integrate the 303(d) and 305(b) reports. For California, this report is called the California 303(d)/305(b) Integrated Report, and is prepared by the SWRCB using Integrated Reports submitted by each RWQCB (SWRCB 2010a). The 303(d) and 305(b) processes are further explained below under State Policies and Regulations.

The California Environmental Protection Agency, SWRCB, and RWQCBs have identified numerous water bodies within the project area that do not comply with applicable water quality standards and either adopted or are developing TMDLs, shown below in Table 6.1.

**Table 6.1 Constituents of Concern per the 303(d) list within the Study Area**

| Region | Waterbody | Constituent of Concern | TMDL Status[1] |
|---|---|---|---|
| Trinity and Lower Klamath Rivers | Trinity Lake (was Claire Engle Lake) | Mercury | Expected: 2019 |
| | Trinity River HU, Lower Trinity HA; Trinity River HU, Middle HA; Trinity River HU, South Fork HA; Trinity River, Upper HA; Trinity River HU, Upper HA, Trinity River, East Fork | Sedimentation/Siltation, Temperature[2], Mercury[3] | Approved: 2001 |
| | Klamath River HU, Lower HA, Klamath Glen HAS | Nutrients, Organic, Enrichment/Low Dissolved Oxygen, Water Temperature | Approved: 2010 |
| | | Sedimentation/Siltation | Expected: 2025 |

| Region | Waterbody | Constituent of Concern | TMDL Status[1] |
|---|---|---|---|
| Sacramento River Basin | Shasta Lake (where West Squaw Creek Enters); Keswick Reservoir (portion downstream from Spring Creek); Spring Creek, Lower (Iron Mountain Mine to Keswick Reservoir) | Acid Mine Drainage[4], Cadmium, Copper, Zinc | Expected: 2020 |
| | Shasta Lake; Whiskeytown Lake (areas near Oak Bottom, Brandy Creek Campgrounds and Whiskeytown); Clear Creek (below Whiskeytown Lake, Shasta County) | Mercury | Expected: 2021 |
| | Sacramento River (Keswick Dam to the Delta)[5] | Unknown Toxicity | Expected: 2019 |
| | | Chlordane[6], DDT, Mercury[7], PCBs, Dieldrin[8] | Expected: 2021 |
| | Colusa Basin Drain | Diazinon | Expected: 2008 |
| | | Malathion | Expected: 2010 |
| | | Azinphos-methyl (Guthion), Group A Pesticides, Unknown Toxicity | Expected: 2019 |
| | | DDT, Dieldrin, E. coli, Low Dissolved Oxygen, Mercury, Carbofuran | Expected: 2021 |
| | Oroville Lake; Feather River, Lower (Lake Oroville Dam to Confluence with Sacramento River), Yuba River, Lower[9] | Group A Pesticides | Expected: 2011 |
| | | Chlorpyrifos, Unknown Toxicity | Expected: 2019 |
| | | Mercury, PCBs | Expected: 2021 |
| | Folsom Lake; Natoma, Lake; American River, Lower (Nimbus Dam to confluence with Sacramento River)[10] | Mercury | Expected: 2019 |
| | | Unknown Toxicity, PCBs | Expected: 2021 |
| | Cache Creek, Lower (Clear Lake Dam to Cache Creek Settling Basin near Yolo Bypass) | Mercury | Approved: 2007 |
| | | Unknown Toxicity | Expected: 2019 |
| | | Boron | Expected: 2021 |
| San Joaquin River and Tulare Basins | Mendota Pool; Panoche Creek (Silver Creek to Belmont Avenue) | Mercury[11] | Expected: 2021 |
| | | Selenium | Expected: 2019 |
| | | Sediment Toxicity[12] | Expected: 2021 |
| | | Sedimentation/Siltation[12] | Expected: 2007 |

| Region | Waterbody | Constituent of Concern | TMDL Status[1] |
|---|---|---|---|
| | Agatha Canal (Merced County); Grasslands Marshes; Mud Slough, North (downstream of San Luis Drain); Salt Slough (upstream from confluence with San Joaquin River)[13] | Selenium[14] | Approved: 2002 |
| | | Chlorpyrifos | Approved: 2008 |
| | | Boron, Electrical Conductivity, Pesticides, Unknown Toxicity[15] | Expected: 2019 |
| | | Escherichia coli, Mercury, pH, Prometryn | Expected: 2021 |
| | San Luis Reservoir | Mercury | Expected: 2021 |
| | O'Neil Forebay | | Expected: 2012 |
| | Millerton Lake; San Joaquin River (Friant Dam to Stanislaus River)[16] | Selenium[17, 18] | Approved: 2002 |
| | | Chlorpyrifos, Diazinon[19] | Approved: 2007 |
| | | DDE20, DDT, Group A Pesticides | Expected: 2011 |
| | | | Expected: 2012 |
| | | Boron[21], Invasive Species[23], Unknown Toxicity | Expected: 2019 |
| | | Arsenic[24], Electrical Conductivity[18, 22], Mercury[18], Water Temperature[26] | Expected: 2021 |
| | | alpha.-BHC[20], Escherichia coli[18, 25], | Expected: 2022 |
| | San Joaquin River (Stanislaus River to Delta Boundary) | Chlorpyrifos, Electrical Conductivity | Approved: 2007 |
| | | DDE, DDT, Group A Pesticides | Expected: 2011 |
| | | Mercury | Expected: 2012 |
| | | Toxaphene, Unknown Toxicity | Expected: 2019 |
| | | Diuron, Escherichia coli, Water Temperature | Expected: 2021 |
| | Merced River, Lower; Tuolumne River, Lower; New Melones Reservoir; Tulloch Reservoir; Stanislaus River, Lower[27] | Diazinon | Expected: 2010 |
| | | Group A Pesticides | Expected: 2011 |
| | | Chlorpyrifos, Mercury, Water Temperature | Expected: 2021 |
| | | Unknown Toxicity | Expected: 2022 |
| | | Invasive Species | Expected: 2019 |

| Region | Waterbody | Constituent of Concern | TMDL Status[1] |
|---|---|---|---|
| | Cosumnes River, Lower (below Michigan Bar; partly in Delta Waterways, eastern portion) | Escherichia coli, Sediment Toxicity | Expected: 2021 |
| | Mokelumne River, Lower (in Delta Waterways, eastern portion) | Copper, Zinc | Expected: 2020 |
| | | Chlorpyrifos, Mercury, Dissolved Oxygen, Unknown Toxicity | Expected: 2021 |
| | Calaveras River, Lower (from Stockton Diverting Canal to the San Joaquin River; partly in Delta waterways, eastern portion) | Chlorpyrifos, Diazinon | Approved: 2007 |
| | | Pathogens | Approved: 2008 |
| | | Organic Enrichment/Low Dissolved Oxygen | Expected: 2012 |
| | | Mercury | Expected: 2021 |
| | Kings River, Lower (Island Weir to Stinson and Empire Weirs); Kings River, Lower (Pine Flat Reservoir to Island Weir); Kaweah River (below Terminus Dam, Tulare County); Kaweah River, Lower (includes St Johns River)[28] | Electrical Conductivity, Molybdenum, Toxaphene | Expected: 2015 |
| | | Chlorpyrifos[29], pH[30], Unknown Toxicity | Expected: 2021 |
| Sacramento-San Joaquin River Delta | Sacramento San Joaquin Delta | Mercury | Approved: 2008 |
| | | PCBs | Expected: 2008 |
| | | Selenium | Expected: 2010 |
| | | Chlordane, DDT, Dieldrin | Expected: 2013 |
| | | Dioxin compounds, Furan Compounds, Invasive Species | Expected: 2019 |
| | Delta waterways (central, eastern, northern, northwestern, western portion, southern portions, export area, and Stockton Ship Channel) | Chlorpyrifos[31], Diazinon, Organic Enrichment/Low Dissolved Oxygen[32] | Approved: 2007 |
| | | Pathogens[32] | Expected: 2008 |
| | | Mercury | Expected: 2009 |
| | | Chlordane[33], DDT, Dieldrin[33], Group A Pesticides | Expected: 2011 |
| | | Dioxin[32], Electrical Conductivity[34], Furan Compounds[32], Invasive Species, PCBs[35], Unknown Toxicity | Expected: 2019 |

| **Region** | **Waterbody** | **Constituent of Concern** | **TMDL Status**[1] |
|---|---|---|---|
| Suisun Bay and Suisun Marsh | Suisun Bay | Mercury | Approved: 2008 |
| | | PCBs | Expected: 2008 |
| | | Selenium | Expected: 2010 |
| | | Chlordane, DDT, Dieldrin | Expected: 2013 |
| | | Dioxin compounds, Furan Compounds, Invasive Species | Expected: 2019 |
| | Suisun Marsh Wetlands | Mercury, Nutrients, Organic Enrichment/Low Dissolved Oxygen, Salinity/TDS/Chlorides | Expected: 2013 |
| San Francisco Bay Region | Carquinez Strait and San Pablo Bay | Mercury | Approved: 2008 |
| | | PCBs | Expected: 2008 |
| | | Selenium | Expected: 2010 |
| | | Chlordane, DDT, Dieldrin | Expected: 2013 |
| | | Dioxin compounds, Furan Compounds, Invasive Species | Expected: 2019 |

Source: SWRCB 2011A

Notes:

1 TMDL status is either expected to be completed or approved by USEPA in the year specified

2 Water temperature is only a constituent of concern for the South Fork Trinity River and a TMDL is expected to be completed in 2019.

3 Mercury is only a constituent of concern for the East Fork Trinity River in the upper hydrologic area and a TMDL is expected to be completed in 2019.

4 Acid Mine Drainage is a constituent of concern at Spring Creek only

5 Chlordane, DDT, PCBs, Dieldrin not constituents of concern for Sacramento River (Keswick Dam to Red Bluff)

6 Chlordane not a constituent of concern for Sacramento River (Red Bluff to Knights Landing)

7 Mercury not a constituent of concern for Sacramento River (Keswick Dam to Cottonwood Creek). Mercury TMDL is expected to be complete in 2012 for Sacramento River (Knights Landing to the Delta)

8 Dieldrin TMDL for Sacramento from Knights Landing to the Delta is expected to be completed in 2022.

9 Mercury is the only constituent of concern for Yuba River and a TMDL is expected to be complete in 2021. Mercury TMDL expected to be complete in 2021 for Feather River, Lower (Lake Oroville Dam to Confluence with Sacramento River). Mercury and PCBs are the only constituents of concern for Lake Oroville and TMDLs are expected to be complete in 2021 for both constituents.

10 Mercury is the only constituent of concern for Folsom Lake and Lake Natoma. Mercury TMDL is expected to be completed in 2010 for American River, Lower (Nimbus Dam to confluence with Sacramento River)

11 Mercury TMDL for Panoche Creek (Silver Creek to Belmont Avenue) expected to be complete in 2020.

12 Not a constituent of concern for Mendota Pool

13 pH and selenium are the only constituents of concern for Agatha Canal (Merced County). Electrical conductivity and Selenium are the only constituents of concern for Grasslands Marshes. Boron, Electrical Conductivity, Pesticides, Selenium, and Unknown Toxicity are the only constituents of concern for Mud Slough, North (downstream of San Luis Drain). pH, selenium, and pesticides are not constituents of concern for Salt Slough (upstream from confluence with San Joaquin River)

14 The CVRWQCB completed a TMDL for selenium in the lower San Joaquin River (downstream of the Merced River) in 2001 and Salt Slough in 1997/1999, and USEPA approved this in 2002.

15 The unknown toxicity TMDL for Mud Slough (downstream of San Luis Drain) is expected to be written and complete in 2021.

16 Mercury is the only constituent of concern for Millerton Lake and a TMDL is expected to be complete in 2019.

17 Selenium is only a constituent of concern in San Joaquin River (Mud Slough to Merced River)

18 Electrical conductivity, Escherichia coli, mercury and selenium are not constituents of concern for San Joaquin River (Mendota Pool to Bear Creek). The Electrical Conductivity TMDL for San Joaquin River (Bear Creek to Merced River) is expected to be written and complete in 2019. The Mercury TMDL for San Joaquin River (Bear Creek to Stanislaus River) is expected to be written and complete in 2012.

19 Diazinon not a constituent of concern for San Joaquin River (Bear Creek to Mud Slough and Merced River to Tuolumne River)

20 DDE and alpha.-BHC is only a constituent of concern in San Joaquin River (Merced River to Tuolumne River)

21 The Boron TMDL for San Joaquin River (Merced to Tuolumne River) was approved by the USEPA in 2007. Boron is not a constituent of concern for the San Joaquin River (Tuolumne River to Stanislaus River).

22 The Electrical Conductivity TMDL for San Joaquin River (Tuolumne River to Stanislaus River) is expected to be written and complete in 2021.

23 Invasive species only a constituent of concern for the San Joaquin River (Friant Dam to Mendota Pool).

24 Arsenic not a constituent of concern in San Joaquin River except Bear Creek to Mud Slough.

25 Escherichia coli is not a constituent of concern for San Joaquin River (Mendota Pool to Bear Creek and Merced River to Stanislaus River). The Escherichia coli TMDL for San Joaquin River (Bear Creek to Mud Slough) is expected to be written and complete in 2021.

26 Water temperature is only a constituent of concern for San Joaquin River (Merced River to Stanislaus River)

27 Mercury is the only constituent of concern for New Melones Reservoir and Tulloch Reservoir. The diazinon TMDL for lower Merced River and lower Stanislaus River is expected to be complete in 2008. The Chlorpyrifos TMDL for the lower Merced River is expected to be complete in 2008. The Mercury TMDL for lower Merced River is expected to be complete in 2019 and lower Stanislaus River TMDL is expected to be complete in 2020. The Unknown Toxicity TMDL for lower Stanislaus River is expected to be complete in 2019 and lower Merced River is expected in 2021.

28 The only constituents of concern for Kings River, Lower (Island Weir to Stinson and Empire Weirs) are electrical conductivity, toxaphene, molybdenum.

29 Chlorpyrifos is only a constituent of concern for Kings River, Lower (Pine Flat Reservoir to Island Weir).

30 pH is only a constituent of concern for Kaweah River (below Terminus Dam, Tulare County).

31 Chlorpyrifos TMDL for Delta waterways (central portion) expected to be complete in 2019. Chlorpyrifos TMDL for Delta waterways (western portion) expected to be complete in 2006.

32 Not a constituent of concern for Delta waterways except for Stockton Ship Channel.

33 Not a constituent of concern for Delta waterways except for northern portion.

34 Not a constituent of concern for Delta waterways (central, northern, eastern portions, and Stockton Ship Channel)

35 Not a constituent of concern for Delta waterways except for the northern portion and the Stockton Ship Channel.

National Toxics Rule (NTR) was established by USEPA in accordance with CWA section 303 to provide ambient water quality criteria for priority toxic pollutants to protect aquatic life and human health.

The Secretary of the Interior established the first antidegradation policy in 1968. In 1975, USEPA included the antidegradation requirements in the Water Quality Standards Regulation (40 Code of Federal Regulations [CFR] 130.17, 40 CFR 55340-41). The requirements were included in the 1987 CWA amendment in section 303(d)(4(B)). The Federal antidegradation policy requires states to develop regulations to allow increases in pollutant loadings or changes in surface water quality only if: 1) existing surface water uses are maintained and protected, and established water quality requirements are met; 2) if water quality requirements cannot be maintained by a project, water quality must be maintained to fully protect “fishable/swimmable” uses and other existing uses; and 3) for Outstanding National Resource Waters water quality criteria where “States may allow some limited activities which result in temporary and short-term changes in water quality” (Water Quality Standards Regulations) but would not impact existing uses or special use of these waters.

### 6.2.2 Major California Water Quality Regulations

The Porter Cologne Water Quality Control Act (Porter-Cologne Act) established the SWRCB and divided the state into nine regions, each overseen by a RWQCB. The nine RWQCBs have the primary responsibility for the coordination and control of water quality within their respective jurisdictional boundaries. The SWRCB and the RWQCBs have been delegated Federal authority to implement the requirements of the Federal CWA in California. The RWQCBs that have jurisdiction over the water bodies in the project area are the NCRWQCB, CVRWQCB, SFB RWQCB, Central Coast RWQCB, Los Angeles RWQCB, Santa Ana RWQCB, San Diego RWQCB, Lahontan RWQCB, and Colorado River RWQCB. The Porter-Cologne Act requires the RWQCBs to prepare and periodically update basin plans. Basin plans establish beneficial uses of water, water quality objectives, and implementation programs for achieving the objectives.

The State of California has adopted several water quality policies that are similar to federal water quality policies, including the California Toxics Rule (CTR) and the Policy for Implementing Toxic Standards for Inland Surface Waters, Enclosed Bays, and Estuaries of California (State Implementation Policy).

The CTR is applicable to all State waters, as are the USEPA advisory National Recommended Water Quality Criteria. Fresh water criteria apply to waters of salinity less than 1 parts per thousand 95 percent or more of the time, seawater criteria are for water greater than 10 parts per thousand 95 percent or more of the time, and estuarine waters use the more stringent of the two possible criteria, in absence of estuary-specific criteria.

The State Implementation Policy for water quality control, adopted in 2000, applies to discharges of toxic pollutants into the inland surface waters, enclosed bays, and estuaries of California subject to regulation under the Porter-Cologne Act and the Federal CWA. This policy establishes:

- Implementation provisions for priority pollutant criteria promulgated by the USEPA through the NTR and the CTR, and for priority pollutant objectives established by RWQCBs in their basin plans;

- Monitoring requirements for 2,3,7,8-tetrachlorodibenzodioxin (TCDD) equivalents; and

- Chronic toxicity control provisions.

#### *6.2.2.1 Basin Plans*

The RWQCBs are required to formulate and adopt basin plans for all areas under their jurisdiction under the Porter-Cologne Act. Each basin plan must contain water quality objectives to ensure the reasonable protection of beneficial uses, as well as a program of implementation for achieving water quality objectives with the basin plans.

Section 13050(f) of the Porter-Cologne Act lists the beneficial uses of the waters of the state that may be protected against water quality degradation, which include but are not limited to: domestic, municipal, agricultural, and industrial supply; power generation; recreation; aesthetic enjoyment; navigation; and preservation and enhancement of fish, and wildlife and other aquatic resources or preserves. Basin plans must designate and protect beneficial uses in the region. A uniform list of beneficial uses is defined by the SWRCB, however each RWQCB may identify additional beneficial uses specific to local water bodies.

Basin plans must adopt water quality standards to protect public health or welfare, enhance the quality of water, and serve the purposes of the CWA. These water quality standards include: designated beneficial uses; water quality objectives to protect the beneficial uses; implementation of the Federal and State policies for antidegradation; and general policies for application and implementation.

The basin plans are subject to modification, considering applicable laws, policies, technologies, water quality conditions and priorities. Basin plans must be assessed every three years for the appropriateness of existing standards and evaluation and prioritization of basin planning issues. In California however, water bodies are assessed every two years for CWA 303(d) and 305(b) requirements. Revisions are accomplished through Basin Plan amendments. Once a Basin Plan amendment is adopted in noticed public hearings, it must be approved by the SWRCB, Office of Administrative Law and in some cases, the USEPA.

##### **6.2.2.1.1 California 303(d)/305(b) Integrated Reports**

The California 303(d)/305(b) Integrated Report is updated biennially for inclusion in the USEPA's national Water Quality Inventory Report to Congress. The report is composed of the current California 303(d) list, and all current listing decisions for contaminants in impaired water bodies. The statewide report is the compilation of 303(d)/305(b) Integrated Reports submitted by each RWQCB. The final California 303(d) list must be submitted to and approved by the USEPA before it becomes effective.

The most recent statewide report is the 2010 California 305(b)/303(d) Integrated Report, accompanied by the 2010 Staff Report, which outlines the process by which water bodies were assessed for impairment and by which listing decisions were made. Each successive 303(d) list updates the previous approved 303(d) list, in this case the 2006 Section 303(d) list. The updates are made by each RWQCB in accordance with the Water Quality Control Policy for Developing California's CWA Section 303(d) list ("Listing Policy").

For the 2010 Integrated Report, the data assessed included the 2006 California CWA Section 303(d) list and its supporting data and information, applicable Surface Water Ambient Monitoring Program (SWAMP) data from 2000 to 2007, data from several local monitoring programs, and data provided during public solicitation. Data incorporated into the assessment were existing and readily available to RWQCB staff.

Data were assessed to identify the beneficial uses for each water body, and whether water quality criteria were being met. The core beneficial uses most commonly evaluated were aquatic life, drinking water supply, fish consumption, non-contact recreation, shell fishing, and swimming. The water quality criteria considered included water quality objectives set forth by RWQCB Basin Plans, criteria included in Statewide Basin Plans, the CTR, and maximum contaminant level MCLs. Narrative "Evaluation Guidelines" were designated for pollutants without numeric Basin Plan Objectives, MCLs or CTR criteria, as described in the Listing Policy.

The data and assessment results were summarized in LOEs for water body segment-contaminant combinations. The LOEs include specific information used to determine whether water quality standards are being met for the water body segment, including: affected beneficial uses; relevant pollutant; relevant water quality criteria; and detailed information regarding data samples and quality assurance information. Fact sheets were prepared that summarize the LOEs and the reasoning for inclusion or exclusion of the water body-pollutant combination from the 303(d) list. The fact sheets are stored in the Water Boards' California Water Quality Assessment (CalWQA) database.

Water body segment-contaminant combinations were categorized into one of three Beneficial Use Support Ratings: fully supporting (supporting), not supporting, and insufficient information. These Beneficial Use Support Ratings were used as the basis for categorizing the water bodies into Integrated Report categories.

For water bodies that are in need of a TMDL, the Listing Policy provides instruction for scheduling TMDL development, based on, among other factors, the significance of the water segment, the degree that water quality objectives are not met or that beneficial uses are threatened, and the potential threat to human health and the environment.

The 2010 California 305(b)/303(d) Integrated Report results in a significant increase in proposed 303(d) listings in comparison to previous years. This is likely the result of a large volume of water quality data available for the 2010 assessment, which was not available for the 2006 assessment. There are also more protective water quality standards for some water bodies, requiring their addition to the 303(d) list.

#### 6.2.2.2 Central Valley Salinity Alternatives for Long-term Sustainability (CV-SALTS)

In 2006, the CVRWQCB, the SWRCB, and stakeholders began a joint effort to address salinity and nitrate problems in California's Central Valley and adopt long-term solutions that will lead to enhanced water quality and economic sustainability. This effort is referred to as the CV-SALTS Initiative. The goal of CV-SALTS is to develop a comprehensive region-wide Salt and Nitrate Management Plan (SNMP) describing a water quality protection strategy that will be implemented through a mix of voluntary and regulatory efforts. The SNMP may include recommendations for numeric water quality objectives, beneficial use designation refinements, and/or other refinements, enhancements, or basin plan revisions. The SNMP will serve as the basis for amendments to the three water quality control plans that cover the Central Valley Region (Sacramento River and San Joaquin River Basin Plan, the Tulare Lake Basin Plan and the Sacramento/San Joaquin Rivers Bay-Delta Plan) and the San Francisco Bay Area Region Basin Plan. The Basin Plan Amendments (BPAs) will likely establish a comprehensive implementation plan to achieve water quality objectives for salinity (including nitrate) in the Region's surface waters and groundwater; and the SNMP may include recommendations for numeric water quality objectives, beneficial use designation refinements, and/or other refinements, enhancements, or Basin Plan revisions.

## 6.3 Affected Environment

This section describes surface water quality that could be potentially affected by the implementation of the alternatives considered in this EIS. Changes in water quality due to changes in CVP and SWP operations may occur in the Trinity River, Central Valley, San Francisco Bay Area, and Central Coast and Southern California regions. Changes to surface water bodies and water supplies are described in Chapter 5, Surface Water Resources and Water Supplies.

This chapter focuses on constituents of concerns that could be affected by changes in CVP and SWP water operations. The constituents of concern have been identified in the Final California 2010 Integrated Report (303(d) List/305(b) Report) as well as other water quality reports. This section provides descriptions of sources of constituents, water quality effects, water quality objectives and/or guidelines, and plans to improve water quality.

### 6.3.1 Beneficial Uses of Surface Waters in the Study Area

Water quality conditions throughout the study area are assessed and described by the RWQCB Basin Plans and Integrated Reports. Each region has specific beneficial uses, as summarized in Table 6.2 and water quality constituents of concern; however, several pollutants are prevalent throughout the study area. The origins and prevalence of these pollutants are discussed below.

**Table 6.2 Designated Beneficial Uses within Project Study Area**

| **Surface Water Body** | **Municipal and Domestic Supply (MUN)** | **Agricultural Supply (AGR)** | **Industrial Service Supply (IND)** | **Industrial Process Supply (PRO)** | **Groundwater Recharge (GWR)** | **Fresh water Replenishment (FRSH)** | **Navigation (NAV)** | **Hydropower Generation (POW)** | **Water Contact Recreation (REC-1)** | **Non-Contact Water Recreation (REC-2)** | **Commercial and Sport Fishing (COMM)** | **Warm Fresh water Habitat (WARM)** | **Cold Fresh water Habitat (COLD)** | **Wildlife Habitat (WILD)** | **Rare, Threatened, or Endangered Species (RARE)** | **Marine Habitat (MAR)** | **Migration of Aquatic Organisms (MIGR)** | **Spawning, Reproduction, and/or Early Development (SPWN)** | **Shellfish Harvesting (SHELL)** | **Estuarine Habitat (EST)** | **Aquaculture (AQUA)** | **Native American Culture (CUL)** | **Flood Peak Attenuation/ Flood Water Storage (FLD)** | **Wetland Habitat (WET)** | **Water Quality Enhancement (WQE)** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Trinity and Lower Klamath Rivers** | | | | | | | | | | | | | | | | | | | | | | | | | |
| Lower Klamath River and Klamath Glen Hydrologic Subarea | E | E | P | P | E | E | E | P | E | E | E | E | E | E | E | E | E | E | E | E | P | E | – | – | – |
| Trinity Lake | E | E | E | E | E | E | E | E | E | E | E | E | E | E | E | – | P | E | – | – | P | – | – | – | – |
| Lewiston Reservoir | E | E | P | P | E | E | E | E | E | E | E | P | E | E | E | – | P | E | – | – | E | – | – | – | – |
| Middle Trinity River and Surrounding Hydrologic Area | E | E | E | P | E | E | E | P | E | E | E | – | E | E | E | – | E | E | – | – | E&P | – | – | – | – |
| Lower Trinity River and Surrounding Hydrologic Area[1] | E&P | E&P | E | E&P | E | E | E | E&P | E | E | E | – | E | E | E | – | E | E | P | – | E&P | E[2] | – | – | – |
| **Sacramento River Basin** | | | | | | | | | | | | | | | | | | | | | | | | | |

| **Surface Water Body** | **Municipal and Domestic Supply (MUN)** | **Agricultural Supply (AGR)** | **Industrial Service Supply (IND)** | **Industrial Process Supply (PRO)** | **Groundwater Recharge (GWR)** | **Fresh water Replenishment (FRSH)** | **Navigation (NAV)** | **Hydropower Generation (POW)** | **Water Contact Recreation (REC-1)** | **Non-Contact Water Recreation (REC-2)** | **Commercial and Sport Fishing (COMM)** | **Warm Fresh water Habitat (WARM)** | **Cold Fresh water Habitat (COLD)** | **Wildlife Habitat (WILD)** | **Rare, Threatened, or Endangered Species (RARE)** | **Marine Habitat (MAR)** | **Migration of Aquatic Organisms (MIGR)** | **Spawning, Reproduction, and/or Early Development (SPWN)** | **Shellfish Harvesting (SHELL)** | **Estuarine Habitat (EST)** | **Aquaculture (AQUA)** | **Native American Culture (CUL)** | **Flood Peak Attenuation/ Flood Water Storage (FLD)** | **Wetland Habitat (WET)** | **Water Quality Enhancement (WQE)** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Shasta Lake | E | E | – | – | – | – | – | E | E | E | – | E[4] | E[4] | E | – | – | – | E[5,6] | – | – | – | – | – | – | – |
| Sacramento River: Shasta Dam to Colusa Basin Drain | E | E | E | – | – | – | E | E | E[3] | E | – | E[4] | E[4] | E | – | – | E[5,6] | E[5,6] | – | – | – | – | – | – | – |
| Colusa Basin Drain | – | E | – | – | – | – | – | – | E[3] | – | – | E[4] | P[4] | E | – | – | E[6] | E[6] | – | – | – | – | – | – | – |
| Sacramento River: Colusa Basin Drain to Eye (“I”) Street Bridge | E | E | – | – | – | – | E | – | E[3] | E | – | E[4] | E[4] | E | – | – | E[5,6] | E[5,6] | – | – | – | – | – | – | – |
| Whiskeytown Lake | E | E | – | – | – | – | – | E | E | E | – | E[4] | E[4] | E | – | – | – | E[6] | – | – | – | – | – | – | – |
| Clear Creek below Whiskeytown Lake | E | E | – | – | – | – | – |  | E[3] | E | – | E[4] | E[4] | E | – | – | E[5] | E[5,6] | – | – | – | – | – | – | – |

| **Surface Water Body** | **Municipal and Domestic Supply (MUN)** | **Agricultural Supply (AGR)** | **Industrial Service Supply (IND)** | **Industrial Process Supply (PRO)** | **Groundwater Recharge (GWR)** | **Fresh water Replenishment (FRSH)** | **Navigation (NAV)** | **Hydropower Generation (POW)** | **Water Contact Recreation (REC-1)** | **Non-Contact Water Recreation (REC-2)** | **Commercial and Sport Fishing (COMM)** | **Warm Fresh water Habitat (WARM)** | **Cold Fresh water Habitat (COLD)** | **Wildlife Habitat (WILD)** | **Rare, Threatened, or Endangered Species (RARE)** | **Marine Habitat (MAR)** | **Migration of Aquatic Organisms (MIGR)** | **Spawning, Reproduction, and/or Early Development (SPWN)** | **Shellfish Harvesting (SHELL)** | **Estuarine Habitat (EST)** | **Aquaculture (AQUA)** | **Native American Culture (CUL)** | **Flood Peak Attenuation/ Flood Water Storage (FLD)** | **Wetland Habitat (WET)** | **Water Quality Enhancement (WQE)** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Feather River below Lake Oroville (Fish Barrier Dam to Sacramento River) | E | E | – | – | – | – | – | – | E[3] | E | – | E[4] | E[4] | E | – | – | E[5,6] | E[5,6] | – | – | – | – | – | – | – |
| American River below Lake Natoma (Folsom Dam to Sacramento River) | E | E | E | – | – | – | – | E | E[3] | E | – | E[4] | E[4] | E | – | – | E[5,6] | E[5,6] | – | – | – | – | – | – | – |
| Yolo Bypass[7] | – | E | – | – | – | – | – | – | E | E | – | E[4] | P[4] | E | – | – | E[5,6] | E[6] | – | – | – | – | – | – | – |
| **Sacramento-San Joaquin River Delta** | | | | | | | | | | | | | | | | | | | | | | | | | |
| Sacramento-San Joaquin River Delta[7,8,9] | E | E | E | E | E | – | E | – | E | E | E | E[4] | E[4] | E | E | – | E[5,6] | E[6] | E | E | – | – | – | – | – |
| **San Joaquin River and Tulare Basin** | | | | | | | | | | | | | | | | | | | | | | | | | |
| San Joaquin River: Friant Dam to Mendota Pool | E | E | – | E | – | – | | | E[3] | E | – | E[4] | E[4] | E | – | – | E[5,6] | E[6],<br>P[5] | – | | | | | | |

| **Surface Water Body** | **Municipal and Domestic Supply (MUN)** | **Agricultural Supply (AGR)** | **Industrial Service Supply (IND)** | **Industrial Process Supply (PRO)** | **Groundwater Recharge (GWR)** | **Fresh water Replenishment (FRSH)** | **Navigation (NAV)** | **Hydropower Generation (POW)** | **Water Contact Recreation (REC-1)** | **Non-Contact Water Recreation (REC-2)** | **Commercial and Sport Fishing (COMM)** | **Warm Fresh water Habitat (WARM)** | **Cold Fresh water Habitat (COLD)** | **Wildlife Habitat (WILD)** | **Rare, Threatened, or Endangered Species (RARE)** | **Marine Habitat (MAR)** | **Migration of Aquatic Organisms (MIGR)** | **Spawning, Reproduction, and/or Early Development (SPWN)** | **Shellfish Harvesting (SHELL)** | **Estuarine Habitat (EST)** | **Aquaculture (AQUA)** | **Native American Culture (CUL)** | **Flood Peak Attenuation/ Flood Water Storage (FLD)** | **Wetland Habitat (WET)** | **Water Quality Enhancement (WQE)** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| San Joaquin River: Mendota Dam to the Mouth of Merced River | P | E | – | E | – | – | | | E[3] | E | – | E[4] | – | E | – | | E[5,6] | E[6],<br>P[5] | – | | | | | | |
| San Joaquin River: Mouth of Merced River to Vernalis | P | E | – | E | – | | | | E[3] | E | – | E[4] | – | E | – | | E[5,6] | E[6] | – | – | – | – | – | – | – |
| New Melones Reservoir | E | E | – | – | – | – | – | E | E | E | – | – | E[4] | E | – | – | – | – | – | – | – | – | – | – | – |
| Tulloch Reservoir | P | E | – | – | – | – | – | E | E | E | – | E[4] | – | E | – | – | – | – | – | – | – | – | – | – | – |
| Stanislaus River: Goodwin Dam to San Joaquin River | P | E | E | E | – | – | – | E | E[3] | E | – | E[4] | E[4] | E | – | – | E[5] | E[5,6] | – | – | – | – | – | – | – |
| San Luis Reservoir | E | E | E | – | – | – | – | E | E | E | – | E[4] | – | E | – | – | – | – | – | – | – | – | – | – | – |
| O'Neill Reservoir | E | E | – | – | – | – | – | – | E | E | – | E[4] | – | – | – | – | – | – | – | – | – | – | – | – | – |

| Surface Water Body | Municipal and Domestic Supply (MUN) | Agricultural Supply (AGR) | Industrial Service Supply (IND) | Industrial Process Supply (PRO) | Groundwater Recharge (GWR) | Fresh water Replenishment (FRSH) | Navigation (NAV) | Hydropower Generation (POW) | Water Contact Recreation (REC-1) | Non-Contact Water Recreation (REC-2) | Commercial and Sport Fishing (COMM) | Warm Fresh water Habitat (WARM) | Cold Fresh water Habitat (COLD) | Wildlife Habitat (WILD) | Rare, Threatened, or Endangered Species (RARE) | Marine Habitat (MAR) | Migration of Aquatic Organisms (MIGR) | Spawning, Reproduction, and/or Early Development (SPWN) | Shellfish Harvesting (SHELL) | Estuarine Habitat (EST) | Aquaculture (AQUA) | Native American Culture (CUL) | Flood Peak Attenuation/ Flood Water Storage (FLD) | Wetland Habitat (WET) | Water Quality Enhancement (WQE) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| California Aqueduct | E | E | E | E | – | – | – | E | E | E | – | – | – | E | – | – | – | – | – | – | – | – | – | – | – |
| Delta-Mendota Canal | E | E | – | – | – | – | – | – | E | E | – | E[4] | – | E | – | – | – | – | – | – | – | – | – | – | – |

Sources: Central Valley RWQCB 2004, SWRCB 2006a, Hoopa Valley TEPA 2008, Central Valley RWQCB 2011, North Coast RWQCB 2011,

Notes:

E: Existing Beneficial Use; P: Potential Beneficial Use

1 Includes beneficial uses for the Trinity River within the Hoopa Valley Indian Reservation as designated by the Hoopa Valley Indian Reservation Water Quality Control Plan, which, in addition to beneficial uses shown, also designates the Lower Trinity River as a Wild and Scenic waterway, providing for scenic, fisheries, wildlife and recreational purposes.

2 Not all beneficial uses are present uniformly throughout this water body. They have been summarized to reflect beneficial uses present in multiple segments of the water body.

3 Canoeing and rafting included in REC-1 designation.

4 Resident does not include anadromous. Any Segments with both COLD and WARM beneficial use designations will be considered COLD water bodies for the application of water quality objectives.

5 Cold water protection for salmon and steelhead.

6 Warm water protection for striped bass, sturgeon, and shad.

7 Beneficial uses vary throughout the Delta and will be evaluated on a case-by-case basis. COMM is a designated beneficial use for the Sacramento San Joaquin Delta and Yolo Bypass waterways listed in Appendix 43 of the Basin Plan for the Sacramento River and San Joaquin River Basins and not any tributaries to the listed waterways or portions of the listed waterways outside of the legal Delta boundary unless specifically designated.

8 Delta beneficial uses are shown as designated by the Water Quality Control Plan for the Sacramento River Basin and the San Joaquin River Basin, and the Water Quality Control Plan for the San Francisco Bay/Sacramento San Joaquin Delta Estuary.

9 Per State Water Board Resolution No. 90-28, Marsh Creek and Marsh Creek Reservoir in Contra Costa County are assigned the following beneficial uses: REC-1 and REC-2 (potential uses), WARM, WILD and RARE. COMM is a designated beneficial use for Marsh Creek and its tributaries listed in Appendix 43 of the Basin Plan for the Sacramento River and San Joaquin River Basins within the legal Delta boundary.

#### 6.3.1.1 Water Temperature

Water temperature is a concern in regions throughout California including the lower Klamath River, Trinity Lake, Sacramento River, and the San Joaquin River. These regions support warm and cold fresh water habitat and other aquatic beneficial uses. Water bodies in these areas must maintain water temperatures supportive of resident and seasonal fish species habitats, particularly for endangered species. Common narrative and numeric water quality objectives for water temperature in water bodies within the study area are specified in each of the basin plans for the North Coast, Central Valley, Tulare Lake and the San Francisco Bay regions (NCRWQCB 2011; CVRWQCB 2004, and 2011; SFB RWQCB 2013):

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

Water quality objectives for water temperature within the project study area are also specified in the SWRCB *Water Quality Control Plan for Control of Temperature in the Coastal and Interstate Waters and Enclosed Bays and Estuaries of California (Statewide Temperature Plan).*

Further information on the measurement and enforcement of water quality objectives for temperature is included in the Statewide Temperature Plan (SWRCB 1998).

#### 6.3.1.2 Salinity

Salinity, a measure of dissolved salts in water, is a concern in the tidally-influenced Delta as it can cause impacts on domestic supply, agriculture, industry, and wildlife (CALFED 2007). The impacts of salinity on the domestic supply of water in the Delta include aesthetic (skin or tooth discoloration), or cosmetic (taste, odor, or color) effects, and increasing the need to reduce salinity for M&I uses by blending which can lead to a reduction in the quantity of usable water. Salts, such as bromide, in drinking water can increase the formation of harmful byproducts (see the Bromide, Organics, and Pathogens section). Salinity in the Delta impacts agriculture by reducing crop yields and salinity in the soil can cause plant stress. Another salt ion, chloride, in high concentrations in municipal and industrial supply has been known to cause corrosion in canned goods because of residual salts in paper boxes or linerboard.

Some fish and wildlife are also affected by salinity concentrations in the Delta because certain levels of salinity are required during different life stages to survive. One measure of salinity in the western Delta is “X2.” X2 refers to the horizontal distance from the Golden Gate Bridge up the axis of the Delta estuary to where tidally averaged near-bottom salinity concentration of 2 parts of salt in 1,000 parts of water occurs. The X2 standard was established to improve shallow water estuarine habitat in the months of February through June and relates to the extent of salinity movement into the Delta (DWR, Reclamation, USFWS and NMFS 2013). The location of X2 is important to both aquatic life and water supply beneficial uses.

The CVP and SWP are operated to achieve salinity objectives in the Delta, as described in detail in Appendix 3A, No Action Alternative: Central Valley Project and State Water Project Operations.

The SWRCB D-1641 includes “spring X2” criteria that require operations of the CVP and SWP to include upstream reservoir releases from February through June to maintain freshwater and estuarine conditions in the western Delta to protect aquatic life. In addition, the 2008 U.S. Fish and Wildlife Service (USFWS) Biological Opinion (BO) also includes an additional Delta salinity requirement in September and October in wet and above normal water years (Fall X2), as described in Chapter 5, Surface Water Resources and Water Supplies.

#### *6.3.1.3 Mercury*

Mercury is a constituent of concern throughout California, both as total mercury and as biologically-formed methylmercury, which is more available for food chain exposure and toxicity. Mercury present in the Delta, its tributaries, Suisun Marsh, and San Francisco Bay is derived both from current processes and as a result of historical deposition. Most of the mercury present in these locations is the result of historical mining of mercury ore in the Coast Ranges (via Putah and Cache creeks to the Yolo Bypass) and the extensive use of elemental mercury to aid gold extraction processes in the Sierra Nevada (via Sacramento, San Joaquin, Cosumnes, and Mokelumne rivers) (Alpers et al. 2008; Wiener et al. 2003). Elemental mercury from historical gold mining processes appears to be more bioavailable than that from mercury ore tailings because mercury used in gold mining processes was purified before use (CVRWQCB 2010a). Additional sources of mercury include atmospheric deposition from both local and distant sources, and discharges from wastewater treatment plants (SWRCB 2014a).

Methylation of mercury is an important step in the entrance of mercury into food chain (USEPA 2001a). This transformation can occur in both sediment and the water column. Methylmercury is absorbed more quickly by aquatic organisms than inorganic mercury, and it biomagnifies (i.e., increases the concentration of methylmercury in predatory fish from eating smaller contaminated fish and invertebrates). The pH of water, the length of the aquatic food chain, water temperature, and dissolved organic material and sulfate are all factors that can contribute to the bioaccumulation of methylmercury in aquatic organisms. The proportion of an area that is wetlands, the soil type, and erosion can also contribute to the amount of mercury that is transported from soils to water bodies. These effects can be seen in the variability in bioaccumulated mercury in the Sacramento-San Joaquin River Delta.

Consumption of contaminated fish is the major pathway for human exposure to methylmercury (USEPA 2001a). Once consumed, methylmercury is almost completely absorbed into the blood and transported to all tissues, and is also transmitted to the fetus through the placenta. Neurotoxicity from methylmercury can result in mental retardation, cerebral palsy, deafness, blindness, and dysarthia in utero, and in sensory and motor impairments in adults. Cardiovascular and immunological effects from low-dose methylmercury exposure have also been reported.

In an effort to protect aquatic and human health, USEPA recommended maximum concentrations "without yielding unacceptable effects" in 2001 for acute exposure, identified as the criteria maximum concentration (CMC), and for chronic exposure, identified as the criterion continuous concentration (CCC) (USEPA 2001a and USEPA 2014a). Current state-wide water quality criteria for mercury were established in the CTR in 2000 (USEPA 2000a). Under these requirements, total recoverable mercury for the protection of human health was set as limits for consumption of water and organisms as well as consumption of organisms only, as summarized in Table 6.3. Mercury objectives are also included in some California RWQCB basin plans, as discussed in subsequent sections of this chapter. Where both a CTR criterion and a Basin Plan objective exist, the more stringent value applies (SWRCB 2006a).

**Table 6.3 Water Quality Criteria for Mercury and Methylmercury (as Total Mercury)**

| | | | |
|---|---|---|---|
| NRWQC | For the protection of freshwater species | | CMC = 1.4 µg/l |
| | | | CCC = 0.77 µg/l |
| | For the protection of saltwater species | | CMC = 1.8 µg/l |
| | | | CCC = 0.94 µg/l |
| | For the protection of human health[1] | | 0.3 mg/kg [2] |
| CTR | For the protection of human health | Consumption of water + organism | 0.050 µg/l |
| | | Consumption of organism only | 0.051 µg/l |

Source: NRWQC (National Recommended Water Quality Criteria) - USEPA 2014a; CTR (California Toxic Rule) - USEPA 2000a, USEPA 2001b

Notes:

1 For the consumption of organisms only and based on a total consumption 0.0175 kg fish and shellfish per day.

2 Methylmercury in fish tissue (wet weight)

A review of the mercury human health criteria by USEPA in 2001 concluded that a fish tissue (including shellfish) residue water quality criterion for methylmercury is more appropriate than a water-column-based water quality criterion (USEPA 2001a). A fish tissue criterion directly addresses the dominant human exposure route for methylmercury, and thus is more closely tied to the CWA goal of protecting public health. The USEPA also strongly encourages States and authorized Tribes to develop local or regional water quality criteria if they will be more appropriate for the target population.

The SWRCB is considering adopting statewide objectives for methylmercury based on the USEPA criteria, which would apply to inland waters, enclosed bays, and estuaries (SWRCB 2006a). These objectives would be applicable to waters that are not listed as impaired or that do not require a TMDL. Potential elements include a methylmercury fish tissue objective, a total mercury water quality objective, a methylmercury water quality objective, or some combination of these. Implementation procedures related to the NPDES permitting process also may be included.

The CTR criterion may be implemented as a fish tissue-based objective (FTO), or it may be converted into an ambient methylmercury water quality objective (AWQO), the latter reflecting the USEPA's fish consumption rate of 0.0175 kg fish/day, or site-specific consumption rates that more accurately reflect local consumption patterns (SWRCB 2006a). A USFWS evaluation of the USEPA criterion for methylmercury concluded that the FTO of 0.3 mg methylmercury/kg fish would be insufficient to protect three species that may occur in the study area including California Least Tern, California Clapper Rail, and Bald Eagle evaluated in the study.

#### 6.3.1.4 Selenium

Selenium is a constituent of concern in the project area because of its potential effects on water quality and on aquatic and terrestrial resources primarily in the San Joaquin Valley and the San Francisco Bay, as well as some locations in Southern California (SWRCB 2011a). Elevated concentrations of selenium in soil and waterways within the San Joaquin Valley, and to some extent in the San Francisco Bay, are due primarily to erosion of uplifted selenium-enriched Cretaceous and Tertiary marine sedimentary rock located at the base of the east-facing side of the Coastal Range (Presser and Piper 1998; Presser 1994). The selenium-enriched soil derived from the eroded rock has been transported to the western San Joaquin Valley through natural processes; selenium is mobilized from the soil by irrigation practices and transported to waterways receiving agricultural drainage (Presser and Ohlendorf 1987). Other sources of selenium to the western Delta and San Francisco Bay include several oil refineries located in the vicinity of Carquinez Strait and San Pablo Bay (Presser and Luoma 2013; SWRCB 2011a). The specific water bodies within these areas that may be affected by the project and are impaired by selenium, as specified on the California CWA Section 303(d) list, include the Panoche Creek (from Silver Creek to Belmont Avenue), Mendota Pool, Grasslands Marshes, San Joaquin River (from Mud Slough to Merced River), Sacramento-San Joaquin Delta, and Suisun Bay (SWRCB 2011a).

Adverse effects of selenium may occur as a result of either a selenium deficiency or excess in the diet (ATSDR 2003; Ohlendorf 2003); the latter is the primary concern in the case of the impaired water bodies on the 303(d) list. Because of the known effects of selenium bioaccumulation from water to aquatic organisms and to higher trophic levels in the food chain, the fresh water, estuarine and wildlife habitat; spawning, reproduction, and/or early development; and rare, threatened, or endangered species beneficial uses of the water bodies are the most sensitive receptors to selenium exposure. Thus, excessive exposure can lead to selenium toxicity or selenosis and result in death or deformities of fish embryos, fry, or larvae (Ohlendorf 2003, Janz et al. 2010). Consequently, regulatory agencies have established exposure criteria to protect the beneficial uses of the water bodies.

Agencies such as the Agency for Toxic Substances and Disease Registry (ATSDR), California Office of Environmental Health Hazard Assessment (OEHHA), USEPA, SWRCB, and RWQCBs have determined acceptable selenium exposure levels for humans and water bodies in California. The ATSDR has stated the minimum risk levels (MRLs) for selenium to be ingested over a one-year period is 0.005 mg/kg/day, with an uncertainty factor of 3 (ATSDR 2013a). The 0.005 mg/kg/day value is also used by OEHHA to develop guidelines for consuming fish (OEHHA 2008). USEPA has set 50 µg/l as the maximum MCL for selenium in drinking water and OEHHA has set a more stringent draft public health goal (PHG) of 30 µg/l for selenium in drinking water (USEPA 2009a; OEHHA 2010). USEPA has also specified through the California Toxics Rule that the water quality criteria for aquatic life in all of California’s fresh water bodies except for the San Joaquin River from Merced River to Vernalis are 20 µg/l for short-term (1-hour average) and 5 µg/l for long-term (4-day average) exposure (USEPA 2000a). For the San Joaquin River from Merced River to Vernalis, the short-term exposure is 12 µg/l and long-term limit is 5 µg/l, as stated in the Sacramento-San Joaquin River Basin Plan (CVRWQCB 2011). The water quality criteria for aquatic life in all of California’s water bodies is 5 µg/l (4-day average exposure) and 20 µg/l (1-hour exposure) (USEPA 2014a).

The USEPA, Reclamation, the SWRCB, and the RWQCBs have created plans to reduce the toxic levels of selenium in California’s impaired water bodies. The USEPA’s Action Plan consists of recommendations to restore water quality and to protect aquatic species in the San Francisco Bay and Sacramento-San Joaquin Delta, which include strengthening selenium water quality criteria to reduce long-term exposure of sensitive aquatic and terrestrial species to selenium (USEPA 2012a). Grasslands Marshes, located in the San Joaquin Valley, include an area contaminated with selenium from agricultural irrigation and drainage practices when the marshes were irrigated with a blend of subsurface agricultural drainage water and higher-quality water. Reclamation’s Grasslands Bypass Project reroutes the discharge of selenium-laden subsurface agriculture water from upstream agricultural dischargers that formerly passed through the Grassland Water District and nearby wildlife refuges and wetlands to Mud Slough by conveying it through a portion of the San Luis Drain. The project began in 1996 and has since reduced the selenium load discharged from the Grassland Drainage Area from 9,600 lbs to 2,200 lbs in 2011 (GBPOC 2013). Both the USEPA Action Plan and the Grasslands Bypass Project reduce selenium levels in waterways to meet the water quality objective targeted for December 2019. The CVRWQCB released a draft waste discharge requirement in May 2014 that suggests a performance goal of 15 µg/l (monthly mean) and water quality objective of 5 µg/l (4-day average) for Mud Slough (north) and the San Joaquin

River (CVRWQCB 2014a). This water quality objective for a 4-day average selenium concentration is consistent with the TMDL for the lower San Joaquin River (CVRWQCB 2001). The USEPA also released draft water quality criteria for the protection of freshwater aquatic life from toxic effects of selenium, shown in Table 6.4 (USEPA 2014b).

**Table 6.4 Draft Water Quality Criteria for Selenium**

| **Media Type** | **Fish Tissue** | **–** | **Water Column[3]** | **–** |
|---|---|---|---|---|
| Criterion Element | Egg/Ovary[1] | Fish Whole-Body or Muscle[2] | Monthly Average Exposure | Intermittent Exposure[4] |
| Magnitude | 15.2 mg/kg | 8.1 mg/kg whole body or 11.8 mg/kg muscle (skinless, boneless filet) | 1.3 µg/l in lentic aquatic systems<br>4.8 µg/l in lotic aquatic systems | $WQC_{int} = \frac{WQC_{30-day} - C_{bkgrnd}(1-f_{in}}{f_{int}}$ |
| Duration | Instantaneous measurement[5] | Instantaneous measurement[5] | 30 days | Number of days/month with an elevated concentration |

Source: USEPA 2014b

1 Overrides any whole-body, muscle, or water column elements when fish egg/vary concentrations are measured.

2 Overrides any water column element when both fish tissue and water concentrations are measured,

3 Water column values are based on dissolved total selenium in water

4 Where $WQC_{30-day}$ is the water column monthly element, for either a lentic or lotic system, as appropriate. $C_{bkgrnd}$ is the average background selenium concentration, and $f_{int}$ is the fraction of any 30-day period during which elevated selenium concentrations occur, with $f_{int}$ assigned a value ≥0.033 (corresponding to 1 day).

5 Instantaneous measurement. Fish tissue data provide point measurements that reflect integrative accumulation of selenium over time and space in the fish at a given site. Selenium concentrations in fish tissue are expected to change only gradually over time in response to environmental fluctuations.

#### *6.3.1.5 Nutrients*

Nutrients are a constituent of concern in the lower Klamath River hydrologic area (Klamath Glen HSA) and the Suisun Marsh Wetlands (SWRCB 2011a) (Klamath Glen HSA; SWRCB 2011a). Nutrients, such as nitrogen and phosphorus, come from natural sources such as weathering of rocks and soil, and from the ocean when nutrients are mixed in the water current, as well as animal manure, atmospheric deposition, and nutrient recycling in sediment (NOAA 2014; USEPA

1998). Anthropogenic sources include fertilizers, detergents, sewage treatment plants, septic systems, combined sewer overflows, and sediment mobilization (USEPA 1998).

Nutrients are essential to maintaining a healthy water system. However, over enrichment of nitrogen and phosphorus can contribute to a process known as eutrophication where there is an excessive growth of macrophytes, phytoplankton, or potentially toxic algal blooms. Eutrophication may also lead to a decrease of dissolved oxygen, typically at night, when plants stop producing oxygen through photosynthesis but continue to use oxygen. Low dissolved oxygen levels can kill fish, cause an imbalance of prey and predator species, and result in a decline in aquatic resources (USEPA 1998). Severely low dissolved oxygen conditions are referred to as anoxic and may enhance methylmercury production (SFB RWQCB 2012a). Over enrichment can also contribute to cloudy or murky water clarity by increasing the amount of materials (i.e., algae) suspended in the water.

#### 6.3.1.6 Dissolved Oxygen

Dissolved oxygen is a constituent of concern in the project area primarily in the lower Klamath River, Sacramento-San Joaquin River Delta, and Suisun Marsh Wetlands (SWRCB 2011a). Oxygen in water comes primarily from the atmosphere through diffusion at the water surface, as well as from groundwater discharge into streams and when plants undergo photosynthesis releasing oxygen in exchange for carbon dioxide (USGS 2014; NOAA 2008a). Levels of dissolved oxygen vary with several factors including season, time of day, water temperature, salinity, and organic matter. The season and time of day dictate photosynthesis processes, which require sunlight. Increases in water temperature and salinity reduce the solubility of oxygen (NOAA 2008b). Fungus and the bacteria use oxygen when decomposing organic matter in water bodies. So, the more organic matter present in a water body, the more potential for dissolved oxygen levels to decline.

Adverse effects of low dissolved oxygen are a concern for water quality and aquatic organisms. Low dissolved oxygen impairs growth, immunity, reproduction, and causes asphyxiation and death (NCRWQCB 2011).

To protect aquatic life, USEPA has established water quality standards for dissolved oxygen (USEPA 1986a). However, to protect the beneficial uses of California's water bodies (Table 6.2), including warm and cold freshwater habitats in both tidal and non-tidal waters, site-specific water quality objectives were established.

Future plans to maintain a healthy level of dissolved oxygen in water bodies are also site-specific, such as plans for the San Joaquin River and the Stockton Deep Water Ship Channel (CVRWQCB 2011).

#### 6.3.1.7 Pesticides

Pesticides are constituents of concern throughout the study area and particularly in the Central Valley. Major pesticides of concern include organophosphate (OP) pesticides – primarily diazinon and chlorpyrifos, and organochlorine (OC) pesticides – mainly Dichloro-Diphenyl-Trichloroethane (DDT) and Group A compounds. The toxicity and fates of these pesticides are described in the following sections.

#### 6.3.1.7.1 Organophosphate Pesticides

The two most prevalent OP pesticides in the study area are man-made pesticides, diazinon and chlorpyrifos, which have been used extensively in agricultural and residential applications. Former and current uses of diazinon and chlorpyrifos have resulted in the contamination of water bodies throughout the Central Valley, as identified on the 303(d) list (SWRCB 2011a). The CVRWQCB has also identified hot spots of contamination, particularly in the Delta and in urban areas of Stockton and Sacramento (CVRWQCB 2003).

Pesticides are primarily transported into streams and rivers in runoff from agriculture (CVRWQCB 2011) but also occur or have occurred in urban non-point runoff and stormwater discharges. Treated municipal wastewater can also be a point source. However, OP pesticides, diazinon and chlorpyrifos, have been banned from non-agricultural uses since December 31st, 2004 and December, 2001, respectively. Reported non-agricultural pesticide use of diazinon and chlorpyrifos declined substantially in some counties between 2000 and 2009 (CVRWQCB 2014b). However, the reduction of OP pesticide use has resulted in the increasing use of pyrethroids and carbamates as alternative pesticides in urban and agricultural areas.

Diazinon was one of the most common insecticides in the U.S. for household lawn and garden pest control, indoor residential crack and crevice treatments and pet collars until all residential uses of diazinon were phased out, between 2002 and 2004 (USEPA 2004). Diazinon usage was then prohibited for several agricultural uses in 2007, with only a few remaining agricultural uses permitted, including uses on some fruit, vegetable, nut and field crops, and as an ear-tag on non-lactating cattle (USEPA 2007). The highest continued use of diazinon is on almonds and stone fruits (USEPA 2004).

#### 6.3.1.7.2 Organochlorine Pesticides

Organochlorine (OC) pesticides are mainly comprised of Dichloro-Diphenyl-Trichloroethane (DDT) and Group A Pesticides (CVRWQCB 2010b). DDT is a persistent chemical that binds tightly to soil and sediment, and breaks down slowly in the environment. It degrades to the isomers o,p'- and p,p'- DDT; o,p'- and p,p'-Dicholoro-Diphenyl-Dichloroethylene (DDE) and o,p'- and p,p'-Dichloro-Diphenyl-Dichloroethane (DDD). Group A Pesticides are made up of the total concentration of the OC pesticides: aldrin, dieldrin, endrin, heptachlor, heptachlor epoxide, chlordane (total), hexachlorocyclohexane (total) including Lindane (gamma-BHC), alpha-BHC, endosulfan (total), and toxaphene. These pesticides have similar chemical properties to DDT and are also persistent in the environment.

Transport of OC pesticides into streams and rivers is primarily from agriculture runoff (CVRWQCB 2011). Other potential point sources of OC pesticides include storm sewer discharges and historic spills. Non-point sources can include areas of previous residential applications, open space and channel erosion, and some background sources through wet and dry atmospheric deposition. Most OC pesticides were previously deposited on terrestrial soils, thus erosion and transport of contaminated sediments continue to contribute to detectable levels in stream bed sediment (CVRWQCB 2010b).

OC pesticides have historically been used as insecticides, fungicides and antimicrobial chemicals in residential and agricultural pest control (CVRWQCB 2010b). Most were banned in the mid-1970s, and fish tissue concentrations declined rapidly since the ban through the mid-1980s (Greenfield et al., 2004); however, they continue to be detected in fish tissue, the water column, and sediment in the Central Valley.

#### 6.3.1.7.3 Pyrethroid Pesticides

Pyrethroids (e.g., bifenthrin, permethrin, cypermethrin) are synthetic insecticides used in agriculture and households. The Surface Water Ambient Monitoring Program (SWAMP) studies indicate that the replacement of organophosphate pesticides by pyrethroids has resulted in an increased contribution of pyrethroids to ambient water and sediment toxicity (Anderson et al. 2011) In the water column, toxicity to the water flea *Ceriodaphnia dubia (C. dubia)* is caused by organophosphate and pyrethroid pesticides. Pyrethroids are also the major chemical class of concern in urban storm water, as indicated by the highly sensitive amphipod *Hyalella azteca (H. azteca)* which is highly sensitive to pyrethroids (Weston and Lydy 2010). Non-polar organic compounds, especially herbicides, and the herbicide Diuron have been identified as causes of algal toxicity in the Central Valley. Of the pyrethroid pesticides, bifenthrin is of major concern (Markiewicz et al. 2012).

Sediment criteria are also under development for pyrethroids that may inform waterbody impairment evaluations (SWRCB 2014b). With regard to sediment, as indicated by *H. azteca*, the majority of toxicity has been attributed to pyrethroids, particularly in urban areas (Markiewicz et al. 2012).

#### 6.3.1.7.4 Other Pesticides

Diuron (3-(3,4-dichlorophenyl)-1,1-dimethylurea or DCMU) was introduced in 1954 and is currently is one of the most-used herbicides in California (CVRWQCB 2012b). It is an herbicide that inhibits photosynthesis and is targeted on controlling annual broadleaf and grassy weeds. EPA has not developed a WQC specific to Diuron but a TMDL in development will include the development of WQO for Diuron in the Central Valley.

#### 6.3.1.7.5 General Pesticide Regulations

In addition to the existing water quality objectives and FCGs for pesticides in the study area, a Basin Plan Amendment for the Sacramento and San Joaquin River watersheds and the Delta is in progress to address those pesticides which currently impact or could potentially impact aquatic life uses in surface waters. The Basin

Plan Amendment will include the establishment of numeric water quality objectives for these selected pesticides. By addressing a greater grouping of pesticides than those included in the current Section 303(d) impaired water body list, the Basin Plan Amendment will help prevent the increased use of those pesticides not included on the 303(d) list (CVRWQCB 2006a).

#### *6.3.1.8 Polychlorinated Biphenyls (PCBs)*

Polychlorinated biphenyls, a group of synthetic organic chemicals, is a constituent of concern throughout California including the Sacramento River region (Sacramento River, Feather River, and American River), the Sacramento-San Joaquin River Delta, Suisun Bay, Carquinez Strait, and San Pablo Bay (SWRCB 2011a). PCBs cause harmful environmental effects and also pose a risk to human health (ATSDR 2000).

PCBs are mixtures of a variety of individual chlorinated biphenyl components, known as congeners. In the United States, many of these mixtures were sold under the trade name Aroclor, manufactured from 1930 to 1977 primarily for use as coolants and lubricants in transformers, capacitors, and other electrical equipment. Although manufacture was banned in 1979, PCBs continue to cause environmental degradation because they are environmentally persistent, easily redistributed between air, water and soil, and tend to accumulate and biomagnify in the food chain (ATSDR 2000, OEHHA 2008).

The “weathering” of PCBs is a process by which the composition of Aroclor mixtures undergo differential partitioning, degradation, and biotransformation. This results in differential environmental persistence and bioaccumulation of the mixtures, where these increase with the degree of chlorination of new mixtures. (OEHHA 2008). The biphenyls with more chlorine atoms tend to be heavier and remain close to the source of contamination, whereas those with fewer chlorine atoms are easily transported in the atmosphere. Atmospheric deposition is the primary source of PCBs to surface waters, although redissolution of sediment-bound PCBs also contributes to surface water contamination. PCBs leave the water column through sorption to suspended solids, volatilization from water surfaces, and concentration in plants and animals (ATSDR 2000).

PCBs cannot be distinctly assessed for health effects, as their toxicity is determined by the interactions of individual congeners and by the interactions of PCBs with other structurally related chemicals, including those combined with or used in the production of PCBs. However, several general health effects of PCB exposure have been identified. When PCBs are absorbed, they are distributed throughout the body and accumulate in lipid-rich tissues, including the liver, skin tissue, and breast milk. They can also be transferred across the placenta to the fetus. Studies have linked oral exposure to cancer and to adverse neurological, reproductive, and developmental effects. The International Agency for Research on Cancer has thus listed PCBs as probable human carcinogens, and OEHHA has administratively listed PCBs on the Proposition 65 list of chemicals known to the State of California to cause cancer (OEHHA 2008).

### 6.3.2 Trinity River Region

The Trinity River Region includes the area in Trinity County along the Trinity River from Trinity Lake to the confluence with the Klamath River; and in Humboldt and Del Norte counties along the Klamath River from the confluence with the Trinity River to the Pacific Ocean.

This water quality analysis includes Trinity Lake, Lewiston Lake, Trinity River downstream of Lewiston Dam, and the Klamath River from its confluence with the Trinity River to the Pacific Ocean. The analysis does not include Trinity River upstream of Trinity Lake, the South Fork of the Trinity River, or the Klamath River upstream of Trinity River, because these areas are not affected by changes in CVP operations.

Several water quality requirements affect the Klamath River and Trinity River basins. Beneficial uses and water quality objectives provided by the NCRWQCB and the Hoopa Valley Tribal Environmental Protection Agency (Hoopa Valley TEPA) are described below, as well as relevant TMDLs. The Yurok Tribe Basin Plan for the Yurok Indian Reservation and the Resighini Rancheria Tribal Water Quality Ordinance also regulate portions of the Trinity and Klamath Rivers that flow into and through the reservations; however, because they have not yet been approved by the USEPA, their objectives are not described in detail here. Oregon water quality requirements also affect the water quality of the Klamath River which originates in Oregon. However, this chapter only discusses the requirements within the Trinity and lower Klamath River Basins.

#### *6.3.2.1 Beneficial Uses*

Beneficial uses for all water bodies in the study area are determined by the NCRWQCB and the Hoopa Valley TEPA (Table 6.2). In addition to the beneficial uses listed in the Trinity and Klamath River basins, the North Coast Basin Plan notes that recreational use (i.e., water contact recreation [REC-1] and non-contact water recreation [REC-2]) occurs in all hydrologic units of the Klamath River Basin, with Trinity River being one of the rivers receiving the largest levels of recreational use (NCRWQCB 2011). Fish and wildlife reside in virtually all of the surface waters within the North Coast Region (NCRWQCB 2011). These species include several that are designated as rare, threatened and endangered. Trinity Dam also provides the beneficial use of hydroelectric power (i.e., POW).

#### *6.3.2.2 Constituents of Concern*

The constituents of concern that are currently not in compliance with existing water quality standards and for which TMDLs are adopted or are in development are summarized in Table 6.1 and discussed below.

##### 6.3.2.2.1 Water Temperature

The majority of the Trinity and Klamath Rivers are not listed on the 303(d) list approved by the USEPA in 2010 as impaired by water temperature. However, the hydrologic area of the South Fork Trinity River and the lower hydrologic area of the Klamath River (Klamath Glen HSA) are listed for elevated water temperatures adversely affecting the cold freshwater habitat (SWRCB 2011c-h).

The Trinity River and lower Klamath River watersheds must maintain water temperatures to protect and support resident and seasonal fish species habitats. The North Coast Basin Plan designates narrative and numeric water temperature objectives applicable to surface waters in the Trinity River and the lower Klamath River basins. Other objectives and criteria specific to each region are specified below.

### *Trinity River*

The South Fork Trinity River flows from its headwaters to the confluence with the mainstem of the Trinity River. It then flows into the lower Klamath River and out to the Pacific Ocean. Elevated water temperatures in the South Fork Trinity River can be attributed to the loss of shade trees due to habitat modification, range grazing, removal of riparian vegetation, streambank modification and destabilization, and water diversions (SWRCB 2011d). This reach supports steelhead, Chinook Salmon, and Coho Salmon (below Grouse Creek) (USDAFS 2014). The mainstem of the Trinity River also supports steelhead, Coho Salmon, and Chinook Salmon.

Water temperature objectives, summarized in Table 6.5, were set forth in the North Coast Basin Plan specifically applicable to the Trinity River, from Lewiston Dam to Douglas City and to the confluence with the North Fork Trinity River. These criteria are reach dependent, and vary seasonally. They were specifically developed to enhance the productivity of Trinity River Fish Hatchery, specifically for salmon and steelhead trout populations (NCRWQCB 2011).

**Table 6.5 Water Quality Objectives for Temperature in the Trinity River**

| Period | Daily Average Temperature Not to Exceed | Trinity River Reach |
|---|---|---|
| July 1 – September 14 | 60° F | Lewiston Dam to Douglas City Bridge |
| September 15 – October 1 | 56° F | Lewiston Dam to Douglas City Bridge |
| October 1 – December 31 | 56° F | Lewiston Dam to confluence of North Fork Trinity River |

Source: NCRWQCB 2011

### *Hoopa Valley Indian Reservation*

Natural causes of temperature exceedances, such as unusually excessive ambient air temperatures coupled with flows, intended to protect aquatic habitat specified in the Trinity River Flow Evaluation report (TRFE), will not be considered to violate the water quality objectives stated in the Hoopa Valley Indian Reservation Basin Plan.

Temperature objectives for the Trinity River as it passes through the Hoopa Valley Reservation vary seasonally and are precipitation dependent (Table 6.6).

The water quality objectives are based on temperature-flow relationships that maintain TRFE flow regimes and protect adult salmonids holding and spawning. The objectives are also consistent with the temperature standards specified in the NCRWQCB Basin Plan (Hoopa Valley TEPA 2008).

**Table 6.6 Trinity River Temperature Criteria for the Hoopa Valley Indian Reservation**

| | **Running 7-Day Average Temperature not to Exceed[1,2]** | |
|---|---|---|
| **Dates** | **Extremely Wet, Wet and Normal Water Years** | **Dry and Critically Dry Water Years** |
| May 23 – June 4 | 59º F | 62.6º F |
| June 5 – July 9 | 62.6º F | 68º F |
| July 10 – September 14 | 72.0º F | 74.0º F[3] |
| September 15 – October 31 | 66.0º F | 66.0º F |
| November 1 – May 22 | 55.4º F | 59.0º F |

Source: Adapted from Hoopa Valley TEPA 2008

1 Temperature standards will be monitored at the Weitchpec temperature monitoring station operated and maintained by Reclamation.

2 Temperature standard violations will be determined if more than ten percent of seven-day running averages exceed the standard, to be determined by the number of days exceeded for that seasonal period (i.e., for June 16 – September 14, a 91 day period, ten percent exceedance will equate to nine days).

3 For the seasonal period of June 16 – September 14, temperatures on the mainstem Trinity River at the Weitchpec gauging station were used to determine running seven-day averages.

The Hoopa Valley TEPA established a goal of attaining a temperature of 21º C (69.8º F) during the July 10 – September 14 period within five years of the adoption of these standards (Hoopa Valley TEPA 2008). If monitoring reveals that temperatures continue to increase, the Hoopa Valley TEPA will employ adaptive management strategies until temperatures begin to decrease

In addition to the seasonal water temperature criteria, the Hoopa Valley TEPA has established varying criteria for each life stage of salmonids (Table 6.7).

**Table 6.7 Tributary Temperature Criteria for the Hoopa Valley Indian Reservation**

| Dates | Maximum Weekly Average Temperature (MWAT)[1,2] | | Applicable Salmonid Life Stage(s)[3] |
|---|---|---|---|
| | Extremely Wet, Wet and Normal Water Years | Dry and Critically Dry Water Years | |
| May 23 – June 4 | 55.4º F | 57.2º F | Adult holding; coho incubation and emergence; spawning; smoltification |
| June 5 – Jul 9 | 60.8º F | 62.6º F | Adult holding; peak temperatures timeframe according to Hoopa Tribal data |
| July 10 – September 14 | 64.4º F | 68.0º F | Adult holding |
| September 15 – October 31 | 57.2º F | 60.8º F | Adult holding; spawning |
| November 1 – May 22 | 50.0º F | 53.6º F | Adult incubation and emergence (including coho); smoltification; spawning |

Source: Adapted from Hoopa Valley TEPA 2008

1 The MWAT is defined as the highest 7-day moving average of equally spaced water temperature measurements for a given time period. In this application, the time period is the duration of the existing salmonids life stage. For the MWAT objective, temperatures may not exceed the numeric objective for every 7-day period during the given life stage.

2 Applicable where a given species and life stage time period exist, and when and where the species and life stage time period existed historically, and have the potential to exist again.

3 Adult migration and juvenile rearing are considered all year life stages.

Water temperature data for Trinity River between 2001 and 2012 show seasonal trends and the warming effect of ambient conditions at the downstream location (Table 6.8 and Figure 6.1). Compliance locations for water quality monitoring along the Trinity River are shown in Figure 6.2.

**Table 6.8 Monthly Average of Water Temperatures Recorded at Trinity River Compliance Locations**

| WY | WYT | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Douglas City** | | | | | | | | | | | | | |
| 2001 | D | 51.9 | 46.6 | 44.2 | 42.0 | 43.2 | 47.5 | 50.7 | 54.4 | 55.5 | 58.5 | 57.0 | 54.2 |
| 2002 | D | 51.0 | 47.7 | 42.7 | 43.1 | 43.8 | 46.6 | 52.5 | 49.4 | 56.1 | 58.9 | 56.2 | 54.4 |
| 2003 | AN | 49.8 | 46.5 | 44.6 | 44.9 | 44.8 | 48.0 | 48.8 | 50.4 | 52.8 | 57.0 | 56.6 | 52.7 |
| 2004 | BN | 51.2 | 46.6 | 43.7 | 41.5 | 43.7 | 47.5 | 51.4 | 50.3 | 51.4 | 54.7 | 56.4 | 53.0 |
| 2005 | AN | 50.9 | 47.4 | 42.9 | 42.8 | 45.3 | 48.2 | 50.8 | 49.9 | 52.2 | 57.9 | 59.5 | 54.7 |
| 2006 | W | 51.5 | 47.4 | 43.9 | 45.5 | 44.4 | 44.2 | 47.5 | 48.4 | 49.3 | 54.9 | NA | NA |
| 2007 | D | NA | NA | 43.0 | 39.8 | 43.1 | 48.4 | 52.5 | 47.9 | 55.8 | 58.7 | 57.2 | 54.1 |
| 2008 | C | 50.3 | 46.9 | 41.8 | 39.8 | 41.2 | 46.4 | 50.0 | 48.6 | 50.8 | 53.4 | 58.0 | 55.3 |
| 2009 | D | 51.4 | 49.3 | 43.5 | 43.0 | 43.4 | 46.8 | 51.7 | 50.9 | 56.6 | 60.5 | 58.1 | 55.9 |
| 2010 | BN | 51.2 | 47.5 | 42.2 | 44.3 | 45.2 | 46.8 | 48.4 | 48.4 | 52.3 | 57.3 | 58.5 | 55.1 |
| 2011 | W | 51.4 | 46.7 | 44.4 | 42.3 | 42.6 | 45.2 | 48.8 | 47.7 | 50.4 | 54.4 | 57.6 | 53.9 |
| 2012 | BN | 50.5 | 45.5 | 41.2 | 40.2 | 43.5 | 45.2 | 48.9 | 49.3 | 50.9 | 55.2 | 55.6 | 52.4 |
| WY | WYT | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **North Fork Trinity near Helena** | | | | | | | | | | | | | |
| 2001 | D | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 2002 | D | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 2003 | AN | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 2004 | BN | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 2005 | AN | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 64.5 | 58.2 |
| 2006 | W | 53.4 | 47.8 | 44.0 | 45.7 | 44.8 | 44.9 | 48.3 | 49.6 | 51.4 | 59.0 | NA | NA |
| 2007 | D | NA | NA | 42.5 | 39.6 | 43.5 | 48.9 | 53.2 | 49.3 | 59.8 | 65.4 | 63.0 | 58.3 |
| 2008 | C | 52.5 | 48.3 | 42.0 | 40.6 | 42.3 | 46.6 | 50.1 | 50.1 | 53.2 | 56.7 | 62.8 | 59.2 |
| 2009 | D | 53.3 | 49.6 | 43.0 | 42.5 | 43.4 | 47.0 | 51.8 | 52.6 | 59.7 | 66.0 | 62.9 | 60.0 |
| 2010 | BN | 53.4 | 47.7 | 41.9 | 44.8 | 45.9 | 47.1 | 48.4 | 49.4 | 53.7 | 60.9 | 63.3 | 59.0 |
| 2011 | W | 53.9 | 47.1 | 45.1 | 43.1 | 43.0 | 45.2 | 45.5 | NA | NA | NA | NA | NA |
| 2012 | BN | 52.8 | 46.4 | 40.9 | 39.9 | 43.8 | 45.1 | 49.1 | 50.6 | 53.3 | 59.3 | 60.3 | 55.9 |
| WY | WYT | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| **Weitchpec** | | | | | | | | | | | | | |
| 2001 | D | 57.9 | 48.2 | 44.8 | 41.9 | 43.5 | 48.8 | 52.1 | 60.9 | 65.8 | 73.8 | 72.1 | 67.0 |
| 2002 | D | 59.3 | 51.2 | 46.0 | 44.7 | 45.8 | 47.4 | 53.9 | 55.9 | 66.1 | 73.6 | 71.1 | 67.2 |
| 2003 | AN | 57.5 | 49.1 | 46.7 | 49.3 | 50.8 | 54.2 | 54.8 | 58.6 | 69.5 | 70.2 | 71.3 | 64.6 |
| 2004 | BN | 59.7 | 50.4 | 46.3 | 45.3 | 46.8 | 53.5 | 58.7 | 56.6 | 62.3 | 70.4 | 72.1 | 64.4 |
| 2005 | AN | 58.6 | 49.9 | 45.0 | 44.3 | 46.7 | 50.0 | 51.5 | 54.6 | 59.5 | 69.8 | 73.0 | 64.9 |
| 2006 | W | 58.8 | 50.6 | 46.4 | 48.8 | 47.5 | 47.8 | 50.2 | 53.8 | 57.1 | 65.2 | NA | NA |
| 2007 | D | NA | NA | 47.9 | 44.9 | 48.3 | 52 | 56.2 | 56.3 | 66.6 | 73.2 | 72.6 | NA |
| 2008 | C | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 2009 | D | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |

| WY | WYT | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2010 | BN | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 2011 | W | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 2012 | BN | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |

Source: DWR 2014a,b,c

Temperatures in the Trinity River within the Reservation boundary will be monitored based on water-year type as established by the TRFE and determined by the Bureau of Reclamation.

Activities that increase water temperatures must comply with Tribal and Federal anti-degradation policies. The responsible party must not increase water temperatures, even if caused by their actions coupled with natural factors (Hoopa Valley TEPA 2008). In some streams, the numeric objectives may not be attainable due to site specific limitations. If this is the case, and provided that the stream has been restored to its full site potential; and the salmonid population is at a level consistent with the National Marine Fisheries Service (NMFS) concept of a 'Viable Salmonid Population'(McElhany et al. 2000), then the Hoopa Valley TEPA may not be applicable.

#### 6.3.2.2.2 Mercury

Trinity Lake and the upper hydrologic area of the East Fork Trinity River are two water bodies in the North Coast that were placed on the Section 303(d) list, approved by USEPA in 2010 (SWRCB 2011a), as impaired due to mercury. Mercury in Trinity Lake can be attributed to atmospheric deposition, natural sources, resource extractions, and other unknown sources (SWRCB 2011b). Significant mercury contamination is likely due to historical gold and mercury mining activities along the East Fork Trinity River at the inactive Altoona Mercury Mine (May et al. 2004).

The commercial or recreational collection of fish, shellfish, or organisms was deemed impaired since fish tissue exceeded USEPA's recommended Fish Tissue Residue Criteria for human health of 0.3 mg of methylmercury (wet weight) per kg of fish tissue (SWRCB 2011b-g). This criterion is based on the consumption-weighted rate of 0.0175 kg of total fish and shellfish per day. Fourteen out of fifty seven fish tissue samples from fish in the North and the East Fork of the lake in September 2001 and 2002 exceeded this fish tissue criterion. Composite fish tissue samples that exceeded the criterion were from White Catfish, Smallmouth Bass, and Chinook Salmon.

For the protection of marine aquatic life, water quality objectives for mercury were set for discharges within the area specified in the North Coast Region Water Quality Control Board Basin Plan as follows (NCRWQCB 2011).

- Six-Month Median: 0.04 µg/l
- Daily Maximum: 0.16 µg/l
- Instantaneous Maximum: 0.4 µg/l (conservative estimate for chronic toxicity)

In an effort to meet the water quality standards in Trinity Lake and the East Fork of Trinity River, a TMDL is expected to be completed by 2019. An approach for calculating effluent limitations was established in the NCRWQCB Basin Plan (NCRWQCB 2011).

#### 6.3.2.2.3 Nutrients

The lower Klamath River was placed on the 303(d) list approved by the USEPA in 2010 for being impaired by nutrients (SWRCB 2011a). Nutrient levels in the Klamath Estuary may cease to be a limiting factor and can promote levels of algal growth that cause a nuisance or adversely affect beneficial uses when excess growth is not consumed by animals or exported by flows (DOI and DFG 2012).

The Klamath River receives the greatest nutrient loading from the Upper Klamath basin, comprising approximately 40 percent of its total contaminant load (NCRWQCB 2010). Tributaries to the Klamath River are the greatest contributors of the remaining nutrient loads, with the Trinity River contributing the most.

The Hoopa Valley TEPA also designates water quality objectives to address contamination by nutrients (Table 6.9).

**Table 6.9 Specific Use Water Quality Criteria for Waters of the Hoopa Valley Indian Reservation**

| Contaminant | Trinity River | Klamath River |
|---|---|---|
| Maximum Annual Periphyton Biomass | – | 150 mg chlorophyll *a*/m$^2$ of streambed area |
| pH | MUN-designated waters: 5.0 – 9.0<br>All other designated uses: 7.0 – 8.5 | 7.0 – 8.5 |
| Total Nitrogen[1] | – | 0.2 mg/l |
| Total Phosphorus[1] | | 0.035 mg/l |
| Microcystis aeruginosa cell density | – | < 5,000 cells/mL for drinking water<br>< 40,000 cells/mL for recreational water |
| Microcystin toxin concentration | | < 1 µg/l total microcystins for drinking water<br>< 8 µg/l total microcystins for recreational water |
| Total potentially toxigenic blue-green algal species[2] | | < 100,000 cells/mL for recreational water |

| Contaminant | Trinity River | Klamath River |
|---|---|---|
| Cyanobacterial scums |  | There shall be no presence of cyanobacterial scums |

Source: Hoopa Valley TEPA 2008

1 There should be at least two samples per 30-day period. If total nitrogen and total phosphorus standards are not achievable due to natural conditions, then the standards shall instead be the natural conditions for total nitrogen and total phosphorus. Through consultation, the ongoing TMDL process for the Klamath River is expected to further define these natural conditions.

2 Includes: Anabaena, Microcystis, Planktothrix, Nostoc, Coelsphaerium, Anabaenopsis, Aphanizomenon, Gloeotrichia, and Oscillatoria.

In addition to the water quality criteria established by the Hoopa Valley TEPA (2008), the 2010 *Klamath River TMDLs Addressing Temperature, Dissolved Oxygen, Nutrient, and Microcystin Impairments in California* provides TMDLs for nutrients which address elevated pH levels (DOI and DFG 2012). Nutrient targets include numeric targets for total phosphorus (TP), total nitrogen (TN) (NCRWQCB 2010).

The Klamath River nutrient TMDLs are in the process of being implemented by the NCRWQCB and other affiliated agencies, including the SWRCB, the USEPA, Reclamation, the USFWS, the Oregon Department of Environmental Quality, responsible for implementation of the Klamath TMDLs in Oregon, and other state, federal, and private agencies with operations that affect the Klamath River (NCRWQCB 2010).

#### 6.3.2.2.4 Organic Matter

The lower Klamath River was placed on the 303(d) list approved by the USEPA in 2010 for impairment due to organic enrichment (SWRCB 2011a).

The Klamath River has several natural sources of organic matter. The river originates from the Upper Klamath Lake, which is a naturally shallow, eutrophic lake, with high levels of organic matter (algae), including nitrogen fixing blue-green algae (NCRWQCB 2010). Other sources of organic matter include runoff from agricultural lands (i.e., irrigation tailwater, storm runoff, subsurface drainage, and animal waste), flow regulations/modification, industrial point sources, and municipal point sources (SWRCB 2011).

To protect the beneficial uses of the lower Klamath River, including cold freshwater habitat, a TMDL was established in 2010 for organic matter and other constituents. The TMDL equals 143,019 pounds of Carbonaceous Biochemical Oxygen Demand (CBOD) per day from the Klamath River (NCRWQCB 2011h). The average organic matter (measured as CBOD) loads from all other Klamath River tributaries are sufficient to meet other related objectives, including dissolved oxygen and biostimulatory substances objectives, in the Klamath River (NCRWQCB 2010). The dissolved oxygen objectives are the primary targets associated with organic matter as well as nutrients. Organic matter allocations were also established for the Klamath River below Salmon River, and the major tributaries to the Klamath, including Trinity River.

Implementation actions and other objectives were established to ensure the TMDL is met to protect the beneficial uses of the Klamath River and other water bodies downstream. The North Coast Basin Plan states that a water quality study will be completed to identify actions for monitoring, evaluating, and implementing any necessary actions to address organic matter loading so that the TMDL will be met (NCRWQCB 2011).

#### 6.3.2.2.5 Dissolved Oxygen

The lower Klamath River was placed on the 303(d) list approved by the USEPA in 2010 for low dissolved oxygen (SWRCB 2011a).

Sources that contribute to low dissolved oxygen include sources of organic enrichment, specified in the previous section; water temperature; and salinity, explained further in Section 6.3.2.6. Other sources that contribute to low dissolved oxygen are runoff from roads and agriculture that can transport nutrients into water bodies and lower dissolved oxygen through biostimulatory effects (NCRWQCB 2010). Over-enrichment and growth of algae and aquatic plants can produce oxygen during the day through photosynthesis but those same plants can deplete dissolved oxygen at night.

To protect the beneficial uses of the lower Klamath River, including the cold freshwater habitat, water quality objectives were established in the North Coast Basin Plan (2010) and the Hoopa Valley TEPA (2008) for dissolved oxygen in the Klamath River and its major tributary, the Trinity River (Table 6.10 and Table 6.11) (NCRWQCB 2011). Site Specific Objectives (SSOs) for dissolved oxygen were calculated as part of TMDLs developed by the NCRWQCB (2011), and have been incorporated into the North Coast Basin Plan (2011) (Table 6.12). For those waters without location-specific dissolved oxygen criteria, dissolved oxygen shall not be reduced below minimum levels, shown in Table 6.13, at any time to protect beneficial uses.

**Table 6.10 Water Quality Objectives for Dissolved Oxygen in Trinity and Lower Klamath**

| | **Dissolved Oxygen (mg/l)** | |
|---|---|---|
| **Water body** | **Minimum** | **50% Lower Limit[1]** |
| Trinity Lake and Lewiston Reservoir | 7.0 | 10.0 |
| Lower Trinity River | 8.0 | 10.0 |
| Lower Trinity Area Streams | 9.0 | 10.0 |
| Lower Klamath River Area Streams | 8.0 | 10.0 |

Source: NCRWQCB 2011

1: 50 percent lower limit represents the 50 percentile values of the monthly means for a calendar year. 50 percent or more of the monthly means must be greater than or equal to the lower limit.

**Table 6.11 Specific Use Water Quality Criteria for Waters of the Hoopa Valley Indian Reservation**

| Contaminant | Trinity River | Klamath River |
|---|---|---|
| Minimum Water Column Dissolved Oxygen Concentration | 11.0 mg/l | SPWN-designated waters[1]: 11.0 mg/l[2]<br>COLD-designated waters: 8.0 mg/l[2] |
| Minimum Inter-gravel Dissolved Oxygen Concentration | 8.0 mg/l | SPWN-designated waters[1]: 8.0 mg/l[2] |

Source: Hoopa Valley TEPA 2008

1 Whenever spawning occurs, has occurred in the past or has potential to occur.

2 7-day moving average of the daily minimum DO. If dissolved oxygen standards are not achievable due to natural conditions, the COLD and SPWN standard shall instead be dissolved oxygen concentrations equivalent to 90 percent saturation under natural receiving water temperatures.

**Table 6.12 Site Specific Objectives for Dissolved Oxygen in the Klamath River[1]**

| Location[2] | Percent Dissolved Oxygen Saturation Based On Natural Receiving Water Temperatures[3] | Time Period |
|---|---|---|
| Downstream of Hoopa-California Boundary to Turwar | 85 | June 1 through August 31 |
| | 90 | September 1 through May 31 |
| Upper and Middle Estuary | 80 | August 1 through August 31 |
| | 85 | September 1 through October 31 and June 1 through July 31 |
| | 90 | November 1 through May 31 |
| Lower Estuary | For the protection of estuarine habitat (EST), the dissolved oxygen content of the Lower Klamath estuary shall not be depressed to levels adversely affecting beneficial uses as a result of controllable water quality factors. | |

Source: NCRWQCB 2011

1 States may establish site specific objectives equal to natural background (USEPA 1986a. Ambient Water Quality Criteria for Dissolved Oxygen, EPA 440/5-86-033; USEPA Memo from Tudor T. Davies, Director of Office of Science and Technology, USEPA Washington, D.C. dated November 5, 1997). For aquatic life uses, where the natural background condition for a specific parameter is documented, by definition that condition is sufficient to support the level of aquatic life expected to occur naturally at the site absent any interference by humans (Davies 1997). These dissolved oxygen objectives are derived from the T1BSR run of the Klamath TMDL model and described in Tetra Tech, December 23, 2009 Modeling Scenarios: Klamath River Model for TMDL Development (Tetra Tech and WR and TMDL Center 2009). They represent natural dissolved oxygen background conditions due only to non-anthropogenic sources and a natural flow regime.

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

3 Corresponding dissolved oxygen concentrations are calculated as daily minima, based on site-specific barometric pressure, site-specific salinity, and natural receiving water temperatures as estimated by the T1BSR run of the Klamath TMDL model and described in Tetra Tech, December 23, 2009 (Tetra Tech and WR and TMDL Center 2009). Modeling Scenarios: Klamath River Model for TMDL Development. The estimates of natural receiving water temperatures used in these calculations may be updated as new data or method(s) become available. After opportunity for public comment, any update or improvements to the estimate of natural receiving water temperature must be reviewed and approved by Executive Officer before being used for this purpose.

**Table 6.13 Water Quality Objectives for Dissolved Oxygen for Specified Beneficial Uses**

| Beneficial Use Designation | Minimum Dissolved Oxygen Limit (mg/l) |
|---|---|
| WARM, MAR, or SAL | 5.0 |
| COLD | 6.0 |
| SPWN | 7.0 |
| SPWN – during critical spawning and egg incubation periods | 9.0 |
| Klamath River Water Column[1] | |
| SPWN-designated waters[2]: | 11.0 mg/l[3] |
| COLD-designated waters: | 8.0 mg/l[3] |
| Klamath River Inter Gravel[1]<br>SPWN-designated waters[2]: | 8.0 mg/l[3] |

Source: NCRWQCB 2011

1 Hoopa Valley TEPA (2008)

2 Whenever spawning occurs, has occurred in the past or has potential to occur.

3 7-day moving average of the daily minimum DO. If dissolved oxygen standards are not achievable due to natural conditions, the COLD and SPWN standard shall instead be

dissolved oxygen concentrations equivalent to 90 percent saturation under natural receiving water temperatures.

The 2010 *Klamath River TMDLs Addressing Temperature, Dissolved Oxygen, Nutrient, and Microcystin Impairments in California* provide numerical targets for dissolved oxygen and other constituents (NCRWQCB 2010). Site specific objectives for dissolved oxygen were proposed in this TMDL and adopted into the North Coast Basin Plan (Table 6.29). The dissolved oxygen objectives are the primary targets associated with nutrient and organic matter, with additional dissolved oxygen-related TMDLs prescribed for total phosphorus (TP), total nitrogen (TN) and organic matter (CBOD) loading, and numerical targets provided for benthic algae biomass, suspended algae chlorophyll-a, *microcystis aeruginosa*, and microcystin toxin discussed in their corresponding sections.

Plans to monitor dissolved oxygen and other constituents in the Klamath River below Trinity River, near Turwar, and the Klamath River Estuary were established in Chapter 7 of the Klamath River TMDLs to further protect the beneficial uses of the Trinity and lower Klamath Rivers (NCRWQCB 2010). The TMDL also includes a proposal to revise SSOs for dissolved oxygen in the Klamath River.

#### 6.3.2.2.6 Sedimentation and Siltation

Sedimentation and siltation are not caused by operation of the CVP. However, the lower Klamath River and Trinity River were placed on the 303(d) list approved in 2010 as impaired by sedimentation and siltation (SWRCB 2011a).

*Trinity River*

Disturbance of sediment and silt is a natural part of stream ecosystems, which can contribute to fluctuating salmonid populations in response to fine sediment embedded in spawning gravels. However, human activities have resulted in an increased severity and frequency of habitat disturbance (TRRP and NCRWQCB 2009). In the Mainstem Trinity River, sediment loading can be attributed to runoff from areas of active or past mining, timber harvest, and road-related activities. Natural sources, such as landsliding, bank erosion, and soil creep, contribute the greatest sediment loads each year (NCRWQCB 2008). Future point sources of sedimentation into the Trinity River Basin, including CalTrans facilities and construction sites larger than five acres have to meet discharge requirements pursuant to California's NPDES general permit for construction site runoff (USEPA 2001f).

The primary adverse impacts of excess sedimentation are those affecting the spawning habitat for anadromous salmonids (TRRP and NCRWQCB 2009). The main affected beneficial uses include commercial or sport fishing, cold fresh water habitat, migration of aquatic organisms, spawning, reproduction, and/or early development; and rare, threatened and endangered species. Recreation in the Trinity River Basin, such as boating, fishing, camping, swimming, sightseeing, and hiking, is also potentially affected because sedimentation can affect the water clarity and water quality (USEPA 2001f). Water quality objectives for sedimentation and siltation were established in the North Coast Basin Plan.

Turbidity criteria for all waters within the Hoopa Valley Indian Reservation are also under development (Hoopa Valley TEPA 2008).

In addition to these water quality objectives, the North Coast Basin Plan also prohibits the discharge of soil, silt, bark, sawdust, or other organic and earthen material from any logging, construction, or associated activity into any stream or watercourse in quantities harmful to beneficial uses, and the placing or disposal of such materials in locations where they can pass into any stream or watercourse in quantities harmful to beneficial uses (NCRWQCB 2011).

Sediment loading in the mainstem Trinity River exceeds applicable water quality standards, and is being addressed by the Trinity River TMDL for sediment, approved by the USEPA in December 2001 (SWRCB 2011b-g, USEPA 2001f). Assimilation capacity for sediment loading was determined for this TMDL and the percent reduction of managed sediment discharge required to meet the TMDL is provided for each subarea. These allocations are adequate to protect aquatic habitat, and are expected to be evaluated on a ten year rolling basis (USEPA 2001f).

*Lower Klamath River*

The Klamath River downstream of Weitchpec has also been included on the 303(d) list for contamination from sedimentation and siltation, due to exceedances of the sediment water quality criteria, and long-term sedimentation and siltation influxes (SWRCB 2011h).

Major sources of sediment discharge in the lower Klamath River are from ongoing logging and runoff from major storm events. According to reports cited by the SWRCB, water quality in runoff from timber harvest in all lower Klamath watersheds exceed cumulative effect thresholds (SWRCB 2011h).

The *Long Range Plan for the Klamath River Basin Fishery Conservation Area Restoration Program* (1986 to 2006) emphasizes sedimentation in the lower Klamath Basin, and notes that the sediment is creating problems with fish passage and stream bed stability (Klamath River Basin Fisheries Task Force 1991). The near extinction of the eulachon indicated problems with sediment supply, size and bed load movement, and that aggradations in salmon spawning reaches are expected to persist for decades (SWRCB 2011h). Increased sediment loads also result from the widening of stream channels, through processes like bank erosion, and with the related reduction of riparian shade can contribute to elevated stream temperatures (NCRWQCB 2010). The North Coast Basin Plan includes the TMDLs for the region, which include those that address sedimentation and siltation (NCRWQCB 2011).

## 6.3.3 Central Valley Region

### *6.3.3.1 Sacramento Valley*

Major watersheds within the Sacramento Valley that could be affected by CVP and SWP operations include the Sacramento River, Feather River, and the lower American River watersheds.

This water quality analysis section focuses on Shasta Lake, Keswick Reservoir, Whiskeytown Lake, Spring Creek and Clear Creek; the Sacramento River from Shasta Lake to the Delta (near Freeport); the Feather River below Lake Oroville; American River below Lake Natoma; and Yolo Bypass.

Beneficial uses for the Sacramento Valley, as defined in the Central Valley Basin Plan, are summarized in Table 6.2. The constituents of concern that are currently not in compliance with existing water quality standards and for which TMDLs are adopted or are in development in this region are summarized in Table 6.1.

#### 6.3.3.1.1 Sacramento River from Shasta Lake to Verona

Water quality in the upper Sacramento River is influenced by releases from Shasta Lake and diversions from Trinity Lake. Annual and seasonal flows in the Sacramento River watershed are highly variable from year to year, as described in Chapter 5, Surface Water Resources and Water Supplies. These variations in flow are a source of variability in water quality in the Sacramento drainage.

The water quality constituents that are currently not in compliance with existing water quality standards and for which TMDLs are adopted or are in development in this region are: mercury, PCBs, unknown toxicity and multiple pesticides. Chlorpyrifos and diazinon have been addressed by changes to the Basin Plan, cadmium, copper, zinc have been addressed by a TMDL, and temperature is also closely monitored.

*Water Temperature*

The Sacramento River was not placed on the 303(d) list approved by the USEPA in 2010 as impaired by water temperature (SWRCB 2011a). However, water bodies in the Upper Sacramento River watershed support the beneficial uses of both warm and cold fresh water habitat, which require that the water bodies maintain water temperatures suitable for multiple fish species (CVRWQCB 2011). Water quality objectives have been established by the SWRCB for Sacramento River, as summarized in Table 6.14 and Appendix 3A, No Action Alternative: Central Valley Project and State Water Project Operations. Compliance locations in the upper Sacramento River basin are shown in Figure 6.2. Performance measures to meet temperature requirements are included in the 2009 NMFS BO, as described in Appendix 3A, No Action Alternative: Central Valley Project and State Water Project Operations.

**Table 6.14 Water Quality Objectives for Temperature in the Sacramento River**

| Applicable Water Bodies | Objective |
|---|---|
| Sacramento River from Keswick Dam to Hamilton City | > 56º F |
| Sacramento River from Hamilton City to the I Street Bridge (during periods when temperature increases will be detrimental to the fishery) | > 68º F |

Source: CVRWQCB 2011

Table 6.15 and Figure 6.3 depict monthly water temperature data at selected compliance locations in the Sacramento River between 2001 and 2012.

**Table 6.15 Monthly Average of Water Temperatures Recorded at Sacramento River Compliance Locations in °F**

| WY | WYT | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Balls Ferry** | | | | | | | | | | | | | |
| 2001 | D | 55.0 | 53.2 | 51.4 | 47.9 | 47.0 | 51.5 | 52.5 | 52.9 | 53.6 | 54.5 | 54.3 | 55.3 |
| 2002 | D | 56.1 | 54.3 | 50.0 | 49.4 | 48.8 | 50.5 | 53.9 | 53.7 | 53.7 | 54.4 | 54.4 | 54.0 |
| 2003 | AN | 54.4 | 54.2 | 50.0 | 49.6 | 49.3 | 51.7 | 53.2 | 53.3 | 53.5 | 53.6 | 54.9 | 55.4 |
| 2004 | BN | 54.7 | 52.6 | 50.2 | 48.3 | 47.6 | 50.9 | 52.5 | 53.0 | 53.7 | 54.5 | 54.6 | 56.7 |
| 2005 | AN | 56.5 | 54.9 | 50.6 | 48.8 | 50.0 | 52.1 | 54.1 | 54.2 | 53.5 | 54.0 | 55.4 | 55.6 |
| 2006 | W | 56.2 | 54.5 | 50.5 | ND | 47.8 | 47.7 | 49.7 | 52.7 | 52.8 | 53.6 | 53.8 | 53.5 |
| 2007 | D | 53.4 | 52.4 | 49.7 | 47.7 | 48.4 | 52.0 | 54.0 | 52.9 | 53.8 | 55.2 | 55.1 | 55.7 |
| 2008 | C | 55.9 | 55.3 | 50.1 | 45.7 | 46.8 | 49.8 | 50.9 | 52.9 | 55.6 | 56.0 | 56.4 | 57.0 |
| 2009 | D | 58.1 | 55.8 | 50.1 | 47.5 | 47.8 | 50.6 | 51.6 | 53.8 | 55.0 | 56.0 | 56.0 | 56.5 |
| 2010 | BN | 56.5 | 55.1 | 49.4 | 48.3 | 49.6 | 50.9 | 52.5 | 54.0 | 53.5 | 53.9 | 54.2 | 54.2 |
| 2011 | W | 54.0 | 51.3 | 51.2 | 49.2 | 48.0 | 48.8 | 51.8 | 54.1 | 53.6 | 53.6 | 54.3 | 54.0 |
| 2012 | BN | 53.1 | 51.2 | 49.6 | 48.4 | 48.6 | 49.6 | 53.6 | 54.5 | 53.4 | 53.6 | 54.0 | 54.1 |
| **WY** | **WYT** | **Oct** | **Nov** | **Dec** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** |
| **Jelly's Ferry** | | | | | | | | | | | | | |
| 2001 | D | 55.5 | 52.9 | 51.1 | 47.5 | 47.0 | 52.3 | 53.6 | 54.5 | 54.7 | 55.6 | 55.6 | 56.3 |
| 2002 | D | 56.7 | 54.4 | 49.1 | 47.9 | 48.6 | 51.0 | 55.4 | 55.1 | 55.1 | 55.6 | 55.5 | 55.1 |
| 2003 | AN | 54.9 | 54.1 | 50.3 | 50.0 | 49.0 | 52.4 | 53.4 | 54.5 | 55.4 | 55.0 | 56.0 | 56.6 |
| 2004 | BN | 55.3 | 52.5 | 50.0 | 47.9 | 48.1 | 52.0 | 54.0 | 54.7 | 55.1 | 55.5 | 55.8 | 57.5 |
| 2005 | AN | 56.8 | 54.6 | 50.2 | 48.4 | 50.3 | 52.8 | 55.3 | 55.6 | 55.3 | 55.6 | 56.7 | 56.5 |
| 2006 | W | 56.5 | 54.3 | 49.9 | 49.1 | 48.3 | 47.9 | 50.7 | 54.6 | 54.8 | 55.1 | 55.0 | 54.6 |
| 2007 | D | 54.2 | 52.6 | 49.0 | 47.1 | 48.7 | 52.8 | 55.0 | 54.2 | 54.9 | 56.0 | 56.0 | 56.6 |
| 2008 | C | 56.3 | 55.4 | 49.6 | 45.4 | 47.0 | 50.5 | 52.2 | 54.5 | 56.6 | 56.9 | 57.3 | 58.0 |
| 2009 | D | 58.0 | 55.8 | 49.8 | 47.4 | 47.9 | 51.2 | 53.3 | 55.7 | 56.4 | 57.1 | 57.0 | 57.8 |
| 2010 | BN | 57.1 | 54.9 | 48.9 | 48.0 | 49.7 | 51.7 | 53.3 | 55.2 | 55.4 | 55.6 | 55.3 | 55.2 |
| 2011 | W | 54.6 | 51.3 | 50.9 | 48.9 | 47.8 | 48.7 | 52.2 | 55.3 | 55.2 | 55.0 | 55.4 | 55.2 |
| 2012 | BN | 53.7 | 51.2 | 49.1 | 48.1 | 48.8 | 49.9 | 54.4 | 56.0 | 54.8 | 54.6 | 55.1 | 55.3 |

| WY | WYT | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **WY** | **WYT** | **Oct** | **Nov** | **Dec** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** |
| **Bend Bridge** | | | | | | | | | | | | | |
| 2001 | D | 55.7 | 52.8 | 50.8 | 47.3 | 47.0 | 52.6 | 54.1 | 55.0 | 55.1 | 56.0 | 56.0 | 56.8 |
| 2002 | D | 56.9 | 54.4 | 49.0 | 48.1 | 48.9 | 51.2 | 55.8 | 55.6 | 55.6 | 56.0 | 56.2 | 55.6 |
| 2003 | AN | 55.1 | 53.9 | 50.2 | 50.0 | 49.0 | 52.6 | 53.8 | 54.7 | 55.9 | 55.4 | 56.7 | 57.0 |
| 2004 | BN | 55.5 | 52.3 | 49.4 | 48.0 | 48.2 | 52.2 | 54.2 | 55.5 | 55.6 | 56.1 | 56.2 | 57.9 |
| 2005 | AN | 57.0 | 54.4 | 50.0 | 48.3 | 50.4 | 53.1 | 55.7 | 55.9 | 55.5 | 56.0 | 57.2 | 56.9 |
| 2006 | W | 56.6 | 54.2 | 50.0 | 49.2 | 48.4 | 48.0 | 50.7 | 54.9 | 55.1 | 55.6 | 55.4 | 54.9 |
| 2007 | D | 54.4 | 52.3 | 49.1 | 46.9 | 48.8 | 52.9 | 55.1 | 54.9 | 55.5 | 56.6 | 56.6 | 57.0 |
| 2008 | C | 56.4 | 55.1 | 49.3 | 45.6 | 47.1 | 51.0 | 52.6 | 55.0 | 57.4 | 57.5 | 57.9 | 58.5 |
| 2009 | D | 57.4 | 55.8 | 49.4 | 47.3 | 48.1 | 52.0 | 53.6 | 56.1 | 56.9 | 57.7 | 57.2 | 58.0 |
| 2010 | BN | 57.0 | 54.8 | 48.6 | 47.9 | 49.6 | 51.6 | 53.3 | 55.4 | 55.5 | 56.2 | 56.2 | 55.8 |
| 2011 | W | 54.4 | 51.0 | 50.7 | 49.0 | 48.0 | 49.0 | 52.5 | 55.7 | 55.6 | 55.8 | 56.2 | 55.6 |
| 2012 | BN | 53.9 | 51.3 | 48.8 | 47.9 | 48.9 | 49.9 | 54.8 | 56.5 | 55.4 | 55.1 | 55.5 | 55.8 |

Source: Reclamation 2013b

*Mercury*

The USEPA approved a new decision to place Shasta Lake, Whiskeytown Lake, Clear Creek, and the Sacramento River from Cottonwood Creek to Red Bluff, on the Section 303(d) list in 2010 for mercury contamination (SWRCB 2011a). The Sacramento River from Red Bluff to Knights Landing has been on the 303(d) list for mercury prior to the final decision in 2010. Mercury is not a constituent of concern for the Sacramento River between Shasta Dam and the Cottonwood Creek.

Mercury in the Sacramento River Basin can be attributed to resource extraction as described in Section 6.3.2 (SWRCB 2011i-l). Significant gold mining activity took place within the Whiskeytown watershed, lands inundated by Whiskeytown Reservoir, in the Clear Creek watershed between Whiskeytown Reservoir, the confluence with the Sacramento River, and within the Sacramento River watershed.

A 2008 CALFED report tabulates methylmercury concentrations in the Sacramento River from Redding (0.3ng/l) to Freeport (0.11 ng/l) from 2003 to 2006 (Foe et al. 2008). For the 2010 listing, composite fish tissue samples were collected from Shasta Lake, Whiskeytown Lake, Clear Creek, and the Sacramento River from Cottonwood Creek to Knights Landing. The commercial or recreational collection of fish, shellfish, or organisms were deemed impaired since fish tissue exceeded USEPA's recommended Fish Tissue Residue Criteria for human health of 0.3 mg of methylmercury (wet weight) per kg of fish tissue (SWRCB 2011i-l).

In an effort to protect the beneficial uses of these water bodies, including the protection of aquatic and human health, USEPA has recommended maximum exposure concentrations. In addition, a TMDL is expected to be completed in 2021 to meet the water quality standards in these water bodies (SWRCB 2011i-l).

*Cadmium, Copper, and Zinc*

Shasta Lake where West Squaw Creek enters the lake, Spring Creek (from Iron Mountain Mine to Keswick Reservoir), and Keswick Reservoir downstream of Spring Creek were placed on the 303(d) list approved by the USEPA in 2010 for impairment by cadmium, copper, and zinc (SWRCB 2011a). The Upper Sacramento River from Keswick Dam to Cottonwood Creek was previously listed on the 303(d) list for impairment by cadmium, copper, and zinc but was delisted after a TMDL was completed in 2002 and the SWRCB determined the water quality standard was met. The elevated levels were primarily the result of acid mine drainage discharged from inactive mines in the upper Sacramento River watershed, located upstream of Shasta and Keswick dams (CVRWQCB 2002a). There are projects underway to clean up many inactive mine sites that discharge high concentrations of metals (CVRWQCB 2011).

Cadmium, copper and zinc contamination in the Sacramento River have been addressed by the *2002 Upper Sacramento River TMDL for Cadmium, Copper and Zinc*, and by water quality objectives in the Basin Plan (CVRWQCB 2002a). Although cadmium, copper, and zinc are generally found as mixtures in surface water, the mixtures tend to be antagonistic – less toxic than when found as individual components – thus the water quality objectives focus on individual parameters. Levels of water hardness affect the toxicity of these metals, where increased hardness decreases toxicity. Thus the water quality objectives at certain locations are determined using specific levels of water hardness (CVRWQCB 2002a). The TMDL for cadmium, copper, and zinc in Shasta Lake, Spring Creek, and Keswick Reservoir is expected to be completed in 2020 (SWRCB 2011i,m,n).

*Pesticides*

The Sacramento River from Red Bluff to Knights Landing was placed on the 303(d) list approved by the USEPA in 2010 as impaired by DDT and the Group A pesticide dieldrin. The Sacramento River from Knights Landing to the Delta was also placed on the 303(d) list as impaired by chlordane, DDT, and dieldrin (SWRCB 2011a). Chlordane, DDT, and dieldrin are legacy pesticides and were discontinued from the early 1970s to the late 1980s.

Although these pesticides have been discontinued since the late 1980's, the narrative water quality objective for toxicity, which applies to single or the interactive effect of multiple pesticides or substances, and states that "All waters shall be maintained free of toxic substances in concentrations that produce detrimental physiological responses in human, plant, animal, or aquatic life" has not been met. Fish concentrations of DDT collected in 2005 exceeded the Total DDT OEHHA screening value of 21 µg/kg by up to five times, which was used as a criterion to evaluate the narrative water quality objective by up to five times. Concentrations of dieldrin were also found to exceed the OEHHA Evaluation Guideline of 0.46 µg/kg (SWRCB 2011o).

To protect the beneficial uses of the Sacramento River and other water bodies downstream, including the impaired commercial or recreational collection of fish, shellfish, or organisms, TMDLs for DDT and dieldrin in the Sacramento River from Red Bluff to Knights Landing are expected to be completed in 2021 (SWRCB 2011o). For the Sacramento River from Knights Landing to the Delta, TMDLs are expected to be completed in 2021 for DDT and chlordane, and in 2022 for dieldrin.

Although the Sacramento River was not placed on the 303(d) list approved by the USEPA in 2010 for chlorpyrifos and diazinon contamination, these pesticides have also been of concern in the Sacramento River (SWRCB 2011o, CVRWQCB 2007a). Water quality sampling from 1999 to 2006 revealed concentrations of both pesticides at levels of concern in the Sacramento and Feather Rivers. In addition to runoff of applied pesticides into irrigation and storm water runoff into the Sacramento and Feather Rivers, atmospheric transport of diazinon from the Central Valley to the Sierra Nevada Mountains has been noted to occur. Of particular concern were the beneficial uses of Warm and Cold Fresh water Habitat.

*PCBs*

The reach of the Sacramento River from Red Bluff to Knights Landing was placed on the 303(d) list approved by the USEPA in 2010 as impaired by PCBs (SWRCB 2011a). According to the *Final California 2010 Integrated Report* (303(d)/305(b) Report) Supporting Information, sources of PCBs in Sacramento River are unknown (SWRCB 2011o). PCBs, a group of synthetic organic chemicals, were manufactured from 1930 to 1977 and were banned in 1979. However, these organic pollutants persistent in the environment (ATSDR 2000).

The OEHHA Fish Contaminant Goal of total PCBs in fish is 3.6 ppb (or 3.6 ng/g) (SWRCB 2011o). Fish tissue samples collected in August and October 2005 exhibited significant exceedances. Six composite samples were analyzed for 48 individual PCB congeners and four Aroclor mixtures, with the four exceedances reported as 102.499 ng/g in channel catfish at Colusa, 9.151 ng/g in channel catfish at Grimes, 6.504 ng/g in Sacramento sucker at Colusa, and 5.767 ng/g in Sacramento sucker at Woodson Bridge.

To protect the beneficial uses of the Sacramento River, including the impaired beneficial use of commercial and sport fishing, a TMDL is expected to be completed in 2021 (SWRCB 2011o).

*Unknown Toxicity*

The Sacramento River from Keswick Reservoir to Knights Landing was placed on the 303(d) list as impaired for unknown toxicity (SWRCB 2011a).

Results of survival, growth, and reproductive toxicity tests performed from 1998 to 2007 showed an increase in mortality and a reduction in growth and reproduction in *C. dubia*, the Fathead Minnow *Pimephales promelas* (*P. promelas*) and the alga *Pseudokirchneriella subcapitata* (*P. subcapitata*, formerly known as *Selenastrum capricornutum*) (SWRCB 2011l,o-q). Observations violated the narrative toxicity objective found in the Sacramento – San Joaquin River Basin Plan, which states that all waters shall be maintained free of toxic substances in concentrations that produce detrimental physiological responses in human, plant, or aquatic life (CVRWQCB 2011). This objective applies regardless of whether the toxicity is caused by a single substance or the interactive effect of multiple substances. Further research is being conducted on the causes of toxicity in the Sacramento River. The TMDL for unknown toxicity in the Upper Sacramento River is expected to be completed in 2019 (SWRCB 2011l,o-q).

A 2012 SWAMP report summarized the occurrences and causes of toxicity in the Central Valley (Markiewicz et al.2012). The SWRCB's Surface Water Ambient Monitoring Program (SWAMP) defines toxicity as a statistically significant adverse impact on standard aquatic test organisms in laboratory exposures. In order to assess the causes of toxicity in California waterways, SWAMP testing uses laboratory test organisms as surrogates for aquatic species in the environment (Anderson et al.2011).

Sediment toxicity was noted to be higher in urban areas including Sacramento, Yuba City, Redding, and Antioch, while sediments from agricultural areas were generally non-toxic (Markiewicz et al.2012). Moderate water toxicity was observed throughout the agricultural and urban-agricultural areas in the upper Sacramento watershed, including in the Colusa Basin, in the vicinity of the Sutter Buttes, and along the eastern valley floor between Chico and Lincoln.

SWAMP studies indicate that the replacement of organophosphate pesticides by pyrethroids has resulted in an increased contribution of pyrethroids to ambient water and sediment toxicity (Anderson et al. 2011). With regard to sediment, as indicated by H. azteca, the majority of toxicity has been attributed to pyrethroids, particularly in urban areas (Markiewicz et al. 2012). Of the pyrethroid pesticides, bifenthrin is of major concern.

#### 6.3.3.1.2 Sacramento River from Verona to Freeport

The water quality of the lower Sacramento River is influenced by the upstream sources discussed above as well as by inflows from the American River and from surrounding urban and agricultural runoff. The major water quality constituents of concern are described below. Water temperature is not a major concern in this lower reach of the Sacramento River because the vitality of aquatic species in this reach are not dependent on temperature.

*Mercury*

The Sacramento River from Verona to Freeport is on the 303(d) list approved by USEPA in 2010 for mercury contamination (SWRCB 2011a).

Mercury in this reach of the river can be attributed to waterborne inputs from the upper Sacramento River, Feather River, Yuba River, and American River (SWRCB 2011q). These major tributaries are also listed as impaired due to mercury. As in the Klamath and Trinity River basins, historic mining has resulted in significant mercury contamination in the Sacramento River Basin.

Flows from the Yuba River are an important source of mercury loading to the lower Sacramento River. Tailings discharged from gold mines in the Sierra Nevada mountains during the nineteenth century contained significant amounts of mercury-laden sediment, due to the use of mercury to extract gold. These discharges caused the formation of anthropogenic alluvial fans at the base of the Sierra Nevada, most notably the Yuba Fan. Singer et al. (2013) predicted that mercury-laden sediment from the original fan deposit will continue to be transported to the Sacramento River for the next 10,000 years.

The Sacramento River is a key source of mercury contamination into the Sacramento – San Joaquin River Delta. Over 80 percent of total mercury flux to the Delta can be attributed to the Sacramento River Basin (CVRWQCB 2010a). The CVRWQCB (2010a) compiled data from 2000 to 2003 and reported an average of 0.10 ng/l in the Sacramento River at Freeport. Similarly, CALFED reported that the Sacramento River at Freeport contributed an average of 0.11 ng/l of methylmercury to the Delta from 2003 to 2006 (Foe et al. 2008).

Water samples were collected from the lower Sacramento River and its tributaries from March 2003 to June 2006 (Foe et al. 2008). For comparison, concentrations in samples from the upper Sacramento River from Redding to Colusa were lower, ranging from 0.03 to 0.10 ng/l. Major tributaries to the lower Sacramento River, including the Feather River (0.05 ng/l), American River (0.06 ng/l), Colusa Basin Drain (0.21 ng/l), and Yuba River (0.05 ng/l), contributed to the mean methylmercury concentration of 0.11 ng/l at Freeport in the Sacramento River.

The commercial or recreational collection of fish, shellfish, or organisms were deemed impaired prior to the current 303(d) list approved in 2010 (SWRCB 2011q). However, no new data were available to be assessed for this updated listing.

Table 6.16 presents streambed sediment mercury concentrations from the Sacramento River and Delta regions in 1995, sampled as part of the National Water Quality Assessment (NWQA) Program for the Sacramento River Basin (MacCoy and Domagalski 1999). Limited data for mercury in sediment exist; however, these data exhibit levels of mercury greatly exceeding the average amount of mercury found on the earth’s surface, of about 0.05 µg/g. The highest streambed sediment concentrations of mercury were measured downstream from the Sierra Nevada and Coast Ranges. Within the Sacramento River, sites downstream of the Feather River had higher concentrations of mercury than sampled locations upstream of this confluence. The highest reported mercury concentrations were from the Yuba River, Bear River, Sacramento River at Verona, and the Feather River which exceeded the threshold effect concentration (0.18 µg/g), but not the probable effect concentration (1.06 µg/g) reported by MacDonald et al. (2000).

**Table 6.15 Streambed sediment concentrations of mercury in the Sacramento River and Delta regions**

| Water body/Site | Concentration |
|---|---|
| **Feather River sites** | |
| Feather River | 0.21 µg/g |
| Yuba River | 0.37 µg/g |
| Bear River | 0.37 µg/g |
| Feather & Sacramento Rivers<br>Downstream of the confluence at Verona | 0.24 µg/g |
| **Sacramento River sites** | |
| Bend Bridge | 0.16 µg/g |
| Freeport | 0.14 µg/g |
| Cache Creek | 0.15 µg/g |
| Arcade Creek | 0.13 µg/g |
| American River | 0.16 µg/g |

Source: MacCoy and Domagalski 1999

Reported in bottom material <63 micron fraction dry weight.

* Concentration exceeds the MacDonald et al. (2000) threshold effect concentration (0.18 µg/g dry weight) but not the probable effect concentration (1.06 µg/g dry weight).

In an effort to protect the beneficial uses of the Sacramento River, including the impaired commercial and recreational collection of fish, shellfish, or organisms, the CVRWQCB (2011) made recommendations for the future reduction of mercury contamination. Additionally, the Delta Mercury Control Program (MERP 2012) provides potential load allocations for mercury pertaining to the Sacramento River and the Yolo Bypass, while the Cache Creek Watershed Mercury Program provides load allocations for Cache Creek, Bear Creek, Sulphur Creek, and Harley Gulch.

### *Pesticides*

The Sacramento River was placed on the 303(d) list approved by the USEPA in 2010 as impaired by the pesticides chlordane, DDT, and dieldrin from Knights Landing to the Delta. These three pesticides listings were based on the evaluation of fish contaminant data from 2005. Chlordane, DDT, and dieldrin are legacy pesticides that were discontinued from the early 1970s to the late 1980s. However, samples collected in the Sacramento River at the Veterans Bridge in September 2005 revealed elevated pesticide concentrations (SWRCB 2011q).

A composite sample of carp and a composite sample of channel catfish had total chlordane concentrations of 6.72 µg/kg and 10.20 µg/kg, respectively, both exceeding OEHHAs (2008) FCG of 5.6 µg/kg for total chlordane in fish tissue (SWRCB 2011q).

Composite samples of carp and Channel Catfish contained total DDT concentrations of 59. µg/kg and 109. µg/kg, respectively. These concentrations exceeded the OEHHAs (2008) FCG of 21 µg/kg (SWRCB 2011q).

Composite samples of carp and Channel Catfish contained total dieldrin concentrations of 0.98 µg/kg and 1.49 µg/kg, respectively, These concentrations both exceeded the OEHHAs (2008) FCG of 0.46 µg/kg (SWRCB 2011q).

*PCBs*

The Sacramento River from Knights Landing to the Delta was placed on the 303(d) list approved by the USEPA in 2010 as impaired by PCBs (SWRCB 2011a).

According to the Final California 2010 Integrated Report (303(d)/305(b) Report) Supporting Information, sources of PCBs in this reach of the Sacramento River are unknown (SWRCB 2011q).

The Sacramento River from Knights Landing to the Delta has also been newly listed as contaminated by PCBs. Three of three composite samples analyzed for total PCBs in September 2005 exceeded the OEHHA Fish Contaminant Goal for total PCBs of 3.6 ppb (or 3.6 ng/g), wet weight. The exceeding concentrations were recorded at 53 ng/g in channel catfish, 6.0 ng/g in Sacramento sucker, and 26 in carp (SWRCB 2011q).

A TMDL for PCBs in the Sacramento River from Knights Landing to the Delta is expected to be completed in 2021 to protect the beneficial uses of the Sacramento River and downstream waterbodies (SWRCB 2011q).

*Dissolved Oxygen*

The Sacramento River was not placed on the 303(d) list approved by the USEPA in 2010 for low dissolved oxygen (SWRCB 2011a).

*Salinity, Electrical Conductivity, and Total Dissolved Solids*

The Sacramento River was not placed on the 303(d) list approved by the USEPA in 2010 as impaired by salinity (SWRCB 2011a).

*Selenium*

Water bodies in the Sacramento River Basin were not listed on the 303(d) list as impaired by selenium. Waterborne selenium concentrations in the Sacramento River near Verona are relatively low compared to concentrations in the San Joaquin River Basin. However, the much larger flow that the Sacramento River contributes to the Delta, in comparison to the San Joaquin River, results in a substantial contribution to the mass loading of selenium to the Delta from the Sacramento River (Cutter and Cutter 2004; SWRCB 2008a). Loads to the Delta from the Sacramento River were projected to be about half of what the Grasslands basin was projected to contribute to the San Joaquin River, with subsequent loading to the Delta from the San Joaquin River dependent on flow (Presser and Luoma 2006).

Data for selenium in fish from the Sacramento River are limited, but Largemouth Bass were sampled in 1999, 2000, 2005, and 2007 from the lower Sacramento

River, San Joaquin River, and Delta by the CVRWQCB. The fillet data and whole-body selenium concentrations, estimated using an equation from Saiki et al. (1991), were used to evaluate potential human and wildlife health risks (Foe 2010). Selenium concentrations in fillets and whole bodies of the bass from the Sacramento River at Veterans Bridge were well below the draft criteria released in May 2014 (11.8 mg/kg for fillets and 8.1 mg/kg for whole body) (USEPA 2014b).

*Unknown Toxicity*

The Sacramento River from Knights Landing to the Delta is listed as impaired by toxicity due to the results of survival, growth and reproductive toxicity tests performed in 2006 and 2007. Observations of increased mortality and reduction in growth and reproduction in *C. dubia* and *P. promelas* compared to laboratory controls violated the narrative toxicity objective of the Basin Plan. The TMDL for toxicity in this reach of the river is expected to be completed in 2019 (SWRCB 2011q).

#### 6.3.3.1.3 Colusa Basin Drain

The Colusa Basin Drain receives inflow from local creeks and discharge and runoff from the Colusa agricultural basin. Under conditions of low water levels, it drains by gravity into the Sacramento River at Knights Landing; however, when the water levels at Knights Landing are too high for this gravity flow to occur, discharge from the Colusa Basin Drain is routed directly to the Yolo Bypass through the Ridge Cut canal (USGS 2002). During the non-storm season, flows from the Colusa Basin Drain can contribute over ten percent of Sacramento River flows at Verona when there are floods in the Colusa Basin, high irrigation discharges, and/or low Sacramento River flows (Colusa Basin Drain Steering Committee 2005).

Beneficial uses designated for the Colusa Basin Drain include agricultural irrigation and stock watering, water contact recreation, and warm and cold water habitat, migration and spawning for aquatic biota (CVRWQCB 2011). In spite of the many uses of the waterway, the Colusa Basin Drain is listed as impaired for numerous contaminants. Water quality constituents of concern impact both local beneficial uses and the water quality of receiving waterways, including the Sacramento River and the Yolo Bypass. Suspended solids, agricultural chemicals, heavy metals and organic matter are often present in concentrations that exceed those in the Sacramento, Feather, and American Rivers (Colusa Basin Drain Steering Committee 2005, SWRCB 2011r, USGS 2002)

*Mercury*

The Colusa Basin Drain is listed on the 303(d) list for contamination by mercury due to multiple exceedances of the USEPA Fish Tissue Residue Criterion for methylmercury in fish of 0.3 mg/kg (or 0.3 ppm) for the protection of human health (SWRCB 2011r). Samples exceeding the criterion included two of seven samples collected at the County Road 99E bridge crossing between 1997 and 2002 (one carp composite sample with a concentration of 0.41 ppm and one white catfish composite sample with concentration of 0.30 ppm) and one of ten samples collected in the Colusa Basin Drain at Abel Road between 1980 and 1988 (one brown bullhead composite sample with concentration of 0.58 ppm).

The Delta mercury TMDL study reported an average concentrations of methylmercury in the Colusa Basin Drain was reported to be 0.214 ng/l between 2000 and 2003. The Colusa Basin Drain contributed 3.3 percent of total mercury inputs to the Sacramento Basin between 1984 and 2003 (CVRWQCB 2010a). A TMDL for the Colusa Basin Drain is expected to be completed in 2021 (SWRCB 2011r).

*Pesticides*

The Colusa Basin Drain is listed as contaminated by the organophosphate pesticides azinphos-methyl (Guthion), diazinon, DDT and malathion. Azinphos-methyl and malathion have been included on the 303(d) list since 2006; thus, supporting information for their listing is not readily available. However, diazinon has been listed due to samples collected between 1996 and 2000 and again in 2004 exceeding the CDFW acute criterion of 0.16 µg/l one hour average. Samples collected in 2004 also exceeded the four day average criterion of 0.10 µg/l. Diazinon was addressed by a 2008 basin plan amendment but has not been removed from the 303(d) list (SWRCB 2011r).

Two of two samples assessed for DDT in the Colusa Basin Drain in 2005 greatly exceeded the OEHHA 2008 FCG for DDT, of 21 µg/kg of total DDT in fish tissue. Concentrations of 44.009 µg/kg and 65.903 µg/kg were recorded in composite samples of white catfish and carp, respectively. The TMDL for DDT is expected to be completed in 2021 (SWRCB 2011r).

The organochlorine pesticide dieldrin, and the Group A pesticides generally, are included on the 303(d) list for the Colusa Basin Drain (SWRCB 2011r). The Group A pesticides have been listed since 2006, thus supporting information is not readily available. Dieldrin is listed due to two of two samples collected in August 2005 exceeding the OEHHA FCGs for dieldrin of 0.46 µg/kg dieldrin in fish tissue. One composite sample of white catfish recorded a concentration of 0.7 µg/kg and one composite sample of carp recorded a value of 1.14 µg/kg. Contamination by organochlorine pesticides in the Colusa Basin Drain will be addressed by the Central Valley Organochlorine Pesticide TMDL and Basin Plan Amendment.

The carbamate pesticide carbofuran is also included on the 303(d) list for the Colusa Basin Drain. It has been listed since 2006; thus, supporting information is not readily available. A TMDL is expected by 2021 (SWRCB 2011r).

*Dissolved Oxygen*

The Colusa Basin Drain was placed on the 303(d) list approved by the USEPA in 2010 for low dissolved oxygen (SWRCB 2011a). According to the Final California 2010 Integrated Report (303(d)/305(b) Report) Supporting Information, sources of contributing to the dissolved oxygen impairment in the Colusa Basin Drain are unknown (SWRCB 2011r).

Samples collected from the Colusa Basin Drain (at Maxwell Road, above Knights Landing, at Highway 162, and at “Colusa Basin Drain #5”) between September 2004 and October 2006 and were tested for dissolved oxygen (SWRCB 2011r). Thirty of the 73 samples exceeded the general number water quality objectives for COLD and SPWN beneficial uses. Five of the samples exceeded the water quality objective for WARM beneficial uses.

*Other Constituents of Concern*

The Colusa Basin Drain is also listed as contaminated by *E. coli*, low dissolved oxygen, and unknown toxicity (SWRCB 2011r). Knights Landing Ridge Cut is listed as contaminated by boron, low dissolved oxygen, and salinity. A USGS study of Yolo Bypass water quality in 2000 also reported that significant concentrations of ammonium and dissolved organic carbon in the Yolo Bypass were correlated with high concentrations in the Colusa Basin Drain, and that the Colusa Basin Drain was a major discharger of sulfate to the Yolo Bypass (USGS 2002)

#### 6.3.3.1.4 Feather River from Lake Oroville to the Confluence with the Sacramento River

Water quality constituents of concern in the Lower Feather River have the potential to affect several supported beneficial uses, including municipal and agricultural water supply, contact and non-contact water recreation, and fish habitat and migration uses, for cold and warm water. The 303(d) listed contaminants in this reach of the Feather River.

*Water Temperature*

The Lower Feather River (downstream of Lake Oroville) is not listed on the 303(d) list as impaired by water temperature (SWRCB 2011a). However, water temperature in the lower Feather River is crucial to maintaining fresh water habitat for both warm and cold fresh water fish species in downstream habitats (DWR 2007). The SWP operates Lake Oroville and the Thermalito Reservoir Complex to meet temperature objectives established through a 1983 agreement with California Department of Fish and Wildlife and biological opinions issued by NMFS, as described in Appendix 3A, No Action Alternative: Central Valley Project and State Water Project Operations. Releases from Lake Oroville determine initial river temperatures. Water is released at different depths through shutters at the intake structures (DWR 2007). Although Lake Oroville releases determine water temperatures initially, atmospheric conditions modify downstream river temperatures. Water temperatures vary seasonally and spatially between the low flow channel (LFC) and high flow channel (HFC) of the Lower Feather River downstream of the fish barrier dam. The LFC is the reach of the river between the Fish Barrier Dam and the confluence with the Thermalito Afterbay Outlet and it is managed to protect cold water fish species. The HFC is the downstream reach of the river, from the Thermalito Afterbay Outlet to the confluence with the Sacramento River.

Warmer temperatures in the LFC start to appear in March, reaching maximum temperatures in July and early August ranging from 61° F upstream of the Feather

River Fish Hatchery to 69º F upstream of the Thermalito Afterbay Outlet (DWR 2007a). Cooling of the LFC begins in September, with a minimum temperature of approximately 45º F occurring in February. At the Feather River Fish Hatchery, water temperatures are generally compliant with the 1983 Agreement. Temperatures from 2002 to 2004 were in compliance 95 percent of the time, exceeding requirements for 23 days during an extended warm period in fall 2002, and dropping below requirements for 13 days during the warm summer months. Water temperatures at Robinson Riffle are almost always met when the fish hatchery temperatures are met. Agricultural temperature requests cannot always be satisfied due to the requirements of the fish species and the fluctuating meteorological conditions.

Temperatures in the HFC are influenced by releases from the Thermalito Afterbay and flow contributions from Honcut Creek, the Yuba River, and the Bear River from April through October (DWR 2007). Except for during high flows from the Thermalito Afterbay (occurring frequently in July and August), releases in the warm season generally raise the water temperature. Honcut and Bear River inflows tend to increase downstream temperatures as well, while flows from the Yuba River tend to cool downstream temperatures during the warmer months.

Warming water temperatures appear in the HFC starting in March, with maximum temperatures occurring in July and August, ranging from 71 to 77º F (DWR 2007). In late august, the HFC begins to cool, reaching minimum temperatures of 44 to 45º F by January or February.

In addition to effects on fish species, agriculture is potentially affected by changes in water temperature, because the temperatures of irrigation water can affect crop growth (DWR 2007). In the Feather River Basin, this is particularly an issue for rice production. Water contact recreation can also be affected by water temperatures, as flows in the LFC are managed for cold water species and thus may be too cold for some water-contact recreation.

*Mercury*

The Lower Feather River is included on the 303(d) list for mercury contamination (SWRCB 2011a). The listing was made before the 2006 Integrated Report; thus, the evidence of water quality exceedance is not readily available. It has been noted, however, that the Feather River has relatively large mercury loadings and high mercury concentrations in suspended sediment, contributing significantly to mercury loading to the Delta. The Feather River transports much of the mercury to the Sacramento River that was released in the Sierra Nevada Mountains during gold mining operations (CVRWQCB 2010a).

FERC relicensing studies indicate that mercury consistently exceeds USEPA guidelines in most fish species and locations, and that biomagnification appears to have caused elevated mercury levels in fish (DWR 2007). A beneficial effect of Lake Oroville is the capture of contaminated sediments, preventing their further transport downstream.

In the Sacramento – San Joaquin Delta Estuary TMDL for methylmercury, the CVRWQCB (2010a) recommends that the Feather River be targeted for mercury reduction during initial efforts focusing on the watersheds that export the largest volumes of highly mercury-contaminated sediment to the Delta.

*Pesticides*

The Feather River below Lake Oroville is listed as contaminated for chlorpyrifos. Samples collected during storm events at the Feather River near Nicolaus in 2004 exceeded the California DFG Hazard Assessment Criteria of 25 ng/l over a one hour average. The TMDL for chlorpyrifos in the Feather River is expected to be completed in 2019 (SWRCB 2011t).

Group A Pesticides have also been detected in exceedance of water quality criteria (SWRCB 2011t). Data collected for organochlorine pesticide contamination in the Feather River between 2000 and 2009 as part of the NPDES permit program did not indicate exceedances of CTR criteria, but did show detections in all samples in the water column. Channel catfish tissue samples from the Feather River at Highway 99 between 1978 and 2008 exhibited high concentrations of DDT and dieldrin. These water quality and fish tissue data were presented as part of supplemental documents in the process to develop a basin plan amendment to address organochlorine pesticides in Central Valley water bodies. This basin plan amendment is currently in development and will include organochlorine pesticides in the Feather River (CVRWQCB 2010c).

*PCBs*

The Lower Feather River was placed on the 303(d) list approved by the USEPA in 2010 as impaired by PCBs (SWRCB 2011a).

According to the *Final California 2010 Integrated Report* (303(d)/305(b) Report) Supporting Information, sources of PCBs in the Feather River are unknown (SWRCB 2011t). However, The Draft Environmental Impact Report for the FERC relicensing notes that PCBs have been detected in all fish and crayfish species from all sampled water bodies. Aroclors were also detected in at least some fish in all water bodies, as well as in crayfish in the Feather River downstream from the State Route 70 bridge (DWR 2007). PCBs have been released into the Feather River watershed from several activities. Two events in the 1980s resulted in PCB contamination in the watershed: oil containing PCBs was applied to a dirt road and entered the Ponderosa Reservoir in surface runoff, and PCBs contaminated soil and water at Belden Forebay due to a landslide which damaged powerhouses. Some remediation was performed in response to these events.

The same narrative water quality objective and evaluation criteria of 3.6 ng/g that was used as guidance to place the Sacramento River on the 303(d) list was also used to evaluate the Feather River. Composite samples of Largemouth Bass and crayfish collected in 2002 and 2003 showed high exceedances of the FCG. Upstream of the Thermalito Afterbay Outlet, a composite sample of Largemouth Bass had a concentration of 15.6 ng/g total PCBs, wet weight. Downstream of the outlet, the concentration of total PCBs in two composite samples of Largemouth Bass were 11.2 and 15.0 ng/g. Downstream of the Highway 70 Bridge, the concentration of total PCBs in a composite sample of crayfish was 56 ng/g (SWRCB 2011t)

An additional study performed in 2003 and 2004 also revealed high exceedances of the OEHHA FCG for PCBs. Concentrations of total PCBs in composite samples of hardhead and pikeminnow were 26 ng/g and 31 ng/g wet weight, respectively. All samples were analyzed for 48 individual PCB congeners and two Aroclor mixtures (SWRCB 2011t)

A TMDL for PCBs in the Lower Feather River is expected to be completed in 2021 to protect the beneficial uses of the Feather River and other water bodies downstream (SWRCB 2011t).

*Other Constituents of Concern*

The Lower Feather River is listed as impaired by unknown toxicity due to significant exceedances of the toxicity criteria outlined by the CVRWQCB (SWRCB 2011t, CVRWQCB 2011). Water samples were tested with *C. dubia, P. promelas*, and *P. subcapitata* for survival, growth and/or reproductive toxicity between 1998 and 2007. Of 212 samples tested with *C. dubia* for survival and/or reproductive toxicity, 85 exceeded the narrative toxicity objective. Of 34 samples tested with *P. promelas* for survival and/or growth toxicity, seven exceeded the objective. Of 23 samples tested with *P. subcapitata*, none exceeded the objective. Samples in violation of the toxicity objective were collected in the Feather River at Nicolaus; in the Thermalito Diversion Pool; downstream from the Feather River Hatchery; upstream and downstream from the Thermalito Afterbay Outlet; downstream from the Sewage Commission Oroville Region (SCOR) Outlet; and downstream from the FERC Project 2100 project boundary.

#### 6.3.3.1.5 American River below Lake Natoma

The lower American River flows for 23 miles from Nimbus Dam to its confluence with the Sacramento River. Water quality in this reach of the river is influenced by releases from upstream reservoirs, including Lake Natoma and Folsom Lake. In general, the runoff that flows into Folsom Reservoir and Lake Natoma, upstream of the lower American River, is of high quality (Wallace, Roberts, and Todd et al. 2003). Water quality parameters measured in Folsom Reservoir, upstream of the lower American River, include pH, turbidity, dissolved oxygen (DO), total organic carbon (TOC), nutrients (nitrogen and phosphorus), electrical conductivity, total dissolved solids (TDS), and fecal coliform.

*Water Temperature*

The lower American River is not listed on the 303(d) list as impaired by water temperature (SWRCB 2011a). The lower American River supports warm and cold fresh water habitat beneficial uses, as well as migration and spawning uses. In particular, in-stream rearing of juvenile steelhead requires certain water temperatures which are targeted through water temperature objectives (CVRWQCB 2011, NMFS 2009).

The CVP operates Folsom Lake to meet temperature objectives, as described in Appendix 3A, No Action Alternative: Central Valley Project and State Water Project Operations.

*Mercury*

The American River from Nimbus Dam to the confluence with the Sacramento River was listed on the 303(d) list for mercury contamination in 2010, due to exceedances of OEHHA's guidance tissue levels for mercury (SWRCB 2011u). The major source of mercury to the lower American River is mercury lost during historic mining activities that is now distributed downstream.

The American River contributes mercury to the Sacramento River, and thus the Delta, due to its relatively large mercury loadings and high mercury concentrations in suspended sediment (CVRWQCB 2010a). Like the Feather River, the lower American River is recommended for initial mercury reduction efforts as part of the Sacramento – San Joaquin Delta Estuary TMDL for Methylmercury. In addition to load allocations recommended as part of the Delta TMDL for methylmercury, mercury contamination in the American River and its reservoirs will be addressed as part of the statewide water quality control program for mercury (SWRCB 2014a).

*PCBs*

The lower American River was placed on the 303(d) list approved by the USEPA in 2010 as impaired by PCBs (SWRCB 2011a).

Composite samples of white catfish and Sacramento sucker collected in the American River at Discovery Park were analyzed for 48 individual PCB congeners and three Aroclor mixtures (SWRCB 2011u). The total PCBs recorded in the White Catfish and Sacramento Sucker were 3.934 ng/g and 44.094 ng/g, respectively. An additional Sacramento Sucker composite sample collected at Nimbus Dam did not exceed the OEHHA goal.

A TMDL for PCBs in the lower American River is expected to be completed in 2021 to protect the beneficial uses of the American River and other water bodies downstream (SWRCB 2011u).

*Unknown Toxicity*

The lower American River is listed as impaired by unknown toxicity. Toxicity has been indicated for vertebrates and invertebrates from samples collected at Discovery Park, using survival, growth, and reproduction toxicity tests with *C. dubia* and *P. promelas*. These tests, conducted between 1998 and 2007, exhibited significant increases in mortality and reductions in growth and reproduction in the test organisms (SWRCB 2011u). The TMDL is expected to be completed in 2021 (SWRCB 2011u).

#### 6.3.3.1.6 Yolo Bypass

The Yolo Bypass supports a variety of beneficial uses, including agricultural supply, recreational uses, and spawning, migration and habitat use. The Yolo Bypass is used for agriculture in times of low flow, and discharges to the San

Francisco Bay-Delta contribute to drinking water supplies. The Yolo Bypass also supports seasonal fish and bird populations when it is inundated, and resident fish species in its perennial channel. Water quality in the Yolo Bypass is of great importance because of the in-Bypass water uses and its effects on receiving waters downstream (CVRWQCB 2011, Sommer et al. 2001)

*Mercury*

The Yolo Bypass contributes a significant amount of methylmercury and total mercury to the Delta. While the Sacramento River is the primary tributary source of mercury to the Delta in dry years, mercury loading from the Yolo Bypass increases in wet years and is comparable to that of the Sacramento River. Although only two thirds of the Yolo Bypass floodplain lie within the legal Delta, the entire floodplain was evaluated as part of the Sacramento – San Joaquin Delta Estuary TMDL for Methylmercury (Delta Methylmercury TMDL) (CVRWQCB 2010a). Compounding the issue of mercury contamination in the Yolo Bypass, the USGS study noted that the Bypass has conditions conducive to the production of methylmercury, including stagnant waters and marshes with an abundance of sulfate and organic carbon (USGS 2002).

A major source of mercury to the Yolo Bypass is Cache Creek. Mercury mine wastes have contributed relatively large mercury loading and high mercury concentrations in suspended sediment, making this area a priority for mercury reduction as part of the Delta Methylmercury TMDL (CVRWQCB 2010a). Elevated methylmercury concentrations in the Colusa Basin Drain are also a concern (USGS 2002).

The Cache Creek Settling Basin (CCSB) captures sediment and mercury transported by Cache Creek; however, any sediment that is not captured is transported to the Yolo Bypass (approximately half of the sediment transported by Cache Creek). The CTR mercury criterion of 0.050 µg/l for drinking water is exceeded in outflow from the CCSB (and possibly in other tributaries to Yolo Bypass), thus it is anticipated that when the Yolo Bypass is dominated by flows from Cache Creek, it also exceeds the CTR criterion (CVRWQCB 2010a).

The Delta Methylmercury TMDL recommends reducing mercury loads entering the CCSB, and regularly excavating the sediment accumulating in the CCSB, in order to increase its effectiveness and prevent its filling and thus cessation of sediment and mercury deposition. Additional reductions in mercury loading to Cache Creek will be achieved through the existing mercury TMDL in the watershed, which includes measures for mine remediation, erosion control in mercury-enriched areas, and the removal of floodplain sediments containing mercury (CVRWQCB 2010a).

In addition to efforts targeting mercury loading reductions in Cache Creek, the TMDL includes methylmercury and total mercury load and waste load allocations for agricultural drainage, tributary inputs and NDPES facilities in the Yolo Bypass to enable reductions in mercury contamination in water and fish (CVRWQCB 2010a).

*Agricultural Runoff*

The City of Woodland developed a water quality management plan for the Yolo Bypass which included water quality testing to identify pollutants of concern. Water quality was monitored within the Yolo Bypass and in its major tributaries, at the locations where they enter the Bypass. The study indicated that the highest concentrations of several contaminants were found in tributaries receiving predominantly agricultural discharge: the Willow Slough Bypass; Knights Landing Ridge Cut, which drains the Colusa Basin Drain; and for some contaminants, the Z Drain (City of Woodland 2005). Although the Yolo Basin is not included as a water body on the 303(d) list, the Tule Canal is listed as contaminated by several of these agricultural by-products, including boron, salinity, E. coli and fecal coliform. These contaminants will be addressed by TMDLs expected to be completed in 2021 (SWRCB 2011w).

Pesticides are of major concern in the agricultural drains tributary to the Yolo Bypass. DDE, a degradation product of the organochlorine pesticide DDT, was detected in the water column in agricultural drains and in Putah Creek sediment. The organophosphate pesticide chlorpyrifos was detected in excess of the concurrent DFG criterion of 0.009 μg/l in four samples, while diazinon was not reported in excess of its criterion. The carbamate pesticides diuron and methomyl were detected, but did not exceed their applicable criteria. Pyrethroids were not monitored, but were noted to be of increasing concern in the Yolo Bypass as in the rest of the Central Valley (City of Woodland 2005).

### *6.3.3.2 San Joaquin Valley*

Water quality conditions in the San Joaquin River are described for locations that would be influenced by implementation of Alternatives 1 through 5, including Stanislaus River near Caswell Park in the vicinity of the confluence with the San Joaquin River; San Joaquin River near Vernalis, and San Joaquin River near Buckley Cove and Stockton

#### 6.3.3.2.1 San Joaquin River

Water quality concerns in the San Joaquin River near Vernalis are primarily salinity, boron, and selenium which are influenced by low flows due to upstream diversions and water use and agricultural return flows.

*Water Temperature*

The reach of the San Joaquin River from Merced River to Stanislaus River was placed on the Section 303(d) list per the partial approval by USEPA in 2010 and the final approval in 2011 (SWRCB 2011a).

According to the *Final California 2010 Integrated Report* (303(d) list/305(b) Report) Supporting Information, water temperature concerns in San Joaquin River from Merced River to Stanislaus River are attributed to unknown sources (SWRCB 2011x,y). However, declines in fish populations, particularly salmon and steelhead trout, have been linked to increases in water temperatures and suggestions have been made that the population declines may be a result of watershed changes from the construction of dams, water diversions, mining, and harvest (NMFS 2009).

USEPA (2011) evaluated salmonid migration and spawning temperatures to assess the water quality of the San Joaquin River. Recommended water temperature criteria for salmon and steelhead trout life stages are presented in Table 6.16. San Joaquin River temperatures from the Merced River to the Stanislaus River in 1996-2007 exceeded USEPA's recommendations, thus impairing the cold freshwater habitat.

**Table 6.16 San Joaquin River Maximum Temperature Criteria and Recommended Uses for Summer**

| Applicable to: | Criteria: |
|---|---|
| Chinook Salmon Adult Migration | 64 °F |
| Chinook Salmon Spawning | 55 °F |
| Chinook Salmon Smoltification and Juvenile Rearing | 61 °F |
| Steelhead Trout Summer Rearing | 64 °F |

Source: SWRCB 2011x,y; USEPA 2003

TMDLs for the lower reaches in the San Joaquin River (Merced to Tuolumne and Tuolumne to Stanislaus) are expected to be completed in 2021 in an effort to further protect the beneficial uses of this water body (SWRCB 2011).

*Selenium*

San Joaquin River from Mud Slough to Merced River was placed on the Section 303(d) list in 2010 for selenium contamination per the list approved by USEPA (SWRCB 2011a). Other water bodies that drain to the San Joaquin River upstream of this reach and are listed as impaired by selenium contamination on the 303(d) list include Mendota Pool, Panoche Creek from Silver Creek to Belmont Avenue, Agatha Canal, Grasslands Marshes, Mud Slough (North, downstream of San Luis Drain), and Salt Slough (upstream from confluence with San Joaquin River).

TMDLs for selenium were approved by the USEPA for the San Joaquin River (Mud Slough to Merced River) (in 2002), Grasslands Marshes (in 2000), Agatha Canal (in 2000), and Mud Slough (north, downstream of San Luis Drain) (in 2002) (SWRCB 2011z-ac). A TMDL is expected to be completed for Panoche Creek in 2019 and another for Mendota Pool in 2021. Water quality objectives defined in the Basin Plan for the Sacramento River basin and the San Joaquin River basin are shown in Table 6.17 (CVRWQCB 2011).

**Table 6.17 Water Quality Objectives for Selenium in the San Joaquin River Region, mg/l**

| Objective | Applies to: |
|---|---|
| 0.012 (maximum concentration) | San Joaquin River, mouth of the Merced River to Vernalis |
| 0.005 (4-day average) | – |
| 0.020 (maximum concentration) | Mud Slough (north), and the San Joaquin River from Sack Dam to the mouth of Merced River |
| 0.005 (4-day average) | – |
| 0.020 (maximum concentration) | Salt Slough and constructed and re-constructed water supply channels in the Grassland watershed* |
| 0.002 (monthly mean) | – |

Source: CVRWQCB 2011

*Applies to channels identified in Appendix 40 of the CVRWQCB (2011) Basin Plan

The drainage area for the Grasslands Bypass Project is a major but decreasing source of selenium to the San Joaquin River. Selenium from subsurface agricultural drainage waters originating in the Drainage Area was historically transported through the Grassland Marshes through tributaries such as Mud Slough and Salt Slough (CVRWQCB 2001). Efforts to decrease the selenium loading to the San Joaquin River include the Grassland Bypass Project, discussed in more detail below, which has decreased selenium loading by an average of 55 percent from the Grasslands Drainage Area in comparison to pre-Grassland Bypass Project conditions (1986-1996 to 1997-2011) (GBPOC 2013). In the San Joaquin River below the Merced River, selenium concentrations decreased from an average of 4.1 µg/l during pre-project conditions (1986 to 1996) to 2 µg/l (1997 to 2011). The continued operation of the Grassland Bypass Project is expected to achieve the CVRWQCB Basin Plan objectives for the San Joaquin Valley (Reclamation & SLDMWA 2009).

Largemouth Bass were sampled during 1999, 2000, 2005, and 2007 from the San Joaquin River, lower Sacramento River, and Delta by the CVRWQCB (Foe 2010). The samples were analyzed as fillets to evaluate potential human health risks, and whole-body selenium concentrations were estimated using an equation from Saiki et al. (1991) to evaluate risks to wildlife. The data do not exceed the draft water quality criteria released by the USEPA in May 2014.

The draft discharge requirements released by the CVRWQCB in 2014 were created in an effort to meet the water quality objective for the San Joaquin River. In 2010, the CVRWQCB and SWRCB approved amendments (Resolution 2010-0046) to the Basin Plan for the Sacramento River and San Joaquin River Basins to address selenium control in the San Joaquin River basin as related to the Grassland Bypass Project (which is described below) (CVRWQCB 2010g, SWRCB 2010b).

Other relevant requirements/actions to meet the water quality objectives for the San Joaquin River, in addition to release of the draft waste discharge requirements by the CVRWQCB (2010g), include the following:

- The Basin Plan amendments (CVRWQCB 2010g, SWRCB 2010b) modify the compliance time schedule for discharges regulated under waste discharge requirements to meet the selenium objective or comply with a prohibition of discharge of agricultural subsurface drainage to Mud Slough (north), a tributary to the San Joaquin River, in Merced County. For Mud Slough (north) and the San Joaquin River from the Mud Slough confluence to the mouth of the Merced River:
  - The interim performance goal is 15 µg/l (monthly mean) by December 31, 2015 (adds to Table 6.46), and
  - The water quality objective to be achieved by December 31, 2019, is 5 µg/l (4-day average).

An extensive water quality and biological monitoring program was implemented in conjunction with the Grassland Bypass Project, and reports are issued periodically through the San Francisco Estuary Institute (e.g., SFEI 2011).

*Electrical Conductivity and Salinity*

Grasslands Marshes, North Mud Slough (downstream of San Luis Dam), Salt Slough (upstream from confluence with San Joaquin River), and San Joaquin River (Bear Creek to Vernalis) are water bodies in the Central Valley that were placed on the Section 303(d) list approved by the USEPA in 2010 as impaired by electrical conductivity (SWRCB 2011a). Salinity, which is linked to electrical conductivity, is a major concern for water quality in the San Joaquin Valley (CVRWQCB 2011). The RWQCB has adopted a TMDL for the San Joaquin River upstream of Vernalis for salt and boron.

Elevated electrical conductivity in Grasslands Marshes, North Mud Slough (downstream of San Luis Dam), Salt Slough (upstream from confluence with San Joaquin River), and San Joaquin River (Bear Creek to Vernalis) can be attributed to agriculture (SWRCB 2011x-aa,ac-af). Likewise, high salinity in the San Joaquin River near Vernalis has been linked to the discharge of water from agricultural practices (CALFED 2007). Saline water from agricultural return flow is added to the southern Delta by the San Joaquin River whereupon a portion is pumped by the export pumps back to the farms that eventually drain back to the river, exacerbating the problem of salinity control and salt buildup in the San Joaquin Valley.

To protect the beneficial uses of these water bodies, including agricultural supply, and municipal and domestic supply, particularly for San Joaquin River from Bear Creek to Mud Slough, water quality objectives were established in the SWRCB (2006a) Basin Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (Table 6.18).

**Table 6.18 SWRCB Water quality objectives for electrical conductivity in the San Joaquin River (Airport Way Bridge, Vernalis)**

| Time Period | Water Quality Objective[1] |
|---|---|
| April 1 to August 31 | 0.7 mmhos (700 µS/cm) |
| September 1 to March 31 | 1.0 mmhos (1000 µS/cm) |

Source: SWRCB 2006a

1 Maximum 30-day running average of mean daily

Several samples from San Joaquin River (Bear Creek to Vernalis) between October 1995 and February 2007 exceeded the SWRCB Basin Plan's water quality objective for electrical conductivity in the San Joaquin River (SWRCB 2011 x-aa,ac-af). Samples were collected from San Joaquin River at Lander Avenue, Fremont Ford, Patterson Fishing Access, Hills Ferry Bridge, and Crows Landing. Guidelines for evaluating Grasslands Marshes, North Mud Slough, and Salt Slough are not available because the listing was made prior to 2006.

The record of monthly average electrical conductivity (EC) readings for recent years for the San Joaquin River at Vernalis is shown in Figure 6.4. Salinity in the lower San Joaquin River as observed at Vernalis often exceeds the water quality objective for individual records during summer months. The highest salt concentrations emanate from Mud and Salt sloughs, while less saline water provides dilution from the Merced River (CALFED 2007). Note the marked increase in salinity during dry months and dry years at Vernalis, ranging from midwinter lows near 100 µmhos/cm up to summer high values near 1000 µmhos/cm.

A TMDL is expected to be completed in 2019, with the exception of San Joaquin River from Tuolumne to Stanislaus River which is expected to be completed in 2021 (SWRCB 2011 x-aa,ac-af). In addition, the Board has implemented the comprehensive salt management program, known as CV-SALTS (Central Valley Salinity Alternatives for Long Term Sustainability), to develop salt control strategies for the San Joaquin and the entire Central Valley watershed (CVRWQCB 2011, 2010h). The San Joaquin River Water Quality Improvement Program (SJRIP) was designed to address issues of chronically saline water, reuse, treatment options, and the development of salt-tolerant crops for this area of the valley, as part of the Grasslands Bypass Project.

### *Mercury*

Mercury is a constituent of concern for the San Joaquin River from Bear Creek to the Delta boundary, and was placed on the 303(d) list in 2010 (SWRCB 2011a). San Joaquin River from Friant Dam to Bear Creek was not included on the 303(d) list for mercury contamination.

Mercury in this reach of the San Joaquin can be attributed to resource extraction. Significant gold mining took place along the major tributaries of the San Joaquin River, including Merced River, Tuolumne River, Stanislaus River, and Cosumnes River in the San Joaquin River basin (CVRWQCB 2010a).

Mercury and enhanced mercury methylation can affect the beneficial uses of the San Joaquin River and receiving waters downstream. At the Delta boundary in Vernalis, the waterborne methylmercury concentration in the San Joaquin River from 2003 to 2006 ranged from 0.10-0.75 ng/l with an average of 0.19 ng/l (Foe et al. 2008). The average fish tissue mercury concentration in Largemouth Bass from Vernalis in 2000 was 0.68 mg/kg (wet weight) (CVRWQCB 2010a). This fish tissue concentration exceeds the USEPA wet weight methylmercury fish tissue criterion (0.3 mg/kg) for the protection of human health.

To further protect the health of humans and wildlife, the Sacramento-San Joaquin Delta TMDL specified narrative and more stringent numeric water quality objectives for the more bioavailable and more toxic form of methylmercury (CVRWQCB 2011). The TMDL for the Sacramento-San Joaquin Delta (CVRWQCB 2010a), which is applicable to the Delta, Yolo Bypass, and their waterways, includes the reach of the San Joaquin River from Bear Creek to the Delta boundary.

*Pesticides*

The San Joaquin River (all segments from Mendota Pool to Vernalis), North Mud Slough (downstream of San Luis Drain), and Salt Slough (upstream from confluence with San Joaquin River) were placed on the Section 303(d) list approved by the USEPA in 2010 as impaired by pesticides (SWRCB 2011a). North Mud Slough is listed as impaired by “pesticides”; Salt Slough by chlorpyrifos and prometryn, and San Joaquin River by OP pesticides (chlorpyrifos and diazinon), OC pesticides (DDT, DDE, Group A Pesticides, including toxaphene), alpha.-BHC, and diuron. Impairment listings vary between reaches of the San Joaquin River. Several other small tributaries to the San Joaquin River from the west are also 303(d) listed as impaired by pesticides (i.e., Mud Slough North (upstream and downstream of San Luis drain).

Pesticides in North Mud Slough, Salt Slough, and the San Joaquin River can be attributed to runoff from agriculture, with the exception of the alpha-BHC in the San Joaquin River (from Merced to Tuolumne) and toxaphene in the San Joaquin River (from Stanislaus to the Vernalis) whose sources are unknown (SWRCB 2011x-z,ac-ag).

*Boron*

The lower San Joaquin River upstream of Vernalis is listed as impaired due to elevated concentrations of boron (CVRWQCB 2002b, 2007c). A draft Amendment to the Basin Plan for the Sacramento River and San Joaquin River Basins for the control of Salt and Boron discharges into the lower San Joaquin River (resolution R5-2004-0108) (CVRWQCB 2007c) describes a pending TMDL and establishes Waste Load Allocations to meet boron water quality objectives near Vernalis (at the Airport Way Bridge).

Mean salinity in the lower San Joaquin River at Vernalis has doubled since the 1940s while boron and other trace elements have also increased to concentrations that exceed the water quality criteria of 750 µg/l. These criteria were established to be protective of sensitive crops under long-term irrigation (USEPA 1986b).

Water quality improves in the San Joaquin River downstream of confluences with the Merced, Tuolumne, and Stanislaus rivers.

Most of the boron load to the Delta comes from the lower San Joaquin River as a result of surface and subsurface agricultural discharges (CVRWQCB 2007c) on soils overlying old marine deposits and from groundwater (Hoffman 2010h, CALFED 2000). Major boron contributions come from Salt and Mud sloughs to the lower river (CVRWQCB 2002b). Point sources contribute very little of the salt and boron loads to the San Joaquin River (CVRWQCB 2007c).

Boron concentrations in surface water from two surface water sources in the lower San Joaquin River are variable, and range from 100 to over 1000 µg/l (Hoffman 2010). Effluent from subsurface drains in the New Jerusalem Drainage District have also been reported up to 4200 µg/l (Hoffman 2010). These concentrations at times exceed the water quality criteria and thresholds for sensitive crops (i.e., bean tolerance threshold is 750 to 1000 µg/l).

The collaborative effort by stakeholders and regulators is developing comprehensive management programs that will lead to attainment of water-quality objectives for salinity and boron. This program, CV-SALTS, is scheduled to be completed by 2016 and may lead to a basin plan amendment that will support the protection of beneficial uses.

*Arsenic*

The San Joaquin River from Bear Creek to Mud Slough was placed on the 303(d) list approved by the USEPA in 2010 for impairment by arsenic (SWRCB 2011a). Arsenic can cause adverse dermal, cardiovascular, respiratory, gastrointestinal, and neurological effects, and can cause cancer (ATSDR 2007). A TMDL addressing impairment due to arsenic is expected to be complete in 2021to protect the beneficial uses of this reach of the San Joaquin River, including the municipal and domestic supply (SWRCB 2011ae).

*Bacteria*

San Joaquin River (Bear Creek to Merced River; Stanislaus River to Delta Boundary) and Salt Slough (upstream from confluence with San Joaquin River) is a water body in the Central Valley that were placed on the Section 303(d) list approved by the USEPA in 2010 as impaired by *E. coli* (SWRCB 2011a).

*Invasive Species*

San Joaquin River (Friant Dam to Mendota Pool) is a water body in the Central Valley that was placed on the Section 303(d) list approved by the USEPA in 2010 as impaired by invasive species (SWRCB 2011a).

A TMDL for invasive species is expected to be completed in 2019 in an effort to meet the narrative water quality objective in San Joaquin River (Friant Dam to Mendota Pool).

#### 6.3.3.2.2 Stanislaus River

*Water Temperature*

The lower Stanislaus River was placed on the 303(d) list per the partial approval by USEPA in 2010 and the final approval in 2011 (SWRCB 2011a). The Stanislaus River supports warm and cold fresh water habitat for aquatic species such as steelhead.

According to the *Final California 2010 Integrated Report* (303(d) list/305(b) Report) Supporting Information, water temperature concerns are attributed to unknown sources (SWRCB 2011). Future climate conditions that are warmer or drier or both will further restrict the extent of suitable habitat for steelhead (NMFS 2009).

USEPA recommended water temperature criteria for different salmon and steelhead trout life stages. Data from 1991 to 2007 exceeded USEPA's criteria and thus impairing the cold freshwater habitat. The 2009 NMFS BO also includes temperature objectives for the Stanislaus River, as described in Appendix 3A, No Action Alternative: Central Valley Project and State Water Project Operations.

*Mercury*

Lower Stanislaus River is a water body in the Central Valley that was placed on the Section 303(d) list approved by the USEPA in 2010 as impaired by mercury (SWRCB 2011a).

Mercury has impaired the beneficial use of the commercial or recreational collection of fish, shellfish, or organisms (SWRCB 2011aj-al). The lower Stanislaus River was evaluated prior to 2006, so the evidence for the list is not readily available. However, the total methylmercury concentration in the Stanislaus River at Caswell State Park from 2003 to 2006 was 0.12 ng/l (Foe et al. 2008). Concentrations of methylmercury in Largemouth Bass, carp, Channel Catfish, and White Catfish tissue samples from the Stanislaus River between 1999 and 2000 exceeded the USEPA methylmercury fish tissue criterion (0.3 mg/kg wet weight) for the protection of human health (Shilling 2003).

In an effort to protect the beneficial uses of these water bodies mentioned above, and including the commercial and recreational collection of fish, shellfish, or organisms beneficial use, TMDLs are expected to be completed between 2019 to 2021 to meet the water quality standards in these water bodies (CVRWQCB 2011).

*Pesticides*

Lower Stanislaus River was placed on the Section 303(d) list approved by the USEPA in 2010 as impaired by pesticides (chlorpyrifos, diazinon, Group A Pesticides) (SWRCB 2011a). OP pesticides (e.g., diazinon and chlorpyrifos) and OC pesticides (e.g., Group A Pesticides) are primarily transported to streams and rivers in runoff from agriculture (CVRWQCB 2011). Sources and descriptions of the listed pesticides are discussed further in Section 6.3.2.7.

*Other Constituents of Concern*

Lower Stanislaus River was placed on the Section 303(d) list approved by the USEPA in 2010 as impaired by unknown toxicity (SWRCB 2011a).

To protect the beneficial uses of Lower Stanislaus River, a narrative water quality objective, which addresses *E. coli*, was established in the CVRWQCB (2011) Basin Plan.

A TMDL is expected to be complete in 2021 in an effort to meet the water quality standards in the lower Stanislaus River.

#### *6.3.3.3 Sacramento-San Joaquin River Delta*

Water quality conditions in the Sacramento and San Joaquin River in the Delta are described in this subsection against criteria to protect the beneficial uses as summarized in Table 6.2. The constituents of concern that are currently not in compliance with existing water quality standards and for which TMDLs are adopted or are in development in this region are summarized in Table 6.1.

##### 6.3.3.3.1 Salinity

Delta waterways were placed on the Section 303(d) List approved by the USEPA in 2010 as impaired by electrical conductivity (SWRCB 2011a). Electrical conductivity is linked to salinity and salinity is of particular concern in the tidally-influenced Delta (CVRWQCB 2011, CALFED 2007).

Electrical conductivity in Delta waterways (export area, northwestern portion, southern portion, western portion) can be attributed to runoff from agricultural practices (SWRCB 2011at-aw). Salinity in the Delta can vary significantly depending on several factors including hydrology, water operations, and Delta hydrodynamics (Jassby et al. 1995). Hydrology and upstream water operations influence the Delta inflows, which in turn influences the balance with the highly saline seawater intrusion. Various upstream watershed sources determine the quality of the Delta inflows, in addition to the in-Delta sources such as agricultural returns, natural leaching, municipal and industrial discharges that influence the Delta salinity conditions. Operation of various Delta gates and barriers, pumping rates of various diversions and volume of the open water bodies are the other key factors that influence the Delta hydrodynamics and salinity transport in the Delta.

The CVP and SWP are operated to achieve salinity objectives in the Delta, as described in detail in Appendix 3A, No Action Alternative: Central Valley Project and State Water Project Operations.

Water quality objectives for electrical conductivity were established in the SWRCB (2006a) Basin Plan to protect the beneficial uses of these Delta waterways, including agricultural supply. Objectives are specific to the western Delta, interior Delta, southern Delta and export area, as well as for inflows and outflows to the delta from other water bodies. Compliance locations in the Delta are shown in Figure 6.5.

The patterns of EC and salinity in the Delta over time and space follow predictable patterns, under the strong influence of higher saline water from the San Joaquin and less saline water from the Sacramento and Eastside streams in an ever-changing balance with tidal influence upstream from Suisun Bay and the losses from south Delta pumping. The record of monthly average EC readings for recent years at five sites throughout the Delta shows the pattern of increasing average EC in the western Delta, as shown in Figures 6.6 through 6.8. The highest salinity occurs in the late summer months when the flows from the Sacramento and San Joaquin rivers are the lowest, and sea water intrusion occurs. The lower Sacramento River at Collinsville experiences strong tidal influence during dry periods (EC above 8000 µmhos/cm) but is flushed with fresh water during winter flows. Historical salinity discharged from the CVP Jones Pumping Plant into the Delta Mendota Canal is summarized in Figure 6.9.

Salinity objectives for the southern Delta are now under review by the SWRCB (SWRCB 2008b).

#### 6.3.3.3.2 Mercury

Mercury is a constituent of concern for the Sacramento-San Joaquin River Delta, which was placed on the 303(d) list in 2010 (SWRCB 2011a). In 2008, the San Francisco Bay Mercury TMDL was approved by the USEPA and the implementation plan is expected to attain the water quality standard 20 years after the approval (SFB RWQCB 2006). In 2010, the RWQCB approved amendments to the Basin Plan for the Sacramento River and San Joaquin River Basins to include the Sacramento-San Joaquin Delta Methylmercury TMDL (CVRWQCB 2011). The TMDL was created to control methylmercury and total mercury in the Sacramento-San Joaquin River Delta Estuary, which is applicable to the Delta, Yolo Bypass, and their waterways (CVRWQCB 2010a). The waterways include the major tributaries to the Delta, the Sacramento River, eastside streams, and the San Joaquin River. Fish tissue and waterborne mercury concentration data for these water bodies are summarized in Tables 6.19 and 6.20.

**Table 6.19 Fish and Waterborne Methylmercury (as Total Mercury) Concentrations by Delta Subarea**

| | Delta Subarea[1] | | | | |
|---|---|---|---|---|---|
| | **Sacramento River** | **Mokelumne River** | **Central Delta** | **San Joaquin River** | **West Delta** |
| **Fish (Sampled in September/October 2000) (mg/kg wet weight)** | | | | | |
| Standardized 350-mm Largemouth Bass[2] | 0.72 | 1.04 | 0.19 | 0.68 | 0.31 |
| **Water (Sampled between March and October 2000) (ng/l)** | | | | | |
| Average | 0.120 | 0.140 | 0.055 | 0.147 | 0.087 |
| Median | 0.086 | 0.142 | 0.032 | 0.144 | 0.053 |
| **Water (Sampled between March 2000 and April 2004) (ng/l)** | | | | | |
| Annual Average | 0.108 | 0.166 | 0.060 | 0.160 | 0.083 |
| Annual Median | 0.101 | 0.161 | 0.051 | 0.165 | 0.061 |
| Cool Season[3] Average | 0.137 | 0.221 | 0.087 | 0.172 | 0.106 |
| Cool Season[3] Median | 0.138 | 0.246 | 0.077 | 0.175 | 0.095 |
| Warm Season[3] Average | 0.094 | 0.146 | 0.050 | 0.156 | 0.075 |
| Warm Season[3] Median | 0.089 | 0.146 | 0.040 | 0.162 | 0.055 |

Source: Adapted from CVRWQCB 2010a.

1 Location of each water and fish collection site provided on Figure 5.1 of the 2008 Draft Staff Report for the Sacramento-San Joaquin Delta Estuary TMDL for Methylmercury (CVRWQCB 2010a).

2 See CVRWQCB 2010a for the method used to calculate standard 350-mm Largemouth Bass mercury concentrations.

3 For this analysis, “cool season” is defined as November through February and “warm season” is defined as March through October.

**Table 6.20 Historical Methylmercury Concentrations in the Five Delta Source Waters for the Period 2000-2008**

| Source Water | Sacramento River | | San Joaquin River | | San Francisco Bay | | East Side Tributaries | | Agriculture in the Delta | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Total[2]** | **Dissolved[3]** | **Total[2]** | **Dissolved[3]** | **Total[2]** | **Dissolved[3]** | **Total[2]** | **Dissolved[3]** | **Total[2]** | **Dissolved[3]** |
| Mean[1] (ng/L) | 0.10 | 0.05 | 0.15 | 0.03 | 0.032 | - | 0.22 | 0.08 | 0.51 | - |
| Minimum (ng/L) | 0.06 | 0.02 | 0.09 | 0.01 | - | - | 0.02 | 0.02 | 0.02 | - |
| Maximum (ng/L) | 0.16 | 0.12 | 0.26 | 0.08 | - | - | 0.32 | 0.41 | 5.44 | - |
| 75th Percentile (ng/L) | 0.13 | 0.08 | 0.18 | 0.06 | - | - | 0.2 | 0.15 | 0.53 | - |
| 99th Percentile (ng/L) | 0.16 | 0.12 | 0.26 | 0.08 | - | - | 0.31 | 0.39 | 4.81 | - |
| Data Source | CEDEN 2014 (Irrigated Lands Regulatory Program) | | Central Valley Water Board 2010a | | SFEI 2014b | - | Central Valley Water Board 2010a | | Heim et al. 2009 | - |
| Station(s) | Sacramento River at Freeport | | San Joaquin River at Vernalis | | Suisun Bay | | Mokelumne and Calaveras Rivers | | Delta locations | |
| Date Range | 12/2006-08/2007 | | 2000-2001; 2003-2004 | 2000-2002 | 2008 | - | 2000-2001; 2003-2004 | 2000-2002 | 10/2005-03/2008 | - |

| **Source Water** | **Sacramento River** | | **San Joaquin River** | | **San Francisco Bay** | | **East Side Tributaries** | | **Agriculture in the Delta** | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Total[2]** | **Dissolved[3]** | **Total[2]** | **Dissolved[3]** | **Total[2]** | **Dissolved[3]** | **Total[2]** | **Dissolved[3]** | **Total[2]** | **Dissolved[3]** |
| ND Replaced with RL | No | | Not Applicable | Yes | - | | Yes | | Not Applicable | |
| Data Omitted | No | | None | | - | | None | | None | |
| No. of Data Points | 8 | 8 | 49 | 25 | - | - | 27 | 9 | 183 | - |

Source: Adapted from DWR, Reclamation, USFWS and NMFS 2013.

1 Geometric mean.

2 Total recoverable concentration of analyte.

3 Dissolved concentration of analyte.

For the protection of the beneficial uses of the Sacramento – San Joaquin Delta, water quality objectives were specified in the San Francisco Bay Mercury TMDL (Table 6.21) and the Sacramento-San Joaquin Delta Methylmercury TMDL (Table 6.22).

**Table 6.21 Water Quality Objectives for Total Mercury in the Delta within the San Francisco Bay Region[1]**

| | |
|---|---|
| For the protection of human health | 0.2 mg/kg wet weight mercury in fish tissue[2] |
| For the protection of aquatic organisms and wildlife | 0.03 mg Hg/kg in fish[3] |
| 1-hour average | 2.1 µg/l, in water |

Source: SFB RWQCB 2013

1 Water quality objectives are applicable to Sacramento/San Joaquin River Delta (within the San Francisco Bay region as specified in the SFB RWQCB Basin Plan, 2013), Suisun Bay, Carquinez Strait, and San Pablo Bay.

2 measured in the edible portion of trophic level 3 and trophic level 4 fish

3 measured in whole fish 3-5 cm in length

**Table 6.22 Water Quality Objectives for total mercury in the Delta within the Central Valley**

| Water body | Wet Weight Methylmercury Concentration of Fish Tissue (mg/kg wet weight) | |
|---|---|---|
| | Trophic Level 3 Fish | Trophic Level 4 Fish |
| Cache Creek, North Fork Cache Creek, and Bear Creek | 0.12 | 0.23 |
| Harley Gulch | 0.05[1] | – |
| Sacramento-San Joaquin Delta[2] and Yolo Bypass | 0.08[3], 0.03[4] | 0.24[3], 0.03[4] |

Source: CVRWQCB 2011

1 Applies to whole fish of trophic levels 2 and 3.

2 Applies to the 146 Sacramento-San Joaquin Delta and Yolo Bypass waterways listed in Appendix 43 of the Basin Plan for the Sacramento River and San Joaquin River Basins.

3 Applies to fish of total length 150-500 mm.

4 Applies to whole fish less than 50 mm in length.

Methylation processes in the Delta are enhanced by environmental characteristics such as the source of inorganic mercury, nutrient enrichment, dissolved oxygen in the water column, sediment organic content and grain size, water residence time and sediment accumulation, periodic drying and wetting, and fish species and age structure (Alpers et al. 2008). The mercury-laden sediment that accumulates in the Delta as a result of waterborne loading is subject to methylation (Heim et al. 2007). Waterborne methylmercury in the Delta may be a more significant factor to bioaccumulation in fish than mercury-laden sediment that is subject to methylation (Melwani et al. 2009). Another factor affecting bioaccumulation in fish may be dissolved organic carbon (DOC). Laboratory studies have shown mercury uptake is much higher in water with lower DOC (as might be expected from the tributaries versus the interior Delta) (Pickhardt et al. 2006).

Mercury exposure and methylation can affect the beneficial uses of the Sacramento-San Joaquin Delta, and receiving waters downstream such as the Suisun Bay, Carquinez Strait, San Pablo Bay, and San Francisco Bay. To protect the beneficial uses of the water body a narrative water quality objective was specified, in addition to numeric water quality objectives, stating that surface waters are to "…be maintained free of toxic substances in concentrations that are toxic to or that produce detrimental physiological responses to human, plant, animal, and aquatic life" (CVRWQCB 2011).

In an effort to meet the water quality objectives, the CVRWQCB plans to continue monitoring metals in the Delta and control mass emissions from inactive or abandoned mines and other significant sources (CVRWQCB 2011). The ongoing interest in controlling mercury in fish in the Delta has spawned the Mercury Exposure Reduction Program (MERP), developed by the CVRWQCB, with the goal of pooling the resources of mercury dischargers to develop reduction programs and a better understanding of mercury bioaccumulation in Delta fish (MERP 2012). The MERP is designed to build on previous CALFED efforts. MERP was included as part of an amendment to the Sacramento River and San Joaquin River Basins Basin Plan in 2011 (CVRWQCB 2011), and is applicable to people eating one meal of trophic level 3 or 4 fish per week (32 g/day) from the Delta and Yolo Bypass, as well as their waterways. The two-phase program was put into effect October 20, 2011 and will be completed in 2030. Phase 1 consists of implementing programs to minimize pollution, implementing interim mass limits for point sources, and controlling potentially methylated sediment-bound mercury in the Delta and Yolo Bypass. Phase 1 also includes developing a program to control mercury in tributaries upstream. Plans for Phase 2 include implementing control programs and monitoring compliance. In addition to the Delta Control Mercury Program, the CVRWQCB designated load and waste load allocations for point sources within and to the Delta as specified in the Basin Plan.

#### 6.3.3.3.3 Selenium

Selenium is a constituent of concern for the Sacramento-San Joaquin River Delta and the Delta was placed on the 303(d) list in 2010 (SWRCB 2011a). Selenium criteria were promulgated for all San Francisco Bay and Delta waters in the NTR (SFB RWQCB 2011a). Although the entire San Francisco Bay is listed as impaired by selenium, the TMDL for the San Francisco Bay focuses on the North San Francisco Bay (North Bay, defined to include a portion of the Delta, Suisun Bay, Carquinez Strait, San Pablo Bay, and the Central Bay) because sources there are substantially different from sources in the South San Francisco Bay (South Bay) (Lucas and Stewart 2007). The NTR criteria specifically apply to San Francisco Bay upstream to and including Suisun Bay and the Delta. The NTR values are 5.0 µg/l (4-day average) and 20 µg/l (1-hour average).

Selenium concentrations in whole-body fish and in bird eggs are most useful for evaluating risks to fish and bird wildlife receptors (Skorupa and Ohlendorf 1991; DOI 1998; Ohlendorf 2003). Analyses of dietary items (such as benthic [sediment-associated] or water-column invertebrates) can be used for evaluating risks through dietary exposure, although with less certainty than when using concentrations measured in fish or wildlife receptors. The USEPA (2014b) released draft water quality criteria for public comment in May 2014 for selenium in fish tissue; they include 15.2 mg/kg in egg/ovary, 8.1 mg/kg whole body, or 11.8 mg/kg muscle (skinless, boneless fillet).

A large number of fish tissue samples were collected from the Sacramento and San Joaquin River watersheds and the Delta between 2000 and 2007 (Foe 2010). As part of the Strategic Workplan for Activities in the San Francisco Bay/Sacramento–San Joaquin Delta Estuary (SWRCB 2008a), archived Largemouth Bass samples were analyzed for selenium to investigate possible sources of selenium being bioaccumulated in bass in the Delta and whether selenium concentrations in bass were above recommended criteria for the protection of human and wildlife health (Foe 2010). Results of this study are the most relevant biota data from the Delta, and they are summarized in Table 6.23 to compare to tissue guidelines.

**Table 6.23 Selenium Concentrations in Largemouth Bass**

| | | Selenium Concentrations in Fish Fillets (mg/kg, wet weight) | | | Selenium Concentrations in Whole-Body Fish (mg/kg, dry weight) | | | Years |
|---|---|---|---|---|---|---|---|---|
| **Site** | **Number of Samples** | **Min.** | **Max.** | **Mean** | **Min.** | **Max.** | **Mean** | **–** |
| Sacramento River at Veterans Bridge | 3 | 0.40 | 0.81 | 0.56 | 1.7 | 2.9 | 2.2 | 2005 |
| Sacramento River at River Mile 44[a] | 9 | 0.27 | 0.72 | 0.46 | 1.2 | 2.7 | 1.9 | 2000, 2005, 2007 |
| Sacramento River near Rio Vista | 9 | 0.30 | 0.80 | 0.44 | 1.3 | 3.2 | 1.9 | 2000, 2005, 2007 |
| San Joaquin River at Freemont Ford | 3 | 0.35 | 0.46 | 0.48 | 1.46 | 2.44 | 1.9 | 2005 |
| San Joaquin River at Vernalis | 8 | 0.15 | 0.63 | 0.40 | 0.77 | 2.5 | 1.7 | 2000, 2005, 2007 |
| Old River near Tracy | 3 | 0.45 | 0.69 | 0.55 | 2.0 | 2.9 | 2.4 | 2005 |
| San Joaquin River at Potato Slough | 9 | 0.22 | 0.89 | 0.38 | 1.1 | 3.5 | 1.6 | 2000, 2005, 2007 |
| Middle River at Bullfrog | 6 | 0.37 | 0.58 | 0.47 | 1.6 | 2.3 | 2.0 | 2005, 2007 |

| Site | Number of Samples | Selenium Concentrations in Fish Fillets (mg/kg, wet weight) | | | Selenium Concentrations in Whole-Body Fish (mg/kg, dry weight) | | | Years |
|---|---|---|---|---|---|---|---|---|
| | | Min. | Max. | Mean | Min. | Max. | Mean | – |
| Franks Tract | 8 | 0.15 | 0.70 | 0.37 | 0.79 | 3.0 | 1.7 | 2000, 2005, 2007 |
| Big Break | 9 | 0.15 | 0.82 | 0.38 | 0.81 | 3.1 | 1.6 | 2000, 2005, 2007 |
| Discovery Bay | 3 | 0.32 | 0.41 | 0.37 | 1.5 | 1.7 | 1.6 | 2005 |
| Whiskey Slough | 2 | 0.35 | 0.47 | 0.41 | 1.6 | 1.9 | 1.7 | 2005 |

Source: Foe 2010

Notes: Means are geometric means.

Max. = maximum, mg/kg = milligrams per kilogram, Min. = minimum.

a. Near Clarksburg.

Average selenium concentrations varied slightly in Largemouth Bass caught in the Sacramento River between Veterans Bridge and Rio Vista in 2005, as well as on the San Joaquin River between Fremont Ford and Vernalis (Foe 2010). These concentrations also varied slightly among years (2000, 2005, and 2007) in the Sacramento River at Rio Vista and in the San Joaquin River at Vernalis. The lack of a significant difference in bioavailable selenium between the two river systems was unexpected because the San Joaquin River is considered a significant source of selenium to the Delta. Selenium concentrations in the Largemouth Bass were compared to criteria recommended for the protection of human health (based on fillets; 2 mg/kg, wet weight) and fish and wildlife health (based on whole-body fish; concern threshold of 4–9 mg/kg, dry weight) (Foe 2010). Geometric means and maximum concentrations (Table 6.23) did not exceed the draft criteria.

Sporadic sampling of selenium has been conducted at a few locations in the Delta. Five major sources, shown in Table 6.24, are Sacramento River, Yolo Bypass, Eastside Delta Tributaries, San Joaquin River, and Martinez/Suisun Bay. Total selenium concentrations in Sacramento and San Joaquin river surface waters just upstream of Mallard Island (near the western limit of the Delta [Regional Monitoring Program stations BG20 and BG30, respectively]) are considered more representative of generalized Delta concentrations than of the individual rivers (SWRCB 2008a). Total and dissolved selenium concentrations were somewhat lower at those locations during low flow in a dry year (<0.1 µg/l in August 2001) than during high flow (>0.1 µg/l in February 2001) (SWRCB 2008a). Cutter and Cutter (2004) reported similar flow-related patterns for those locations. The maximum selenium concentration found in the Delta was 2 µg/l at an Old/Middle River location in the south subarea of the Delta. Except for that location, the available data show geometric mean concentrations well below 1 µg/l.

**Table 6.24 Selenium Concentrations in Water at Inflow Sources to the Delta**

| Source Water[1] | Sacramento River | San Joaquin River | San Francisco Bay | East Side Tributaries[3] | Agriculture in the Delta |
|---|---|---|---|---|---|
| Mean[2] (ng/L) | 0.10 | 0.54 | 0.09 | 0.1 | 0.11 |
| Minimum (ng/L) | 0.04 | 0.07 | 0.03 | 0.1 | 0.11 |
| Maximum (ng/L) | 0.23 | 1.50 | 0.45 | 0.1 | 0.11 |
| 75th Percentile (ng/L) | 0.11 | 0.76 | 0.12 | 0.1 | 0.11 |
| 99th Percentile (ng/L) | 0.23 | 1.50 | 0.44 | 0.1 | 0.11 |
| Data Source | USGS Website 2014b | USGS Website 2014c | SFEI 2014b | None | Lucas and Stewart 2007 |
| Station(s) | Sacramento River at Freeport | San Joaquin River at Vernalis | Central-West; San Joaquin River Near Mallard Island | None | Mildred Island, Center |
| Date Range | 11/2007-07/2014 | 11/2007-08/2014 | 02/2000-08/2013 | None | 2000, 2003-2004 |
| ND Replaced with RL | Not Applicable | Not Applicable | Yes | Not Applicable | No |
| Data Omitted | None | None | - | Not Applicable | No |
| No. of Data Points | 88 | 93 | 14 | None | 1 |

Sources: Adapted from DWR, Reclamation, USFWS and NMFS 2013; U.S. Geological Survey 2014b,c; San Francisco Estuary Institute 2014b; Lucas and Stewart 2007

1 Dissolved selenium concentration.

2 Geometric mean.

3 Dissolved selenium concentration in Mokelumne, Calaveras, and Cosumnes Rivers is assumed to be 0.1 µg/L because of lack of available data and lack of sources that would be expected to result in concentrations greater than 0.1 µg/L

In efforts to address the selenium in the Delta and water bodies downstream, the SFB RWQCB is conducting a new TMDL project to address selenium toxicity in the North Bay (SFB RWQCB 2011, 2013). The North Bay selenium TMDL will identify and characterize selenium sources to the North Bay and the processes that control the uptake of selenium by fish and wildlife. The TMDL will quantify selenium loads, develop and assign waste load and load allocations among sources, and include an implementation plan designed to achieve the TMDL and protect beneficial uses.

USEPA's Action Plan for Water Quality Challenges in the San Francisco Bay/Sacramento-San Joaquin Estuary (USEPA 2012a) identifies selenium as one of seven priority items for action. The plan indicated that USEPA will draft new site-specific numeric selenium criteria by December 2012 to protect aquatic and terrestrial species dependent on the aquatic habitats of the Bay Delta Estuary. More stringent selenium water quality criteria will require actions that decrease allowable concentrations of selenium in surface waters of the Bay Delta Estuary and may set allowable levels of selenium in the tissue of fish and wildlife. Following the development of the Bay Delta selenium criteria, USEPA plans to develop site-specific criteria for other parts of California, including the San Joaquin Valley watershed (USEPA 2012a). USEPA also is engaged in other efforts to minimize selenium discharges to the San Joaquin River and the Bay Delta Estuary, including the Grasslands Bypass Project and the North San Francisco Bay TMDL.

#### 6.3.3.3.4 PCBs

The Sacramento-San Joaquin River Delta was placed on the 303(d) list approved by the USEPA in 2010 as impaired by PCBs (SWRCB 2011a). A TMDL for PCBs in the Sacramento River from Knights Landing to the Delta is expected to be completed in 2021 to protect the beneficial uses of the Sacramento River and other water bodies downstream (SWRCB 2011ax).

#### 6.3.3.3.5 Pesticides

Sacramento-San Joaquin River Delta (central, eastern, northern, northwestern, southern, western portions, the export area, and the Stockton Ship Channel) were placed on the Section 303(d) List approved by the USEPA in 2010 as impaired by pesticides (chlorpyrifos, DDT, Diazinon, Group A Pesticides, Chlordane, Dieldrin, Dioxin, and Furan and Dioxin compounds) (SWRCB 2011a).

Samples were collected from Sacramento River at Rio Vista, near Hood along the Sacramento/Yolo County line, San Joaquin River at Highway 4 and Antioch, 1 1/2 miles upstream from the Mossdale launch ramp, and other locations north portion of the Delta waterways (SWRCB 2011at-bb).

In an effort to meet the water quality standards in Sacramento-San Joaquin River Delta, TMDLs are expected to be complete in 2019 with the exception of the TMDL for chlorpyrifos and diazinon. A Delta Diazinon and Chlorpyrifos TMDL Project was approved in 2007.

#### 6.3.3.3.6 Nutrients

The Sacramento-San Joaquin River Delta was not placed on the 303(d) list approved by USEPA in 2010 as impaired by nutrients (SWRCB 2011a). However, nutrients are a cause of concern in the Delta (e.g., CVRWQCB 2010j) and have been the subject of discussion. A decline in pelagic fish species in the Delta, known as the pelagic organism decline (POD), including the endangered California Delta smelt, may be related to bottom-up effects from nutrients among other drivers (Baxter et. al. 2010; Sommer et al. 2007). However, unlike most waterbodies where nutrients cause too much primary production, the problem affecting beneficial uses in parts of the Delta is too little primary production to support fish populations. Nutrient effects are also dependent on flow and other factors (e.g., temperature, turbidity, and invasive species) that are potentially associated with the POD. Specific hypotheses for an association between nutrients and the POD are that ammonium (a dominant form of nitrogen in the Delta and Suisun Bay, inhibits the uptake of nitrate which is a better fuel for algae blooms (Dugdale et al. 2007) and that changes in nutrient forms and rations have caused a shift in the food web (Glibert et al. 2011). Alternatively, causes of the POD may be related to reduced phosphorus that has become a limiting factor for primary production (Van Nieuwenhuyse 2007), or that invasive clam consumption of algae have made this food source unavailable to zooplankton and fish since their introduction in the mid-1980s (Lucas and Thompson 2012; Kimmerer et al. 1994).

The Delta is a major source of anthropogenic ammonium loading to the Suisun Bay, which exchanges nutrients with Suisun Marsh, an estuarine habitat impaired by nutrients (Senn et al. 2014, Tetra Tech Inc. and WWR 2013). Primary sources of nutrients are erosion, agricultural runoff, urban runoff, and treated effluent. The Sacramento Regional Wastewater Treatment Plant (SRWTP) is the largest major point source of ammonium in the Delta, contributing 90 percent of ammonium in the river from 1986 to 2005 (Jassby 2008). Nitrogen inputs to the Delta will change as SRWTP's current NPDES permit (NO. CA0077682) includes effluent limits for nitrogen that require the addition of nitrification and denitrification treatment by 2020. Another source of ammonium loading has already changed as the Stockton Regional Wastewater Control Facility, which discharges to the San Joaquin River began implementing nitrification and denitrification treatment in 2007 (SWRCB 2012b).

Nutrients, primarily nitrogen and phosphorous, may trigger excessive growth of algae or toxic blue-green cyanobacteria. However, within the Delta, it is generally recognized that nutrients are too high in concentration to be limiting (as compared to light, for example) (Jassby et al. 2002). The secondary effects of nutrient enrichment and oxygen depletion are most often found in the central and southern Delta near Stockton rather than the Sacramento River.

#### 6.3.3.3.7 Dissolved Oxygen

The Stockton Ship Channel in the Delta waterways was placed on the Section 303(d) list approved by the USEPA in 2010 as impaired by dissolved oxygen (SWRCB 2011a).

Low dissolved oxygen is of concern in the central and southern Delta because of enhanced treated effluent loading from Stockton, agricultural runoff, and reduced flushing of dead-end channels. Middle River, Old River, and the Stockton Deep Water Ship Channel are listed as impaired due to dissolved oxygen depletion, with dissolved oxygen concentrations criteria set at 6 mg/L minimum for the San Joaquin River between Turner Cut and Stockton between September 1 and November 30 (SWRCB 2011a, SWRCB 2006a). Loading from the Stockton Regional Wastewater Control Facility had the greatest effect in reducing DO, with hydrologic flushing (as related to upstream river flows, upstream discharges of materials that increase biological oxygen demand), geometrical cross-sections of the channels, temperature, and phytoplankton being less important (Jassby and Niewenhuyse 2005). Following recent upgrades to the Stockton Regional Wastewater Control Facility in 2006, less oxygen demand constituents have been discharged into the channels.

A TMDL addressing impairment due to dissolved oxygen was approved by the USEPA in 2007 to meet the water quality standards in the Stockton Ship Channel.

#### 6.3.3.3.8 Organics and Pathogens

The Stockton Ship Channel in the Delta waterways was placed on the Section 303(d) list approved by the USEPA in 2010 as impaired by organic enrichment and pathogens (SWRCB 2011a).

The Delta as a source of drinking water is impaired through the presence of disinfection byproducts from treated wastewater effluent and the interactions with bromide and dissolved organic carbon, which may produce potentially harmful disinfection byproducts such as the carcinogenic trihalomethanes and haloacetic acid (Healey et al. 2008). Bromide and organic carbon are natural chemical constituents of the estuarine ecosystem but they exacerbate drinking water quality impairment through discharges, agriculture drainage, or water management, when combined with disinfectants during water treatment processes. Changes to flow or use patterns or discharges to the Delta must be examined for their potential effects to concentrations of these disinfection byproduct precursors and compounds.

Pathogens are another potential concern impairing the Delta for drinking water use. Giardia and Cryptosporidium are common protozoans found in urban runoff and sometimes found to be in exceedance of drinking water standards in the Delta (SWRCB 2007). A TMDL addressing impairment due to pathogens was approved by the USEPA in 2008 to meet the water quality standards in the Stockton Ship Channel.

#### 6.3.3.3.9 Invasive Species

Sacramento-San Joaquin River Delta (central, eastern, northern, northwestern, southern, western portions, the export area, and the Stockton Ship Channel) was placed on the Section 303(d) list approved by the USEPA in 2010 as impaired by invasive species (SWRCB 2011a).

A TMDL addressing impairment due to invasive species is expected to be completed in 2019 in an effort to meet the water quality standards in Sacramento-San Joaquin River Delta (central, eastern, northern, northwestern, southern, western portions, the export area, and the Stockton Ship Channel).

#### 6.3.3.3.10 Unknown Toxicity

Sacramento-San Joaquin River Delta (central, eastern, northern, northwestern, southern, western portions, the export area, and the Stockton Ship Channel) were placed on the Section 303(d) list approved by the USEPA in 2010 as impaired by unknown toxicity (SWRCB 2011a).

A TMDL is expected to be completed in 2019 to protect the beneficial uses of Sacramento-San Joaquin River Delta and its waterways, including impaired warm fresh water habitat.

### *6.3.3.4 Suisun Bay and Suisun Marsh*

Suisun Bay and Suisun Marsh are located in transition zones between upstream fresh water inputs and tidal saline flux from San Francisco Bay. Beneficial uses of these areas are summarized in Table 6.2. Constituents of concern are summarized in Table 6.1.

Historically, the chlorophyll maxima were found to coincide with the mixing (entrapment) zone but recent alterations by invasive species of benthic grazing clams has greatly altered the Suisun Bay food web and these historical patterns (Kimmerer 2004; Jassby et al. 2002). Although turbidity remains high and limiting to primary productivity in Suisun Bay, there has been a long term trend toward increased water clarity. Suisun Bay has low retention time, low salinity (average of 5.8 ppt), low nutrients, and high particulate matter and light attenuation (Cloern and Jassby 2012).

#### 6.3.3.4.1 Salinity

The Suisun Marsh Wetlands was placed on the 303(d) list approved by the USEPA in 2010 for impairment by salinity. The wetlands are also impaired by TDS and chlorides (SWRCB 2011a).

In an effort to protect the beneficial uses, including estuarine habitat, narrative and numeric objectives were specified by the SWRCB in Decision 1641. The CVP and SWP are operated to achieve salinity objectives in the Delta, as described in detail in Appendix 3A, No Action Alternative: Central Valley Project and State Water Project Operations.

The salinity objective in Suisun Bay, X2, which is the location, as measured in kilometers upstream from the Golden Gate bridge, of the 2 ppt isohaline (2.64

mS/cm) was established as part of the Water Quality Control Plan of 1995 (SWRCB 1995). X2 is a constantly fluctuating position in the continuum between the Delta fresh water (salinity less than 2 ppt) upstream and San Francisco Bay tidal influence, downstream (salinity greater than 2 ppt).

#### 6.3.3.4.2 Mercury

Mercury is a constituent of concern for Suisun Bay and Suisun Marsh, which were placed on the 303(d) list in 2010 (SWRCB 2011a). For the Suisun Bay, a TMDL was specified in the San Francisco Bay Mercury TMDL (SFB RWQCB 2013), which was approved by the USEPA in February 2008 and the implementation plan is expected to attain the water quality standard 20 years after the approval. For the Suisun Marsh, a TMDL was specified in the Sacramento-San Joaquin Delta Methylmercury TMDL (CVRWQCB 2010a) and was completed in September 2012 (SFB RWQCB 2012a).

Water quality objectives for Suisun Bay are specified in the San Francisco Bay Mercury TMDL (SFB RWQCB 2013). Suisun Marsh standards, as specified in Suisun Marsh TMDL, are shown in Table 6.25 (SFB RWQCB 2012a). There are future plans to adopt the Suisun Bay standards for the Suisun Marsh as well as implementation plans to improve the water quality in Suisun Marsh.

**Table 6.25 Water Quality Objectives for Total Mercury in Suisun Marsh**

| | | |
|---|---|---|
| For the Protection of Marine and Freshwater Aquatic Life | 4-day average (adverse effects from acute toxicity[1]) | 0.25 µg/l |
| | 1-hour average (adverse effects from chronic toxicity) | 2.1 µg/l |

Source: SFB RWQCB 2012a

1 Applicable to marine aquatic life, where salinity is greater than 10 parts per thousand. The same objectives apply to freshwater aquatic life because the marine objective is more stringent.

#### 6.3.3.4.3 Selenium

Although the Suisun Marsh Wetlands is not identified as an impaired water body for selenium contamination on the 303(d) list in 2010, selenium is identified as a cause for impairment for the adjacent water body, Suisun Bay (SWRCB 2011a).

The impairment of Suisun Bay by selenium can be attributed to exotic species as well as discharge from industrial point sources and natural sources (SWRCB 2011bd). *Corbula (Potamocorbula) amurensis*, a species of clam that is an important food source for sturgeon and certain ducks, is a bioaccumulator for selenium (Beckon and Maurer 2008). This exotic species was first discovered in Suisun Bay in 1986 and became very common by 1990 from San Pablo Bay through Suisun Bay (Cohen 2011). Industrial point sources, such as oil refineries, discharge waste containing selenium to the Suisun Bay (SFB RWQCB 2011).

To best protect the most susceptible fish, white sturgeon, from selenium toxicity, a TMDL for Selenium in the North San Francisco Bay, defined to include also a portion of the Delta, Suisun Bay, Carquinez Strait, San Pablo Bay, and the Central

Bay, is being completed and a Preliminary Project Report was released in 2011 (SFB RWQCB 2011). A range of concentrations for selenium in fish tissue from 6.0 to 8.1 µg/g dry weight was proposed as a numeric target. This range is based on the minimal effects of selenium in whole-body freshwater fish and the 10 percent effect level concentration.

#### 6.3.3.4.4 Nutrients

Suisun Marsh is a water body in the San Francisco Bay that was placed on the Section 303(d) list approved by USEPA in 2010 as impaired by nutrients (SWRCB 2011a).

According to the Final California 2010 Integrated Report (303(d) list/305(b) Report) Supporting Information, nutrients in Suisun Marsh can be attributed to flow regulation/modification and urban runoff/storm sewers (SWRCB 2011bc). More specific sources of nutrients to Suisun Marsh include agricultural, urban, and livestock grazing drainage through tributaries, the Sacramento River and San Joaquin River through the Sacramento-San Joaquin River Delta, nutrient exchange with Suisun Bay, atmospheric deposition, and discharge from the Fairfield Suisun Sewer District wastewater treatment plant (Tetra Tech Inc. and WWR 2013).

Concentrations of ammonia from 2000-2011, in the receiving waters from Boynton, Peytonia, Sheldrake and Chadbourne Sloughs (0-0.4 mg/l), as well as in Suisun Slough (0-0.3mg/l), exceeded the maximum water quality objective concentration for ammonia (Tetra Tech Inc. and WWR 2013). Elevated concentrations of chlorophyll-a, in comparison to concentrations at reference sites at Mallard, suggest possible impairments by nutrients. Other possible impairments of the narrative criteria by nutrients were suggested resulting in excess algal growth in wetlands, elevated organic carbon, and impacts on dissolved oxygen and mercury methylation.

#### 6.3.3.4.5 Dissolved Oxygen

Suisun Marsh Wetlands were placed on the 303(d) list approved by the USEPA in 2010 for dissolved oxygen impairment (SWRCB 2011a). Insufficient dissolved oxygen can alter the well-being of the estuarine habitat, fish spawning, warm freshwater habitat, and wildlife habitat (SFB RWQCB 2013).

Flow regulation and modification, as well as urban runoff and storm sewers dictate the dissolved oxygen levels in the marsh (SWRCB 2011bc). Specific oxygen demanding sources that cause low dissolved oxygen levels are “grazed open areas, nutrient-enriched wastewater discharge from Fairfield-Suisun Sewer District, wastes from boats in Suisun City marina, and tidal marshes,” in addition to tides, delta outflow, agricultural drainage from surrounding watersheds and urban areas, and managed wetlands (Tetra Tech, Inc. and WWR 2013). Slough size and hydrology also influenced the low dissolved oxygen conditions in Suisun Marsh Wetlands (Siegel et al. 2010).

Low dissolved oxygen levels in exceedances of water quality objectives between 2000 and 2011 in Suisun Slough, Montezuma Slough, and Goodyear Slough are presented in Table 6.26 (Tetra Tech, Inc. and WWR 2013).

**Table 6.26 Percentage of Observations Exceeding Water Quality Objectives for Dissolved Oxygen**

| Location | WQO Exceedances | |
|---|---|---|
| | **7 mg/l** | **< 80% Saturation[1]** |
| Suisun Slough | 10 – 40% | 2% |
| Montezuma Slough | < 10% | 60 – 68% |
| Goodyear, Peytonia, and Boynton Sloughs | > 50% | 73 – 94%[2] |

Source: Tetra Tech, Inc. and WWR 2013

1 3-month median above 80 percent dissolved oxygen saturation

2 Lower Goodyear Slough exceeded the 3-month media above 80 percent dissolved oxygen saturation 48.1 percent of the time

To further protect the beneficial uses of the Suisun Marsh Wetlands from low dissolved oxygen concentrations, water quality objectives more representative of natural conditions are currently being developed (Tetra Tech, Inc. and WWR 2013). A TMDL for Suisun Creek, a tributary of Suisun Marsh Wetlands that is impaired by low dissolved oxygen, is expected to be completed in 2021 (SWRCB 2011bc).

#### 6.3.3.4.6 Organics

Suisun Marsh was placed on the 303(d) list approved by USEPA in 2010 for organic enrichment (SWRCB 2011a). Organic enrichment enhances microbial production and activity, such as the methylation of mercury, and the decomposition of organic matter can cause low dissolved oxygen levels (Tetra Tech, Inc. and WWR 2013).

#### 6.3.3.4.7 Pesticides

Suisun Bay, and other water bodies in the San Francisco Bay area including Carquinez Strait and San Pablo Bay were placed on the Section 303(d) list for pesticides (chlordane, DDT, dieldrin) contamination per the list approved by USEPA in 2010 (SWRCB 2011a). However, according to the 2013 Regional Monitoring Program Report, pesticides (chlordane, DDT, and dieldrin) in the estuary are being considered for delisting (SFEI 2013).

A TMDL for the Diazinon and Pesticide-related Toxicity in Urban Creeks was added as an amendment to the Basin Plan and was approved by the USEPA in 2007 (SFB RWQCB 2005).

#### 6.3.3.4.8 PCBs

Suisun Bay, and several other water bodies within San Francisco Bay area including Carquinez Strait and San Pablo Bay, were placed on the Section 303(d) list for the contamination of PCBs per the list approved by USEPA in 2010 (SWRCB 2011a). The following is applicable to all water bodies specified in the San Francisco Bay PCBs TMDL, including Suisun Bay, Carquinez Strait, and San Pablo Bay (SFB RWQCB 2013).

A TMDL was approved by the USEPA in 2010. The TMDL allows 10 kilograms of PCBs to be discharged to San Francisco Bay per year (SFB RWQCB 2013). It is projected that this load allocation will be achieved in 20 years with implementation of plans and actions for external and internal sources, such as municipal and industrial dischargers, as stated in the San Francisco Bay TMDL.

#### 6.3.3.4.9 Other Constituents of Concern

Suisun Bay was placed on the Section 303(d) list for invasive species contamination per the list approved by USEPA in 2010 (SWRCB 2011a).

Invasive species in Suisun Bay can be attributed to ballast water, fresh or salt water placed on a ship for stability (SWRCB 2011bd). *Corbula (Potamocorbula) amurensis*, a native clam of southern China estuaries, was discovered in Suisun Bay in 1986 and was introduced to San Pablo Bay shortly after (USFWS and NSGCP 1995). This species of clam is important as a food source for sturgeon, diving ducks, etc. and consequently a bioaccumulator of selenium (USFWS 2008). Other species introduced to the Suisun Bay are reported in the *Nonindigenous Aquatic Species in a United States Estuary: A Case Study of the Biological Invasions of the San Francisco Bay and Delta* (USFWS and NSGCP 1995).

Invasive species can affect the beneficial uses of Suisun Bay, as listed in Table 6.2, including estuarine habitat. For the protection of marine aquatic life, a TMDL is expected to be completed in 2019.

Other contaminants in the Suisun Bay include furan compounds and dioxin compounds. These contaminants were placed on Section 303(d) list per the list approved by USEPA in 2010 (SWRCB 2011bd).

## 6.3.4 Delta Water Quality Issues for CVP and SWP Water Users

The designated beneficial uses and constituents of concern for the study area and for each RWQCB region are described in Section 6.3.1, Beneficial Uses of Surface Waters in the Study Area. In this section, the beneficial uses of water from the Delta are generalized and categorized by purpose of use into those associated with municipal and industrial, agricultural, groundwater recharge, and recycling and blending uses.

### *6.3.4.1 Municipal and Industrial Uses*

The Delta is a source of drinking water supply to over 25 million people, or sixty percent of the state population. The CVP and SWP water users that use water from the Delta as a source of potable water supply for municipal and industrial uses have two main water quality concerns: protection, preservation, and improvement of source water quality; and capability of treatment processes to meet stringent drinking water quality regulatory requirements. To protect public health and safety, water providers apply a multi-barrier approach: seek the highest quality source water available, protect and preserve the source water quality to ensure non-degradation, operate and periodically upgrade drinking water treatment processes, and maintain safe distribution systems.

The Delta, as a drinking water source, is compromised by high levels of naturally occurring and manmade constituents of concern. Some of the naturally occurring constituents, such as organic carbon and nutrients, are necessary components of the Delta ecosystem. Salinity, another natural constituent, is inherent with the tidal cycles of the estuary. Other anthropogenic constituents such as pathogens and contaminants are results of point and non-point source discharges into the Delta.

Water containing organic carbon reacts with chlorine, commonly used as a disinfectant in drinking water treatment processes, to form disinfection byproducts (DBP) such as trihalomethanes and haloacetic acids. Delta waters contain high levels of both dissolved organic compounds and bromide, increasing the formation of DBP. Use of chloramines for disinfection would reduce the production of DBP, but chloramination can lead to the formation of carcinogenic N-nitrosamines, including N-nitrosodimethylamine (NDMA). These interactions complicate the design of drinking water treatment processes and create the necessity to balance and trade off disinfection effectiveness with DBP creation. Balance and tradeoffs are also necessary between source water quality protection and ecosystem restoration actions that could increase the levels of organic carbon.

The Water Quality Control Plan for the Sacramento River and San Joaquin River Basins (Basin Plan) designated drinking water municipal and domestic supply beneficial use for most waters in the Central Valley, including the Delta. It includes narrative objectives for chemical constituents, taste and odor, sediment, suspended material, and toxicity, and numeric objectives for chemical constituents and salinity. The Basin Plan incorporates by reference the primary and secondary maximum contaminant levels specified in Title 22 of the California Code of Regulations for waters designated for municipal uses.

Through the triennial review process, stakeholders prioritized the need for a drinking water policy and identified a number of drinking water constituents of concern including: salt (including bromide), nutrients, organic carbon and pathogens such as *Cryptosporidium* and *Giardia*.

In 2013, the Central Valley RWQCB adopted Resolution No. R5-2013-0098, an amendment to the Basin Plan to establish a drinking water policy for surface waters of the Delta and its upstream tributaries. The amendment was approved by the SWRCB in the same year, and approved by the Office of Administrative Law and US EPA in 2014.

The Amendment modifies the water quality objectives of the Basin Plan to add a narrative water quality objective for *Crytosporidium* and *Giardia*, and clarifies that existing narrative objective for chemical constituents includes drinking water chemical constituents of concern, such as organic carbon. The Amendment also establishes a Drinking Water Policy to maintain high quality of water, anti-degradation, application of water quality objectives, implementation of toxics standards for inland surface waters, enclosed bays, and estuaries, and continued coordinated monitoring, assessment, and reporting of identified drinking water constituents of concern.

#### 6.3.4.1.1 Organic Carbon

Delta water is high in dissolved and suspended organic carbon, due to the high peat soil composition and estuarine environment. Organic carbon combines with disinfectants in drinking water treatment processes to produce DBP that are harmful to human health. In a 1998 study and a 2003 update, expert panels for the California Urban Water Agencies recommended that TOC in the Delta source water should not exceed 3.0 mg/L, in order for Delta-dependent water agencies to be able to meet treated drinking water regulatory requirements. This recommendation was based on an analysis of the various existing and planned treatment processes, residual (distribution systems) disinfection requirements, as well as the interaction among TOC and other DBP precursors.

In the 2013-14 Basin Plan amendment, indicates that the state waters shall not contain chemical constituents in concentrations that adversely affect beneficial uses, and that this includes drinking water chemical constituents of concern, such as organic carbon.

#### 6.3.4.1.2 Bromide and Other Disinfection By-product (DBP) Precursors

Bromide is a naturally occurring constituent in waters subjected to tidal influences such as the Delta. It reacts with ozone, a disinfectant often used for inactivation or removal of *Cryptosporidium* and for controlling taste and odor issues, to form bromate which is a regulated DBP for its cancer-causing potential. The combination of TOC and bromide in Delta waters poses an especially challenging scenario for treatment processes in balancing the need for microbiological removal and minimizing the formation of organically-based brominated DBP. The 1998/2003 expert panels for California Urban Water Agencies recommended that bromide levels should not exceed 50 µg/L in order for Delta-dependent water agencies to be able to meet treated water regulatory requirements.

#### 6.3.4.1.3 Nutrients and Other Discharges

Municipal discharges and agricultural return flows into the Sacramento and San Joaquin river watersheds and the Delta contribute pollutants and constituents of concern that could potentially degrade water quality.

Nutrients such as nitrogen and phosphorus originate from natural sources and from anthropogenic sources including point and non-point source discharges. Although nutrients are necessary for a healthy ecosystem, over enrichment of nitrogen and phosphorus can contribute to eutrophication and toxicity. Eutrophication also results in elevated levels of TOC, a DBP precursor.

In August 2015, USEPA published revisions to the federal Water Quality Standards Regulations required the state to develop implementation methods to conduct analyses if ongoing or future projects would degrade high quality waters. The regulations require analysis of a range of non-degrading or less-degrading alternatives and make a finding that degradation is necessary to accommodate important social or economic development in the area where the waters are located.

The SWRCB's Policy with Respect to Maintaining High Quality of Water in California (Resolution No. 68-16) incorporates the federal antidegradation policy and restricts reductions in water quality even if beneficial uses are protected. The Drinking Water Policy in the 2013-14 Basin Plan amendment stated that drinking water constituents of concern shall continue to be considered when waste discharge facilities conduct antidegradation analyses. The 2013-14 Drinking Water Policy also requires the RWQCBs to consider the necessity for inclusion of monitoring of organic carbon, salinity, and nutrients for waste discharge permit renewals if the facilities are located near drinking water intakes, if a concentration load has significantly increased, and the importance of the data submitted by the discharger to management decisions to protect drinking water.

#### 6.3.4.1.4 Pathogens and Emerging Contaminants

Point and non-point source discharges into Delta waters have the potential to introduce and elevate the levels of pathogens and other contaminants. *Cryptosporidium* and *Giardia* are two main pathogens of concern that are the focus of drinking water regulatory requirements promulgated by USEPA. In addition, other contaminants of emerging concern, particularly pharmaceuticals and personal care products, have been widely distributed and persistent in the environment. These chemicals bio-accumulate and cause endocrine disruption.

The 2013-14 Basin Plan amendment includes a narrative water quality objective for *Cryptosporidium* and *Giardia* within the Sacramento-San Joaquin Delta and its tributaries below the first major dams. Compliance with this objective will be assessed at existing and new public water system intakes to maintain existing levels of pathogens at public water system intakes.

The Basin Plan amendment also includes support of a one-time special study to characterize ambient levels of *Cryptosporidium*, to better understand the relationship between source loading and ambient *Cryptosporidium* concentrations, and to better understand the movement of *Cryptosporidium* through the system.

#### 6.3.4.1.5 Salinity and TDS

Salinity is commonly measured in units of EC or TDS. Salinity standards, in the form of chloride objectives, have been established in the Basin Plan to protect the various beneficial uses. The most restrictive is the 150 mg/L chloride objective for Contra Costa Canal and the City of Antioch intake. The objective was originally established to protect an industrial manufacturing facility that has since closed. In terms of drinking water, bromide is the most critical component of salinity that impacts drinking water treatment processes. No standards have been set for bromide, although there is a MCL for the disinfection byproduct bromate. Secondary MCLs for TDS (500 mg/L), chloride (250 mg/L), and sulfate (250 mg/L) have been set to address cosmetic or aesthetic effects such as staining, mineral deposits, taste, odor, and color. The CV-SALTS Executive Committee is currently considering potential revisions to water quality objectives for secondary MCL, as part of the developing Salt and Nitrate Management Plan for the Central Valley.

Salinity also affects non-potable uses such as industrial processes, irrigation, groundwater recharge, and recycling. High salinity waters may render them infeasible for certain industrial processes, or reduce the efficiency by reducing the number of recirculation cycles. Impacts of salinity on irrigation, groundwater recharge, and recycling are discussed in the following subsections.

Changes in operation of the CVP and SWP could exacerbate salinity and bromide problems, through changes in allowable export pumping windows during the year and for different year types, as well as the operation of the Delta Cross-Channel gates, as described in Appendix 3A, No Action Alternative: Central Valley Project and State Water Project Operations.

#### *6.3.4.2 Agricultural Uses*

The main water quality issues related to agricultural use of Delta exported supplies are salinity and drainage, as discussed in the following subsections.

##### 6.3.4.2.1 Salinity, Sodium, and Toxicity

Delta waters are high in salinity due to tidal influence and upstream discharges. High salinity in irrigation water inhibits water and nutrients intake by plants, resulting in yield reduction. Saline conditions could be a result of high salinity source water used for direct irrigation, or saline soil water due to saline water accumulation and poor drainage. Plant uptake of water through osmo-regulation is restricted when the soil water salinity is greater than the internal salinity of the plant. Water with a TDS above 1,500 to 2,600 mg/L (EC greater than 2.25 to 4 mmho/cm) is generally considered problematic for irrigation use on crops with low or medium salt tolerance.

Irrigation water containing high levels of sodium is of special concern because of its potential to create a sodium hazard in the soil. Sodium hazard, expressed as sodium adsorption ratio, is the phenomenon when sodium is adsorbed and becomes attached to soil particles, rendering the soil hard and compact when dry and increasingly impervious to water penetration. Fine textured soils high in clay content are most vulnerable to the sodium hazard.

High salinity in irrigation water could also result in plant toxicity due to accumulation of ions in the leaves. The most common ions which cause toxicity are chloride, sodium, and boron. Boron is particularly troublesome because toxicity can occur in very low concentrations, despite the fact that boron is an essential plant nutrient. Boron can also accumulate in the soil.

Sulfate salts affect sensitive crops by limiting the uptake of calcium and increasing the adsorption of sodium and potassium, upsetting the cationic balance within the plant. High concentrations of potassium may introduce a magnesium deficiency and iron chlorosis.

Different crops have different toleration for salinity, with forage crops being the most resistant and fruit crops being the most sensitive. Crops are also most sensitive to salinity during seed germination, and more tolerant during later growth stages. Changes in salinity of Delta waters due to seasonal fluctuations or different year types may affect crops, depending on the timing within the growth cycle. To protect salt sensitive crops during the irrigation season, the EC overall objectives in the San Joaquin River and the interior southern Delta are generally at 0.7 mS/cm (700 µS/cm) during the irrigation season (April to August) and at 1.0 mS/cm for the remainder of the year.

Generally, salinity in groundwater is higher than surface water in the San Joaquin Valley. Changing from irrigating with surface water to groundwater, due to shortages of CVP and/or SWP water supplies, could exacerbate salinity issues.

##### 6.3.4.2.2 Agricultural Drainage

The Central Valley RWQCB initiated the Irrigated Lands Regulatory Program (ILRP) in 2003 to prevent agricultural runoff containing pesticides, fertilizers, salts, pathogens, and sediment from impairing surface waters. Waste discharge requirements were subsequently developed and adopted to address irrigated agricultural discharges throughout the Central Valley, in order to protect both surface water and groundwater for all beneficial uses. The waste discharge requirements replaced pre-2003 waivers and previous interim regulatory requirements under a Conditional Waiver of Waste Discharge Requirements. All commercial irrigated lands, including nurseries and managed wetlands, are required to obtain regulatory coverage by joining a coalition group, or obtaining coverage as an individual grower under general waste discharge requirements, or obtaining an individual permit.

The recently adopted waste discharge requirements have been expanded to include discharges to groundwater, in order to address the critical need to protect this drinking water source from contaminants such as nitrate that are associated with fertilizer application. The waste discharge requirements are tailored to known threats to water quality and specific geographic areas or commodities.

According to the Central Valley RWQCB, there are about 35,000 growers in the Central Valley and nearly 5 million acres of land that are part of water quality coalition groups. The coalition groups conduct water quality monitoring and analysis, perform vulnerability assessments, prepare regional plans to address water quality problems, determine the effectiveness of management actions, and perform education and outreach to growers. Coalitions are required to prepare Water Quality Management Plans anytime water quality objectives have been exceeded more than once in three years. The growers are required to implement management practices to protect surface and groundwater, especially in areas where monitoring has identified problems associated with irrigated agriculture such as the pesticides chlorpyrifos and diazinon, indicators of pathogens such as *e. coli*, or nitrates. Growers are required to conduct farm evaluations to determine the effectiveness of farm practices in protecting water quality. Nutrient management is a key element for all growers. A certified nitrogen management plan is required for growers in areas where groundwater is known to be severely impacted by nitrates, pesticides or other constituents associated with agriculture.

#### 6.3.4.3 Groundwater Recharge Uses

In addition to direct use for municipal, industrial, and agricultural purposes, some of the CVP and SWP water from the Delta is used for groundwater recharge purposes through direct application or indirect potable recharge by blending with recycled water. The quality of the applied water could affect hydrogeological properties of the aquifer, or impair the quality of groundwater for subsequent use.

Hydrogeological properties of the aquifer could be affected by precipitation reactions between the recharge water and native soil material or groundwater, causing mechanical blockage of aquifer pores. Ion exchange reactions could adversely affect the shrink/swell properties of some clays present in an aquifer. Sodium adsorption is particularly of concern due to the high salinity of Delta water.

Chemical and microbial contaminants in the recharge water could build up in the aquifer and impair the subsequent use of the groundwater. Secondarily treated domestic wastewaters and many industrial wastewaters, urban stormwater drainage, agricultural and rural stormwater runoff, and irrigation return waters contain high concentrations of a wide variety of inorganic and organic, dissolved, particulate, and colloidal contaminants that can adversely impact groundwater and aquifer quality. Nonconventional and emergent contaminants in pharmaceuticals and body care products may not have been removed through conventional secondary treatment. Furthermore, chloramination of wastewater effluents especially during water reuse processes could create NDMA, a known carcinogen. For some CVP and SWP water users, the CVP and/or SWP water supplies are used to dilute some of these potential contamintants to protect groundwater quality.

#### 6.3.4.4 Water Recycling Use

Salinity in Delta waters reduces the utility of the water for reuse or blending purposes by CVP and SWP water users. A higher salinity source water exacerbates the increase in salinity from use and reuse, reducing the applicability of the recycled water for non-potable purposes such as landscape and agricultural irrigation or industrial cooling and reuse. Residential use of water could add 200 to 300 mg/L of TDS to the wastewater stream. Conventional wastewater treatment processes are designed to remove suspended solids but not dissolved solids. Depending on the TDS levels of the source water, the TDS levels in recycled water could reach beyond the threshold of market acceptance for irrigation. TDS removal or demineralization would require an advanced treatment process and add to the cost of recycling.

#### *6.3.4.5 Blending Use*

Some SWP water users in Southern California rely on Delta water exported from the SWP to blend with the higher TDS water from the Colorado River. Water imported through the Colorado River Aqueduct has an average TDS of 650 mg/L, and has exceeded 900 mg/L during drought events. Delta water imported through the SWP has a lower TDS by comparison, with an average TDS of 250 to 325 mg/L. The real time TDS levels fluctuate significantly due to variations in hydrology, tidal cycles, and project operations. Article 19 of the SWP long-term water supply contracts contains a water quality objective for TDS of below 440 ppm for monthly averages, and below 220 ppm for 10-year averages. These objectives were set in the 1960s when SWP deliveries were thought to be more assured. Metropolitan Water District of Southern California has used these SWP delivered water quality objectives to set a salinity-by-blending objective of 500 mg/L for its blended supply. Reduced SWP deliveries would pose challenges in meeting this blending objective.

#### *6.3.4.6 San Luis Reservoir Low-Point Issues*

As described in Chapter 5, Surface Water Resources and Water Supplies, the San Luis Reservoir provides off-stream storage for CVP water used by Santa Clara Valley Water District and San Benito County Water District. These districts withdraw their CVP supplies from the Upper Pacheco Intake at the San Luis Reservoir. This supply is at risk when water elevations in San Luis Reservoir reach very low levels during late summer and early fall. High temperatures combined with low water levels foster algae growth to as much as 35 feet thick on the water surface. Algae captured in the intake and conveyed to the CVP water users is not suitable for municipal water treatment or agricultural drip irrigation systems. As water levels continue to drop below the level of the intake, water supply to these CVP water users ceases.

The Santa Clara Valley Water District has partnered with Reclamation and the San Luis and Delta-Mendota Water Authority to complete the San Luis Low Point Improvement Project. The project purpose is to identify a feasible alternative that will address the uncertainty of CVP delivery schedules and the water supply reliability problems associated with the low-point issues.

### 6.3.5 Drought Impacts on Water Quality

California is currently in the fourth consecutive year of a severe drought, with precipitation way below average and record high temperatures. The availability of water supplies throughout the state have declined substantially as described in Section 5.3.4, Surface Water Resources and Water Supplies during Droughts. In addition, there are chronic and significant shortages in supplies and historically low groundwater levels, as described in Chapter 7, Groundwater Resources and Groundwater Quality. Drought conditions affect many Delta water quality constituents, including changes in temperatures and dissolved oxygen conditions in the lower San Joaquin River, temperature in the Sacramento River, and salinity in the Delta.

#### *6.3.5.1 Water Quality Conditions in the Lower San Joaquin River*

The San Joaquin River watershed in particular has experienced severely dry conditions, with water year 2012 classified as dry and water years 2013-2015 classified as critically dry. Lack of precipitation has resulted in historically low reservoir storage levels, creating significant concerns about low flows, high temperatures, low dissolved oxygen conditions and other factors that have significant effects on steelhead and fall-run Chinook Salmon.

As described in Section 5.3.4, Surface Water Resources and Water Supplies during Droughts, Reclamation and DWR filed a Temporary Urgency Change Petition (TUCP) with the SWRCB on January 23, 2015, seeking to make changes to their water right permits and license for the CVP and SWP. The TUCP sought changes to D-1641 requirements on flow-dependent and operational water quality objectives. The TUCP was approved in part on February 3, 2015, subject to conditions, and modified on March 5, 2015 and April 6, 2015. Reclamation submitted a request on May 21, 2015 to modify and renew the TUCP Order, which was approved on July 3, 2015 and modified on August 4, 2015 with changes effective through November 30, 2015.

The August 4, 2015 Order conditionally approved a change to Reclamation's water rights to modify the Stanislaus River dissolved oxygen requirement from 7.0 mg/L to 5.0 mg/L at and below Ripon on the Stanislaus River. It also included other conditions, including the development, coordinated implementation, evaluation, and update of operations plans that would affect flows, temperatures and dissolved oxygen conditions, to ensure that the change can be made without unreasonable effects on fish, wildlife, or other instream beneficial uses, and to ensure that the change is in the public interest.

#### *6.3.5.2 Temperature Conditions in the Lower San Joaquin River*

Reclamation files an annual Sacramento River Temperature Management Plan to guide the release of water from Shasta Lake in order to maintain downstream water temperatures to protect the fisheries during the higher temperature months of summer and fall. In 2014, temperature targets were not achieved in the upper reaches of the Sacramento River late in the fall, despite Reclamation's efforts.

In early 2015, Reclamation developed a release plan in conjunction with DWR, USFWS, NMFS, CDFW, SWRCB, and others to meet the CVP authorized purposes and regulatory requirements to the extent possible. The plan was submitted and provisionally approved by the SWRCB on May 14, 2015. On May 29, 2015, Reclamation informed the SWRCB that the proposed temperature target will unlikely be met, due to faulty equipment used to obtain temperature data for modeling. The SWRCB suspended the plan in June while Reclamation developed and submitted a revised Temperature Plan on June 25, 2015. On July 1, 2015, NMFS provided conditional concurrence with the revised plan. On July 7, 2015, the SWRCB conditionally approved the June 25, 2015 plan, placing numerous monitoring, consultation, and update requirements on Reclamation, as well as correlating the Temperature Plan with conditions in the July 3, 2015 approved TUCP filed by Reclamation and DWR.

#### *6.3.5.3 Delta Salinity Conditions*

As described in Section 5.3.4, Surface Water Resources and Water Supplies during Droughts, in early 2015, as a result of very low precipitation and diminished reservoir storage, DWR planned and installed an emergency drought barrier on West False River in the Delta to help repel salt water intrusion into the central Delta and to minimize the amount of upstream reservoir releases. The barrier installation was completed in early June. Removal began on September 8, 2015 and must be completed by mid-November to provide capacity for wet weather flows in the winter season and to comply with fisheries protection requirements.

In June and July 2015, some of the salinity objectives were not met, despite the drought barrier and other project operations to mitigate for the effects of the severe drought. Exceedances were reported by Reclamation and DWR at: the South Delta agricultural objective at San Joaquin River near Brandt Bridge compliance station, the two western Delta agricultural objectives of 14-day running average EC values at Sacramento River at Three Mile Slough and San Joaquin River at Jersey Point, and the 30-day running average EC value at Old River near Middle River.

Salinity in CVP and SWP water supplies has increased since the onset of the drought.

#### *6.3.5.4 Municipal and Industrial Water Users Responses to Drought-related Water Quality Impacts*

With low surface water runoff, increased temperature, and concentrated nutrient levels due to the drought, algae growth in surface water proliferated, leading to increased turbidity, taste and odor issues, as well as increased potential for algal cyanotoxins from the blue-green algae, *Microcystis*. Urban water agencies that have alternative supply sources use blending, coupled with changes in treatment processes such as increased use of ozone, to address the taste and odor issues. Some of the larger urban agencies are participating in studies to investigate alternative treatment processes to address algal toxin issues. Other studies raised concern with respect to changes in pH due to low flows and their effects on toxicity and bioaccumulation of ionizable contaminants. The Metropolitan Water District of Southern California announced plans to apply copper sulfate to treat algae at Lake Skinner, Lake Mathews, and Diamond Valley Lake in accordance with its NPDES permit.

Many urban water agencies accelerated their investments in recycled water development during the current drought. Most notably, a lot of these investments are focused on advanced treatment processes for indirect, as well as direct, potable reuse. For example, the Santa Clara Valley Water District began operations of the 8 million gallon/day Silicon Valley Advanced Water Purification Center in 2014, to test and demonstrate its advanced treatment processes in producing highly purified recycled water that meets drinking water standards. Advanced treated recycled water has historically been used to blend with tertiary-treated recycled water to reduce the level of total dissolved solids for expanded industrial and irrigation use, thereby offsetting potable demand during droughts.

## 6.4 Impact Analysis

This section describes the potential mechanisms and analytical methods for change in surface water quality; results of the impact analysis; potential mitigation measures; and cumulative effects.

### 6.4.1 Potential Mechanisms for Change and Analytical Methods

As described in Chapter 4, Approach to Environmental Analysis, the impact analysis considers changes in surface water quality conditions related to changes in CVP and SWP operations under the alternatives as compared to the No Action Alternative and Second Basis of Comparison.

Changes in CVP and SWP operations under the alternatives as compared to the No Action Alternative and Second Basis of Comparison could result in changes to surface water quality due to changes in river flows and surface water deliveries. Based on the discussion above, the following water quality changes are further analyzed in the Evaluation of Alternatives section.

As described in Section 6.3 Affected Environment, there are numerous constituents of concern that have been identified in the study area. These components are not all critical in each region and may not be all affected by changes in CVP and SWP operations considered in the alternatives of this EIS. The groups of constituents that could be affected by implementation of the alternatives has been identified through consideration of constituents of concern described in Section 6.3, Affected Environment, and the anticipated implementation of TMDLs by 2030. These constituents were grouped into major categories, as shown in Table 6.27. The constituents that already have approved TMDLs in certain regions are not further analyzed for those regions, as it is expected that the TMDL will be implemented by 2030. A complete list of TMDLs and the anticipated completion dates is provided in Table 6.1.

**Table 6.27 List of Surface Water Quality Constituents Considered for this Analysis**

| Constituent/Parameter Group | Individual Constituents/Parameters |
|---|---|
| Water Temperature | Water Temperature |
| Salinity Indicators | EC, TDS, Chloride, Bromide, Delta X2 |
| Nutrients | Nitrate, phosphorus |
| Mercury | Mercury, methylmercury |
| Selenium | Selenium |
| Dissolved Oxygen | Dissolved Oxygen |
| Other Constituents | Pesticides, PCBs, DOC/TOC, Boron, Trace Metals, Pathogens, TSS, Turbidity, Unknown Toxicity |

Each constituent group is further discussed below, to determine whether changes would occur due to implementation of the alternatives.

#### *6.4.1.1 Changes in Water Temperature*

Changes in CVP and SWP operations would change water temperatures in rivers downstream of CVP and SWP reservoirs. Changes in water temperatures are presented in Appendix 6B, Surface Water Temperature Modeling. However, the effects of change in temperature are related to the changes on aquatic habitat. Therefore, analysis of changes in temperature is presented in Chapter 9, Fish and Aquatic Resources.

#### *6.4.1.2 Changes in Salinity*

Changes in salinity due to changes in CVP and SWP operations would be focused in the Delta. Salinity indicators generally considered in this analysis include electrical conductivity, total dissolved solids, chloride, bromide, and X2.

The DSM2, a one-dimensional hydrodynamic and water quality simulation model, is used to evaluate changes in salinity (as represented by EC) in the Delta and at the CVP/SWP export locations. CalSim II outputs are used to evaluate changes in location of X2 in the Delta.

#### *6.4.1.3 Changes in Mercury/Methylmercury Concentrations*

Changes in CVP and SWP operations under the alternatives could affect mercury concentrations in the Delta and Suisun Marsh. The changes in CVP and SWP operations would not affect mercury concentrations in the tributaries to the Sacramento and San Joaquin rivers.

A modeling framework is used to evaluate changes in methylmercury concentrations in the Delta reaches and qualitatively estimate mercury concentration changes at the San Luis Reservoir and O'Neill Forebay.

The methylmercury impacts analysis uses CalSim II, DSM2, and the Central Valley Regional Water Quality Control Board Total Maximum Daily Load model (RWQCB model) to assess and quantify effects of the alternatives on the long-term operations and the environment, as described in Appendix 6C, Methylmercury Model Documentation.

The QUAL module of DSM2 is used to simulate source water finger printing which can determine the relative contributions of water sources to the volume at any specified location. DSM2 water quality and volumetric fingerprinting results are used to assess changes in concentration of methylmercury in Delta waters. CalSim II, DSM2 (water), and the RWQCB model (fish tissue) are used in sequence to estimate the effects of CVP and SWP operations on water and fish tissue quality in the Delta.

#### *6.4.1.4 Changes in Selenium Concentrations*

Changes in CVP and SWP operations under the alternatives could affect selenium concentrations in the San Joaquin River, Delta, and Suisun Marsh. Selenium also is of a concern in the Southern California Region because the use of water supplies from both the Delta and the Colorado River.

A suite of modeling tools is used to evaluate changes in selenium concentrations in the Delta reaches and in the San Francisco Bay, based on the western Delta model outputs. The selenium impacts analysis uses CalSim II, DSM2, and Delta-specific selenium bioaccumulation modeling to assess and quantify effects of the alternatives on the long-term operations and the environment. Appendix 6D, Selenium Model Documentation, provides information about the development and calibration of a Delta-wide bioaccumulation model for selenium in fish, use of outputs from that model to estimate bioaccumulation in bird eggs and fish fillets, and modeling of selenium bioaccumulation in sturgeon living in the western Delta using inputs from other models. Modeling assumptions for the selenium analysis are also provided in that appendix.

The selenium impact analysis focuses on evaluation of changes to selenium concentrations in tissues that affect the health of fish as well as wildlife and humans consuming fish in the Delta.

CalSim II, DSM2, and bioaccumulation modeling are used in sequence to estimate the effects of CVP and SWP operations on water quality relative to selenium in the Delta. The DSM2-QUAL module simulates one-dimensional source tracking in the Delta. Results from DSM2 are multiplied by source concentrations to determine annual average waterborne selenium concentrations in the Delta for all year types. Output from the DSM2-QUAL model (expressed as percent inflow from different sources) is used in combination with the available measured waterborne selenium concentrations to model concentrations of selenium at locations throughout the Delta. These modeled waterborne selenium concentrations are used in the relationship model to estimate bioaccumulation of selenium in whole-body fish and in bird eggs.

#### *6.4.1.5 Changes in Nutrient Concentrations*

Nutrients generally considered in this analysis include nitrate and phosphorus. The two main anthropogenic sources of these constituents are urban point sources (wastewater effluent), and agricultural non-point sources (agricultural runoff and return flows of fertilizers mixed in irrigation water). By 2030, wastewater treatment plants that discharge into the Sacramento and San Joaquin rivers watersheds and the Delta that are currently implementing nutrient removal projects will have completed those projects. Agricultural non-point source discharges are regulated under the Long-Term Irrigated Lands Regulatory Program (ILRP) Waste Discharge Requirements, which mandate monitoring of nutrients in the major agricultural reaches and the implementation of Best Management Practices to reduce nutrient discharges to streams, and controlling fertilizer application and management. Since nutrient loadings would be managed through regulatory processes by 2030, it is anticipated that nutrient conditions would be similar under the No Action Alternative, Alternatives 1 through 5, and the Second Basis of Comparison. Therefore, changes in nutrients are not evaluated in this EIS.

#### 6.4.1.6 Changes in Dissolved Oxygen Concentrations

Dissolved oxygen has been found to be a parameter of concern primarily in the lower Klamath River, Sacramento-San Joaquin River Delta, and the Suisun Marsh. By 2030, it is anticipated that TMDLs would be implemented to address the dissolved oxygen issues. Since dissolved oxygen conditions would be managed through regulatory processes by 2030, it is anticipated that dissolved oxygen conditions would similar under the No Action Alternative, Alternatives 1 through 5, and the Second Basis of Comparison. Therefore, changes in dissolved oxygen are not evaluated in this EIS.

#### 6.4.1.7 Changes in Other Constituents

Conditions for other water quality constituents are expected to be similar under the No Action Alternative, Alternatives 1 through 5, and the Second Basis of Comparison because critical factors that affect the sources, transport mechanisms or chemical transformations are not expected to be affected by changes in CVP and SWP operations. Therefore, changes in the other constituents are not analyzed in this EIS.

#### 6.4.1.8 Effects Related to Water Transfers

Historically water transfer programs have been developed on an annual basis. The demand for water transfers is dependent upon the availability of water supplies to meet water demands. Water transfer transactions have increased over time as CVP and SWP water supply availability decreased, especially during drier water years.

Parties seeking water transfers generally acquire water from sellers who have available surface water who can make the water available through releasing previously stored water, pump groundwater instead of using surface water (groundwater substitution); crop idling; or substituting crops that uses less water in order to reduce normal consumptive use of surface water.

Water transfers using CVP and SWP Delta pumping plants and south of Delta canals generally occur when there is unused capacity in these facilities. These conditions generally occur in drier water year types when the flows from upstream reservoirs plus unregulated flows are adequate to meet the Sacramento Valley water demands and the reduced CVP and SWP export allocations. In non-wet years, the CVP and SWP water allocations would be less than full contract amounts; therefore, capacity may be available in the CVP and SWP conveyance facilities to move water from other sources.

Projecting future water quality conditions related to water transfer activities is difficult because of the wide variability in sources of transfer water, conveyance, and recipients involved in each specific water transfer action. Use of the transfer water would change each year due to changing hydrological conditions, CVP and SWP water availability, specific local agency operations, and local cropping patterns. Reclamation recently prepared a long-term regional water transfer environmental document which evaluated potential changes in conditions related to water transfer actions (Reclamation 2014c). Results from this analysis were used to inform the impact assessment of potential effects of water transfers under the alternatives as compared to the No Action Alternative and the Second Basis of Comparison.

### 6.4.2 Conditions in Year 2030 without Implementation of Alternatives 1 through 5

This EIS includes two bases of comparison, as described in Chapter 3, Description of Alternatives: the No Action Alternative and the Second Basis of Comparison. Both of these bases are evaluated at 2030 conditions. Changes that would occur over the next 15 years without implementation of the alternatives are not analyzed in this EIS. Changes to water quality that are assumed to occur by 2030 under the No Action Alternative and the Second Basis of Comparison are summarized in this section and included in all alternatives. Many of the changed conditions would occur in the same manner under both the No Action Alternative and the Second Basis of Comparison.

#### *6.4.2.1 Common Changes in Conditions under the No Action Alternative and Second Basis of Comparison*

Conditions in 2030 would be different than existing conditions due to:

- Climate change and sea level rise
- General plan development throughout California, including increased water demands in portions of Sacramento Valley
- Implementation of reasonable and foreseeable water resources management projects to provide water supplies

##### 6.4.2.1.1 Effects due to Climate Change and Sea Level Rise

It is anticipated that climate change would result in more short-duration high-rainfall events and less snowpack runoff in the winter and early spring months. The reservoirs would be full more frequently by the end of April or May by 2030 than in recent historical conditions. However, as the water is released in the spring, there would be less snowpack to refill the reservoirs. This condition would reduce reservoir storage and available water supplies, including water supplies released to maintain freshwater conditions in the western Delta and at the CVP and SWP Delta intakes. Ambient temperatures are also expected to increase. Therefore, water temperatures in the CVP and SWP reservoirs and in the rivers downstream of the reservoirs are expected to increase by 2030 under the No Action Alternative as compared to recent historical conditions.

##### 6.4.2.1.2 Effects due to Reasonable and Foreseeable Projects and Programs

Under the No Action Alternative and the Second Basis of Comparison, land uses in 2030 would occur in accordance with adopted general plans. Development under the general plans would change water quality, especially near municipal areas.

The No Action Alternative and the Second Basis of Comparison assumes completion of water resources management and environmental restoration projects that would have occurred without implementation of Alternatives 1 through 5, including regional and local recycling projects, surface water and groundwater storage projects, conveyance improvement projects, and desalination projects, as described in Chapter 3, Description of Alternatives. The No Action Alternative and the Second Basis of Comparison also assumes implementation of actions included in the 2008 U.S. Fish and Wildlife Service (USFWS) Biological Opinion (BO) and 2009 National Marine Fisheries Service (NMFS) BO that would have been implemented without the BOs by 2030, as described in Chapter 3, Description of Alternatives. These projects would include several projects that could affect surface water quality in beneficial and adverse manners, including restoration of more than 10,000 acres of intertidal and associated subtidal wetlands in Suisun Marsh and Cache Slough; and at least 17,000 to 20,000 acres of seasonal floodplain restoration in Yolo Bypass.

The reasonable and foreseeable projects also would include issuance and implementation of TMDL programs and other programs to improve water quality, including those that address salinity, mercury, and selenium.

*Potential Changes in Salinity Indicators*

In the Central Valley, changes in salinity under the No Action Alternative and the Second Basis of Comparison as compared to recent historical conditions are anticipated primarily to occur in the Delta. The salinity in the Delta is anticipated to increase with projected sea level rise; and therefore, the region of the Delta influenced by daily tidal fluctuations will increase, and the increased tidal mixing may result in salt transport further upstream. The average water depth in the Delta will increase, allowing for increased gravitational circulation and upstream transport of salinity further into the Delta. The increased salinity potentially will decrease the flexibility to meet regulatory requirements at compliance locations, municipal and industrial water intakes, and export facilities.

*Potential Changes in Mercury Concentrations*

In the Central Valley, mercury concentrations in the Sacramento River watershed would be similar under the No Action Alternative and the Second Basis of Comparison as compared to recent historical conditions. Programs would be implemented to reduce the sources of mercury into water bodies by 2030; however, the results of those programs are not anticipated to change mercury concentrations prior to 2030.

Changes in mercury in the Yolo Bypass are also anticipated under the No Action Alternative and the Second Basis of Comparison as floodplain restoration is implemented, as compared to recent historical conditions.

Under the No Action Alternative and the Second Basis of Comparison, it is anticipated that mercury concentrations in fish tissue within the Delta will be either similar or greater than recent historical conditions. Phase 1 of the Delta Mercury Program mandated by the CVRWQCB is currently being completed to protect people eating one meal per week of larger fish from the Delta, including Largemouth Bass. This program also would reduce wildlife exposure to excess mercury. Phase 1 is focused on studies and pilot projects to develop and evaluate management practices to control methylmercury from mercury sources in the Delta and Yolo Bypass; and to reduce total mercury loading to the San Francisco Bay. Following completion of Phase 1 in 2019, Phase 2 will be implemented through 2030. Phase 2 will focus on methylmercury control programs and reduction programs for total inorganic mercury. Due to the length of these studies and limited time for implementation of recommendations, it is not anticipated that changes in methylmercury or total mercury concentrations in fish tissue would be reduced by 2030 under the No Action Alternative and the Second Basis of Comparison as compared to recent historical conditions.

The No Action Alternative and the Second Basis of Comparison include the same projected tidal wetland and floodplain restoration within or adjacent to the Delta. These projects considered in the No Action Alternative and the Second Basis of Comparison have undergone environmental compliance and include methods to reduce mercury loading. For example, in Suisun Marsh, tidal wetland restoration activities will include cooperation with regional monitoring and research efforts, and sediment and fish monitoring. The collected information would be used adaptively to correct long-term construction and management plans and activities associated with tidal wetland restoration (Reclamation et al. 2011).

*Potential Changes in Selenium Concentrations*

Selenium is a constituent of concern in the San Joaquin Valley and the Delta, and TMDLs have been adopted for the San Joaquin River from Mud Slough to Merced River, Grasslands Marshes, Agatha Canal, and Mud Slough. It is assumed that water quality concerns for selenium in those reaches will be addressed before 2030. TMDLs are anticipated prior to 2030 for Panoche Creek and Mendota Pool. However, it is assumed that these TMDLs for water quality issues related to selenium may not be fully implemented by 2030.

It is expected that a TMDL may be developed separately for the Delta. To increase the database for evaluation of constituents of concern in the Delta, a large number of fish tissue samples were collected from the Sacramento and San Joaquin River watersheds and the Delta between 2000 and 2007 for selenium analysis. As part of the Strategic Workplan for Activities in the San Francisco Bay/Sacramento–San Joaquin Delta Estuary (State Water Resources Control Board 2008b), archived Largemouth Bass samples were analyzed for selenium to determine the primary source of the selenium being bioaccumulated in bass in the Delta and whether selenium concentrations in bass were above recommended criteria for the protection of human and wildlife health (Foe 2010). There were no differences in selenium concentrations in Largemouth Bass caught in the Sacramento River at Rio Vista and in the San Joaquin River at Vernalis in 2000, 2005, and 2007. However, because the TMDL is not yet under development, it is assumed that it would not be in place by 2030 under the No Action Alternative and the Second Basis of Comparison.

Reclamation is actively engaged with the Grassland Area Farmers who discharge subsurface agricultural drainage waters through the Grassland Bypass Project, which is a significant source of selenium to the San Joaquin River and to the Delta. Reclamation and the Grassland Area Farmers are continuing to reduce the amount of agricultural drainage water produced in the Grassland Drainage Area, preventing the discharge of this water into local Grassland wetland water supply channels, and improving the quality of water in the San Joaquin River. The Grassland Bypass Project is based upon an agreement between Reclamation and the San Luis and Delta-Mendota Water Authority to use a 28-mile segment of the San Luis Drain to convey agricultural subsurface drainage water from the Grassland Drainage Area to Mud Slough (North), a tributary of the San Joaquin River. An extensive monitoring program (e.g., San Francisco Estuary Institute [SFEI] 2013) continues to document the effectiveness of actions such as source control and other measures being taken by the Grassland Area Farmers. These actions by the Grassland Area Farmers are described in Chapter 2 of SFEI (2013). Briefly, these activities have included the Grassland Bypass Project and the San Joaquin River Improvement Project, formation of a regional drainage entity, newsletters and other communication with the farmers, a monitoring program, using State Revolving Fund loans for improved irrigation systems, installing and using drainage recycling systems to mix subsurface drainage water with irrigation supplies under strict limits, tiered water pricing and a tradable loads programs.

### 6.4.3 Evaluation of Alternatives

Alternatives 1 through 5 have been compared to the No Action Alternative; and the No Action Alternative and Alternatives 1 through 5 have been compared to the Second Basis of Comparison.

During review of the numerical modeling analyses used in this EIS, an error was determined in the CalSim II model assumptions related to the Stanislaus River operations for the Second Basis of Comparison, Alternative 1, and Alternative 4 model runs. Appendix 5C includes a comparison of the CalSim II model run results presented in this chapter and CalSim II model run results with the error corrected. Appendix 5C also includes a discussion of changes in the comparison of groundwater conditions for the following alternative analyses.

- No Action Alternative compared to the Second Basis of Comparison
- Alternative 1 compared to the No Action Alternative
- Alternative 3 compared to the Second Basis of Comparison
- Alternative 5 compared to the Second Basis of Comparison.

#### *6.4.3.1 No Action Alternative*

The No Action Alternative is compared to the Second Basis of Comparison.

##### 6.4.3.1.1 Potential Changes in Salinity Indicators

Salinity in the Sacramento River at Emmaton would be lower in September through January, higher in June, and similar in all other months over long-term average conditions under the No Action Alternative as compared to the Second Basis of Comparison, as summarized in Appendix 6E, Table 6E.2.4.

Salinity in the San Joaquin River at Vernalis would be lower in April and October, and higher in all other months under the No Action Alternative as compared to the Second Basis of Comparison, as summarized in Appendix 6E, Table 6E.15.4.

Salinity in the San Joaquin River at Jersey Point would be lower in September through January, higher in June, and similar in all other months, for long-term average conditions under the No Action Alternative as compared to the Second Basis of Comparison, as summarized in Appendix 6E, Table 6E.3.4.

Salinity in the western Delta at Port Chicago, Chipps Island, and Collinsville would be substantially lower in September through January, moderately lower February through May, higher in June, and similar in all other months, for long-term average conditions under the No Action Alternative as compared to the Second Basis of Comparison, as summarized in Appendix 6E, Table 6E.6.4, 6E.4.4, and 6E.2.4.

Salinity at the CVP Contra Costa Canal and Jones pumping plants and the SWP Banks Pumping Plant intakes in the Delta would be lower in September through January, and higher in all other months for long-term average conditions under the No Action Alternative as compared to the Second Basis of Comparison, as summarized in Appendix 6E, Tables 6.E.11.4, 6E.7.4, and 6E.8.4. Salinity at the Contra Costa Water District Old River and Middle River intakes also would be lower in September through January, and higher in all other months for long-term average conditions under the No Action Alternative as compared to the Second Basis of Comparison, as summarized in Appendix 6E, Tables 6E.12.4 and 6E.13.4. Changes in salinity at the intakes would influence the salinity in water delivered in the San Joaquin Valley which could influence salinity in water bodies that receive agricultural return flows from CVP and SWP water users. Chloride and bromide concentrations at the intakes are expected to change in a similar manner to other salinity indicators.

Another indication of salinity is the measurement of X2. X2 decreases with increases in Delta outflow as freshwater from the Central Valley flows towards San Francisco Bay. Under the No Action Alternative, Delta outflow would increase and X2 would move towards the west as compared to the Second Basis of Comparison, as shown in Table C.16.4 and Figures C.16.1.1 through C.16.1.8 and C.16.2.1 through C.16.2.8 in Appendix 5A, Section C, CalSim II and DSM2 Modeling Results. X2 distances would be lower in September through May, and similar in all other months in long-term average conditions under the No Action Alternative as compared to the Second Basis of Comparison.

#### 6.4.3.1.2 Potential Changes in Mercury Concentrations

Changes in mercury from the rivers result in changes in mercury concentrations in fish used for human consumption in the Delta, including Largemouth Bass, as summarized in Tables 6.28 and 6.29 for long-term average conditions and dry and critical dry years, respectively. All values exceed the threshold of 0.24 milligram/ kilogram wet weight (mg/kg ww) for mercury.

**Table 6.28 Changes in Mercury Concentrations 350-millimeter Largemouth Bass over the Long-term Average Conditions under the No Action Alternative as Compared to the Second Basis of Comparison**

| Delta Location | No Action Alternative (mg/kg ww) | Second Basis of Comparison (mg/kg ww) | Changes |
|---|---|---|---|
| San Joaquin River at Stockton | 1.00 | 0.99 | 0.1% |
| San Joaquin River at Turner Cut | 0.89 | 0.87 | 3% |
| San Joaquin River at San Andreas Landing | 0.59 | 0.58 | 3% |
| San Joaquin River at Jersey Point | 0.57 | 0.54 | 5% |
| Victoria Canal | 0.85 | 0.82 | 4% |
| Sacramento River at Emmaton | 0.50 | 0.49 | 2% |
| San Joaquin River at Antioch | 0.50 | 0.47 | 7% |
| Montezuma Slough at Hunter Cut and Beldon’s Landing (Suisun Marsh) | 0.35 | 0.32 | 7% |
| SWP Barker Slough Pumping Plant Intake | 0.56 | 0.56 | 1% |
| CVP Contra Costa Pumping Plant Intake | 0.73 | 0.68 | 6% |
| SWP Banks Pumping Plant Intake | 0.79 | 0.75 | 5% |
| CVP Jones Pumping Plant Intake | 0.83 | 0.79 | 3% |

Notes:

Long-term values calculated using 1976-1991 results from DSM2 model. Dry and critical dry years values calculated using 1987-1991 results from DSM2 model.

Concentrations greater than 0.24 mg/kg ww Hg exceed CVRWQCB threshold

mg/kg – milligram/kilogram; ww – wet weight

**Table 6.29 Changes in Mercury Concentrations 350-millimeter Largemouth Bass in Dry and Critical Dry Years under the No Action Alternative as Compared to the Second Basis of Comparison**

| Delta Location | No Action Alternative (mg/kg ww) | Second Basis of Comparison (mg/kg ww) | Changes |
|---|---|---|---|
| San Joaquin River at Stockton | 1.06 | 1.06 | 0.3% |
| San Joaquin River at Turner Cut | 0.84 | 0.81 | 4% |
| San Joaquin River at San Andreas Landing | 0.54 | 0.53 | 3% |
| San Joaquin River at Jersey Point | 0.52 | 0.50 | 4% |
| Victoria Canal | 0.82 | 0.76 | 7% |
| Sacramento River at Emmaton | 0.48 | 0.47 | 2% |
| San Joaquin River at Antioch | 0.43 | 0.41 | 5% |
| Montezuma Slough at Hunter Cut and Beldon's Landing (Suisun Marsh) | 0.28 | 0.26 | 5% |
| SWP Barker Slough Pumping Plant Intake | 0.59 | 0.57 | 2% |
| CVP Contra Costa Pumping Plant Intake | 0.67 | 0.62 | 8% |
| SWP Banks Pumping Plant Intake | 0.75 | 0.69 | 8% |
| CVP Jones Pumping Plant Intake | 0.82 | 0.77 | 7% |

Notes:

Long-term values calculated using 1976-1991 results from DSM2 model. Dry and critical dry years values calculated using 1987-1991 results from DSM2 model.

Concentrations greater than 0.24 mg/kg ww Hg exceed CVRWQCB threshold

mg/kg – milligram/kilogram; ww – wet weight

#### 6.4.3.1.3 Potential Changes in Selenium Concentrations

It is anticipated that the selenium loadings would be similar under the No Action Alternative and the Second Basis of Comparison; and that selenium concentrations in the San Joaquin River also would be similar.

Selenium in the water column at various locations in the Delta under No Action Alternative and the Second Basis of Comparison are shown in Appendix 6D, Selenium Model Documentation. Selenium in the water column at the three western Delta locations under No Action Alternative would be identical to conditions under the Second Basis of Comparison, as shown in Appendix 6D, Table 6D.16. Selenium in the water column would be below the NTR criterion of 5 µg/L for the San Francisco Bay. Similarly, they would be below the draft USEPA (2014b) criterion for lentic aquatic systems (1.3 µg/L).

In the western Delta and at the Barker Slough Pumping Plant intake, the selenium would be similar (within 5 percent change) under the No Action Alternative and the Second Basis of Comparison.

Selenium at the Contra Costa Pumping Plant intake would be similar under the No Action Alternative and Second Basis of Comparison, as shown in Table 6D.9 of Appendix 6D. Selenium at the Jones and Banks pumping plant intakes under the No Action Alternative would be slightly higher than Second Basis of Comparison, as shown in Appendix 6D, Table 6D.9.

Estimated selenium concentration in biota (whole-body fish, bird eggs [invertebrate diet], bird eggs [fish diet], and fish fillets) at all locations in the Delta under the No Action Alternative would be similar as under the Second Basis of Comparison, as shown in Appendix 6D, Table 6D.10. As shown in Appendix 6D, Table 6D.13, Exceedance Quotients (EQs) computed with respect to the applicable benchmarks show that selenium concentrations in biota under the No Action Alternative would be below the thresholds identified for ecological risk.

For sturgeon in the western Delta, modeling also suggests that whole-body concentrations would be similar under the No Action Alternative and the Second Basis of Comparison (Appendix 6D, Table 6D.17), and the EQs would be similar (Appendix 6D, Table 6D.18). Low Toxicity Threshold EQs for selenium concentrations in sturgeon in the western Delta would remain under 1.0 for long-term average conditions, and slightly exceed 1.0 (indicating a higher probability for adverse effects) for drought years at the three western Delta locations under both the No Action Alternative and the Second Basis of Comparison (Table 6D.18 of Appendix 6D). Estimated EQs for High Toxicity Threshold at all locations are less than 1.0 under all hydrologic conditions.

#### 6.4.3.1.4 Effects Related to Cross Delta Water Transfers

Potential effects to water quality could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c). Potential effects to water quality were identified as:

- Potential for sediment and other constituents to be transported from crop idled lands into adjacent water bodies.
- Water transfer practices could change reservoir storage or stream flow patterns in a manner that would affect water quality, including upstream temperatures and Delta water quality.
- Use of transferred water could increase drainage flows in the purchaser's service areas.

The analysis indicated that these potential impacts would not be substantial because the amount of land subject to crop changes in the seller's and purchaser's service areas would be within the historical range of irrigated lands and crop idled lands. The groundwater substitution practices would be implemented with monitoring and mitigation programs to avoid long-term adverse impacts, including impacts to water quality. The water transfers would not be allowed to occur if the program harmed other water users or the environment, including changes to water quality in the rivers or the Delta. Therefore, water quality conditions would be similar with and without the water transfers.

Under the No Action Alternative, the timing of cross Delta water transfers would be limited to July through September and include annual volumetric limits, in accordance with the 2008 USFWS BO and 2009 NMFS BO. Under the Second Basis of Comparison, water could be transferred throughout the year without an annual volumetric limit. Overall, the potential for cross Delta water transfers would be less under the No Action Alternative than under the Second Basis of Comparison.

### *6.4.3.2 Alternative 1*

As described in Chapter 3, Description of Alternatives, Alternative 1 is identical to the Second Basis of Comparison. As described in Chapter 4, Approach to Environmental Analysis, Alternative 1 is compared to the No Action Alternative and the Second Basis of Comparison. However, because water quality factors under Alternative 1 are identical to water quality factors under the Second Basis of Comparison; Alternative 1 is only compared to the No Action Alternative.

#### 6.4.3.2.1 Alternative 1 Compared to the No Action Alternative

*Potential Changes in Salinity Indicators*

Salinity in the Sacramento River at Emmaton would be higher in September through January, lower in June, and similar in all other months over long-term average conditions under Alternative 1 as compared to the No Action Alternative, as summarized in Appendix 6E, Table 6E.2.1.

Salinity in the San Joaquin River at Vernalis would be higher in April and October, lower in May through June, lower in November through February and similar in March and July through September and higher in all other months under Alternative 1 as compared to the No Action Alternative, as summarized in Appendix 6E, Table 6E.15.1.

Salinity in the San Joaquin River at Jersey Point would be higher in September through January, lower in June, and similar in all other months, for long-term average conditions under Alternative 1 as compared to the No Action Alternative, as summarized in Appendix 6E, Table 6E.3.1.

Salinity in the Delta at Port Chicago, Chipps Island, and Collinsville would be higher in September through January, moderately higher February through May, lower in June, and similar in all other months, for long-term average conditions under Alternative 1 as compared to the No Action Alternative, as summarized in Appendix 6E, Tables 6E.6.1, 6E.4.1, and 6E.2.1.

Salinity at the CVP Contra Costa Canal and Jones pumping plants and the SWP Banks Pumping Plant intakes in the Delta would be higher in September through January, and lower in all other months for long-term average conditions under Alternative 1 as compared to the No Action Alternative, as summarized in Appendix 6E, Tables 6E.11.1, 6E.7.1, and 6E.8.1. Salinity at the Contra Costa Water District Old River and Middle River intakes also would be higher in September through January, and lower in all other months, for long-term average conditions under Alternative 1 as compared to the No Action Alternative, as summarized in Appendix 6E, Tables 6E.12.1 and 6E.13.1. Changes in salinity at the intakes would influence the salinity in water delivered in the San Joaquin Valley which could influence salinity in water bodies that receive agricultural return flows from CVP and SWP water users. Chloride and bromide concentrations at the intakes are expected to change in a similar manner to other salinity indicators.

X2 decreases with increases in Delta outflow as freshwater from the Central Valley flows towards San Francisco Bay. Under Alternative 1, Delta outflow would decrease and X2 would move towards the east as compared to the No Action Alternative, as shown in Table C.16.1 and Figures C.16.1.1 through C.16.1.8 and C.16.2.1 through C.16.2.8 in Appendix 5A, Section C, CalSim II and DSM2 Modeling Results. X2 distances would be higher in September through May, and similar in all other months in long-term average conditions under Alternative 1 as compared to the No Action Alternative.

#### *Potential Changes in Mercury Concentrations*

Changes in mercury from the rivers result in changes in mercury concentrations in fish used for human consumption in the Delta, including Largemouth Bass, as summarized in Tables 6.30 and 6.31 for long-term average conditions and dry and critical dry years, respectively. All values exceed the threshold of 0.24 milligram/kilogram wet weight (mg/kg ww) for mercury.

**Table 6.30 Changes in Mercury Concentrations 350-millimeter Largemouth Bass over the Long-term Average Conditions under Alternative 1 as Compared to the No Action Alternative**

| Delta Location | Alternative 1 (mg/kg ww) | No Action Alternative (mg/kg ww) | Changes |
|---|---|---|---|
| San Joaquin River at Stockton | 0.99 | 1.00 | 0% |
| San Joaquin River at Turner Cut | 0.87 | 0.89 | -3% |
| San Joaquin River at San Andreas Landing | 0.58 | 0.59 | -3% |
| San Joaquin River at Jersey Point | 0.54 | 0.57 | -4% |
| Victoria Canal | 0.82 | 0.85 | -4% |
| Sacramento River at Emmaton | 0.49 | 0.50 | -2% |
| San Joaquin River at Antioch | 0.47 | 0.50 | -6% |
| Montezuma Slough at Hunter Cut and Beldon's Landing (Suisun Marsh) | 0.32 | 0.35 | -6% |
| SWP Barker Slough Pumping Plant Intake | 0.56 | 0.56 | 0% |
| CVP Contra Costa Pumping Plant Intake | 0.68 | 0.73 | -6% |
| SWP Banks Pumping Plant Intake | 0.75 | 0.79 | -5% |
| CVP Jones Pumping Plant Intake | 0.79 | 0.83 | -4% |

Notes:

Long-term values calculated using 1976-1991 results from DSM2 model. Dry and critical dry years values calculated using 1987-1991 results from DSM2 model.

Concentrations greater than 0.24 mg/kg ww Hg exceed CVRWQCB threshold

mg/kg – milligram/kilogram; ww – wet weight

**Table 6.31 Changes in Mercury Concentrations 350-millimeter Largemouth Bass in Dry and Critical Dry Years under the Alternative 1 as Compared to the No Action Alternative**

| Delta Location | Alternative 1 (mg/kg ww) | No Action Alternative (mg/kg ww) | Changes |
|---|---|---|---|
| San Joaquin River at Stockton | 1.06 | 1.06 | 0% |
| San Joaquin River at Turner Cut | 0.81 | 0.84 | -4% |
| San Joaquin River at San Andreas Landing | 0.53 | 0.54 | -3% |
| San Joaquin River at Jersey Point | 0.50 | 0.52 | -4% |
| Victoria Canal | 0.76 | 0.82 | -6% |
| Sacramento River at Emmaton | 0.47 | 0.48 | -2% |
| San Joaquin River at Antioch | 0.41 | 0.43 | -5% |
| Montezuma Slough at Hunter Cut and Beldon's Landing (Suisun Marsh) | 0.26 | 0.28 | -5% |
| SWP Barker Slough Pumping Plant Intake | 0.57 | 0.59 | -2% |
| CVP Contra Costa Pumping Plant Intake | 0.62 | 0.67 | -7% |
| SWP Banks Pumping Plant Intake | 0.69 | 0.75 | -8% |
| CVP Jones Pumping Plant Intake | 0.77 | 0.82 | -6% |

Notes:

Long-term values calculated using 1976-1991 results from DSM2 model. Dry and critical dry years values calculated using 1987-1991 results from DSM2 model.

Concentrations greater than 0.24 mg/kg ww Hg exceed CVRWQCB threshold

mg/kg – milligram/kilogram; ww – wet weight

*Potential Changes in Selenium Concentrations*

It is anticipated that the selenium loadings would be similar under Alternative 1 as compared to the No Action Alternative; and that selenium concentrations in the San Joaquin River also would be similar.

Selenium in the water column at various locations in the Delta under Alternative 1 as compared to the No Action Alternative are shown in Appendix 6D, Selenium Model Documentation. Selenium in the water column at the three western Delta locations under Alternative 1 would be identical to conditions under the No Action Alternative, as shown in Appendix 6D, Table 6D.16. Selenium in the water column would be below the NTR criterion of 5 µg/L for the San Francisco Bay. Similarly, they would be below the draft USEPA (2014b) criterion for lentic aquatic systems (1.3 µg/L).

In the western Delta and at the Barker Slough Pumping Plant intake, selenium in the water column would be similar under Alternative 1 as compared to the No Action Alternative.

Selenium at the Contra Costa Pumping Plant intake would be similar under Alternative 1 as compared to the No Action Alternative, as shown in Table 6D.9 of Appendix 6D. Selenium at the Jones and Banks pumping plant intakes under Alternative 1 would be lower than under the No Action Alternative, as shown in Appendix 6D, Table 6D.9.

Estimated selenium concentration in biota (whole-body fish, bird eggs [invertebrate diet], bird eggs [fish diet], and fish fillets) at all locations in the Delta under Alternative 1 would be similar as under the No Action Alternative, as shown in Appendix 6D, Table 6D.10. As shown in Appendix 6D, Table 6D.13, EQs computed with respect to the applicable benchmarks show that selenium concentrations in biota under Alternative 1 would be below the thresholds identified for ecological risk.

For sturgeon in the western Delta, modeling also suggests that whole-body concentrations would be similar under Alternative 1 and the No Action Alternative (Appendix 6D, Table 6D.17), and the EQs would be similar (Appendix 6D, Table 6D.18). Low Toxicity Threshold EQs for selenium concentrations in sturgeon in the western Delta would remain under 1.0 for long-term average conditions, and slightly exceed 1.0 (indicating a higher probability for adverse effects) for drought years at the three western Delta locations under Alternative 1 and the No Action Alternative (Table 6D.18 of Appendix 6D). Estimated EQs for High Toxicity Threshold at all locations are less than 1.0 under all hydrologic conditions.

*Effects Related to Cross Delta Water Transfers*

Potential effects to water quality could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c) as described above under the No Action Alternative compared to the Second Basis of Comparison. For the purposes of this EIS, it is anticipated that similar conditions

would occur during implementation of cross Delta water transfers under Alternative 1 and the No Action Alternative, and that impacts on water quality would not be substantial in the seller's service area due to implementation requirements of the transfer programs.

Under Alternative 1, water could be transferred throughout the year without an annual volumetric limit. Under the No Action Alternative, the timing of cross Delta water transfers would be limited to July through September and include annual volumetric limits, in accordance with the 2008 USFWS BO and 2009 NMFS BO. Overall, the potential for cross Delta water transfers would be increased under Alternative 1 as compared to the No Action Alternative.

#### 6.4.3.2.2 Alternative 1 Compared to the Second Basis of Comparison

Alternative 1 is identical to the Second Basis of Comparison.

### *6.4.3.3 Alternative 2*

The CVP and SWP operations under Alternative 2 are identical to the CVP and SWP operations under the No Action Alternative; therefore, Alternative 2 is only compared to the Second Basis of Comparison.

#### 6.4.3.3.1 Alternative 2 Compared to the Second Basis of Comparison

The CVP and SWP operations under Alternative 2 are identical to the CVP and SWP operations under the No Action Alternative. Therefore, changes to surface water quality under Alternatives 2 as compared to the Second Basis of Comparison would be the same as the impacts described in Section 6.4.3.1, No Action Alternative.

### *6.4.3.4 Alternative 3*

As described in Chapter 3, Description of Alternatives, CVP and SWP operations under Alternative 3 are similar to the Second Basis of Comparison and Alternative 1 with modified Old and Middle River flow criteria. As described in Chapter 4, Approach to Environmental Analysis, Alternative 3 is compared to the No Action Alternative and the Second Basis of Comparison.

#### 6.4.3.4.1 Alternative 3 Compared to the No Action Alternative

*Potential Changes in Salinity Indicators*

Salinity in the Sacramento River at Emmaton would be higher in September through January, lower in June, and similar in all other months over long-term average conditions under Alternative 3 as compared to the No Action Alternative, as summarized in Appendix 6E, Table 6E.2.2.

Salinity in the San Joaquin River at Vernalis would be higher in February through July and in October, lower in November through December, and similar in other months under Alternative 3 as compared to the No Action Alternative, as summarized in Appendix 6E, Table 6E.15.2.

Salinity in the San Joaquin River at Jersey Point would be higher in September through January, lower in June, and similar in all other months, for long-term average conditions under Alternative 3 as compared to the No Action Alternative, as summarized in Appendix 6E, Table 6E.3.2.

Salinity in the Delta at Port Chicago, Chipps Island, and Collinsville would be higher in September through December, moderately higher January and April, and similar in all other months, for long-term average conditions under Alternative 3 as compared to the No Action Alternative, as summarized in Appendix 6E, Tables 6E.6.2, 6E.4.2, and 6E.2.2.

Salinity at the CVP Jones Pumping Plant and the SWP Banks Pumping Plant intakes in the Delta would be higher in September through January, and lower or similar in all other months for long-term average conditions under Alternative 3 as compared to the No Action Alternative, as summarized in Appendix 6E, Table 6E.7.2 and Table 6E.8.2. Salinity at the CVP Contra Costa Canal Pumping Plant and at the Contra Costa Water District Old River and Middle River intakes would be higher in September through January, lower in February through June, and similar in July and August for long-term average conditions under Alternative 3 as compared to the No Action Alternative, as summarized in Appendix 6E, Tables 6E.11.2, 6E.12.2, and 6E.13.2. Changes in salinity at the intakes would influence the salinity in water delivered in the San Joaquin Valley which could influence salinity in water bodies that receive agricultural return flows from CVP and SWP water users. Chloride and bromide concentrations at the intakes are expected to change in a similar manner to other salinity indicators.

X2 decreases with increases in Delta outflow as freshwater from the Central Valley flows towards San Francisco Bay. Under Alternative 3, Delta outflow would decrease and X2 would move towards the east as compared to the No Action Alternative, as shown in Table C.16.2 and Figures C.16.1.1 through C.16.1.8 and C.16.2.1 through C.16.2.8 in Appendix 5A, Section C, CalSim II and DSM2 Modeling Results. X2 distances would be higher in September through December and in April and May, and similar in all other months in long-term average conditions under Alternative 3 as compared to the No Action Alternative.

*Potential Changes in Mercury Concentrations*

Changes in mercury from the rivers result in changes in mercury concentrations in fish used for human consumption in the Delta, including Largemouth Bass, as summarized in Tables 6.32 and 6.33 for long-term average conditions and dry and critical dry years, respectively. All values exceed the threshold of 0.24 milligram/kilogram wet weight (mg/kg ww) for mercury.

**Table 6.32 Changes in Mercury Concentrations 350-millimeter Largemouth Bass over the Long-term Average Conditions under Alternative 3 as Compared to the No Action Alternative**

| Delta Location | Alternative 3 (mg/kg ww) | No Action Alternative (mg/kg ww) | Changes |
|---|---|---|---|
| San Joaquin River at Stockton | 1.00 | 1.00 | 1% |
| San Joaquin River at Turner Cut | 0,88 | 0.89 | -2% |
| San Joaquin River at San Andreas Landing | 0.58 | 0.59 | -3% |
| San Joaquin River at Jersey Point | 0.55 | 0.57 | -4% |
| Victoria Canal | 0.83 | 0.85 | -2% |
| Sacramento River at Emmaton | 0.49 | 0.50 | -2% |
| San Joaquin River at Antioch | 0.48 | 0.50 | -6% |
| Montezuma Slough at Hunter Cut and Beldon's Landing (Suisun Marsh) | 0.33 | 0.35 | -6% |
| SWP Barker Slough Pumping Plant Intake | 0.56 | 0.56 | 0% |
| CVP Contra Costa Pumping Plant Intake | 0.69 | 0.73 | -5% |
| SWP Banks Pumping Plant Intake | 0.77 | 0.79 | -3% |
| CVP Jones Pumping Plant Intake | 0.81 | 0.83 | -3% |

Notes:

Long-term values calculated using 1976-1991 results from DSM2 model. Dry and critical dry years values calculated using 1987-1991 results from DSM2 model.

Concentrations greater than 0.24 mg/kg ww Hg exceed CVRWQCB threshold

mg/kg – milligram/kilogram; ww – wet weight

**Table 6.33 Changes in Mercury Concentrations 350-millimeter Largemouth Bass in Dry and Critical Dry Years under the Alternative 3 as Compared to the No Action Alternative**

| Delta Location | Alternative 3 (mg/kg ww) | No Action Alternative (mg/kg ww) | Changes |
|---|---|---|---|
| San Joaquin River at Stockton | 1.07 | 1.06 | 1% |
| San Joaquin River at Turner Cut | 0.82 | 0.84 | -3% |
| San Joaquin River at San Andreas Landing | 0.53 | 0.54 | -2% |
| San Joaquin River at Jersey Point | 0.51 | 0.52 | -2% |
| Victoria Canal | 0.79 | 0.82 | -3% |
| Sacramento River at Emmaton | 0.47 | 0.48 | -1% |
| San Joaquin River at Antioch | 0.42 | 0.43 | -3% |
| Montezuma Slough at Hunter Cut and Beldon's Landing (Suisun Marsh) | 0.27 | 0.28 | -3% |
| SWP Barker Slough Pumping Plant Intake | 0.58 | 0.59 | -1% |
| CVP Contra Costa Pumping Plant Intake | 0.64 | 0.67 | -4% |
| SWP Banks Pumping Plant Intake | 0.72 | 0.75 | -4% |
| CVP Jones Pumping Plant Intake | 0.80 | 0.82 | -3% |

Notes:

Long-term values calculated using 1976-1991 results from DSM2 model. Dry and critical dry years values calculated using 1987-1991 results from DSM2 model.

Concentrations greater than 0.24 mg/kg ww Hg exceed CVRWQCB threshold

mg/kg – milligram/kilogram; ww – wet weight

*Potential Changes in Selenium Concentrations*

It is anticipated that the selenium loadings would be similar under Alternative 3 as compared to the No Action Alternative; and that selenium concentrations in the San Joaquin River also would be similar.

Selenium in the water column at various locations in the Delta under Alternative 3 as compared to the No Action Alternative are shown in Appendix 6D, Selenium Model Documentation. Selenium in the water column at the three western Delta locations under Alternative 3 would be similar to conditions under the No Action Alternative, as shown in Appendix 6D, Table 6D.9. Selenium in the water column would be below the NTR criterion of 5 µg/L for the San Francisco Bay. Similarly, they would be below the draft USEPA (2014b) criterion for lentic aquatic systems (1.3 µg/L).

In the western Delta and at the Barker Slough Pumping Plant intake, selenium in the water column would be similar under Alternative 3 as compared to the No Action Alternative.

Selenium at the Contra Costa Pumping Plant intake would be similar under Alternative 3 as compared to the No Action Alternative, as shown in Table 6D.9 of Appendix 6D. Selenium at the Jones and Banks pumping plant intakes under Alternative 3 would be lower than under the No Action Alternative, as shown in Appendix 6D, Table 6D.9.

Estimated selenium concentration in biota (whole-body fish, bird eggs [invertebrate diet], bird eggs [fish diet], and fish fillets) at all locations in the Delta under Alternative 3 would be similar as under the No Action Alternative, as shown in Appendix 6D, Table 6D.10. As shown in Appendix 6D, Table 6D.14, EQs computed with respect to the applicable benchmarks show that selenium concentrations in biota under Alternative 3 would be below the thresholds identified for ecological risk.

For sturgeon in the western Delta, modeling also suggests that whole-body concentrations would be similar under Alternative 3 and the No Action Alternative (Appendix 6D, Table 6D.17), and the EQs would be similar (Appendix 6D, Table 6D.18). Low Toxicity Threshold EQs for selenium concentrations in sturgeon in the western Delta would remain under 1.0 for long-term average conditions, and slightly exceed 1.0 (indicating a higher probability for adverse effects) for drought years at the three western Delta locations under Alternative 3 and the No Action Alternative (Table 6D.18 of Appendix 6D). Estimated EQs for High Toxicity Threshold at all locations are less than 1.0 under all hydrologic conditions.

*Effects Related to Cross Delta Water Transfers*

Potential effects to water quality could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c) as described above under the No Action Alternative compared to the Second Basis of Comparison. For the purposes of this EIS, it is anticipated that similar conditions

would occur during implementation of cross Delta water transfers under Alternative 3 and the No Action Alternative, and that impacts on water quality would not be substantial in the seller's service area due to implementation requirements of the transfer programs.

Under Alternative 3, water could be transferred throughout the year without an annual volumetric limit. Under the No Action Alternative, the timing of cross Delta water transfers would be limited to July through September and include annual volumetric limits, in accordance with the 2008 USFWS BO and 2009 NMFS BO. Overall, the potential for cross Delta water transfers would be increased under Alternative 3 as compared to the No Action Alternative.

#### 6.4.3.4.2 Alternative 3 Compared to the Second Basis of Comparison

*Potential Changes in Salinity Indicators*

Salinity in the Sacramento River at Emmaton would be higher in October through November and June, lower in December through March and July through September, and similar in April and May over long-term average conditions under Alternative 3 as compared to the Second Basis of Comparison, as summarized in Appendix 6E, Table 6E.2.5.

Salinity in the San Joaquin River at Vernalis would be higher in November through March and May through June, and similar in all other months under Alternative 3 as compared to the Second Basis of Comparison, as summarized in Appendix 6E, Table 6E.15.5.

Salinity in the San Joaquin River at Jersey Point would be higher in October through November and June through August, lower in December through March and September, and similar in April and May for long-term average conditions under Alternative 3 as compared to the Second Basis of Comparison, as summarized in Appendix 6E, Table 6E.3.5.

Salinity in the western Delta at Port Chicago, Chipps Island, and Collinsville would be lower in December through April and July through September, higher in May and June, and similar in all other months, for long-term average conditions under Alternative 3 as compared to the Second Basis of Comparison, as summarized in Appendix 6E, Tables 6E.6.5, 6E.4.5, and 6E.2.5.

Salinity at the CVP Contra Costa Canal intake would be lower in December through February, as summarized in Appendix 6E, Table 6E.11.5. Salinity at Jones Pumping Plant and the SWP Banks Pumping Plant intakes in the Delta would be higher in January through May, lower in June, and similar in all other months for long-term average conditions under Alternative 3 as compared to the Second Basis of Comparison, as summarized in Appendix 6E, Table 6E.7.5 and Table 6E.8.5. Salinity at the Contra Costa Water District Old River and Middle River intakes also would be higher in January through April, lower in May and June, and similar in all other months, for long-term average conditions under Alternative 3 as compared to the Second Basis of Comparison, as summarized in Appendix 6E, Tables 6E.12.5 and 6E.13.5. Changes in salinity at the intakes would influence the salinity in water delivered in the San Joaquin Valley which could influence salinity in water bodies that receive agricultural return flows from CVP and SWP water users.

X2 decreases with increases in Delta outflow as freshwater from the Central Valley flows towards San Francisco Bay. Under Alternative 3, Delta outflow generally would increase and X2 would move towards the west as compared to the Second Basis of Comparison, as shown in Table C.16.5 and Figures C.16.1.1 through C.16.1.8 and C.16.2.1 through C.16.2.8 in Appendix 5A, Section C, CalSim II and DSM2 Modeling Results. X2 distances would be lower (towards the west) in December through April and July through September, higher in May and June (towards the east), and similar in all other months in long-term average conditions under Alternative 3 as compared to the Second Basis of Comparison.

*Potential Changes in Mercury Concentrations*

Changes in flows in the rivers result in similar changes to erosional inputs and resuspension of both inorganic and methylmercury fractions. Changes in mercury from the rivers result in changes in mercury concentrations in fish used for human consumption in the Delta, including Largemouth Bass, as summarized in Tables 6.34 and 6.35 for long-term average conditions and dry and critical dry years, respectively. All values exceed the threshold of 0.24 milligram/kilogram wet weight (mg/kg ww) for mercury.

**Table 6.34 Changes in Mercury Concentrations 350-millimeter Largemouth Bass over the Long-term Average Conditions under Alternative 3 as Compared to the Second Basis of Comparison**

| Delta Location | Alternative 3 (mg/kg ww) | Second Basis of Comparison (mg/kg ww) | Changes |
|---|---|---|---|
| San Joaquin River at Stockton | 1.00 | 0.99 | 1% |
| San Joaquin River at Turner Cut | 0,88 | 0.87 | 1% |
| San Joaquin River at San Andreas Landing | 0.58 | 0.58 | 0% |
| San Joaquin River at Jersey Point | 0.55 | 0.54 | 1% |
| Victoria Canal | 0.83 | 0.82 | 2% |
| Sacramento River at Emmaton | 0.49 | 0.49 | 0% |
| San Joaquin River at Antioch | 0.48 | 0.47 | 1% |
| Montezuma Slough at Hunter Cut and Beldon's Landing (Suisun Marsh) | 0.33 | 0.32 | 1% |
| SWP Barker Slough Pumping Plant Intake | 0.56 | 0.56 | 0% |
| CVP Contra Costa Pumping Plant Intake | 0.69 | 0.68 | 1% |
| SWP Banks Pumping Plant Intake | 0.77 | 0.75 | 2% |
| CVP Jones Pumping Plant Intake | 0.81 | 0.79 | 2% |

Notes:

Long-term values calculated using 1976-1991 results from DSM2 model. Dry and critical dry years values calculated using 1987-1991 results from DSM2 model.

Concentrations greater than 0.24 mg/kg ww Hg exceed CVRWQCB threshold

mg/kg – milligram/kilogram; ww – wet weight

**Table 6.35 Changes in Mercury Concentrations 350-millimeter Largemouth Bass in Dry and Critical Dry Years under Alternative 3 as Compared to the Second Basis of Comparison**

| Delta Location | Alternative 3 (mg/kg ww) | Second Basis of Comparison (mg/kg ww) | Changes |
|---|---|---|---|
| San Joaquin River at Stockton | 1.07 | 1.06 | 1% |
| San Joaquin River at Turner Cut | 0.82 | 0.81 | 1% |
| San Joaquin River at San Andreas Landing | 0.53 | 0.53 | 1% |
| San Joaquin River at Jersey Point | 0.51 | 0.50 | 2% |
| Victoria Canal | 0.79 | 0.76 | 3% |
| Sacramento River at Emmaton | 0.47 | 0.47 | 0% |
| San Joaquin River at Antioch | 0.42 | 0.41 | 2% |
| Montezuma Slough at Hunter Cut and Beldon's Landing (Suisun Marsh) | 0.27 | 0.26 | 2% |
| SWP Barker Slough Pumping Plant Intake | 0.58 | 0.57 | 2% |
| CVP Contra Costa Pumping Plant Intake | 0.64 | 0.62 | 4% |
| SWP Banks Pumping Plant Intake | 0.72 | 0.69 | 4% |
| CVP Jones Pumping Plant Intake | 0.80 | 0.77 | 4% |

Notes:

Long-term values calculated using 1976-1991 results from DSM2 model. Dry and critical dry years values calculated using 1987-1991 results from DSM2 model.

Concentrations greater than 0.24 mg/kg ww Hg exceed CVRWQCB threshold

mg/kg – milligram/kilogram; ww – wet weight

*Potential Changes in Selenium Concentrations*

It is anticipated that the selenium loadings would be similar under Alternative 3 and the Second Basis of Comparison; and that selenium concentrations in the San Joaquin River also would be similar.

Selenium in the water column at various locations in the Delta under Alternative 3 and the Second Basis of Comparison are shown in Appendix 6D, Selenium Model Documentation. Selenium in the water column at the three western Delta locations under Alternative 3 would be identical to conditions under the Second Basis of Comparison, as shown in Appendix 6D, Table 6D.16. Selenium in the water column would be below the NTR criterion of 5 µg/L for the San Francisco Bay. Similarly, they would be below the draft USEPA (2014b) criterion for lentic aquatic systems (1.3 µg/L).

In the western Delta and at the Barker Slough Pumping Plant intake, the selenium would be similar under Alternative 3 and the Second Basis of Comparison.

Selenium at the Contra Costa Pumping Plant and Banks Pumping Plant intakes would be similar under Alternative 3 and Second Basis of Comparison, as shown in Appendix 6D, Table 6D.9. Selenium at the Jones Pumping Plant intake under Alternative 3 would be slightly higher than Second Basis of Comparison, as shown in Appendix 6D, Table 6D.9.

Estimated selenium concentration in biota (whole-body fish, bird eggs [invertebrate diet], bird eggs [fish diet], and fish fillets) at all locations in the Delta under Alternative 3 would be similar as under the Second Basis of Comparison, as shown in Appendix 6D, Table 6D.11. As shown in Appendix 6D, Table 6D.14, EQs computed with respect to the applicable benchmarks show that selenium concentrations in biota under Alternative 3 would be below the thresholds identified for ecological risk.

For sturgeon in the western Delta, modeling also suggests that whole-body concentrations would be similar under Alternative 3 and the Second Basis of Comparison (Appendix 6D, Table 6D.17), and the EQs would be similar (Appendix 6D, Table 6D.18). Low Toxicity Threshold EQs for selenium concentrations in sturgeon in the western Delta would remain under 1.0 for long-term average conditions, and slightly exceed 1.0 (indicating a higher probability for adverse effects) for drought years at the three western Delta locations under both Alternative 3 and Second Basis of Comparison (Table 6D.18 of Appendix 6D). Estimated EQs for High Toxicity Threshold at all locations are less than 1.0 under all hydrologic conditions.

*Effects Related to Cross Delta Water Transfers*

Potential effects to water quality could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c) as described above under the No Action Alternative compared to the Second Basis of Comparison. For the purposes of this EIS, it is anticipated that similar conditions would occur during implementation of cross Delta water transfers under

Alternative 3 and the Second Basis of Comparison, and that impacts on water quality would not be substantial in the seller's service area due to implementation requirements of the transfer programs.

Under Alternative 3 and the Second Basis of Comparison, water could be transferred throughout the year without an annual volumetric limit. Overall, the potential for cross Delta water transfers would be similar under Alternative 3 and the Second Basis of Comparison.

#### *6.4.3.5 Alternative 4*

Water quality under Alternative 4 would be identical to the conditions under the Second Basis of Comparison; therefore, Alternative 4 is only compared to the No Action Alternative.

##### 6.4.3.5.1 Alternative 4 Compared to the No Action Alternative

The CVP and SWP operations under Alternative 4 are identical to the CVP and SWP operations under the Second Basis of Comparison and Alternative 1. Therefore, changes in water quality under Alternative 4 as compared to the No Action Alternative would be the same as the impacts described in Section 12.4.3.2.1, Alternative 1 Compared to the No Action Alternative.

#### *6.4.3.6 Alternative 5*

As described in Chapter 3, Description of Alternatives, CVP and SWP operations under Alternative 5 are similar to the No Action Alternative with modified Old and Middle River flow criteria and New Melones Reservoir operations. As described in Chapter 4, Approach to Environmental Analysis, Alternative 5 is compared to the No Action Alternative and the Second Basis of Comparison.

##### 6.4.3.6.1 Alternative 5 Compared to the No Action Alternative

*Potential Changes in Salinity Indicators*

Salinity in the Sacramento River at Emmaton would be lower in May through September, and similar in all other months over long-term average conditions under Alternative 5 as compared to the No Action Alternative, as summarized in Appendix 6E, Table 6E.2.3.

Salinity in the San Joaquin River at Vernalis would be lower in April and May, and similar in all other months under Alternative 5 as compared to the No Action Alternative, as summarized in Appendix 6E, Table 6E.15.3.

Salinity in the San Joaquin River at Jersey Point would be lower in December through February, higher in June through August, and similar in all other months, for long-term average conditions under Alternative 5 as compared to the No Action Alternative, as summarized in Appendix 6E, Table 6E.3.3.

Salinity in the Delta at Port Chicago, Chipps Island, and Collinsville would be lower in April through June, and similar in all other months, for long-term average conditions under Alternative 5 as compared to the No Action Alternative, as summarized in Appendix 6E, Tables 6E.6.3, 6E.4.3, and 6E.2.3.

Salinity at the Jones pumping plants and the SWP Banks Pumping Plant intakes in the Delta would be lower in May and slightly higher in June through September, and similar in all other months for long-term average conditions under Alternative 5 as compared to the No Action Alternative, as summarized in Appendix 6E, Table 6E.7.3 and Table 6E.8.3. Salinity at the CVP Contra Costa Canal intake and at the Contra Costa Water District Old River and Middle River intakes also would be higher in April through September, and similar in all other months, for long-term average conditions under Alternative 5 as compared to the No Action Alternative, as summarized in Appendix 6E, Tables 6E.11.3, 6E.12.3, and 6E.13.3. Changes in salinity at the intakes would influence the salinity in water delivered in the San Joaquin Valley which could influence salinity in water bodies that receive agricultural return flows from CVP and SWP water users. Chloride and bromide concentrations at the intakes are expected to change in a similar manner to other salinity indicators.

X2 decreases with increases in Delta outflow as freshwater from the Central Valley flows towards San Francisco Bay. Under Alternative 5, Delta outflow would increase and X2 would move towards the west as compared to the No Action Alternative, as shown in Table C.16.3 and Figures C.16.1.1 through C.16.1.8 and C.16.2.1 through C.16.2.8 in Appendix 5A, Section C, CalSim II and DSM2 Modeling Results. X2 distances would be lower (towards the west) in April and May, and similar in all other months in long-term average conditions under Alternative 5 as compared to the No Action Alternative.

#### *Potential Changes in Mercury Concentrations*

Changes in flows in the rivers result in similar changes in erosional inputs and resuspension of both inorganic and methylmercury fractions. Changes in mercury from the rivers results in changes in mercury concentrations in fish used for human consumption in the Delta, including Largemouth Bass, as summarized in Tables 6.36 and 6.37 for long-term average conditions and dry and critical dry years, respectively. All values exceed the threshold of 0.24 milligram/kilogram wet weight (mg/kg ww) for mercury.

**Table 6.36 Changes in Mercury Concentrations 350-millimeter Largemouth Bass over the Long-term Average Conditions under Alternative 5 as Compared to the No Action Alternative**

| Delta Location | Alternative 5 (mg/kg ww) | No Action Alternative (mg/kg ww) | Changes |
|---|---|---|---|
| San Joaquin River at Stockton | 1.00 | 1.00 | 0% |
| San Joaquin River at Turner Cut | 0.89 | 0.89 | 0% |
| San Joaquin River at San Andreas Landing | 0.55 | 0.59 | 1% |
| San Joaquin River at Jersey Point | 0.57 | 0.57 | 1% |
| Victoria Canal | 0.85 | 0.85 | 0% |
| Sacramento River at Emmaton | 0.50 | 0.50 | 0% |
| San Joaquin River at Antioch | 0.51 | 0.50 | 1% |
| Montezuma Slough at Hunter Cut and Beldon's Landing (Suisun Marsh) | 0.35 | 0.35 | 1% |
| SWP Barker Slough Pumping Plant Intake | 0.56 | 0.56 | 0% |
| CVP Contra Costa Pumping Plant Intake | 0.74 | 0.73 | 2% |
| SWP Banks Pumping Plant Intake | 0.79 | 0.79 | 0% |
| CVP Jones Pumping Plant Intake | 0.83 | 0.83 | 0% |

Notes:

Long-term values calculated using 1976-1991 results from DSM2 model. Dry and critical dry years values calculated using 1987-1991 results from DSM2 model.

Concentrations greater than 0.24 mg/kg ww Hg exceed CVRWQCB threshold

mg/kg – milligram/kilogram; ww – wet weight

**Table 6.37 Changes in Mercury Concentrations 350-millimeter Largemouth Bass in Dry and Critical Dry Years under the Alternative 5 as Compared to the No Action Alternative**

| Delta Location | Alternative 5 (mg/kg ww) | No Action Alternative (mg/kg ww) | Changes |
|---|---|---|---|
| San Joaquin River at Stockton | 1.05 | 1.06 | 0% |
| San Joaquin River at Turner Cut | 0.85 | 0.84 | 1% |
| San Joaquin River at San Andreas Landing | 0.55 | 0.54 | 2% |
| San Joaquin River at Jersey Point | 0.53 | 0.52 | 2% |
| Victoria Canal | 0.82 | 0.82 | 0% |
| Sacramento River at Emmaton | 0.49 | 0.48 | 1% |
| San Joaquin River at Antioch | 0.44 | 0.43 | 2% |
| Montezuma Slough at Hunter Cut and Beldon's Landing (Suisun Marsh) | 0.28 | 0.28 | 0% |
| SWP Barker Slough Pumping Plant Intake | 0.58 | 0.59 | 0% |
| CVP Contra Costa Pumping Plant Intake | 0.70 | 0.67 | 5% |
| SWP Banks Pumping Plant Intake | 0.74 | 0.75 | -1% |
| CVP Jones Pumping Plant Intake | 0.82 | 0.82 | 1% |

Notes:

Long-term values calculated using 1976-1991 results from DSM2 model. Dry and critical dry years values calculated using 1987-1991 results from DSM2 model.

Concentrations greater than 0.24 mg/kg ww Hg exceed CVRWQCB threshold

mg/kg – milligram/kilogram; ww – wet weight

*Potential Changes in Selenium Concentrations*

It is anticipated that the selenium loadings would be similar under Alternative 5 as compared to the No Action Alternative; and that selenium concentrations in the San Joaquin River also would be similar.

Selenium in the water column at various locations in the Delta under Alternative 5 as compared to the No Action Alternative are shown in Appendix 6D, Selenium Model Documentation. Selenium in the water column at the three western Delta locations under Alternative 5 would be similar to conditions under the No Action Alternative, as shown in Appendix 6D, Table 6D.16. Selenium in the water column would be below the NTR criterion of 5 µg/L for the San Francisco Bay. Similarly, they would be below the draft USEPA (2014b) criterion for lentic aquatic systems (1.3 µg/L).

In the western Delta and at the Barker Slough Pumping Plant intake, selenium in the water column would be similar under Alternative 5 as compared to the No Action Alternative.

Selenium at the Contra Costa Pumping Plant and Banks Pumping Plant intakes would be higher under Alternative 5 as compared to the No Action Alternative, as shown in Table 6D.9 of Appendix 6D. Selenium at the Jones Pumping Plant intake under Alternative 5 would be similar to conditions under the No Action Alternative, as shown in Appendix 6D, Table 6D.9.

Estimated selenium concentration in biota (whole-body fish, bird eggs [invertebrate diet], bird eggs [fish diet], and fish fillets) at all locations in the Delta under Alternative 5 would be similar as under the No Action Alternative, as shown in Appendix 6D, Table 6D.12. As shown in Appendix 6D, Table 6D.15, Exceedance Quotients (EQs) computed with respect to the applicable benchmarks show that selenium concentrations in biota under Alternative 5 would be below the thresholds identified for ecological risk.

For sturgeon in the western Delta, modeling also suggests that whole-body concentrations would be higher under Alternative 5 than under the No Action Alternative (Appendix 6D, Table 6D.17), and the EQs would be similar (Appendix 6D, Table 6D.18). Low Toxicity Threshold EQs for selenium concentrations in sturgeon in the western Delta would remain under 1.0 for long-term average conditions, and slightly exceed 1.0 (indicating a higher probability for adverse effects) for drought years at the three western Delta locations under Alternative 5 and the No Action Alternative (Table 6D.18 of Appendix 6D). Estimated EQs for High Toxicity Threshold at all locations are less than 1.0 under all hydrologic conditions.

*Effects Related to Cross Delta Water Transfers*

Potential effects to water quality could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c) as described above under the No Action Alternative compared to the Second Basis of Comparison. For the purposes of this EIS, it is anticipated that similar conditions

would occur during implementation of cross Delta water transfers under Alternative 5 and the No Action Alternative, and that impacts on water quality would not be substantial in the seller's service area due to implementation requirements of the transfer programs.

Under Alternative 5 and the No Action Alternative, the timing of cross Delta water transfers would be limited to July through September and include annual volumetric limits, in accordance with the 2008 USFWS BO and 2009 NMFS BO. Overall, the potential for cross Delta water transfers would be similar under Alternative 5 and the No Action Alternative.

#### 6.4.3.6.2 Alternative 5 Compared to the Second Basis of Comparison

*Potential Changes in Salinity Indicators*

Salinity in the Sacramento River at Emmaton would be lower in September through January, higher in June, and similar in all other months over long-term average conditions under Alternative 5 as compared to the Second Basis of Comparison, as summarized in Appendix 6E, Table 6E.2.6.

Salinity in the San Joaquin River at Vernalis would be lower in April through May and October, higher in November through March, and similar in all other months under Alternative 5 as compared to the Second Basis of Comparison, as summarized in Appendix 6E, Table 6E.15.6.

Salinity in the San Joaquin River at Jersey Point would be lower in September through January, higher in July and August, and similar in all other months for long-term average conditions under Alternative 5 as compared to the Second Basis of Comparison, as summarized in Appendix 6E, Table 6E.3.6.

Salinity in the western Delta at Port Chicago, Chipps Island, and Collinsville would be lower in all months for long-term average conditions under Alternative 5 as compared to the Second Basis of Comparison, as summarized in Appendix 6E, Tables 6E.6.6, 6E.4.6, and 6E.2.6.

Salinity at Jones Pumping Plant and the SWP Banks Pumping Plant intakes in the Delta would be lower in September through January, and higher in all other months for long-term average conditions under Alternative 5 as compared to the Second Basis of Comparison, as summarized in Appendix 6E, Table 6E.7.6 and Table 6E.8.6. Salinity at the CVP Contra Costa Canal intake and the Contra Costa Water District Old River and Middle River intakes also would be lower in September through January and higher in February through August for long-term average conditions under Alternative 5 as compared to the Second Basis of Comparison, as summarized in Appendix 6E, Tables 6E.11.6, 6E.12.6, and 6E.13.6. Changes in salinity at the intakes would influence the salinity in water delivered in the San Joaquin Valley which could influence salinity in water bodies that receive agricultural return flows from CVP and SWP water users.

X2 decreases with increases in Delta outflow as freshwater from the Central Valley flows towards San Francisco Bay. Under Alternative 5, Delta outflow generally would increase and X2 would move towards the west, especially in September through May, as compared to the Second Basis of Comparison, as shown in in Table C.16.6 and Figures C.16.1.1 through C.16.1.8 and C.16.2.1 through C.16.2.8 in Appendix 5A, Section C, CalSim II and DSM2 Modeling Results.

*Potential Changes in Mercury Concentrations*

Changes in mercury from the rivers result in changes in mercury concentrations in fish used for human consumption in the Delta, including Largemouth Bass, as summarized in Tables 6.38 and 6.39 for long-term average conditions and dry and critical dry years, respectively. All values exceed the threshold of 0.24 milligram/kilogram wet weight (mg/kg ww) for mercury.

**Table 6.38 Changes in Mercury Concentrations 350-millimeter Largemouth Bass over the Long-term Average Conditions under Alternative 5 as Compared to the Second Basis of Comparison**

| Delta Location | Alternative 5 (mg/kg ww) | Second Basis of Comparison (mg/kg ww) | Changes |
|---|---|---|---|
| San Joaquin River at Stockton | 1.00 | 0.99 | 0% |
| San Joaquin River at Turner Cut | 0.89 | 0.87 | 3% |
| San Joaquin River at San Andreas Landing | 0.55 | 0.58 | 4% |
| San Joaquin River at Jersey Point | 0.57 | 0.54 | 5% |
| Victoria Canal | 0.85 | 0.82 | 4% |
| Sacramento River at Emmaton | 0.50 | 0.49 | 3% |
| San Joaquin River at Antioch | 0.51 | 0.47 | 7% |
| Montezuma Slough at Hunter Cut and Beldon’s Landing (Suisun Marsh) | 0.35 | 0.32 | 7% |
| SWP Barker Slough Pumping Plant Intake | 0.56 | 0.56 | 1% |
| CVP Contra Costa Pumping Plant Intake | 0.74 | 0.68 | 8% |
| SWP Banks Pumping Plant Intake | 0.79 | 0.75 | 5% |
| CVP Jones Pumping Plant Intake | 0.83 | 0.79 | 5% |

Notes:

Long-term values calculated using 1976-1991 results from DSM2 model. Dry and critical dry years values calculated using 1987-1991 results from DSM2 model.

Concentrations greater than 0.24 mg/kg ww Hg exceed CVRWQCB threshold

mg/kg – milligram/kilogram; ww – wet weight

**Table 6.39 Changes in Mercury Concentrations 350-millimeter Largemouth Bass in Dry and Critical Dry Years under Alternative 5 as Compared to the Second Basis of Comparison**

| Delta Location | Alternative 5 (mg/kg ww) | Second Basis of Comparison (mg/kg ww) | Changes |
|---|---|---|---|
| San Joaquin River at Stockton | 1.05 | 1.06 | 0% |
| San Joaquin River at Turner Cut | 0.85 | 0.81 | 4% |
| San Joaquin River at San Andreas Landing | 0.55 | 0.53 | 4% |
| San Joaquin River at Jersey Point | 0.53 | 0.50 | 5% |
| Victoria Canal | 0.82 | 0.76 | 7% |
| Sacramento River at Emmaton | 0.49 | 0.47 | 3% |
| San Joaquin River at Antioch | 0.44 | 0.41 | 7% |
| Montezuma Slough at Hunter Cut and Beldon's Landing (Suisun Marsh) | 0.28 | 0.26 | 7% |
| SWP Barker Slough Pumping Plant Intake | 0.58 | 0.57 | 2% |
| CVP Contra Costa Pumping Plant Intake | 0.70 | 0.62 | 13% |
| SWP Banks Pumping Plant Intake | 0.74 | 0.69 | 7% |
| CVP Jones Pumping Plant Intake | 0.82 | 0.77 | 7% |

Notes:

Long-term values calculated using 1976-1991 results from DSM2 model. Dry and critical dry years values calculated using 1987-1991 results from DSM2 model.

Concentrations greater than 0.24 mg/kg ww Hg exceed CVRWQCB threshold

mg/kg – milligram/kilogram; ww – wet weight

*Potential Changes in Selenium Concentrations*

It is anticipated that the selenium loadings would be similar under Alternative 5 and the Second Basis of Comparison; and that selenium concentrations in the San Joaquin River also would be similar.

In the Delta, selenium concentrations are related to the movement of flows from the San Joaquin River and the accumulation in certain areas of the Delta due to tidal flow patterns.

Selenium in the water column at various locations in the Delta under Alternative 5 and the Second Basis of Comparison are shown in Appendix 6D, Selenium Model Documentation. Selenium in the water column at the three western Delta locations under Alternative 5 would be similar to conditions under the Second Basis of Comparison, as shown in Appendix 6D, Table 6D.16. Selenium in the water column would be below the NTR criterion of 5 µg/L for the San Francisco Bay. Similarly, they would be below the draft USEPA (2014b) criterion for lentic aquatic systems (1.3 µg/L).

In the western Delta and at the Barker Slough Pumping Plant intake, the selenium would be similar under Alternative 5 and the Second Basis of Comparison. There would be small increases in selenium along the Sacramento River at Emmaton under Alternative 5 as compared to the Second Basis of Comparison.

Selenium at the Contra Costa Pumping Plant, Jones Pumping Plant, and Banks Pumping Plant intakes would be higher under Alternative 5 than Second Basis of Comparison, as shown in Appendix 6D, Table 6D.9.

Estimated selenium concentration in biota (whole-body fish, bird eggs [invertebrate diet], bird eggs [fish diet], and fish fillets) at all locations in the Delta under Alternative 5 would be similar as under the Second Basis of Comparison, as shown in Appendix 6D, Table 6D.12. As shown in Appendix 6D, Table 6D.13, EQs computed with respect to the applicable benchmarks show that selenium concentrations in biota under Alternative 5 would be below the thresholds identified for ecological risk.

For sturgeon in the western Delta, modeling also suggests that whole-body concentrations would be higher under Alternative 5 than the Second Basis of Comparison (Appendix 6D, Table 6D.17), and the EQs would be similar (Appendix 6D, Table 6D.18). Low Toxicity Threshold EQs for selenium concentrations in sturgeon in the western Delta would remain under 1.0 for long-term average conditions, and slightly exceed 1.0 (indicating a higher probability for adverse effects) for drought years at the three western Delta locations under both Alternative 5 and Second Basis of Comparison (Table 6D.18 of Appendix 6D). Estimated EQs for High Toxicity Threshold at all locations are less than 1.0 under all hydrologic conditions.

*Effects Related to Cross Delta Water Transfers*

Potential effects to water quality could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c) as described above under the No Action Alternative compared to the Second Basis of Comparison. For the purposes of this EIS, it is anticipated that similar conditions would occur during implementation of cross Delta water transfers under Alternative 5 and the Second Basis of Comparison, and that impacts on water quality would not be substantial in the seller's service area due to implementation requirements of the transfer programs.

Under Alternative 5, the timing of cross Delta water transfers would be limited to July through September and include annual volumetric limits, in accordance with the 2008 USFWS BO and 2009 NMFS BO. Under the Second Basis of Comparison, water could be transferred throughout the year without an annual volumetric limit. Overall, the potential for cross Delta water transfers would be reduced under Alternative 5 as compared to the Second Basis of Comparison.

#### *6.4.3.7 Summary of Environmental Consequences*

The results of the environmental consequences of implementation of Alternatives 1 through 5 as compared to the No Action Alternative and the Second Basis of Comparison are presented in Tables 6.40 and 6.41.

It should be noted that since concentrations of nutrients, dissolved oxygen, and other constiuents of current concern (except salinity, mercury, and selenium) would be managed through regulatory processes by 2030, it is assumed that concentrations of these constituents would be similar under the No Action Alternative, Alternatives 1 through 5, and the Second Basis of Comparison, as described in Section 6.4.1., Potential Mechanisms of Change and Analytical Methods.

Environmental effects associated with changes in water temperatures are related to impacts on biological resources (as described in Chapter 9, Fish and Aquatic Resources. Therefore, the, potential impacts of the action alternatives related to changes in water temperature, including changes resulting from including reasonably and foreseeable actions are presented in Chapter 9.

**Table 6.40 Comparison of Alternatives 1 through 5 to No Action Alternative**

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| Alternative 1 | Salinity increases near Emmaton in almost all months (5 to 377 percent), particularly in September, October and November of wet and above normal years; decreases in June except for June of critical years; and is similar in wet and above normal of spring months (February through May); and dry and critical years of August and September.<br>Salinity increases near Antioch (5 to 265 percent) in almost all months except it decreases in June of wet, above normal, and below normal years ( 7 to 14 percent) and when it is similar in February, March, and April of wet years, July and August, and September of below normal, dry and critically dry years.<br>Salinity increases near CVP and SWP intakes (6 to 36 percent) in October, November, and December (and January for only SWP), decreases (5 to 22 percent) in February through June, and is similar in other months.<br>Salinity increases near Contra Costa Water District intakes (8 to 65 percent) in October through January and September of wet and above normal years, decreases (5 to 32 percent) March through May and June of wet, above normal, and below normal years, and is similar in other months. Changes in Contra Costa Water District intakes are different for each location. Please refer to Appendix 6E for a detailed summary of the changes in salinity.<br>Salinity increases (5 to 96 percent) near Port Chicago October through February, April, March of below normal, dry, and critically dry years, and September of wet and above normal years; and is similar in other months.<br>Similar mercury concentrations in Largemouth Bass in most of the Delta; and a 6 percent decrease near Rock Slough, San Joaquin River at Antioch, and Montezuma Slough over the long-term conditions.<br>Similar selenium concentrations in whole body fish, bird eggs, and fish fillets. | Coordination of CVP and SWP operations between Reclamation, DWR, USFWS, and NMFS to reduce salinity near the CVP, SWP, Contra Costa Water District, and Antioch intakes and near Emmaton. |

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| Alternative 2 | Water quality conditions would be the same as under the No Action Alternative. | None needed |
| Alternative 3 | Salinity increases near Emmaton (7 to 378 percent) October through January and September of wet and above normal years, in September, October and November of wet and above normal years; decreases (7 and 8 percent) in June of above normal years and September of below normal years, and is similar in all other months.<br>Salinity increases near Antioch (6 to 262 percent) in almost all months except it is similar in March, July, August, below normal, dry, and critically dry years of September, and wet, above normal, and dry years of February.<br>Salinity increases near CVP intakes (6 to 29 percent) in October, November, and December, decreases (5 to 13 percent) in June, and is similar in other months.<br>Salinity increases near SWP intakes (5 to 41 percent) in October, November, December, and January, decreases (5 to 19 percent) in April through June, and is similar in other months.<br>Salinity increases near Contra Costa Water District intakes (6 to 76 percent) in October through December, January of above normal, below normal, and dry years, and September of wet and above normal years; decreases (5 to 34 percent) April through June; and is similar in other months.<br>Salinity increases (6 to 95 percent) near Port Chicago October through January, April, and May, June and September of wet and above normal years; and is similar in other months.<br>Similar mercury concentrations in Largemouth Bass in most of the Delta; and a 6 percent decrease near San Joaquin River at Antioch and Montezuma Slough over the long-term conditions.<br>Similar selenium concentrations in whole body fish, bird eggs, and fish fillets. | Coordination of CVP and SWP operations between Reclamation, DWR, USFWS, and NMFS to reduce salinity near the CVP, SWP, Contra Costa Water District, and Antioch intakes. |
| Alternative 4 | Same effects as described for Alternative 1 compared to the No Action Alternative. | None needed |
| Alternative 5 | | None needed |

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| | Salinity near Emmaton is similar in all months except it increases (6 and 8 percent) January and February and decreases (6 to 15 percent) in April through June of critically dry years.<br>Salinity decreases (9 to 20 percent) near Antioch in April and May of below normal, dry, and critically dry years and June of critically dry years; increases (7 percent) in February of critically dry years; and is similar in all other months.<br>Salinity is similar near CVP and SWP intakes in most months, and increases (8 to 12 percent) in June of dry and critically dry years.<br>Salinity increases near Contra Costa Water District intakes (6 to 40 percent) in April, May, and June of below normal, dry, and critical years; and is similar in other months. Changes in Contra Costa Water District intakes are different for each location. Please refer to Appendix 6E for a detailed summary of the changes in salinity.<br>Salinity near Port Chicago is similar in all months except it decreases (5 to 8 percent) in April and May of dry and critical years.<br>Similar mercury concentrations in Largemouth Bass throughout the Delta.<br>Similar selenium concentrations in whole body fish, bird eggs, and fish fillets. | |

Notes:

1 In general, D-1641 Delta salinity standards are met in all alternatives except for few dry and critical years where there is no stored fresh water available for release The differences in salinity between alternatives mostly point to results of other operations beyond meeting the D-1641 salinity standards; such as whether or not reservoirs are releasing to meet 2008 USFWS Biological Opinion Action 4 (Fall X2), Delta Cross Channel operations, or whether or not south Delta exports are allowed in a particular month. As a result, changes in salinity for each location in Delta shows wide month to month variation between alternatives. Please refer to Appendix 6E for detailed comparison of salinity between the alternatives.

2 Due to the limitations and uncertainty in the CalSim II monthly model and other analytical tools, incremental differences of 5 percent or less between alternatives and the Second Basis of Comparison are considered to be “similar.”

**Table 6.41 Comparison of No Action Alternative and Alternatives 1 through 5 to Second Basis of Comparison**

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| No Action Alternative | Salinity decreases near Emmaton in almost all months (5 to 79 percent), particularly in September, October and November of wet and above normal years; increases (9 to 21 percent) in June except for June of critical years; and is similar in wet and above normal of spring months (February through May); and dry and critical years of August and September.<br>Salinity decreases near Antioch (5 to 73 percent) in almost all months except it increases (7 to 16 percent) in June of wet, above normal, and below normal years; and is similar in February, March, and April of wet years, July and August, and September of below normal, dry and critically dry years.<br>Salinity decreases near CVP and SWP intakes (6 to 28 percent) in October, November, and December (and January for only SWP), increases (5 to 23 percent) in February through June, and is similar in other months.<br>Salinity decreases near Contra Costa Water District intakes (7 to 42 percent) in October through January and September of wet and above normal years, increases (5 to 47 percent) March through May and June of wet, above normal, and below normal years, and is similar in other months. Changes in Contra Costa Water District intakes are different for each location. Please refer to Appendix 6E for a detailed summary of the changes in salinity.<br>Salinity decreases (6 to 49 percent) near Port Chicago October through May, and September of wet and above normal years; and is similar in other months.<br>Similar mercury concentrations in Largemouth Bass in the most of the Delta; and a 7 percent increase near Rock Slough, San Joaquin River at Antioch, and Montezuma Slough over the long-term conditions.<br>Similar selenium concentrations in whole body fish, bird eggs, and fish fillets. | Not considered for this comparison. |

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| Alternative 1 | No effects on public health issues. | Not considered for this comparison. |
| Alternative 2 | Same effects as described for No Action Alternative as compared to the Second Basis of Comparison. | Not considered for this comparison. |
| Alternative 3 | Salinity increases near Emmaton (5 to 35 percent) in June except for critically dry years; decreases (5 to 24 percent) in December and January of above normal years, January through March and July through September of below normal years, January, February, and July of dry years, and March of critically dry years; and it is similar in all other months.<br>Salinity increases near Antioch (8 to 20 percent) in June except critically dry years and in May of wet years; decreases (7 to 40 percent) in January through April, and is similar in all other months.<br>Salinity is similar near CVP and SWP intakes except for increase (5 to 23 percent) mostly in February through May of dry and critically dry years.<br>Salinity increases near Contra Costa Water District intakes (5 to 16 percent) in March and April of dry and critically dry years; decreases (5 to 23 percent) in December, January and February of dry and critically dry years; and is similar in other months. Changes in Contra Costa Water District intakes are different for each location. Please refer to Appendix 6E for a detailed summary of the changes in salinity.<br>Salinity decreases (5 to 25 percent) near Port Chicago January through March; increases (7 to 9 percent) in June of wet, above normal, and below normal years; and is similar in other months.<br>Similar mercury concentrations in Largemouth Bass throughout the Delta.<br>Similar selenium concentrations in whole body fish, bird eggs, and fish fillets. | Not considered for this comparison. |
| Alternative 4 | No effects on water quality issues. | Not considered for this comparison. |
| Alternative 5 | Salinity decreases near Emmaton in almost all months (5 to 79 percent), particularly in September, October and November of wet and above normal | Not considered for this comparison. |

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| | years; increases (7 to 21 percent) in June except for June of critical years; and is similar in wet and above normal of spring months (February through May); and dry and critical years of August and September.<br>Salinity decreases near Antioch (5 to 73 percent) in almost all months except it increases (7 to 14 percent) in June of wet, above normal, and below normal years; and is similar in February, March, and April of wet years, July and August, and September of below normal, dry and critically dry years.<br>Salinity decreases near CVP and SWP intakes (5 to 28 percent) in October, November, and December (and January for only SWP), increases (5 to 26 percent) in February through June, and is similar in other months.<br>Salinity decreases near Contra Costa Water District intakes (7 to 41 percent) in October through January and September of wet and above normal years, increases (5 to 63 percent) March through June, and is similar in other months. Changes in Contra Costa Water District intakes are different for each location. Please refer to Appendix 6E for a detailed summary of the changes in salinity.<br>Salinity decreases (5 to 49 percent) near Port Chicago October through May, and September of wet and above normal years; and is similar in other months. Similar mercury concentrations in Largemouth Bass in the most of the Delta; and a 7 percent increase near Rock Slough, San Joaquin River at Antioch, and Montezuma Slough over the long-term conditions.<br>Similar selenium concentrations in whole body fish, bird eggs, and fish fillets. | |

Notes:

1 In general, D-1641 Delta salinity standards are met in all alternatives except for few dry and critical years where there is no stored fresh water available for release The differences in salinity between alternatives mostly point to results of other operations beyond meeting the D-1641 salinity standards; such as whether or not reservoirs are releasing to meet 2008 USFWS Biological Opinion Action 4 (Fall X2), Delta Cross Channel operations, or whether or not south Delta exports are allowed in a particular month. As a result, changes in salinity for each location in Delta shows wide month to

month variation between alternatives. Please refer to Appendix 6E for detailed comparison of salinity between the alternatives.

2 Due to the limitations and uncertainty in the CalSim II monthly model and other analytical tools, incremental differences of 5 percent or less between alternatives and the Second Basis of Comparison are considered to be "similar."

#### *6.4.3.8 Potential Mitigation Measures*

Mitigation measures are presented in this section to avoid, minimize, rectify, reduce, eliminate, or compensate for adverse environmental effects of Alternatives 1 through 5 as compared to the No Action Alternative. Mitigation measures were not included to address adverse impacts under the alternatives as compared to the Second Basis of Comparison because this analysis was included in this EIS for information purposes only.

Environmental effects associated with changes in water temperatures are related to impacts on biological resources (as described in Chapter 9, Fish and Aquatic Resources. Therefore, mitigation measures related to changes in temperatures as compared to the No Action Alternative conditions are presented in Chapter 9.

##### 6.4.3.8.1 Salinity Water Quality Conditions

Implementation of Alternatives 1 through 5 would not result in adverse impacts to mercury and selenium concentrations as compared to the No Action Alternative. Therefore, no mitigation measures are required for these constituents.

Implementation of Alternatives 1, 3, and 4 would result in adverse impacts to salinity concentrations as compared to the No Action Alternative. A potential mitigation measure to reduce these effects would be:

- Coordination of CVP and SWP operations between Reclamation, DWR, USFWS, and NMFS to reduce salinity near the CVP, SWP, Contra Costa Water District, and Antioch intakes.

Under the No Action Alternative and Alternatives 1 through 5, it is anticipated that the ongoing real-time decision making meetings between Reclamation, DWR, USFWS, and NMFS would continue in a manner similar to that described in Section 3A.3 of Appendix 3A, No Action Alternative: Central Valley Project and State Water Project Operations. Under this mitigation measure, a specific agenda item would be added to the groups' actions to reduce salinity impacts on the beneficial uses in the Delta. Potential changes could be to modify intake operations in accordance with real-time flows, observations related to fish presence, and real-time water quality observations.

#### *6.4.3.9 Cumulative Effects Analysis*

As described in Chapter 3, the cumulative effects analysis considers projects, programs, and policies that are not speculative; and are based upon known or reasonably foreseeable long-range plans, regulations, operating agreements, or other information that establishes them as reasonably foreseeable.

The cumulative effects analysis Alternatives 1 through 5 for Water Quality are summarized in Table 6.42.

**Table 6.42 Summary of Cumulative Effects on Water Quality of Alternatives 1 through 5 as Compared to the No Action Alternative**

| Scenarios | Actions | Cumulative Effects of Actions |
|---|---|---|
| Past & Present, and Future Actions included in the No Action Alternative and in All Alternatives in Year 2030 | Consistent with Affected Environment conditions plus:<br>Actions in the 2008 USFWS BO and 2009 NMFS BO that Would Have Occurred without implementation of the BOs, as described in Section 3.3.1.2 (of Chapter 3, Descriptions of Alternatives), including climate change and sea level rise<br>Actions not included in the 2008 USFWS BO and 2009 NMFS BO that would have occurred without implementation of the BOs, as described in Section 3.3.1.3 (of Chapter 3, Descriptions of Alternatives):<br>- Implementation of Federal and state policies and programs, including Clean Water Act (e.g.,Total Maximum Daily Loads); Safe Drinking Water Act; Clean Air Act; and flood management programs<br>- Trinity River Restoration Program.<br>- Central Valley Project Improvement Act programs<br>- Iron Mountain Mine Superfund Site<br>- Dutch Slough Tidal Marsh Restoration<br>- Suisun Marsh Habitat Management, Preservation, and Restoration Plan Implementation<br>- Tidal Wetland Restoration: Yolo Ranch, Northern Liberty Island Fish Restoration Project, Prospect Island Restoration Project, and Calhoun Cut/Lindsey Slough Tidal Habitat Restoration Project<br>- San Joaquin River Restoration Program<br>- Stockton Deep Water Ship Channel Dissolved Oxygen Project<br>- Grasslands Bypass Project<br>- Central Valley Salinity Alternatives for Long-Term Sustainability (CV-SALTS)<br>- Future water supply projects, including water recycling, desalination, groundwater banks and wellfields, and conveyance facilities | These effects would be the same in all alternatives.<br>Climate change and sea level rise area anticipated to increase salinity in the Delta and expand the region of the Delta influenced by tidal fluctuations.<br>Water quality programs to reduce nutrient loadings from wastewater treatment plant effluent and other point source discharges under the TMDLs would be fully implemented by 2020; and it is anticipated that nutrient concentrations would be reduced by 2030.<br>Programs to meet TMDLs related to dissolved oxygen, pesticides, mercury, selenium, and other constituents of concern are anticipated to be fully defined and implemented in the early 2020s to reduce, but not necessarily meet TMDL objectives, by 2030. These programs include projects to reduce effects of agricultural drainage.<br>Tidal restoration programs would change salinity gradients in the Delta, including increased salinity in the western and central Delta, depending upon the location of the tidal restoration lands. Estuarine tidal restoration could reduce constituents from runoff of adjacent upland areas, depending upon the location of the restored lands. |

| Scenarios | Actions | Cumulative Effects of Actions |
|---|---|---|
| | (projects with completed environmental documents) | |
| Future Actions considered as Cumulative Effects Actions in All Alternatives in Year 2030 | Actions as described in Section 3.5 (of Chapter 3, Descriptions of Alternatives):<br>- Bay-Delta Water Quality Control Plan Update<br>- FERC Relicensing Projects<br>- Bay Delta Conservation Plan (including the California WaterFix alternative)<br>- EcoRestore<br>- Irrigated Lands Regulatory Program<br>- San Luis Reservoir Low Point Improvement Project<br>- *Westlands Water District v. United States Settlement*<br>- Future water supply projects, including water recycling, desalination, groundwater banks and wellfields, and conveyance facilities (projects that did not have completed environmental documents during preparation of the EIS) | <u>These effects would be the same in all alternatives.</u><br>Some of the future reasonably foreseeable actions are anticipated to reduce water quality issues, including Bay-Delta Water Quality Control Plan Update, FERC Relicensing Projects, agricultural drainage programs, and San Luis Reservoir Low Point Improvement Project.<br>Future reasonably foreseeable actions related to tidal restoration projects could increase salinity and mercury water quality issues. |
| No Action Alternative with Associated Cumulative Effects Actions in Year 2030 | Full implementation of the 2008 USFWS BO and 2009 NMFS BO | Implementation of No Action Alternative would result in increased salinity in the western and central Delta due to climate change and sea level rise.<br>Numerous projects would be implemented by 2030 to reduce water quality issues related to nutrients, agricultural drainage, and other discharges of constituents of concern by 2030.<br>Depending upon the location of tidal restoration lands, salinity in the No Action Alternative could increase in the western and interior Delta. |
| Alternatives 1 and 4 with Associated Cumulative Effects Actions in Year 2030 | No implementation of the 2008 USFWS BO and 2009 NMFS BO actions unless the actions would have been implemented without the BO (e.g., Red Bluff Pumping Plant) | Implementation of Alternatives 1 and 4 with reasonably foreseeable actions would increase salinity in the western and interior Delta as compared to the No Action Alternative with these added actions. Other water quality conditions under Alterantives 1 through 4 with reasonably foreseeable actions would be similar to conditions under the No Action Alternative with the added actions. |

| Scenarios | Actions | Cumulative Effects of Actions |
|---|---|---|
| Alternative 2 with Associated Cumulative Effects Actions in Year 2030 | Full implementation of the 2008 USFWS BO and 2009 NMFS BO CVP and SWP operational actions<br>No implementation of structural improvements or other actions that require further study to develop a more detailed action description. | Implementation of Alternative 2 with reasonably foreseeable actions would result in the same conditions as under the No Action Alternative with the added actions. |
| Alternative 3 with Associated Cumulative Effects Actions in Year 2030 | No implementation of the 2008 USFWS BO and 2009 NMFS BO actions unless the actions would have been implemented without the BO (e.g., Red Bluff Pumping Plant)<br>Slight increase in positive Old and Middle River flows in the winter and spring months | Implementation of Alternative 3 with reasonably foreseeable actions would increase salinity in the western and interior Delta as compared to the No Action Alternative with the added actions. Other water quality conditions under Alterantive 3 with reasonably foreseeable actions would be similar to conditions under the No Action Alternative with the added actions. |
| Alternative 5 with Associated Cumulative Effects Actions in Year 2030 | Full implementation of the 2008 USFWS BO and 2009 NMFS BO<br>Positive Old and Middle River flows and increased Delta outflow in spring months | Implementation of Alternative 5 with reasonably foreseeable actions would result in similar salinity conditions as compared to the No Action Alternative with the added actions. Other water quality conditions under Alterantive 5 with with reasonably foreseeable actions would be similar to conditions under the No Action Alternative with the added actions. |

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## Chapter 6

# Surface Water Quality Figures

The following figures are included in Chapter 6, Surface Water Quality.

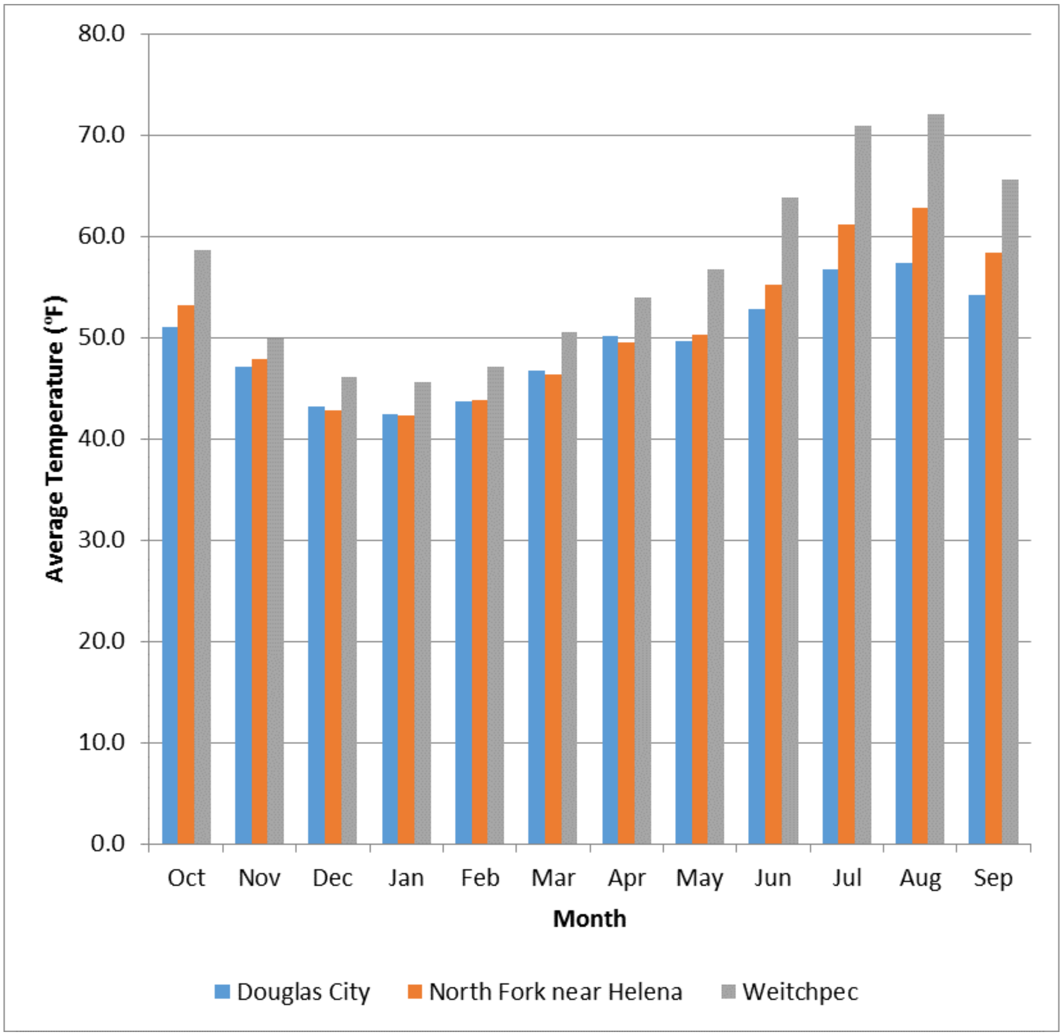

**Figure 6.1 Monthly Average of Water Temperatures Recorded at Trinity River Compliance Locations (2001-2012)**

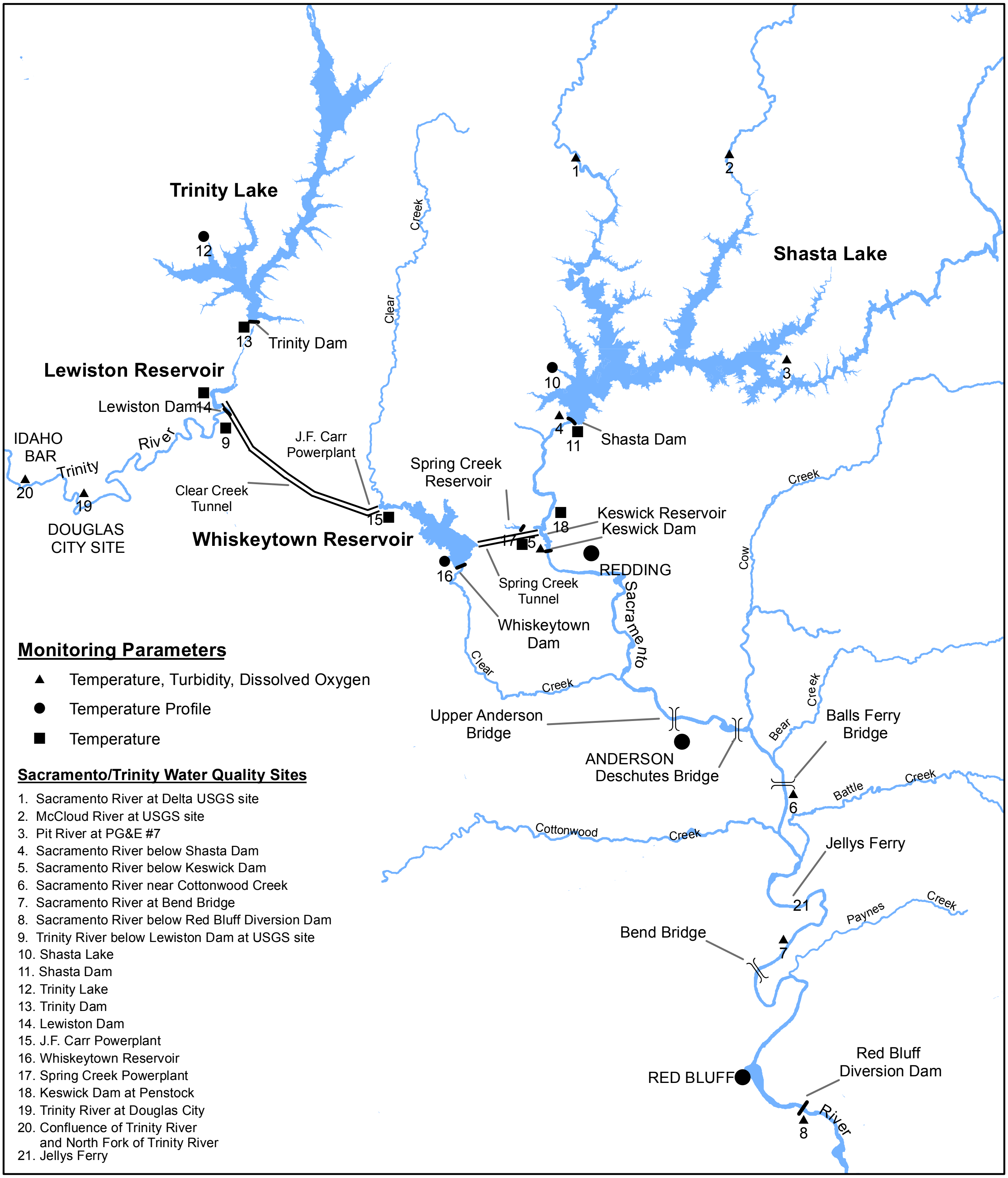

**Figure 6.2 Water Quality Compliance Stations Along Trinity River and Upper Sacramento River**

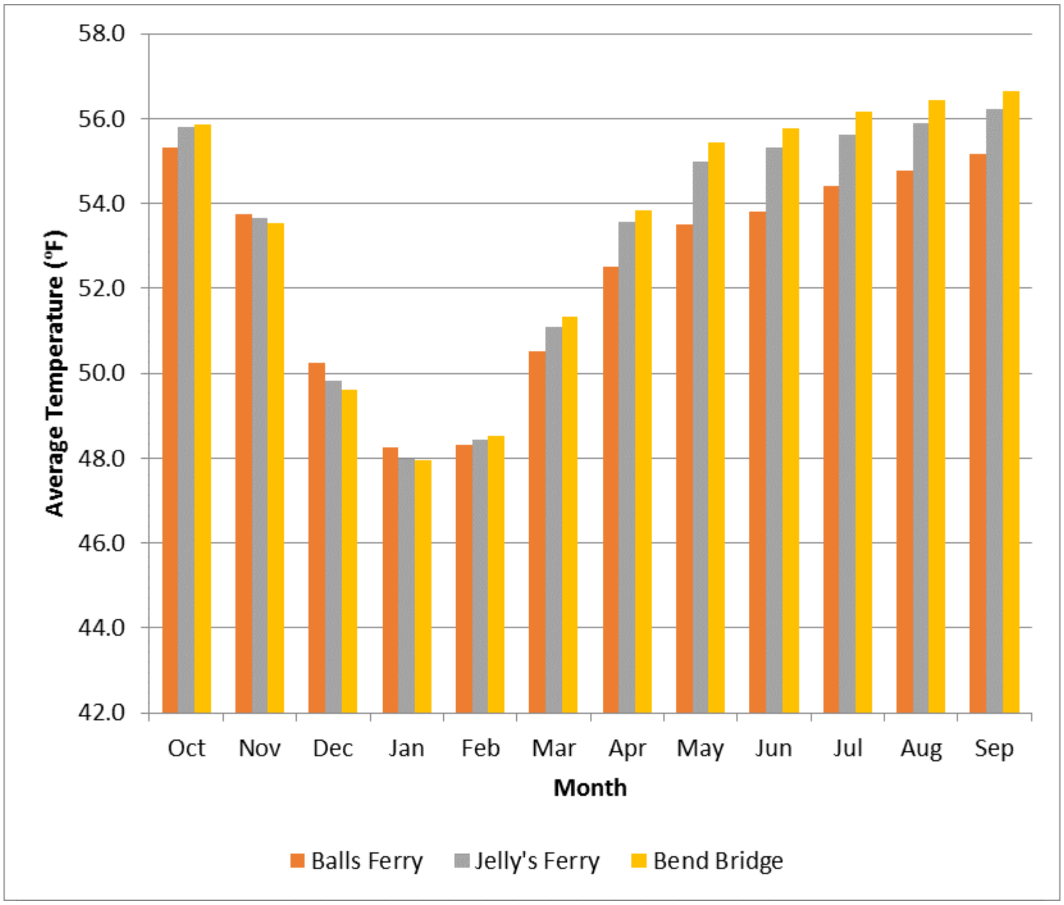

**Figure 6.3 Monthly Average of Water Temperatures Recorded at Sacramento River Compliance Locations (2001-2012)**

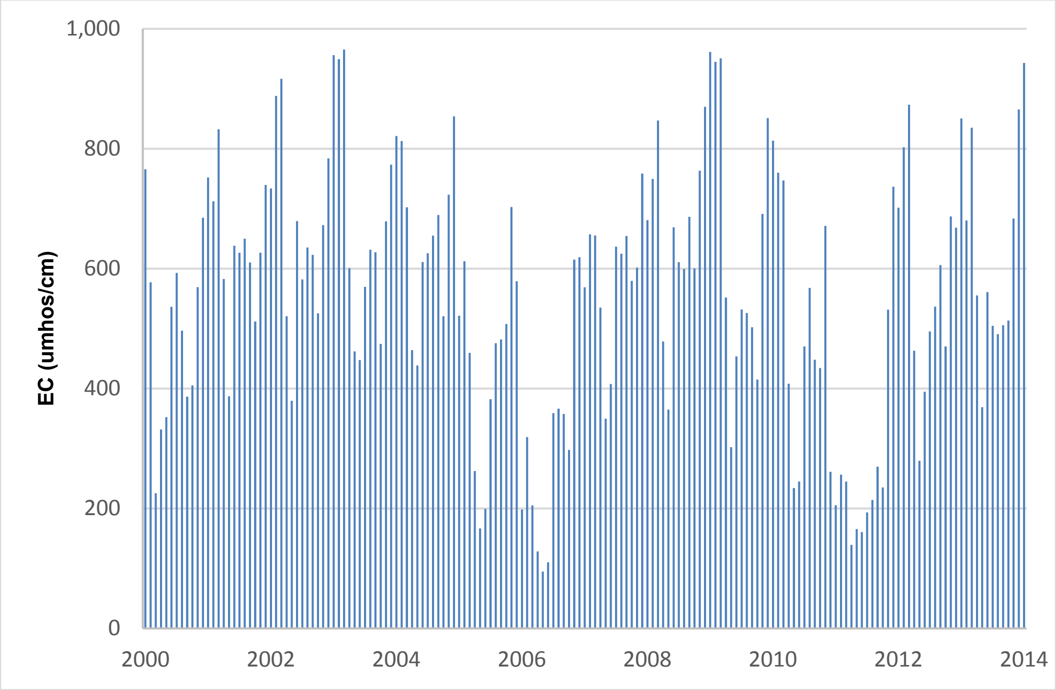

**Figure 6.4 Monthly Average Specific Conductance in San Joaquin River at Vernalis (Reclamation 2013e)**

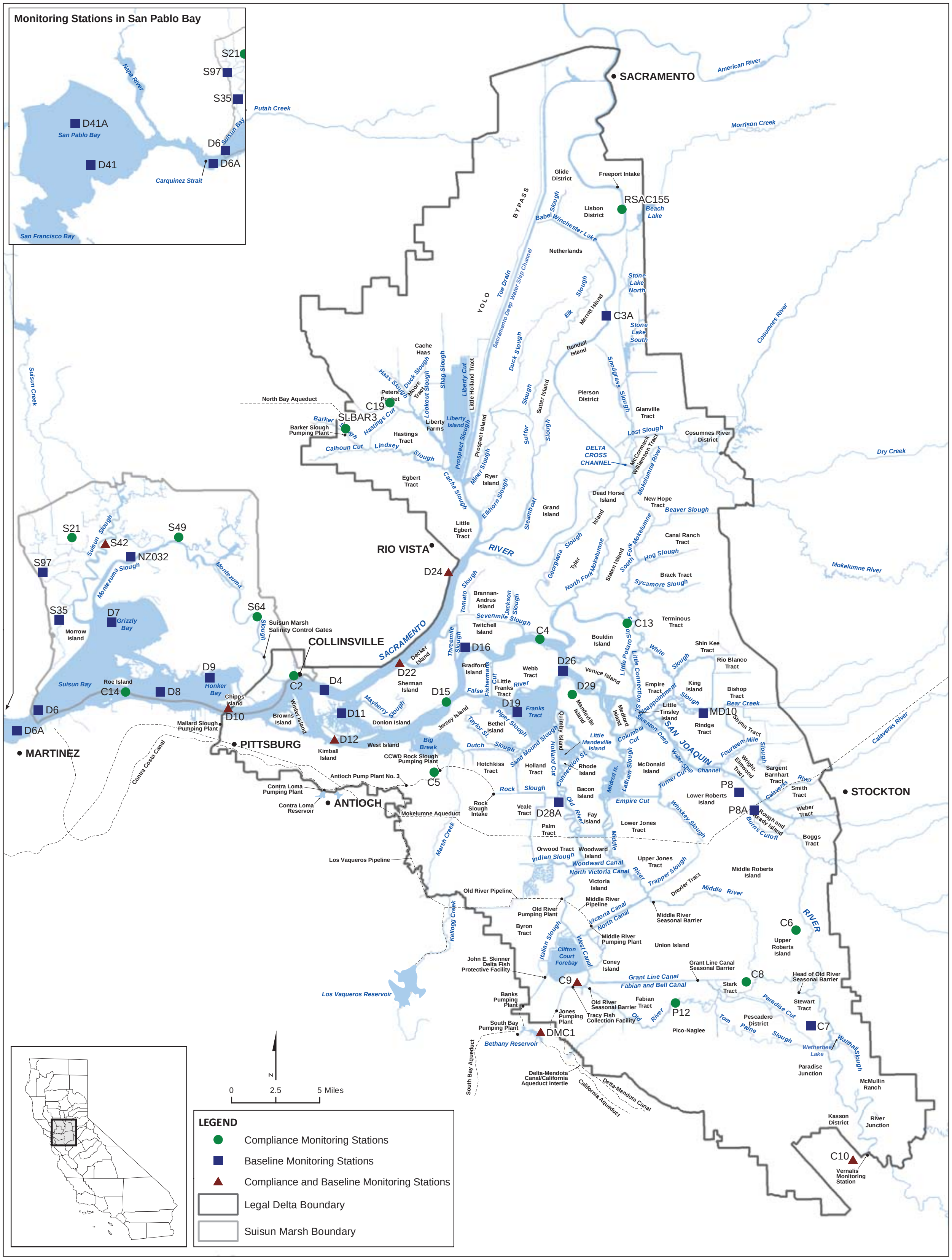

Figure 6.5. Water Quality Compliance Stations in the Delta

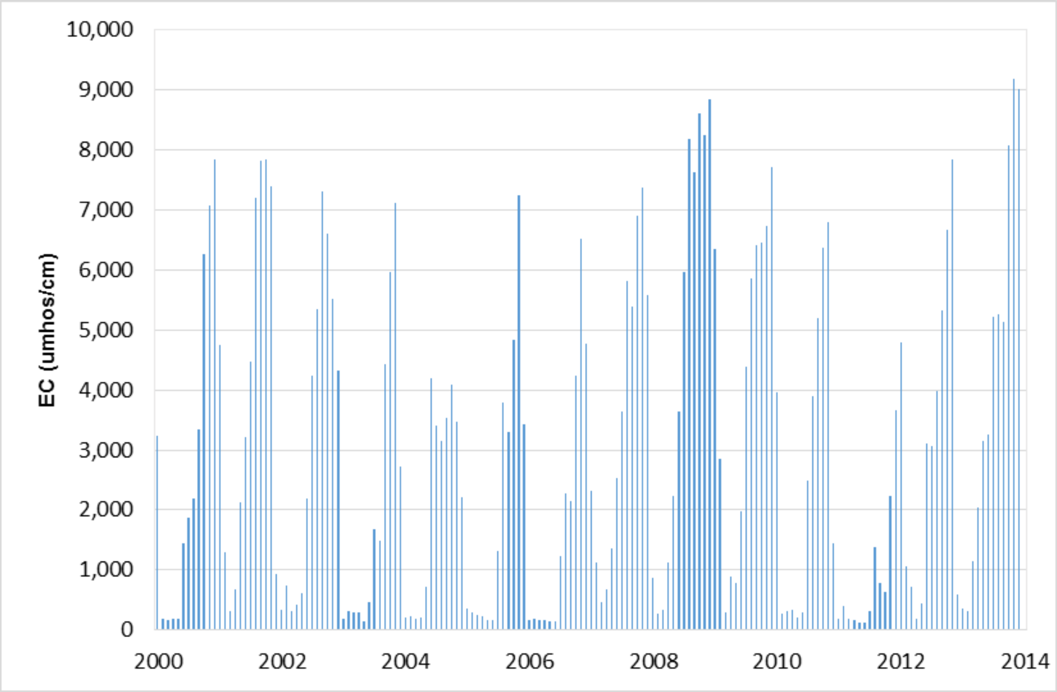

**Figure 6.6 Monthly Average Specific Conductance in Sacramento River at Collinsville (Reclamation 2013e)**

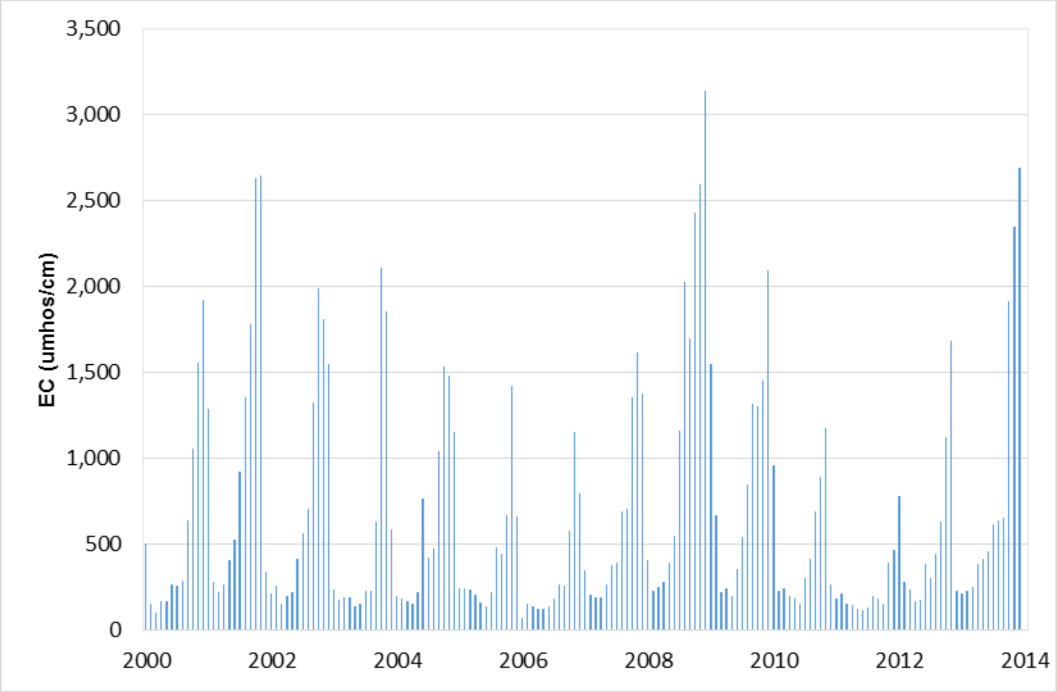

**Figure 6.7 Monthly Average Specific Conductance in Sacramento River at Emmaton (Reclamation 2013e)**

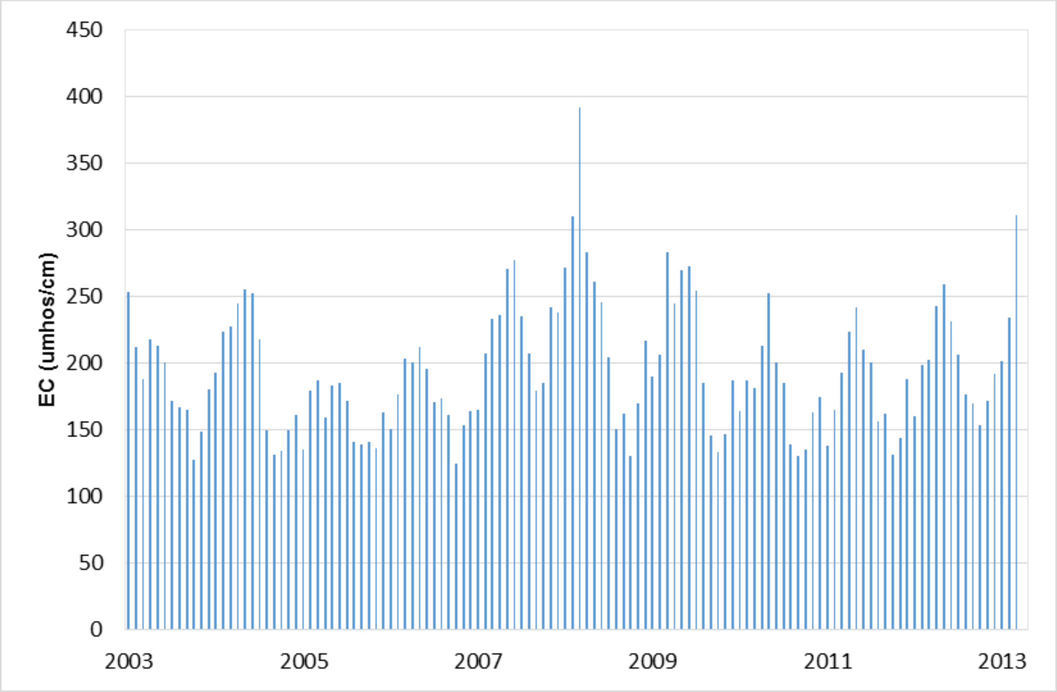

**Figure 6.8 Monthly Average Specific Conductance in Sacramento River at Rio Vista (Reclamation 2013e)**

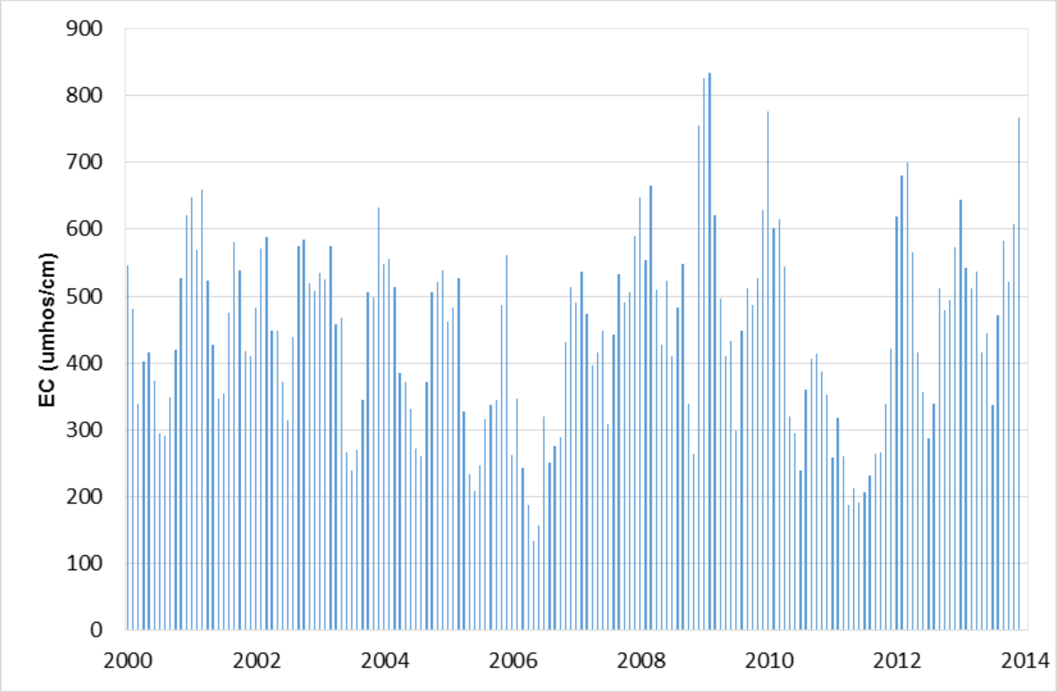

**Figure 6.9 Monthly Average Specific Conductance at Delta Mendota Canal Intake (Reclamation 2013e)**

## Chapter 7

# Groundwater Resources and Groundwater Quality

## 7.1 Introduction

This chapter describes groundwater resources and groundwater quality in the study area, and potential changes that could occur as a result of implementing the alternatives evaluated in this Environmental Impact Statement (EIS). Implementation of the alternatives could affect groundwater resources through potential changes in operation of the Central Valley Project (CVP) and State Water Project (SWP) and ecosystem restoration.

## 7.2 Regulatory Environment and Compliance Requirements

Potential actions that could be implemented under the alternatives evaluated in this EIS could affect groundwater resources in the areas along the rivers impacted by changes in the operations of CVP or SWP reservoirs and in the vicinity of and lands served by CVP and SWP water supplies. Groundwater basins that may be affected by implementation of the alternatives are in the Trinity River Region, Central Valley Region, San Francisco Bay Area Region, Central Coast Region, and Southern California Region.

Actions located on public agency lands or implemented, funded, or approved by Federal and state agencies would need to be compliant with appropriate Federal and state agency policies and regulations, as summarized in Chapter 4, Approach to Environmental Analyses.

Several of the state policies and regulations described in Chapter 4 have resulted in specific institutional and operational conditions in California groundwater basins, including the basin adjudication process, California Statewide Groundwater Elevation Monitoring Program (CASGEM), California Sustainable Groundwater Management Act (SGMA), and local groundwater management ordinances, as summarized below.

### 7.2.1 Groundwater Basin Adjudication

Basin adjudications are determined through court decisions or pre-court mediation on litigation that determines the groundwater rights of all the groundwater users overlying the basins. The court identifies the extractors or well owners and the amount of groundwater those well owners are allowed to extract, and appoints a Watermaster whose role is to ensure that the basin is managed in accordance with the court's decree. The Watermaster must report periodically to the court. There are currently 23 adjudicated groundwater basins in California, most of which are located in Southern California. Table 7.1 lists the adjudicated groundwater basins located in the study area.

**Table 7.1 Adjudicated Groundwater Basins in the Study Area**

| Basin Name | Date of Final Court Decision | County |
|---|---|---|
| Antelope Valley Groundwater Basin | Under way | Kern and Los Angeles |
| Beaumont – Upper Santa Ana Groundwater Basin | 2004 | Riverside |
| Brite Groundwater Basin | 1970 | Kern |
| Central Subbasin of the Coastal Plain of Los Angeles Basin | 1965 | Los Angeles |
| Chino Subbasin of the Upper Santa Ana Valley Basin | 1978 | Riverside and San Bernardino |
| Cucamonga Subbasin of the Upper Santa Ana Valley Basin | 1978 | San Bernardino |
| Cummings Valley Groundwater Basin | 1972 | Kern |
| Goleta Groundwater Basin | 1989 | Santa Barbara |
| San Jacinto Groundwater Basin | 2013 | Riverside |
| Los Osos Valley Groundwater Basin | Under way | San Luis Obispo |
| Mojave Basin Area (Lower Mojave River Valley, Middle Mojave River Valley, Upper Mojave River Valley, El Mirage Valley, and Lucerne Valley groundwater basins) | 1996 | San Bernardino |
| San Gabriel Valley Groundwater Basin – excluding Raymond Groundwater Basin | 1973 | Los Angeles |
| San Gabriel Valley Groundwater Basin – Puente Narrows | 1985 | Los Angeles |
| Raymond Groundwater Basin | 1944 | Los Angeles |
| Rialto-Colton Subbasin of the Upper Santa Ana Valley Basin | 1961 | San Bernardino |
| Santa Margarita River Watershed – Santa Margarita Valley, Temecula Valley, and Cahuilla Valley groundwater basins | 1966* | Riverside and San Diego |
| Santa Maria Valley Groundwater Basin | 2008 | San Luis Obispo and Santa Barbara |
| Santa Paula Subbasin of the Santa Clara River Valley Groundwater Basin | 1996 | Ventura |
| Six Basins Area in upper Santa Ana Valley | 1998 | Los Angeles and San Bernardino |
| Tehachapi Valley West Basin and Tehachapi Valley East Basin | 1973 | Kern |

| Basin Name | Date of Final Court Decision | County |
|---|---|---|
| Upper Los Angeles River Area–<br>San Fernando Valley Groundwater Basin | 1979 | Los Angeles |
| Warren Valley Groundwater Basin | 1977 | San Bernardino |
| West Coast Subbasin of the Coastal Plain of Los Angeles Basin | 1961 | Los Angeles |
| Western San Bernardino – Upper Santa Ana Groundwater Basin | 1969 | San Bernardino |

Sources: DWR 2003a, 2014a; LOCSD 2013

Note:

* Santa Margarita Watershed Adjudication addresses both groundwater and surface water if water contributes to Santa Margarita River and its tributaries flows (SMRW 2014). The agreements include interlocutory judgements for Murrieta-Temecula Groundwater Basin that describes non-Indian water rights subject to court jurisdiction, land and water rights not subject to court jurisdiction, reserved water rights for the Pechanga Reservation, and appropriative storage and diversion rights in conjunction with use of groundwater by the Vail Company.

### 7.2.2 California Statewide Groundwater Elevation Monitoring Program

Senate Bill X7-6, enacted in November 2009, mandates a statewide groundwater elevation monitoring program to track seasonal and long-term trends in groundwater elevations in California's groundwater basins defined in Bulletin 118. This amendment to Division 6 of the Water Code, specifically Part 2.11 Groundwater Monitoring, requires the collaboration between local monitoring entities and California Department of Water Resources (DWR) to collect groundwater elevation data. The law requires local agencies to monitor and report the groundwater elevation in the basins. To achieve this goal, DWR developed the CASGEM Program to establish a permanent, locally-managed program of regular and systematic monitoring in all of the state's alluvial groundwater basins.

DWR is required to establish a priority schedule for monitoring groundwater basins, and to report to the Legislature on the findings from these investigations (Water Code section 10920 et. seq). The 2012 CASGEM Status Report to the Legislature describes that more than 400 monitoring entities have been identified and water level data are being submitted to DWR (DWR 2012). The prioritization of basins is to identify, evaluate, and determine the need for additional groundwater level monitoring. The prioritization approach includes the following eight criteria.

- Overlying population in the groundwater basin
- Projected growth of the overlying population
- Number of public water supply wells

- Total number of water supply wells
- Irrigated acreage overlying the groundwater basin
- Reliance on groundwater as the primary source of water by the overlying land uses
- Impacts on groundwater, including overdraft, subsidence, saline intrusion, and other water quality degradation
- Any other information relevant to the groundwater conditions

Groundwater basins designations in the study area are described for each basin in the following subsection of this chapter (DWR 2014e).

### 7.2.3 Sustainable Groundwater Management Act

In September 2014, the SGMA was enacted. The SGMA establishes a new structure for locally managing California's groundwater in addition to existing groundwater management provisions established by Assembly Bill (AB) 3030 (1992), Senate Bill (SB) 1938 (2002), and AB 359 (2011), as well as SBX7-6 (2009).

The SGMA includes the following key elements:

- Provides for the establishment of a Groundwater Sustainability Agency (GSA) by one or more local agencies overlying a designated groundwater basin or subbasin identified in DWR Bulletin 118-03
- Requires all DWR Bulletin 118 groundwater basins found to be of "high" or "medium" priorities to prepare Groundwater Sustainability Plans (GSPs)
- Provides for the proposed revisions, by local agencies, to the boundaries of a DWR Bulletin 118 basin, including the establishment of new subbasins
- Provides authority for DWR to adopt regulations to evaluate GSPs, and review the GSPs for compliance every 5 years
- Requires DWR to establish best management practices and technical measures for GSAs to develop and implement GSPs
- Provides regulatory authority to the State Water Resources Control Board (SWRCB) for developing and implementing interim groundwater management plans under certain circumstances (such as lack of compliance with development of GSPs by GSAs)

The SGMA defines sustainable groundwater management as "the management and use of groundwater in a manner that can be maintained during the planning and implementation horizon without causing undesirable results." Undesirable results are defined as any of the following effects.

- Chronic lowering of groundwater levels (not including overdraft during a drought if a basin is otherwise managed)
- Significant and unreasonable reduction of groundwater storage

- Significant and unreasonable seawater intrusion
- Significant and unreasonable degraded water quality, including the migration of contaminant plumes that impair water supplies
- Significant and unreasonable land subsidence that substantially interferes with surface land uses
- Depletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of the surface water

Based on basin priority definitions defined by DWR's CASGEM program in June 2014 and confirmed in January 2015, the SGMA requires the formation of GSPs by 2020 or 2022. GSPs for medium and high priority basins identified subject to critical conditions of overdraft are required by 2022. All other high and medium priority basins must complete a GSP by 2020. Updates to CASGEM-defined June 2014 designated priorities are possible and can affect GSP deadline requirements. Sustainable groundwater operations must be achieved within 20 years following completion of the GSPs.

### 7.2.4 Regional and Local Groundwater Ordinances

Many counties within the study area considered in this EIS have adopted or are considering groundwater ordinances. The ordinances primarily address well installation, groundwater extraction, and export of the groundwater to areas outside the basin of origin. Local county groundwater ordinances vary by authority, agency, or region but typically involve permitting for well installation, and provisions to limit or prevent groundwater overdraft, to regulate transfers, and to protect groundwater quality.

Table 7.2 provides a list of substantial county groundwater ordinances within the study area that could affect groundwater supply availability.

**Table 7.2 County Groundwater Ordinances in the Study Area with a Summary of Regulations**

| County | Ordinance Number and Title | Description |
|---|---|---|
| Trinity | County Code Title 15: Buildings and Construction, Chapter 15.20: Water wells. | Well standards. |
| Trinity and Humboldt | Hoopa Valley Tribal Council Title 37: Pollution Discharge Prohibition Ordinance | Regulates surface water and groundwater operations. |
| Humboldt | County Code Title VI: Water and Sewage, Division 3: Wells. | Well standards. |
| | Hoopa Valley Tribe: Not identified at this time. | Not applicable. |
| Del Norte | County Code Title 7: Health and Welfare Chapter 32: Regulations of Wells and Preservation of Groundwater. | Well standards. |

| County | Ordinance Number and Title | Description |
|---|---|---|
| Shasta | County Code Title 18: Environment<br>18.08: Groundwater Management. | Requires permit for groundwater extraction for use outside county. |
| Shasta | County Code Title 8: Health and Safety, 8.56: Water Wells. | Well standards. |
| Plumas | County Code Title 6: Sanitation and Health, Chapter 8: Water Wells. | Well standards.<br>Groundwater management plans have been adopted in Plumas County, but not in the vicinity of the study area. |
| Tehama | County Code Title 9: Health and Safety, Chapter 9.40: Aquifer Protection. | Prohibits groundwater from being exported out of county.<br>Requires permit to use groundwater from wells on a parcel on other parcels of land. |
| Tehama | County Code Title 9: Health and Safety, Chapter 9.42: Well Construction, Rehabilitation, Repair and Destruction. | Well standards. |
| Glenn | County Code Title 20: Water<br>20.030: Groundwater Coordinated Resource Management Plan. | Basin Management Objectives and monitoring network to detect changes in groundwater level, quality, land subsidence; and defines acceptable ranges of groundwater levels. |
| | County Code Title 20: Water, 20.080: Water Well Drilling Permits and Standards. | Well standards. |
| Colusa | County Code Chapter 43: Groundwater Management. | Requires permit for groundwater extraction for use outside county. |
| | County Code Chapter 35: Well Standards. | Well standards. |
| Butte | County Code Chapter 33A: Basin Management. | Basin Management Objectives for: groundwater quality and groundwater levels, and other protections to reduce land subsidence. |
| | County Code Chapter 23B: Water Wells. | Well standards. |
| Yuba | County Code Title VII: Health and Sanitation, Chapter 7.03: Water wells. | Well standards. |

| County | Ordinance Number and Title | Description |
|---|---|---|
| Sutter | County Code Section 700: Health and Sanitation, Chapter 765: Water Wells. | Well standards. |
| Placer | County Code Chapter 13: Public Services, Article 13.08: Water Wells. | Well standards. |
| El Dorado | County Code Title 8: Health and Safety, Chapter 8.39: Well Standards. | Well standards.<br>Groundwater management plans have been adopted in El Dorado County, but not in the vicinity of the study area. |
| Sacramento | County Code Title 6: Health and Sanitation, Chapter 6.28: Wells and Pumps. | Well standards. |
| Yolo | County Code Title 10: Environment Chapter 7: Groundwater. | Requires permit for groundwater extraction for use outside of the county. |
| | County Code Title 6: Sanitation and Health, Chapter 8: Water Quality, Article 10: Standards, Criteria, and Regulations of Wells. | Well standards. |
| Solano | County Code Chapter 13.6: Injection Wells. | Restricts operation of injection wells. |
| | County Code Chapter 13.10: Well Standards. | Well standards. |
| Napa | County Code Title 13: Waters, Sewers, and Public Services<br>Chapter 13.15: Groundwater Conservation. | Regulates the use of groundwater. |
| | County Code Title 13: Waters, Sewers, and Public Services<br>Chapter 13.12: Wells. | Well standards. |
| San Joaquin | County Code Title 5: Health and Sanitation, Division 4: Wells and Well Drilling. | Well standards. |
| | County Code Title 5: Health and Sanitation, Division 8: Groundwater. | Requires permit for groundwater use outside of the county. |
| Stanislaus | County Code Title 9: Health and Safety, Chapter 9.37: Groundwater Mining and Export Prevention. | Regulates groundwater use and prohibits export of water outside of the county (except as noted in the requirements). |
| | County Code Title 9: Health and Safety, Chapter 9.36: Water Wells. | Well standards. |

| County | Ordinance Number and Title | Description |
|---|---|---|
| Madera | County Code Title 13: Waters and Sewers, V Groundwater Exportation, Groundwater Banking, and Importation of Foreign Water, for Purposes of Groundwater Banking, to Areas of Madera County which are Outside of Local Water Agencies that Deliver Water to Lands Within their Boundaries.<br>Chapter 13.1: Rules and Regulations Pertaining to Groundwater Banking—Importation of Foreign Water, for the Purpose of Groundwater Banking, to Areas of Madera County which are Outside of Local Water Agencies that Deliver Water to Lands within their Boundaries—Exportation of Groundwater Outside the County. | Regulates development of groundwater banking, including importation of groundwater to be stored in the groundwater bank, and exportation of groundwater for use outside of the county; and prohibits groundwater injection. |
| | County Code Title 13: Waters and Sewers, I: Water, Chapter 13.52: Well Standards. | Well standards. |
| Merced | County Code Title 9: General Health and Safety, Chapter 9.28: Wells. | Well standards. |
| Fresno | County Code Title 14: Waters and Sewers, Chapter 14.03: Groundwater Management. | Regulates groundwater use outside of the county. |
| | County Code Title 14: Waters and Sewers, Chapter 14.04: Well Regulations – General Provisions. | Well standards. |
| | County Code Title 14: Waters and Sewers Chapter 14.08: Well Construction, Pump Installation and Well Destruction Standards. | Well standards. |
| Tulare | County Code Part IV: Health, Safety, and Sanitation, Chapter 13: Well. | Well standards. |
| Kings | County Code Chapter 14A: Water Wells. | Well standards. |
| Kern | County Code Title 14: Utilities Chapter 14.08: Water Supply Systems, Article III: Well Standards. | Well standards. |
| Contra Costa | County Code Title 4: Health and Safety, Chapter 414: Waterways and Water Supply, Chapter 414-4: Water supply. | Well standards. |
| Alameda | County Code Title 6: Health and Safety, Chapter 6.88: Water Wells. | Well standards. |

| County | Ordinance Number and Title | Description |
|---|---|---|
| Santa Clara | Santa Clara Valley Water District Act (California Water Code Appendix, Chapter 60). | Santa Clara Valley Water District is the designated agency to manage water within Santa Clara County, including groundwater management to recharge the basin, conserve water, increase water supply, and prevent waste or diminution of the water supply. |
| | Santa Clara Valley Water District Well Ordinance 90-1. | Well standards. |
| San Benito | County Code Title 15: Public Works, Chapter 5.05: Water, Article I: Groundwater Aquifer Protections. | Regulates use of groundwater on non-contiguous parcels with separate owners than parcel with well, injection of groundwater, and operations that could adversely affect other groundwater users or the groundwater aquifer. |
| | County Code Title 15: Public Works, Chapter 5.05: Water, Article III: Well Standards. | Well standards. |
| San Luis Obispo | County Code Title 8: Health and Sanitation, Chapter 8.40: Construction, Repair, Modification and Destruction of Wells. | Well standards. |
| Santa Barbara | County Code Chapter 34A: Wells. | Well standards. |
| Ventura | County Code Division 4: Public Health, Chapter 8: Water, Article 1: Groundwater Conservation. | Well standards. |
| Los Angeles | County Code Title 11: Health and Safety, Chapter: 11.38 Water and Sewers, Part 2: Water and Water Wells. | Well standards. |
| Orange | County Code Title 4: Health and Sanitation and Animal Regulations, Division 5: Water Conservation, Article 3 Construction and Abandonment of Water Wells. | Well standards. |

| County | Ordinance Number and Title | Description |
|---|---|---|
| San Diego | County Code Title 6: Health and Sanitation, Division 7: Water and Water Supplies, Chapter 4: Wells. | Well standards. |
| | County Code Title 6: Health and Sanitation, Division 7: Water and Water Supplies, Chapter 7: Groundwater. | Regulates actions for the protection, preservation, and maintenance of groundwater resources. |
| Riverside | County Code Title 13: Public Services, Chapter 13.20: Water Wells. | Well standards. |
| San Bernardino | County Code Title 3: Health and Sanitation, Division 3: Environmental Health, Chapter 6: Domestic Water Sources and Systems, Article 3: Water Wells. | Well standards. |
| | County Code Title 3: Health and Sanitation, Division 3: Environmental Health, Chapter 6: Domestic Water Sources and Systems, Article 5: Desert Groundwater Management. | Regulates groundwater basins not adjudicated by judicial decree; and wells not within the boundaries of the Mojave Water Agency and public water agencies within the Morongo Basin, incorporated areas, or Federal lands. This section does not apply to wells used for existing mining operations, small agricultural operations, small wells, or replacement wells of similar size to abandoned wells. This section does not apply to areas with a groundwater management plan and a memorandum of understanding with the county. |

Sources: Trinity County 2014; Hoopa Valley Tribe 2008; Humboldt County 2014; Del Norte County 2014; Shasta County 2014 a, b; Plumas County 2014; Tehama County 2014; Glenn County 2014; Colusa County 2014 a, b; Butte County 2014 a, b; Yuba County 2014; Sutter County 2014; Placer County 2014; El Dorado County 2014; Sacramento County 2014; Yolo County 2014; Solano County 2014; Napa County 2014; San Joaquin County 2014; Stanislaus County 2014; Madera County 2014; Merced County 2014; Fresno County 2014; Tulare County 2014; Kings County 2014; Kern County 2014; Contra Costa County 2014; Alameda County 2014; SCVWD 2014 a, b; San Benito County 2014; San Luis Obispo County 2014a; Santa Barbara County 2014; Ventura County 2014; Los Angeles County 2014a; Orange County 2014; San Diego County 2014; Riverside County 2014; San Bernardino County 2014

# 7.3 Affected Environment

This section describes groundwater resources that could be potentially affected by the implementation of the alternatives considered in this EIS. Changes in groundwater resources due to changes in CVP and SWP operations may occur in the Trinity River, Central Valley, San Francisco Bay Area, Central Coast, and Southern California regions.

Groundwater occurs throughout the study area. However, the groundwater resources that could be directly or indirectly affected through implementation of the alternatives analyzed in this EIS are related to groundwater basins which include users of CVP and SWP water supplies that also use groundwater, and areas along the rivers downstream of CVP or SWP reservoirs that use groundwater supplies. Therefore, the following description of the affected environment is limited to these areas and does not include groundwater basins or subbasins that area not directly or indirectly affected by changes in CVP and SWP operations.

## 7.3.1 Overview of California Groundwater Resources

As described in Chapter 5, Surface Water Resources and Water Supplies, groundwater is a vital resource in California. Groundwater supplied about 37 percent of the state's average agricultural, municipal, and industrial water needs between 1998 and 2010, and 40 percent or more during dry and critical water years in that period (DWR 2013i). About 20 percent of the nation's groundwater demand is supplied from the Central Valley aquifers, making it the second-most-pumped aquifer system in the United States (USGS 2009). The three Central Valley hydrologic regions (Tulare Lake, San Joaquin River, and Sacramento River) account for about 75 percent of the state's average annual groundwater use (DWR 2013i).

The DWR has delineated 515 distinct groundwater systems throughout the state, as described in Bulletin 118-03 (DWR 2003a), that are considered to be the most important groundwater basins. These basins and subbasins have various degrees of supply reliability considering yield, storage capacity, and water quality, and are typically alluvial, or non-consolidated (non-fractured rock) aquifers. Figure 7.1 shows the statewide occurrence of groundwater in the groundwater basins and subbasins identified by DWR as Bulletin 118 basins. A majority of the descriptions provided herein are summarized form DWR Bulletin 118 reports.

The importance of groundwater as a resource varies regionally. The Central Coast has the most reliance on groundwater to meet its local uses, with more than 80 percent of the agricultural, municipal, and industrial water supplies by groundwater in an average year. The central and southern San Joaquin Valley (described as the Tulare Lake Area of the San Joaquin Valley Groundwater Basin in this chapter) groundwater use, on average, meets about 50 percent of the total water supplies. The Sacramento Valley and northern portion of the San Joaquin Valley Groundwater Basin use groundwater to meet approximately 30 and 40 percent of the agricultural, municipal, and industrial water demand, respectively. In the coastal areas of Southern California, groundwater use varies from less than 10 percent in western San Diego County to between 35 and 50 percent of the agricultural, municipal, and industrial water supplies in counties along the coast western Ventura, Los Angeles, and Riverside counties and Orange County, on an annual average basis. In the inland areas of Southern California, groundwater use varies from approximately 45 to over 90 percent of the agricultural, municipal, and industrial water supplies (DWR 2013).

A comprehensive assessment of overdraft in all of the state's groundwater basins has not been conducted since Bulletin 118-80 was published in 1980, but overdraft is estimated at between 1 to 2 million acre-feet annually (DWR 2003a). In DWR's Bulletin 118-80 (DWR 1980), an assessment of critically overdrafted basins was conducted, as shown in Figure 7.2. This assessment identified 11 basins in critical condition of overdraft. Based on SGMA requirements, the state must identify basins subject to critical conditions of overdraft in 2015, publish the final list in 2016, and use this list in the Bulletin 118 Interim Update 2017. This revised list is being finalized at the same time as this EIS document is finalized. This revised draft list added three basins in the EIS study area that are considered in critical conditions of overdraft (DWR 2015):

- Merced (5-22.04): Subsidence in El Nido area of 0.6 to 1.0 ft/year
- Delta-Mendota ((5-22.07): Significant, on-going and irreversible subsidence
- Westside (5-22.09): Significant, on-going and irreversible subsidence

In the past 20 years, specific groundwater studies have been conducted by regional water agencies or the U.S. Geological Survey (USGS) to update the statewide survey conducted by DWR in 1980 (USGS 2000a, 2006, 2008, 2009, 2012, 2014). The results of many of those studies are discussed in the following subsections of this chapter.

### 7.3.2 Trinity River Region

The Trinity River Region includes the area along the Trinity River from Trinity Lake to the confluence with the Klamath River; and along the Klamath River from the confluence with the Trinity River to the Pacific Ocean.

Most usable groundwater in the Trinity River Region occurs in widely scattered alluvium filled valleys, such as those immediately adjacent to the Trinity River. These valleys contain only small quantities of recoverable groundwater, and, therefore, are not considered a major source. A number of shallow wells adjacent to the river provide water for domestic purposes (Reclamation et al. 2006a; NCRWQCB et al. 2009). Groundwater present in these alluvial valleys is in close hydraulic connection with the Trinity River and its tributaries. Both groundwater discharge to surface streams as well as leakage of steam flow to underlying aquifers are expected to occur at various locations.

The Bulletin 118-03 (DWR 2003a, 2004do, 2004dp) identified only two groundwater basins underlying the Trinity River Region in the Study Area, Hoopa

Valley and Lower Klamath River Valley groundwater basins, as shown in Figure 7.3. These groundwater basins are small, isolated, valley-fill aquifers that provide a very limited quantity of groundwater to satisfy local domestic, municipal, and agricultural needs. Groundwater pumped from these aquifer systems is used strictly for local supply.

As described in Chapter 5, Surface Water Resources and Water Supplies, several communities use infiltration galleries along the Trinity River and the tributaries to convey surface water to groundwater wells, including the Lewiston Community Services District, Lewiston Valley Water Company, and Lewiston Park Mutual Water Company (NCRWQCB et al. 2009).

Groundwater within the Hoopa Valley Indian Reservation occurs along alluvial terraces (Hoopa Valley Tribe 2008). The aquifers are approximately 10 to 80 feet deep. Some of the shallow wells are productive only during winter and early spring months.

The Lower Klamath River Valley Groundwater Basin extends over 7,030 acres in Del Norte and Humboldt counties, including areas along the Lower Klamath River (Reclamation 2010a). Groundwater along the Lower Klamath River occurs in alluvial fans near the confluences of major tributaries and along terrace and floodplain deposits adjacent to the river (Yurok Tribe 2012). The aquifers range in depth from 10 to 80 feet and are used by some members of the community.

The Hoopa Valley and Lower Klamath River Valley groundwater basins were designated by the CASGEM program as very low and low priorities, respectively.

Groundwater quality is suitable for many beneficial uses in the region. In other locations, the groundwater can include naturally occurring metals, including manganese, cadmium, zinc, and barium (Hoopa Valley Tribe 2008). Other groundwater quality issues include nitrate contamination (DWR 2013i). Groundwater and surface water contamination is suspected at several former and existing mill sites that historically used wood treatment chemicals. Discharges of pentachlorophenol, polychlorodibenzodioxins, and polychlorodibenzofurans have likely occurred due to the poor containment practices typically used in historical wood treatment applications. Additional investigation, sampling and monitoring, and enforcement actions have been limited by the insufficient resources that exist to address this historical toxic chemical problem (NCRWQCB 2005).

### 7.3.3 Central Valley Region

The Central Valley Region extends from above Shasta Lake to the Tehachapi Mountains, and includes the Sacramento Valley, San Joaquin Valley, Delta, and Suisun Marsh.

Groundwater for the Central Valley Region is described in relation to the basins described by DWR in Bulletin 118-03 (DWR 2003a). The overall area includes the Sacramento Valley Basin which extends through the Sacramento Valley, and the San Joaquin Valley Groundwater Basin (including the Tulare Lake Area, which extends through the San Joaquin Valley). The Delta and Suisun Marsh area are located partially in the Sacramento Valley Basin and partially in the

San Joaquin Valley Groundwater Basin. The Delta and Suisun Marsh area is described separately because of its distinct characteristics as an estuary at the confluence of the Sacramento and the San Joaquin rivers.

### *7.3.3.1 Sacramento Valley*

The Sacramento Valley includes the Redding Groundwater Basin and the Sacramento Valley Groundwater Basin. The Sacramento Valley Groundwater Basin is one of the largest groundwater basins in the state, and extends from Redding in the north to the Delta in the south (USGS 2009).

Approximately one-third of the Sacramento Valley's urban and agricultural water needs are met by groundwater (DWR 2003a). The portion of the water diverted for irrigation but not actually consumed by crops or other vegetation becomes recharge to the groundwater aquifer or flows back to surface waterways.

Overall, the Sacramento Groundwater Basin is approximately balanced with respect to annual recharge and pumping demand. However, there are several locations showing early signs of persistent drawdown, suggesting limitations due to increased groundwater use in dry years. Locations of persistent drawdown include: Glenn County, areas near Chico in Butte County, northern Sacramento County, and portions of Yolo County.

The water quality of groundwater in the Sacramento Valley is generally good, as described below for individual basins. Several areas have localized aquifers with high nitrate, total dissolved solids (TDS) or boron concentrations. High nitrate concentrations frequently occur due to residuals from agricultural operations or septic systems. High TDS, a measure of salinity, concentration can be an indicator of brackish or connate water when it occurs in high concentrations. High boron concentration usually is associated with naturally occurring deposits.

#### 7.3.3.1.1 Overview of Groundwater Basins in the Sacramento Valley

The Sacramento Valley includes the Redding Groundwater Basin and the Sacramento Valley Groundwater Basin. The Redding Groundwater Basin is situated in the extreme northern end of the valley and is a separate, isolated groundwater basin, but due to similarities in geology and stratigraphy is discussed as part of the overall Sacramento Valley. It is bordered by the Coast Ranges on the west, and by the Cascade Range and Sierra Nevada mountains on the east.

The Sacramento Valley Groundwater Basin has been divided into 17 subbasins by DWR, as shown in Figure 7.4, based on groundwater characteristics, surface water features, and political boundaries (DWR 2003a). However, from a hydrologic standpoint, these individual groundwater subbasins have a high degree of hydraulic connection because the rivers do not always act as barriers to groundwater flow. Therefore, the Sacramento Valley Groundwater Basin functions primarily as a single laterally extensive alluvial aquifer, rather than numerous discrete, smaller groundwater subbasins.

For discussion purposes, and due to their common characteristics, the Sacramento Valley is further sub-divided into the Upper Sacramento Valley, the Lower

Sacramento Valley West of the Sacramento River, and the Lower Sacramento Valley East of the Sacramento River.

### *General Hydrogeology of the Sacramento Valley*

Freshwater in the Sacramento Valley Groundwater Basin occurs within the continental deposits. Hydrogeologic units containing freshwater along the eastern portion of the basin, primarily occur in the Tuscan and Mehrten formations, and are derived from the Sierra Nevada. Toward the southeastern portion of the Sacramento Valley, the Mehrten formation is overlain by sediments of the Laguna, Riverbank, and Modesto formations, which also originated in the Sierra Nevada. The primary hydrogeologic unit in the western portion of the Sacramento Valley is the Tehama formation, which was derived from the Coast Ranges. In most of the Sacramento Valley, these deeper units are overlain by younger alluvial and floodplain deposits. Generally, groundwater flows inward from the edges of the basin toward the Sacramento River, then in a southerly direction parallel to the river. Depth to groundwater throughout most of the Sacramento Valley averages about 30 feet below the ground surface, with shallower depths along the Sacramento River and greater depths along the basin margins. Wells developed in the sediments of the valley provide excellent supply to irrigation, municipal, and domestic uses. The deepest elevation of the base of freshwater in the Sacramento Valley ranges between 400 feet and 3,350 feet below mean sea level (Berkstresser 1973). The location where the base of freshwater is the deepest occurs in the Delta near Rio Vista. Near the valley margins and the Sutter Buttes, the base of freshwater is relatively shallow; suggesting that the base of freshwater may coincide with bedrock or connate water trapped in shallower deposits close to the basin margins (Berkstresser 1973).

Today, groundwater levels are generally in balance valley-wide, with pumping matched by recharge from the various sources annually. Some locales show the early signs of persistent drawdown, especially in areas where water demands are met primarily, and in some locales exclusively, by groundwater. These areas include portions of the far west side of the Sacramento Valley in Glenn County, portions of Butte County near Chico, in portions of Yolo County, and in the northern Sacramento County area. The persistent areas of drawdown could be early signs that the limits of sustainable groundwater use have been reached in these areas. Due to the drought that started in 2011, surface water supplies have declined and new wells have been installed. Between January and October 2014, over 100 water supply wells were drilled in both Shasta and Butte counties (DWR 2014d).

Land subsidence in the Sacramento Valley has resulted from inelastic deformation (non-recoverable changes) of fine-grained sediments related to groundwater withdrawal. Areas of subsidence from groundwater level declines have been measured in the Sacramento Valley at several locations. Subsidence monitoring was established following several studies in the 1990s that indicated more than four feet of subsidence since 1954 in some areas, such as in Yolo County (Ikehara 1994). Initial data from the Yolo County extensometers indicated subsidence in the Zamora area, which has subsequently been confirmed with a countywide global positioning system network installed in 1999 and monitored in 2002 and 2005. Subsidence up to 0.4 feet occurred between 1999 and 2005 in the Zamora area (Frame Surveying and Mapping 2006). The Zamora area does not currently use CVP or SWP water supplies. However, this area was designated as part of the CVP Sacramento Valley Irrigation Canals service area in the Reclamation Act of 1950 and as amended in the Reclamation Act of 1980 and Central Valley Project Improvement Act.

#### 7.3.3.1.2 Upper Sacramento Valley

The Upper Sacramento Valley includes the Redding Groundwater Basin and upper portions of the Sacramento Valley Groundwater Basin (DWR 2003a). The Redding Groundwater Basin extends from approximately Redding in Shasta County through the northern portions of Tehama County. The portions of the Sacramento Valley Groundwater Basin in the Upper Sacramento Valley are located primarily in Tehama County with small portions extending into Glenn County near Orland and Butte County near Chico in the south. The geology of this area is dominated by the Tuscan and Tehama Formations. The hydrology of this area is dominated by numerous smaller drainages that originate in the Sierra Nevada, Cascade, and Coast Ranges and drain to the Sacramento River (DWR 2003a).

*Hydrogeology and Groundwater Conditions*

The Redding Groundwater Basin comprises the northernmost part of the Sacramento Valley and is bordered by the Klamath Mountains to the north, the Coast Ranges to the west, the Cascade Mountains to the east, and the Red Bluff Arch to the south. This basin consists of a sediment-filled, symmetrical, southward-dipping trough formed by folding of the marine sedimentary basement rock. These deposits are overlain by a thick sequence of inter-bedded, continentally-derived, sedimentary, and volcanic deposits of Late Tertiary and Quaternary age. The primary fresh water-bearing deposits in the basin are the Pliocene age volcanic deposits of the Tuscan Formation and the Pliocene age continental deposits of the Tehama Formation (DWR 2003a, 2003b, 2004a, 2004b, 2004c, 2004d, 2004e, 2004f).

The Tehama Formation consists of unconsolidated to moderately consolidated coarse and fine-grained sediments derived from the Coast Ranges to the west. The Tehama Formation is up to 4,000 feet thick and varies in depth from a few feet to several hundred feet below the land surface, with depth generally increasing to the east towards the Sacramento River (DWR 2003a, 2004a, 2004b, 2004c, 2004d, 2004e, 2004f). The Tuscan formation is derived from the Cascade Range to the east and is primarily composed of volcaniclastic sediments.

The Redding Groundwater Basin includes six subbasins: Anderson, Rosewood, Bowman, Enterprise, Millville, and South Battle Creek (DWR 2003a, 2004a, 2004b, 2004c, 2004d, 2004e, 2004f). The Anderson subbasin is one of the main groundwater units in the Redding Basin. Groundwater levels in the unconfined and confined portions of the aquifer system fluctuate annually by 2 to 4 feet during normal precipitation years and up to 10 to 16 feet during drought years (DWR 2003b). Between spring 2010 and spring 2014 in the Redding Groundwater Basin, recent information indicates that groundwater levels declined at multiple wells by up to 10 feet. The groundwater levels in some areas declined up to 10 feet between Fall 2013 and Fall 2014 (DWR 2014c, 2014d).

Tehama County overlies three subbasins within the Redding Groundwater Basin and seven subbasins in the Sacramento Valley Groundwater Basin. The Rosewood, South Battle Creek, and Bowman subbasins in the Redding Groundwater Basin are located in Tehama County. The Red Bluff, Corning, Bend, Antelope, Dye Creek, Los Molinos, and Vina subbasins in the Sacramento Valley Groundwater Basin are located in Tehama County (DWR 2004b, 2004c, 2004f, 2004g, 2004h, 2004i, 2004j, 2004k, 2004l, 2006a). The Corning subbasin extends into northern Glenn County near Orland. The Vina subbasin extends into northern Butte County near Chico. Groundwater levels in these subbasins show a significant seasonal variation due to high groundwater use for irrigation during the summer months. Groundwater levels showed significant declines in some wells associated with the 1976 to 1977 and 1987 to 1992 drought periods. Groundwater levels appeared to recover quickly during subsequent wet years. Groundwater levels in the Corning area of Tehama County showed a general decline before 1965 due to increased groundwater pumping for agricultural uses. Following construction by the CVP of the Tehama-Colusa Canal and the Corning Canal, surface water was delivered to these areas and there was a subsequent upward trend in groundwater levels following initial operations (Tehama County Flood Control and Water Conservation District 1996). Between spring 2010 and spring 2014 in the Upper portion of the Sacramento Valley Groundwater Basin, recent information indicates that groundwater levels declined at multiple wells approximately 2.5 feet to 10 feet (DWR 2014c, 2014d). The groundwater levels in some areas declined up to 10 feet between fall 2013 and fall 2014, and in some areas more than 10 feet.

Groundwater quality in the Redding Groundwater Basin is generally good to excellent for most uses. Some areas of poor quality due to high salinity from marine sedimentary rock exist at the margins of the basin. Portions of the basin are characterized by high boron, iron, manganese, and nitrates in localized areas (DWR 2004a, 2004b, 2004c, 2004d, 2004e, 2004f). In general, groundwater in the Sacramento Valley Groundwater Basin within Tehama County is of excellent quality, with some localized areas with groundwater quality concerns related to boron, calcium, chloride, magnesium, nitrate, phosphorous, and TDS (DWR 2004g, 2004h, 2004i, 2004j, 2004k, 2004l, 2006a). In the vicinity of Antelope, east of Red Bluff, historical high nitrates in groundwater occur. Higher boron levels have been detected in wells located in the eastern portion of Tehama County. High salinity occurs near Salt Creek, which most likely originates from the Tuscan Springs, which is a source of high boron and sulfates.

The Vina subbasin was designated by the CASGEM program as high priority. The Anderson, Enterprise, Bowman, Red Bluff, Corning, Antelope, Dye Creek, and Los Molinos subbasins were designated medium priority. The Rosewood, Millville, South Battle Creek, and Bend subbasins were designated very low priority in the June 2014 CASGEM designation.

*Groundwater Use and Management*

Tehama County uses groundwater to meet approximately 65 percent of its total water needs (Tehama County Flood Control and Water Conservation District 2008). Groundwater in the county provides water supply for agricultural, domestic, environmental, and industrial uses.

One of the main users of groundwater in this area is the Anderson-Cottonwood Irrigation District. Approximately 5 percent of the irrigated acres rely upon groundwater (DWR 2003b). Groundwater also is the primary water supply for residences and small scale agricultural operations.

#### 7.3.3.1.3 Lower Sacramento Valley (West of Sacramento River)

The Lower Sacramento Valley area west of the Sacramento River includes three main groundwater subbasins: Colusa, Yolo, and Solano (DWR 2003a, 2004m, 2004n, 2006b).

*Hydrogeology and Groundwater Conditions*

*Colusa Subbasin*

The Colusa subbasin is bordered by the Coast Ranges to the west, Stony Creek to the north, Sacramento River to the east, and Cache Creek to the south. The Colusa subbasin extends primarily in western Glenn and Colusa counties. This subbasin is composed of continental deposits of late Tertiary age, including the Tehama and the Tuscan Formations, to Quaternary age, including alluvial and floodplain deposits as well as Modesto and Riverbank Formations. The Tehama Formation represents the main water bearing formation for the Colusa subbasin (DWR 2003b, 2006b). Groundwater levels are fairly stable in this subbasin, except during droughts, such as in 1976 and 1977 and 1987 to 1992 (DWR 2013a). Groundwater levels in the Colusa subbasin declined in the 2008 drought, and increased during the wetter periods of 2010 and 2011 to the pre-drought 2008 levels (DWR 2014c, 2014d). Historically, groundwater levels fluctuate by approximately 5 feet seasonally during normal and dry years (DWR 2006b, 2013a). Recent information indicates that groundwater levels declined at multiple wells in the Colusa subbasin approximately 10 to 20 feet between spring 2010 and spring 2014 in southwestern Colusa subbasin (DWR 2014c, 2014d). The groundwater levels in some areas declined up to 10 feet between fall 2013 and fall 2014, and in some areas more than 10 feet.

Groundwater quality for the Colusa subbasin is characterized by moderate to high TDS; with localized areas of high nitrate and manganese concentrations near the town of Colusa (DWR 2013a, 2006b). High TDS and boron concentrations have been observed near Knights Landing. High nitrate levels have been observed near Arbuckle, Knights Landing, and Willows.

The Colusa subbasin was designated by the CASGEM program as medium priority.

### *Yolo Subbasin*

The Yolo subbasin lies to the south of the Colusa subbasin primarily within Yolo County. The primary water bearing formations for the Yolo subbasin are the same as those for the Colusa subbasin. Younger alluvium from flood basin deposits and stream channel deposits lie above the saturated zone and tend to provide significant well yields. In general, groundwater levels are stable in this subbasin, except during periods of drought, and in certain localized pumping depressions in the vicinity of Davis, Woodland, and Dunnigan and Zamora areas (DWR 2004m, 2013a). However, between spring 2010 and spring 2014 in the Yolo subbasin, recent information indicates that groundwater levels declined at multiple wells at least 10 feet and in some areas up to 20 feet (DWR 2014c, 2014d). The groundwater levels in some areas declined up to 10 feet between fall 2013 and fall 2014, and in some areas more than 10 feet.

Groundwater quality is generally good for beneficial uses except for localized impairments including elevated concentrations of boron in groundwater along Cache Creek and in the Cache Creek Settling Basin area, elevated levels of selenium present in the groundwater supplies for the City of Davis, and localized areas of nitrate contamination (DWR 2004m, 2013a). The cities of Davis and Woodland, which heavily rely on groundwater supply, lost nine municipal wells since 2011 due to high nitrate concentrations (YCFCWCD 2012). Sources of high nitrate concentrations near these cities have been determined to be primarily from agricultural and wastewater operations. High salinity levels have also been reported in some areas that may be related to groundwater use for irrigation which tends to increase salt concentrations in groundwater.

In Yolo County, as much as 4 feet of groundwater withdrawal-related subsidence has occurred since the 1950s. Groundwater withdrawal-related subsidence has damaged or reduced the integrity of highways, levees, irrigation canals, and wells in Yolo County, particularly in the vicinities of Zamora, Knights Landing, and Woodland (Water Resources Association of Yolo County 2007).

The Yolo subbasin was designated by the CASGEM program as high priority.

### *Solano Subbasin*

The Solano subbasin includes most of Solano County, southeastern Yolo County, and southwestern Sacramento County. In the Solano subbasin, general groundwater flow directions are from the northwest to the southeast (DWR 2004n, 2013a). Increasing agricultural and urban development in the 1940s in the Solano subbasin has caused significant groundwater level declines. Today, groundwater levels are relatively stable but show significant declines during drought cycles. Groundwater level data also suggest that these declines tend to recover quickly during subsequent wet years. Between spring 2010 and spring 2014 in the Solano subbasin, recent information indicates that groundwater levels declined at multiple wells by at least 10 feet (DWR 2014c, 2014d).

Groundwater quality in the Solano subbasin is generally good and is deemed appropriate for domestic and agricultural use (DWR 2004n, 2013a). However, TDS concentrations are moderately high in the central and southern areas of the basin with localized areas of high calcium and magnesium.

The Solano subbasin was designated by the CASGEM program as medium priority.

*Groundwater Use and Management*

Many irrigators on the west side of the Sacramento Valley relied primarily on groundwater prior to completion of the CVP Tehama-Colusa Canal facilities which conveyed surface water to portions of Colusa County.

In the Colusa subbasin, although surface water is the primary source of water to meet water supply needs, groundwater is also used to assist in meeting agricultural, domestic, municipal, and industrial water needs, primarily in areas outside of established water districts. The Tehama Colusa Canal Authority service area is also an area of groundwater use in the Colusa subbasin. Although the Tehama-Colusa Canal Authority delivers surface water to agricultural users when the CVP water supplies are restricted due to hydrologic conditions, water users rely upon groundwater to supplement limited surface water supplies.

Groundwater is the source of water for municipal and domestic uses in Yolo County except for the City of West Sacramento, as described in Chapter 5, Surface Water Resources and Water Supplies. Recently, in normal years, approximately 40 percent of the irrigation users in Yolo County rely on groundwater (Yolo County 2009). For the East Yolo South area of the County (eastern Yolo subbasin), a 2006 study estimated that groundwater supplies about 80 to 85 percent of the total annual water demand in the county (YCFCWCD 2012).

Within Yolo and Sacramento counties portions of the Solano subbasin, groundwater is primarily used for domestic and irrigation uses. Within Solano County, groundwater is used exclusively by most rural residential landowners and the cities of Rio Vista and Dixon (Solano County 2008). The City of Vacaville uses groundwater to provide approximately 30 percent of the water supply. Other communities rely upon surface water, as described in Chapter 5, Surface Water Resources and Water Supplies. Irrigation users within the Solano Irrigation District rely upon surface water. All other irrigation users rely upon groundwater.

#### 7.3.3.1.4 Lower Sacramento Valley (East of Sacramento River)

The Lower Sacramento Valley area is located to the east of the Sacramento River, and includes seven groundwater subbasins: West Butte, East Butte, North Yuba, South Yuba, Sutter, North American, and South American (DWR 2003a, 2004o, 2004p, 2004q, 2006c, 2006d, 2006e, 2006f).

*Hydrogeology and Groundwater Conditions*

The aquifer system throughout the Lower Sacramento Valley east of the Sacramento River is composed of Tertiary to late Quaternary age deposits. The confined portion of the aquifer system includes the Tertiary-age Tuscan and Laguna formations. The Tuscan formation consists of volcanic mudflows, tuff breccia, tuffaceous sandstone, and volcanic ash deposits. The Laguna formation consists of moderately consolidated and poorly to well cemented interbedded alluvial sand, gravel, and silt with a low permeability, overall. The Quaternary portion of the aquifer system, typically unconfined, is largely composed of unconsolidated gravel, sand, silt, and clay stream channel and alluvial fan deposits. South and east of the Sutter Buttes, the deposits contain Pleistocene alluvium, which is composed of loosely compacted silts, sands, and gravels that are moderately permeable; however, nearly impermeable hardpans and claypans also exist in this deposit, which restrict the vertical movement of groundwater (DWR 2003a, 2004o, 2004p, 2004q, 2006c, 2006d, 2006e, 2006f).

#### *West and East Butte Subbasins*

The West Butte subbasin is located within Butte, Glenn, and Sutter counties. In the West Butte subbasin, groundwater levels declined during the 1976 to 1977 and 1987 to 1992 droughts, followed by a recovery in groundwater levels to pre-drought conditions of the early 1980s and 1990s (DWR 2004o, 2013a). A comparison of spring-to-spring groundwater levels from the 1950s and 1960s, to levels in the early 2000s, indicates about a 10-foot decline in groundwater levels in portions of this subbasin. Several groundwater depressions exist in the Chico area, due to year-round groundwater extraction for municipal uses. Between spring 2010 and spring 2014 in the West Butte subbasin, recent information indicates that groundwater levels declined at multiple wells at least 10 feet and in some areas up to 20 feet near Chico (DWR 2014c, 2014d). The groundwater levels in some areas declined up to 10 feet between fall 2013 and fall 2014.

The East Butte subbasin is located with Butte and Sutter counties. In the northern portion of the East Butte subbasin, annual groundwater fluctuations in the confined and semi-confined aquifer system ranges from 15 to 30 feet during normal years (DWR 2004p, 2013a). In the southern part of Butte County, groundwater fluctuations for wells constructed in the confined and semi-confined aquifer system average 4 feet during normal years and up to 5 feet during drought years. Between spring 2010 and spring 2014 in the East Butte subbasin, recent information indicates that groundwater levels either increased or declined at multiple wells by approximately 2 to 3 feet near Oroville (DWR 2014c, 2014d).

High nitrates occur near the Chico area in the West Butte subbasin. There are localized areas in the subbasin with high boron, calcium, electrical conductivity (EC), and TDS concentrations (DWR 2004 o, 2013a). There are several groundwater areas near Chico that historically had high perchloroethylene concentrations from industrial sites. Following implementation of groundwater treatment, the chemicals have not been detected (Butte County 2010).

There are localized high concentrations of calcium, salinity, iron, manganese, magnesium, and TDS throughout the East Butte subbasin (DWR 2004p, 2013a).

The West Butte subbasin was designated by the CASGEM program as high priority. The East Butte subbasin was designated as medium priority.

### *North and South Yuba Subbasins*

The North Yuba subbasin is located within Butte and Yuba counties. The South Yuba subbasin is located within Yuba County. In the North Yuba and South Yuba subbasins areas along the Feather River, the groundwater levels have been generally stable since at least 1960, with some seasonal fluctuations between spring and summer conditions. Groundwater levels in the central parts of the two subbasins declined until about 1980, when surface water deliveries were extended to these areas and groundwater levels started to rise. Hydrographs in the central portions of the North and South Yuba subbasins also show the effect of groundwater substitution transfers (during 1991, 1994, 2001, 2002, 2008, and 2009), in the form of reduced groundwater levels followed by recovery to pre-transfer levels (YCWA 2010). Between spring 2010 and spring 2014 in the North Yuba and South Yuba subbasins, recent information indicates that groundwater levels declined at multiple wells by 10 to 20 feet, especially near Yuba City (DWR 2014c, 2014d). The groundwater levels in some areas declined up to 10 feet between fall 2013 and fall 2014.

Historical water quality data show that in most areas of the North and South Yuba subbasins, trends of increasing concentrations of calcium, bicarbonate, chloride, alkalinity, and TDS occur. In general, groundwater salinity increases with distance from the Yuba River. No groundwater quality impairments were documented at the DWR monitoring wells in the North Yuba subbasin (DWR 2006c). High salinity occurred in the Wheatland area of the South Yuba subbasin within the South Yuba Water District and Brophy Irrigation District (DWR 2006d; YCWA 2010).

The North Yuba and South Yuba subbasins were designated by the CASGEM program as medium priority.

### *Sutter Subbasin*

The Sutter subbasin is located in Sutter County. In the Sutter subbasin, groundwater levels have remained relatively constant. The water table is very shallow and most groundwater levels in the subbasin tend to be within about 10 feet of ground surface (DWR 2006e, 2013a). Between the spring 2010 and spring 2014 in the Sutter subbasin, recent information indicates that groundwater levels declined at multiple wells by up to 10 feet (DWR 2014c, 2014d). The groundwater levels in some areas declined up to 10 feet between fall 2013 and fall 2014, and in some areas more than 10 feet.

Groundwater quality in the western portion of the Sutter subbasin includes areas with high concentrations of arsenic, boron, calcium magnesium bicarbonate, chloride, fluoride, iron, manganese, sodium, and TDS. In the southern portion of the subbasin, groundwater in the upper aquifer system tends to be high in salinity (DWR 2003b, 2006e).

The Sutter subbasin was designated by the CASGEM program as medium priority.

### *North American Subbasin*

The North American subbasin underlies portions of Sutter, Placer, and Sacramento Counties, including several dense urban areas. Since at least the 1950s, concentrated groundwater extraction occurred east of downtown Sacramento, which resulted in a regionally extensive cone of depression. Drawdown in the wells in this areas have been in excess of 70 feet over the past 60 years (SGA 2008). Water purveyors have constructed facilities to import surface water to allow groundwater levels to recover from the historic levels of drawdown. In general, since around the mid-1990s to the late 2000s, water levels remained stable in the southern portion of the subbasin and in some cases groundwater levels are continuing to increase slightly in response to increases in conjunctive use and reductions in pumping near McClellan Air Force Base (SGA 2014). Groundwater levels in Sutter and northern Placer Counties generally have remained stable, although some wells in southern Sutter County have experienced declines (DWR 2006f, 2013a). Overall, groundwater levels are higher along the eastern portion of the North American subbasin and decline towards the western portion (Roseville et al. 2007). There is a groundwater depression in the southern Placer-Sutter counties area near the border with Sacramento County. Between the spring 2010 and spring 2014 in the North American subbasin, recent information indicates that groundwater levels declined at multiple wells by up 10 feet (DWR 2014c, 2014d). The groundwater levels were relatively constant between fall 2013 and fall 2014.

The area along the Sacramento River extending from Sacramento International Airport northward to the Bear River contains high levels of arsenic, bicarbonate, chloride, manganese, sodium, and TDS (DWR 2006f, 2013a). In an area between Reclamation District 1001 and the Sutter Bypass, high TDS concentrations occur. There have been three sites within the subbasin with significant groundwater contamination issues: the former McClellan Air Force Base, the Union Pacific Railroad Rail Yard in Roseville, and the Aerojet Superfund Site. Mitigation operations have been initiated for all of these sites. In the deeper portions of the aquifer, the groundwater geochemistry indicates the occurrence of connate water from the marine sediments underlying the freshwater aquifer, which mixes with the fresh water. Water quality concerns due to this type of geology include elevated levels of arsenic, bicarbonate, boron, chloride, fluoride, iron, manganese, nitrate, sodium, and TDS (DWR 2003b).

The North American subbasin was designated by the CASGEM program as high priority.

### *South American Subbasin*

The South American subbasin is located within Sacramento County. Groundwater levels in the South American subbasin have fluctuated over the past 40 years, with the lowest levels occurring during periods of drought. From 1987 to 1995, water levels declined by about 10 to 15 feet and then recovered to levels close to the mid-80s by 2000. Over the past 60 years, a general lowering of groundwater levels was caused by intensive use of groundwater in the region. Areas affected by municipal pumping show a lower groundwater level recovery than other areas (DWR 2004q, 2013a). A large cone of depression is centered in the southwestern portion of the subbasin. Between the spring 2010 and spring 2014 in the South American subbasin, recent information indicates that groundwater levels declined at multiple wells by up 10 feet (DWR 2014c, 2014d). The groundwater levels were relatively constant between fall 2013 and fall 2014.

The groundwater quality is characterized by low to moderate TDS concentrations (DWR 2004q, 2013a). Seven sites historically had significant groundwater contamination, including three Superfund sites near the Sacramento metropolitan area. These sites are in various stages of cleanup.

The South American subbasin was designated by the CASGEM program as high priority.

#### *Groundwater Use and Management*

In this area, groundwater is used for agricultural, domestic, municipal, and industrial purposes. Most of the groundwater extraction occurs via privately owned domestic and agricultural wells.

##### *West and East Butte Subbasins*

The primary water source in Butte County is surface water (approximately 70 percent, by volume), and groundwater use accounts for about 30 percent of total county water use. In Butte County, most of the irrigation users rely upon surface water and approximately 75 percent of the residential water users rely upon groundwater (Butte County 2004, 2010).

The cities of Chico and Hamilton City are served by groundwater provided by California Water Service Company (California Water Service Company 2011g).

##### *North and South Yuba Subbasins*

The Yuba County Water Agency actively manages surface water and groundwater conjunctively to prevent groundwater overdraft in the North and South Yuba subbasins. The majority of water demand in these subbasins is crop water use from irrigated agriculture (YCWA 2010).

##### *Sutter Subbasin*

Agricultural water use in Sutter County is composed, on average, of approximately 60 percent surface water, 20 percent groundwater, and 20 percent of land irrigated by both surface water and groundwater. Permanent crops are predominantly irrigated with groundwater. Groundwater is also used for small communities and rural domestic uses (Sutter County 2011).

##### *North American Subbasin*

Several agencies manage water resources in the North American subbasin: South Sutter Water District, Placer County Water Agency, Natomas Central Mutual Water Company, and several urban water purveyors which are part of the Sacramento Groundwater Authority (SGA), a joint powers authority (SGA 2014). The northern portion of this subbasin is rural and agricultural, while the southern portion is urbanized, including the Sacramento Metropolitan area. Many of the urban agencies in Placer County rely upon surface water for normal operations, and have developed or are planning on developing groundwater for emergency situations (Roseville et al. 2007). In the urban area encompassed by SGA, some agencies rely entirely on groundwater for their water supply (SGA 2014).

Local planning efforts have been implemented in a local groundwater planning area known as the American River Basin region. This area encompasses Sacramento County and the lower watershed portions of Placer and El Dorado counties, and overlies the productive North American and South American subbasins. Groundwater is a regionally significant source of water supply, and is used as a primary source for many agencies in the region. However, in recent years, regional conjunctive use programs have allowed for the optimization of water supplies and a decrease in groundwater use has been observed in the past 5 years (RWA 2013).

Since 2000, groundwater extraction decreased in the northeastern portion of the North American subbasin as additional surface water supplies were made available under conjunctive use operations implemented following the Water Forum Agreement in 2000. In 2007, groundwater extraction increased because additional surface water was not available due to dry surface water supply conditions (SGA 2008, 2011).

##### *South American Subbasin*

The South American subbasin lies entirely within Sacramento County and is overlain by a majority of urban and densely populated areas. Many of the water users in this subbasin use surface water.

The main water purveyors that use South American subbasin groundwater include the Elk Grove Water District, California-American Water Company, Golden State Water Company, and the Sacramento County Water Agency. The entities serve the communities of Antelope, Arden, Lincoln Oaks, Parkway, Rosemont, and portions of the City of Rancho Cordova (California-American Water Company 2011; EGWD 2011; Golden State Water Company 20111; Sacramento County Water Agency 2011).The majority of groundwater pumping is for agricultural uses (SCGA 2010). The South American subbasin also includes portions of the area known as the American River Basin, as described above under the North American subbasin section.

#### *7.3.3.2 Delta*

The Delta overlies the western portion of the area where the Sacramento River and San Joaquin River groundwater basins converge, as shown in Figure 7.5. The Delta includes the Solano subbasin and the South American subbasin in the Sacramento Valley Groundwater Basin (as described above); the Tracy subbasin, the Eastern San Joaquin subbasin, and the Cosumnes subbasin in the San Joaquin Valley Groundwater Basin (as described in subsequent sections of this chapter for the San Joaquin); and the Suisun-Fairfield Valley Basin (as described in subsequent sections of this chapter for the San Francisco Bay Area Region).

#### 7.3.3.2.1 Hydrogeology and Groundwater Conditions

In some areas of the western and central Delta floodplain, floodplain deposits contain organic material (peat) that range in thickness from 0 to 150 feet. Below the surficial floodplain deposits, unconsolidated non-marine sediments occur, at depths of a few hundred feet near the Coast Range to nearly 3,000 feet near the eastern margin of the Sacramento Valley Groundwater Basin. These non-marine sediments form the major water-bearing formations in the Delta.

In general, shallow groundwater conditions and extensive groundwater-surface water interaction characterize the Delta. Spring runoff generated by melting snow in the Sierra Nevada increases flows in the Sacramento and San Joaquin rivers and their tributaries and cause groundwater levels near the rivers to rise. Because the Delta is a large floodplain and the shallow groundwater is hydraulically connected to the surface water, changes in river stages affect groundwater levels and vice versa. Groundwater levels in the central Delta are very shallow, and land subsidence on several islands has resulted in groundwater levels close to the ground surface. Maintaining groundwater levels below crop rooting zones is critical for successful agriculture, especially for islands that lie below sea level. Many farmers rely on an intricate network of drainage ditches and pumps to maintain groundwater levels of about 3 to 6 feet below ground surface. The accumulated agricultural drainage is discharged into adjoining surface water bodies (USGS 2000a). Without this drainage system, many of the islands would be subject to extremely high groundwater, bogs, or localized flooding.

Groundwater generally flows from the Sierra Nevada in the east toward the low-lying lands of the Delta to the west. However, a number of pumping depressions have reversed this trend, and groundwater inflow from the Delta toward these pumping areas has been observed, primarily in the Stockton area.

Subsidence in the Delta is well-documented and a major source of concern for farming operations. The oxidation of peat soils is the primary mechanism of subsidence in the Delta, and some areas are located below sea level. Another mechanism for subsidence is wind erosion. There is a possibility that certain areas in the Delta could continue to subside 2 to 4 more feet over the next 35 years (DWR 2013i).

#### 7.3.3.2.2 Groundwater Use and Management

Groundwater is used throughout the Delta for domestic and irrigation water supplies. Irrigation supplies are provided by wells and plant uptake in the root zone. An accurate accounting of groundwater used in the region is not available because wells are not metered and there is no method to measure root-zone irrigation.

Groundwater is used for potable water supplies by the Delta communities of Clarksburg, Courtland, Freeport, Hood, Isleton, Rio Vista, Ryde, and Walnut Grove. In the rural portions of the Delta, private groundwater wells provide residential and agricultural water supplies (Sacramento County 2010; Yolo County 2009; SCWA et al. 2005; Solano County 2008; San Joaquin County 2009;

Contra Costa County 2005). In some portions of the Delta, groundwater use is limited because of low well yields and poor water quality. Shallow groundwater in the western Delta may be saline due to hydraulic connection with western Delta waterways that are influenced by sea water intrusion. Shallow groundwater levels can be detrimental if the groundwater encroaches into the crop root zones. Therefore, groundwater pumping frequently is used to drain shallow groundwater and surface water from agricultural fields.

### *7.3.3.3 Suisun Marsh*

To the west, the Suisun Marsh overlies the Suisun–Fairfield Valley subbasin. The Suisun-Fairfield Groundwater Basin is adjacent to, but hydrogeologically distinct from, the Sacramento River Groundwater Basin, and is adjacent to Suisun Bay. This basin is bounded by the Coast Ranges to the north and west and the Sacramento River Groundwater Basin in the east, as shown in Figure 7.5. It is separated from the Sacramento River Groundwater Basin by the English Hills.

#### 7.3.3.3.1 Hydrogeology and Groundwater Conditions

In the Suisun-Fairfield Valley Groundwater Basin, freshwater occurs within the alluvial deposits that overlie the Sonoma volcanics (Travis AFB 1997; USGS 1960).

The overall direction of groundwater flow in the Suisun-Fairfield Valley Groundwater Basin is from the uplands toward Suisun Marsh (USGS 1960; Reclamation et al. 2011). Depth to groundwater varies seasonally, with higher groundwater levels occurring during the rainy season (Solano County 2008). Prior to implementation of the Solano Project that conveys water into Solano County from Lake Berryessa as part of the Solano Project and the SWP North Bay Aqueduct, groundwater depressions were occurring near Fairfield. Following importation of surface water from the Solano Project and the North Bay Aqueduct, surface water was used more extensively to reduce the groundwater overdraft (Solano County 2008; Travis AFB 1997). Few groundwater monitoring sites exist in the basin, and most are near ongoing groundwater investigations. Data from these groundwater investigations suggest that groundwater levels in the basin are generally stable.

Groundwater quality issues within the Suisun-Fairfield Valley Groundwater Basin include high boron, TDS, and volatile organic compound concentrations near Travis Air Force Base (USGS 1960, 2008). Volatile organic compound plumes at Travis Air Force Base are largely contained on base, but volatile organic compound constituents have migrated up to 0.5-mile off base at three sites. Containment and remediation is occurring at each of these sites (Travis AFB 2005).

The Suisun-Fairfield Valley Groundwater Basin was designated by the CASGEM program as very low priority.

##### 7.3.3.3.2 Groundwater Use and Management

Information on groundwater supplies in the Suisun-Fairfield Valley Groundwater Basin is limited. Groundwater was the primary water source for the Suisun–Fairfield Valley Groundwater Basin, including the cities of Fairfield and Suisun City, through the 1950s. This groundwater production resulted in local areas of depressed groundwater levels. As surface water became available, groundwater use declined. Studies have shown that the basin provides low well yields and therefore is probably not used as a major water supply (Reclamation et al. 2011). Many private well owners in the Suisun-Fairfield Valley Groundwater Basin use groundwater for irrigation. However, due to the brackish quality of the groundwater, surface water is used for potable water supplies (Reclamation et al. 2011).

#### *7.3.3.4 San Joaquin Valley*

The San Joaquin Valley Groundwater Basin extends from the Sacramento-San Joaquin Delta in the north to the Tehachapi Mountains in the South. Groundwater is estimated to provide over 47 percent of the overall water supply in the San Joaquin Valley, including 70 percent of municipal uses and 43 percent of irrigation supplies from 2005 through 2010 (DWR 2013i). The San Joaquin Valley has an average annual precipitation between 5 to 18 inches. Due to the low amounts of average annual precipitation, limited surface water supply and extensive agricultural water use, there are areas of significant overdraft that exist in the San Joaquin Valley Groundwater Basin. Eight subbasins in the San Joaquin Valley Groundwater Basin were identified in a state of critical overdraft: Chowchilla, Eastern San Joaquin, Madera, Kings, Kaweah, Tule, Tulare Lake, and Kern (DWR 1980). Three of these subbasins are on the eastern side of the San Joaquin River: Eastern San Joaquin, Chowchilla, and Madera. Recent studies have indicated that overdraft continues to exist in these subbasins (DWR 2013i). By 1970, over 5,200 square miles of irrigable land had subsided by a minimum of 1 foot. The maximum subsidence occurred near Mendota at almost 30 feet (9 meters) (Reclamation 2013a). Due to the drought that started in 2011, surface water supplies have declined and new wells have been constructed. Between January and October 2014, over 100 wells were drilled in both Kern and Kings counties, almost 200 in Stanislaus County, almost 250 in Merced County, and over 350 in both Fresno and Tulare counties (DWR 2014d).

The elevation of the base of freshwater in the western and central San Joaquin Valley ranges from 600 to 800 feet below mean sea level (WWD 2013). This area has experienced subsidence of up to 28 feet between 1926 and 1970 (USGS 2009). The water quality of the semi-perched aquifer on the western side of the San Joaquin Valley is impaired with high salinity, selenium, and boron concentrations. These constituents are from both naturally occurring deposits in the Coast Ranges to the west and agricultural activities. The chemicals become trapped in the soil matrix due to the low permeability clay layers close to the surface. There are also localized areas with high concentrations of naturally occurring arsenic or selenium.

Portions of the San Joaquin Valley Groundwater Basin in the Cosumnes, Tracy, and Eastern San Joaquin subbasins were designated by the State Water Resources Control Board in 2000 as Hydrogeologically Vulnerable Areas and Groundwater Protection Areas based on hydrogeologic permeability. These areas could be more vulnerable to groundwater quality impairment if applied surface water, including recycled water, contained high concentrations of constituents of concern to the beneficial users of the groundwater (CVRWQCB 2014b).

#### 7.3.3.4.1 Northern Portions of the San Joaquin Valley Groundwater Basin

Extending south into the Central Valley from the Delta to the southern extent marked by the San Joaquin River, DWR has delineated nine subbasins within the northern portion of the San Joaquin Valley Groundwater Basin based on groundwater divides, barriers, surface water features, and political boundaries (DWR 2003a), as shown in Figure 7.6. The Cosumnes, Eastern San Joaquin, and Tracy subbasins partially underlie the Delta. The Delta-Mendota, Modesto, Turlock, Merced, Chowchilla, and Madera subbasins are located between the Delta and the San Joaquin River.

The northern portion of the San Joaquin Valley Groundwater Basin is marked by laterally extensive deposits of thick fine-grained materials deposited in lacustrine and marsh depositional systems. These units, which can be tens to hundreds of feet thick, create vertically differentiated aquifer systems within the subbasins. The Corcoran Clay (or E-Clay), occurs in the Tulare Formation and separates the alluvial water-bearing formations into confined and unconfined aquifers. The direction of groundwater flow generally coincides with the primary direction of surface water flows in the area, which is to the northwest toward the Delta (DWR 2003a, 2004r, 2004s, 2004t, 2004u, 2006g, 2006h, 2006k). Groundwater levels fluctuate seasonally and a strong correlation exists between depressed groundwater levels and periods of drought, when more groundwater is pumped in the area to support agricultural operations.

Water users in the northern portion of the San Joaquin Valley Groundwater Basin rely upon groundwater, which is used conjunctively with surface water for agricultural, industrial, and municipal supplies (DWR 2003a). Groundwater is estimated to account for about 38 percent of the overall water supply in the northern portion of the San Joaquin Valley Groundwater Basin (DWR 2013i). Annual groundwater pumping in the northern portion of the San Joaquin Valley Groundwater Basin accounts for about 19 percent of all groundwater pumped in the state of California. Groundwater use in the northern portion of the San Joaquin Valley Groundwater Basin is estimated to average 3.2 million acre-feet per year between 2005 and 2010.

According to the Draft California Water Plan 2013 Update (DWR 2013i), three planning areas within the northern portion of the San Joaquin Valley Groundwater Basin rely heavily on groundwater pumping: the Eastern Valley Floor Planning Area, the Lower Valley Eastside Planning Area, and the Valley West Side Planning Area. Each of these areas has limited local surface water supplies and uses extensive groundwater pumping for their agricultural water supply (DWR 2013i).

The northern portion of the San Joaquin Valley Groundwater Basin discussion is divided into two sub-regions: West of the San Joaquin River, and East of the San Joaquin River, as described below.

#### *West of the San Joaquin River*

The Tracy and the Delta-Mendota subbasins are located on the west side of the San Joaquin River.

##### *Hydrogeology and Groundwater Conditions*

Along the western portion of the San Joaquin Valley, the Tulare formation comprises the primary freshwater aquifer. The Tulare Formation originated as reworked sediments from the Coast Ranges re-deposited in the San Joaquin Valley as alluvial fan, flood basin, deltaic (pertaining to a delta) or lacustrine, and marsh deposits (USGS 1986).

###### *Tracy Subbasin*

The Tracy subbasin underlies eastern Contra Costa County and western San Joaquin County. A large portion of the subbasin is located within the Delta. In the Tracy subbasin, groundwater generally flows from south to north and discharges into the San Joaquin River. According to DWR and the San Joaquin County Flood Control and Water Conservation District, groundwater levels in the Tracy subbasin have been relatively stable over the past 10 years, apart from seasonal variations resulting from recharge and pumping (DWR 2006g, 2013b). Recent information indicates that between the spring 2010 and spring 2014, groundwater levels declined at some wells in the Tracy subbasin by up to 10 feet (DWR 2014c, 2014d). The groundwater levels in some areas declined up to 10 feet between fall 2013 and fall 2014, and in some areas more than 10 feet.

In the Tracy subbasin, areas of poor water quality exist throughout the area. Elevated chloride concentrations are found along the western side of the subbasin near the City of Tracy and along the San Joaquin River. Overall, Delta groundwater wells in the Tracy subbasin are characterized by high levels of chloride, TDS, arsenic, and boron (DWR 2006g, 2013b; USGS 2006). The Central Valley Regional Water Quality Board recently adopted general waste discharge requirements to protect groundwater, as well as surface water, within the San Joaquin County and Delta areas, including the Tracy subbasin (CVRWQCB 2014b). Supporting information recognizes the potential for groundwater impairment due to the water quality of applied water to crops if the applied water quality contains high concentrations of constituents of concern.

The Tracy subbasin was designated by the CASGEM program as medium priority.

###### *Delta-Mendota Subbasin*

The Delta-Mendota subbasin underlies portions of Stanislaus, Merced, Madera, and Fresno counties. The geologic units present in the Delta-Mendota subbasin consist of the Tulare Formation, terrace deposits, alluvium, and flood-basin deposits. Groundwater occurs in three water-bearing zones: the lower zone contains confined fresh water in the lower section of the Tulare Formation; the upper zone contains confined, semi-confined, and unconfined water in the upper section of the Tulare formation; and a shallow zone that contains unconfined water (DWR 2006h, 2013b). The groundwater is characterized by moderate to extremely high salinity with localized areas of high iron, fluoride, nitrate, and boron (DWR 2006h, 2013b).

In the Delta-Mendota subbasin, groundwater levels have generally declined by as much as 20 feet in the northern portion of the basin near Patterson between 1958 and 2006. Surface water imports in the early 1970s resulted in decreased pumping, and a steady recovery of groundwater levels. However, the lack of imported surface water availability during the drought periods of 1976 to 77, 1986 to 1992, and 2007 to 2009 resulted in increases in groundwater pumping, and associated declines in groundwater levels to near-historic lows (USGS 2012). Recent information indicates that between the spring 2010 and spring 2014, groundwater levels declined at some wells in the Delta-Mendota subbasin by up to 20 feet (DWR 2014c, 2014d).

In areas adjacent to the Delta-Mendota Canal in this subbasin, extensive groundwater withdrawal has caused land subsidence of up to 10 feet in some areas. Land subsidence can cause structural damage to the Delta-Mendota Canal which has caused operational issues for CVP water delivery. Historical wide-spread soil compaction and land subsidence between 1926 and 1970 has caused reduced freeboard and flow capacity of the Delta-Mendota Canal, the California Aqueduct, other canals, and roadways in the area. To better understand subsidence issues near the Delta-Mendota Canal and improve groundwater management in the area, the U.S. Geological Survey (USGS) provided and evaluated information on groundwater conditions and the potential for additional land subsidence in the San Joaquin Valley (USGS 2013a). Results show that at least 1.8 feet of subsidence occurred near the San Joaquin River and the Eastside Bypass from 2008 to 2010 period, affecting the southern part of the Delta-Mendota Canal by about 0.8 inches of subsidence during the same period. It was estimated that subsidence rates doubled in 2008 in some areas. The subsidence measured was primarily inelastic (or permanent, not reversible, due to the compaction of fine-grained material). The area of maximum active subsidence is shown to be located southwest of Mendota and extends into the Merced subbasin to the south of El Nido. Land subsidence in this area is expected to continue to occur due to uncertainties and limitations (especially climate-related changes) in surface water supplies to meet irrigation demand and the continuous need to supplement water supply with groundwater pumping.

#### *Groundwater Use and Management*

In this area, groundwater is used for agricultural, domestic, municipal, and industrial purposes.

*Tracy Subbasin*

The primary water source in Contra Costa County is surface water. Groundwater is used by individual homes and businesses and the communities of Brentwood, Bethel Island, Knightsen, Byron and Discovery Bay (Contra Costa County 2005).

The Diablo Water District groundwater blending facility provides water to users in the City of Oakley by blending groundwater and treated water from Contra Costa Water District (DWD 2011).

Contra Costa Water District has an agreement with the East Contra Costa Irrigation District to purchase surplus irrigation water for municipal and industrial purposes in East Contra Costa Irrigation District's service area (CCWD 2011). The agreement includes an option to implement an exchange of surface water for groundwater that can be used in the Contra Costa Water District service area when the CVP allocations are less than full contract amounts. This groundwater exchange water was implemented during the 2007 to 2009 drought.

Groundwater and surface water are used within western San Joaquin County for agricultural operations and for the cities of Stockton, Lathrop, and Tracy (San Joaquin 2009). In the 1980s, about 30 percent of the water supplies in San Joaquin County were based on groundwater (including the Tracy, Cosumnes, and Eastern San Joaquin subbasins). By 2007, groundwater was used to supply over 60 percent of water demand in the county.

*Delta-Mendota Subbasin*

Groundwater is used for agricultural and domestic water supplies in the Delta-Mendota subbasin (Reclamation and DWR 2011). Groundwater is primarily used for domestic and industrial water supplies in Stanislaus County, including for the City of Patterson (Stanislaus County 2010; Patterson 2014). In the Delta-Mendota subbasin within Merced County, approximately 3 percent of groundwater withdrawals are used for municipal and industrial purposes (including uses in the city of Gustine, Los Banos, and Santa Nella), and 97 percent of the groundwater withdrawals are used for agricultural purposes (Merced County 2012). Most of the portions of Madera County within the Delta-Mendota subbasin use groundwater for domestic and agricultural uses (Madera County 2002, 2008). In portions of Western Fresno County within the Delta-Mendota subbasin, domestic water users rely upon groundwater (including the cities of Mendota and Firebaugh), and agricultural water users rely upon surface water and/or groundwater (Mendota 2009; Firebaugh 2015; Fresno County 2000).

*East of the San Joaquin River*

The east side of the San Joaquin River is underlain by seven groundwater subbasins: the Cosumnes, Eastern San Joaquin, Modesto, Turlock, Merced, Chowchilla, and Madera subbasins. Three of these subbasins are in a critical state of overdraft: the Chowchilla, Eastern San Joaquin, and Madera (DWR 2013i).

#### *Hydrogeology and Groundwater Conditions*

Several of the hydrogeologic units present in the southern Sacramento Valley extend south into the San Joaquin Valley. Along the eastern boundary of the Central Valley, the Ione, Mehrten, Riverbank, and Modesto formations are primarily composed of sediments originating from the Sierra Nevada.

Historically, surface water and groundwater were hydraulically connected in most areas of the San Joaquin River and its tributaries. This resulted in a significant quantity of groundwater actively discharging into streams in most of this watershed. However this condition changed as increased groundwater pumping in the area lowered groundwater levels and reversed the hydraulic gradient between the surface water and groundwater systems, resulting in surface water recharging the underlying aquifer system through streambed seepage. Long-term groundwater production throughout this basin has lowered groundwater levels faster than natural recharge rates. Areas where this overdraft has occurred include eastern San Joaquin County, Merced County, and western Madera County. This occurs along the San Joaquin River where the riverbed is highly permeable and river water readily seeps into the underlying aquifer. This condition reduces groundwater and surface water outflows to the Delta, lowers the water table, and may increase the potential for land subsidence (USFWS 2012).

Generally, the groundwater in the San Joaquin River subbasins east of the San Joaquin River is of suitable quality for most urban and agricultural uses with only local impairments. There are localized areas with high concentrations of boron, chloride, iron, nitrate, TDS, and organic compounds (DWR 2003a, 2004r, 2004s, 2004t, 2004u, 2006i, 2006j, 2006k). The use of groundwater for agricultural supply is impaired in western Stanislaus and Merced counties due to elevated boron concentrations. Groundwater use for drinking water supply is also impaired in the Tracy, Modesto-Turlock, Merced, and Madera areas due to elevated nitrate concentrations (USFWS 2012).

Dibromochloropropane (DBCP), a soil fumigant that was extensively used on grapes and cotton before it was banned, is prevalent in groundwater near Merced and Stockton and in the Merced, Modesto, Turlock, Cosumnes, and Eastern San Joaquin subbasins (CVRWQCB 2011; DWR 2004r; USFWS 2012). Many areas with high concentrations of DBCP have undergone groundwater remediation, and the DBCP concentrations are declining.

Declining groundwater levels in the subbasins east of the San Joaquin River have resulted in an area approximately 16-miles long with high salinity due to saltwater intrusion from the Delta (USFWS 2012).

##### *Cosumnes Subbasin*

The Cosumnes subbasin underlies western Amador County, northwestern Calaveras County, southeastern Sacramento County, and northeastern San Joaquin County. Groundwater levels in the Cosumnes subbasin have fluctuated significantly over the past 40 years, with the lowest levels occurring during periods of drought. From 1987 to 1995, water levels declined by about 10 to 15 feet and then recovered by that same amount through 2000. Areas affected by municipal pumping show a lower magnitude of groundwater level recovery during this period than in other areas of the subbasin (DWR 2006i, 2013b). Within the portion of Sacramento County in the Cosumnes subbasin, it is estimated that the recent average annual decline in groundwater levels has been approximately 1 foot, with a lower rate of decline in more recent years (South Area Water Council 2011). Recent information indicates that between the spring 2010 and spring 2014, groundwater levels declined at some wells in the Cosumnes subbasin by up to 10 feet (DWR 2014c, 2014d).

The Cosumnes subbasin contains groundwater of very good quality, with localized high concentrations of calcium bicarbonate and pesticides (DWR 2006i, 2013b).

The Cosumnes subbasin was designated by the CASGEM program as medium priority.

#### *Eastern San Joaquin Subbasin*

The Eastern San Joaquin subbasin underlies western Calaveras County, a large portion of San Joaquin County, and a portion of Stanislaus County. Groundwater levels in the Eastern San Joaquin subbasin have continuously declined in the past 40 years due to groundwater overdraft. Cones of depression are present near major pumping centers such as the City of Stockton and the City of Lodi (DWR 2006j, 2013b). Groundwater level declines of up to 100 feet have been observed in some wells. In the 1990s, groundwater levels were so low that many wells were inoperable and many groundwater users were obligated to construct new deeper wells (NSJCGBA 2004). Recent information indicates that between the spring 2010 and spring 2014, groundwater levels declined at some wells in the Eastern San Joaquin subbasin by up to 20 feet (DWR 2014c, 2014d).

In the Eastern San Joaquin subbasin, the groundwater is characterized with low to high salinity levels and localized areas of high calcium or magnesium bicarbonate, salinity, nitrates, pesticides, and organic constituents (DWR 2006j, 2013b). The high groundwater salinity is attributed to poor-quality groundwater intrusion from the Delta caused by the pumping-induced decline in groundwater levels, especially in the groundwater underlying the Stockton area since the 1970s (SJCFCWCD 2008). High chloride concentrations have also been observed in the Eastern San Joaquin subbasin. Ongoing studies are evaluating the sources of chloride in groundwater along a line extending from Manteca to north of Stockton. Initial concern was that long-term overdraft conditions in the eastern portion of the subbasin were enabling more saline water from the Delta to migrate inland. Other possible sources include upward movement of deeper saline formation water and agricultural practices (USGS 2006). In addition, large areas of groundwater with elevated nitrate concentrations have been observed in several portions of the subbasin, such as areas southeast of Lodi and south of Stockton and east of Manteca, and in areas extending towards the San Joaquin-Stanislaus County line (USFWS 2012).

The Eastern San Joaquin subbasin was designated by the CASGEM program as high priority.

### *Modesto Subbasin*

The Modesto subbasin underlies northern Stanislaus County. In the Modesto subbasin, water levels have declined nearly 15 feet on average between 1970 and 2000 (DWR 2004r, 2013b), with the major declines occurring in the eastern portion of the subbasin. Recent information indicates that between the spring 2010 and spring 2014, groundwater levels declined at some wells in the Modesto subbasin by up to 20 feet (DWR 2014c, 2014d).

The groundwater is characterized by low to high TDS concentrations with localized areas of boron, chlorides, DBCP, iron, manganese, and nitrate concentrations (DWR 2004r, 2013b; Stanislaus County 2010).

The Modesto subbasin was designated by the CASGEM program as high priority.

### *Turlock Subbasin*

The Turlock subbasin underlies portions of Stanislaus and Merced counties. In the Turlock subbasin, water levels declined nearly 7 feet on average from 1970 through 2000 (DWR 2006k, 2013b). Comparison of groundwater contours from 1958 and 2006 shows that historically, groundwater flows occurred from east to west, toward the San Joaquin River. Groundwater pumping centers to the east of the City of Turlock have drawn the groundwater toward these cones of depression, allowing less water to flow toward the San Joaquin River, and diminishing the discharge of groundwater to the river. Recent information indicates that between the spring 2010 and spring 2014, groundwater levels declined at some wells in the Turlock subbasin by up to 20 feet (DWR 2014c, 2014d). The storage capacity of the Turlock subbasin is estimated at about 15,800,000 acre-feet (DWR 2006k, 2013b).

The groundwater quality is characterized with low to high concentrations of TDS and localized high concentrations of boron, chlorides, DBCP, nitrates, and TDS (DWR 2013b).

The Turlock subbasin was designated by the CASGEM program as high priority.

### *Merced Subbasin*

The Merced subbasin underlies most of Merced County. In the Merced subbasin, water levels have declined nearly 30 feet on average from 1970 through 2000. Water level declines have been more severe in the eastern portion of the subbasin (DWR 2004s, 2013b). The estimated specific yield of the groundwater subbasin is 9 percent. Recent information indicates that between the spring 2010 and spring 2014, groundwater levels declined at some wells in the Merced subbasin by up to 20 feet (DWR 2014c, 2014d).

The groundwater quality is characterized by low to high TDS concentrations and localized areas with high concentrations of chloride, DBCP, iron, and nitrate (DWR 2004s, 2013b; USFWS 2012).

The Merced subbasin was designated by the CASGEM program as high priority.

#### *Chowchilla Subbasin*

The Chowchilla subbasin underlies southwestern Merced County and northwestern Madera County. In the Chowchilla subbasin, water levels declined nearly 40 feet on average from 1970 to 2000. Water level declines were more severe in the eastern portion of the subbasin from 1980 to present, but the western portion of the subbasin showed the strongest declines before 1980 (DWR 2004t, 2013b). Groundwater recharge in this subbasin is primarily from irrigation water percolation. Recent information indicates that between the spring 2010 and spring 2014, groundwater levels declined at some wells in the western Chowchilla subbasin by up to 10 feet (DWR 2014c, 2014d).

There are localized areas with high concentrations of chloride, iron, nitrate, and hardness (DWR 2004t, 2013b). Organic chemicals were detected in some wells in the Chowchilla subbasin between 1983 and 2003 (CVRWQCB 2011).

The Chowchilla subbasin was designated by the CASGEM program as high priority.

#### *Madera Subbasin*

The Madera subbasin underlies most of Madera County. In the Madera subbasin, water levels have declined nearly 40 feet on average from 1970 through 2000. Water level declines have been more severe in the eastern portion of the subbasin from 1980 to the present, but the western subbasin showed the strongest declines before this period (DWR 2004u, 2013b). Recent information indicates that between the spring 2010 and spring 2014, groundwater levels declined at some wells in the western Chowchilla subbasin by up to 10 feet (DWR 2014c, 2014d).

Groundwater in the Madera subbasin is characterized by low to high TDS and localized areas with high concentrations of chlorides, iron, nitrates, and hardness (DWR 2004u, 2013b). Occurrences of organic chemicals have been observed including DBCP and pesticides (CVRWQCB 2011; DWR 2004u, 2013b).

The Madera subbasin was designated by the CASGEM program as high priority.

### *Groundwater Use and Management*

In this area, groundwater is used for agricultural, domestic, municipal, and industrial purposes.

#### *Cosumnes Subbasin*

Currently, urban and agricultural water users on the valley floor are reliant on groundwater for water supply. Water demands in the Cosumnes Subbasin area are supported by nearly 95 percent groundwater (South Area Water Council 2011). Groundwater and surface water are used for agricultural and domestic water supplies in the Cosumnes subbasin (CVRWQCB 2011). Groundwater is used by many agricultural water users and the community of Galt (CVRWQCB 2011; South Area Water Council 2011).

The Central Valley Regional Water Quality Board recently adopted general waste discharge requirements to protect groundwater, as well as surface water, within the San Joaquin County and Delta areas, including the Cosumnes subbasin. The new requirements do not address protection of groundwater related to use of recycled water on crops because those operations would require separate discharge permits from the Central Valley Regional Water Quality Board and are not anticipated to be widely used in this area due to availability of recycled water near farms. However, the supporting information recognizes the potential for groundwater impairment due to the water quality of applied water to crops if the applied water quality contains high concentrations of constituents of concern (CVRWQCB 2014b).

#### *Eastern San Joaquin Subbasin*

Groundwater and surface water are used for agricultural and domestic water supplies in the Eastern San Joaquin subbasin (CVRWQCB 2011). Groundwater is the major source of water supply for agricultural areas in eastern San Joaquin County (NSJCGBA 2007). Groundwater is used by many agricultural water users and the communities of Escalon, Lodi, Manteca, Ripon, and Stockton (NSJCGBA 2004, 2007). The cities of Manteca and Stockton use both groundwater and surface water, while Lodi, Escalon, and Ripon primarily use groundwater for their municipal needs.

The City of Stockton uses both surface water and groundwater for its municipal and industrial water needs. Due to overdraft of the aquifer beneath Stockton, the city has limited annual groundwater extraction. All of these demands on the finite groundwater resources available in the basin historically have resulted in annual groundwater withdrawals in excess of the natural recharge volume in the East San Joaquin subbasin (DWR 2003a, 2006j). This extensive use of groundwater to meet local demand results in localized overdraft conditions within the subbasin.

The Northeastern San Joaquin County Groundwater Banking Authority is a joint-powers authority that develops local projects to strengthen water supply reliability in Eastern San Joaquin County. The Northeastern San Joaquin County Groundwater Banking Authority facilitated the development and adoption of the Eastern San Joaquin Groundwater Basin Groundwater Management Plan and completed an Integrated Regional Water Management Plan (IRWMP). This plan outlines the requirements for an integrated conjunctive use program that takes into account the various surface water and groundwater facilities in eastern San Joaquin County and promotes better groundwater management to meet future basin demands (NSJCGBA 2004). Conjunctive use refers to the use and management of the groundwater resource in coordination with surface water supplies by users overlying the basin. Potential projects that could be implemented to improve groundwater conditions in the area include urban and agricultural water use efficiency projects, recycled municipal water projects, groundwater banking operations, new surface water storage opportunities, improved conveyance facilities, and utilizing new sources of surface water (NSJCGBA 2007). Pursuant to the IRWMP, a program-level Environmental Impact Report identified potential changes to the environmental and mitigation measures to reduce identified significant adverse impacts (NSJCGBA 2011).

The Farmington Groundwater Recharge Program led by Stockton East Water District, in conjunction with the U.S. Army Corp of Engineers, and other local water agencies, was developed to utilize flood-season and excess irrigation water supplies in the Eastern San Joaquin groundwater subbasin to recharge the groundwater aquifer. This program supports replenishment of a critically overdrafted groundwater basin by recharging an average of 35,000 acre-feet of water annually into the Eastern San Joaquin subbasin. The program includes recharge of surface water on 800 to 1,200 acres of land using direct field-flooding. In addition, the program increases surface water deliveries in-lieu of groundwater pumping to reduce overdraft (Farmington Program 2012).

A joint conjunctive use and groundwater banking project was evaluated by the East San Joaquin Parties Water Authority and East Bay Municipal Utility District, named the Mokelumne Aquifer Recharge and Storage Project (NSJCGBA 2004). The goal of this project was to store surface water underground in wet years, and in dry years, East Bay Municipal Utility District would extract and export the recovered water supply (NSJCGBA 2004, 2009). Several studies have concluded that the test area is suitable for recharge and recovery of groundwater; however, more testing needs to be done to further evaluate the feasibility of this project.

The Central Valley Regional Water Quality Control Board recently adopted general waste discharge requirements to protect groundwater, as well as surface water, within the San Joaquin County and Delta areas. The new requirements do not address protection of groundwater related to use of recycled water on crops because those operations would require separate discharge permits from the Central Valley Regional Water Quality Board and are not anticipated to be widely used in this area due to availability of recycled water near farms. However, the supporting information recognizes the potential for groundwater impairment due to the water quality of applied water to crops if the applied water quality contains high concentrations of constituents of concern (CVRWQCB 2014b).

#### *Modesto Subbasin*

Groundwater is used for agricultural and domestic water supplies in the Modesto subbasin (Reclamation and DWR 2011). Groundwater is used by many agricultural water users and the community of Modesto (DWR 2004r; Stanislaus County 2010).

#### *Turlock Subbasin*

Groundwater is used for agricultural and domestic water supplies in the Turlock subbasin (Reclamation and DWR 2011). Groundwater is used by many agricultural water users and the community of Turlock in Stanislaus County and the communities of Delhi and Hilmar in Merced County (DWR 2006k; Stanislaus County 2010; Merced County 2012).

#### *Merced Subbasin*

Groundwater is used for agricultural and domestic water supplies in the Merced subbasin (Reclamation and DWR 2011). Groundwater is used by many agricultural water users and the communities of Atwater, El Nido, Le Grand, Livingston, Merced, Planada, and Winton (DWR 2004s; Merced County 2012).

*Chowchilla Subbasin*

Groundwater is used for agricultural and domestic water supplies in the Chowchilla subbasin (Reclamation and DWR 2011). Groundwater is used by many agricultural water users and the community of Chowchilla (DWR 2006k; Madera County 2002).

*Madera Subbasin*

Groundwater is used for agricultural and domestic water supplies in the Madera subbasin (Reclamation and DWR 2011). Groundwater is used by many agricultural water users and the community of Madera (DWR 2006k; Madera County 2002, 2008).

#### 7.3.3.4.2 Tulare Lake Area of the San Joaquin Valley Groundwater Basin

The Tulare Lake Area overlies seven groundwater subbasins of the San Joaquin Valley Groundwater Basin, as defined by DWR (DWR 2003a): the Westside, Kings, Tulare Lake, Kaweah, Tule, Pleasant Valley, and Kern subbasins, as shown in Figure 7.7. The Kern and Pleasant Valley subbasins have distinct hydrogeology and groundwater management from the other subbasins, and therefore are described separately.

*Northern Tulare Lake Area: Westside, Kings, Tulare Lake, Kaweah, Tule, Pleasant Valley, and Kern Subbasins*

*Hydrogeology and Groundwater Conditions*

*Hydrogeology*

The aquifer system in the Tulare Lake Area consists of younger and older alluvium, flood-basin deposits, lacustrine and marsh deposits and unconsolidated continental deposits. These deposits are configured within most parts of the basin to form an unconfined to semi-confined upper aquifer and a confined lower aquifer. These aquifers are separated by the Corcoran Clay (E-Clay) member of the Tulare Formation, which occurs at depths between 200 and 850 feet within the central and western portions of the basin, specifically in the Westside and Tulare Lake subbasins and in the western Kings, Kaweah, and Tule subbasins. Fine-grained lacustrine deposits up to 3,600 feet thick also are present in the Tulare Lake region (DWR 2003a, 2004v, 2004w, 2006l, 2006m, 2006n, 2006o, 2006p).

Prior to extensive use of groundwater in the basin, groundwater generally flowed toward Tulare Lake. Due to depressed groundwater levels and interception of surface water, the Tulare Lake Area is dry except during extreme flood events; and recharge of the Tulare Lake Area is limited.

Groundwater withdrawals in the Tulare Lake Area account for approximately 38 percent of the total groundwater withdrawals in the state of California (DWR 2013i). The CVP and SWP surface water supplies are used by many agricultural water users and several communities in the Tulare Lake Area to reduce reliance on groundwater and allow for groundwater recharge. In drier years when the CVP and SWP water supplies are limited, extensive groundwater pumping occurs to meet the water demands. In drier years, water users in the

Westside, Kings, Tulare Lake, and Kaweah subbasins may use groundwater for up to 75 percent of their water supply (DWR 2013i).

Areal recharge from precipitation provides most of the groundwater recharge, and seepage from stream channels provides the remaining groundwater recharge. Most of the recharge occurs as mountain-front recharge in the coarse-grained upper alluvial fans where streams enter the basin (USGS 2009). Prior to development of the Tulare Lake Area, surface water and groundwater exchange occurred throughout the basin in response to hydrologic conditions. When rapid agricultural growth and groundwater development occurred, the primary interaction of surface water with groundwater occurred as stream flow loss to underlying aquifers. In areas of severe overdraft in the Tulare Lake Area of the San Joaquin Valley Groundwater Basin, complete disconnection between groundwater and overlying surface water systems has occurred. In some areas with disconnected hydrology where streambeds are used as conveyance elements for irrigation purposes and to recharge groundwater, the streams become losing streams. Recent information indicates that between the spring 2010 and spring 2014, groundwater levels declined at some wells in this area by up to 10 feet (DWR 2014c, 2014d). The groundwater levels in some areas declined up to 10 feet between fall 2013 and fall 2014, and in some areas more than 10 feet.

#### *Groundwater Quality*

In the northern Tulare Lake Area (including the Westside, Tulare Lake, Kings, Kaweah, and Tule subbasins), groundwater in the upper unconfined/semi-confined aquifer is characterized by high calcium and magnesium sulfate as well as high TDS (DWR 2006l, 2006m, 2006n, 2013c). The lower confined aquifer is approximately 300 feet below the ground surface and above the Corcoran Clay, and is characterized by high sodium sulfates and less dissolved solids than the upper aquifer.

Groundwater quality in the northern Tulare Lake Area is poor in portions of the upper aquifer, due to agricultural drainage issues and naturally occurring high salinity soils. Groundwater in the Westside subbasin is of poor quality due to historical agricultural drainage. The high clay content of the soils that comprise the upper aquifer restricts the movement of groundwater in the aquifer, further contributing to water quality impacts from root zone drainage. Studies have shown that the quality of the upper 20 to 200 feet of the saturated groundwater zone have been affected by crop irrigation and drainage issues (Reclamation 2006). The eastward movement of saline groundwater from the Westside subbasin also adversely affects the groundwater quality in adjacent subbasins, such as in the vicinity of the City of Mendota and Fresno Slough (Reclamation 2006).

The Westside and Kings subbasins also have localized areas with high boron concentrations (CVRWQCB 2011). The Kings and Tulare Lake subbasins have localized areas with high arsenic and hydrogen sulfide. In the Kaweah subbasin and the northern portion of the Tule subbasin, groundwater is of the calcium bicarbonate type with high TDS and localized areas with high nitrate concentrations (DWR 2004v, 2004w, 2013c). In the Kaweah subbasin, groundwater is characterized by moderate to high TDS concentrations (DWR 2004v, 2013c). In the Tule subbasin, low to moderate TDS concentrations occur in the most of the subbasin with high concentrations in areas with poor drainage (DWR 2004w, 2013c). On the western side of the subbasin there is shallow saline water. The eastern side of the subbasin has areas of high nitrates (DWR 2013c, 2004b). The Westside and Kings subbasins also have localized areas with high boron concentrations (CVRWQCB 2011). The Kings and Tulare Lake subbasins have localized areas with high arsenic and hydrogen sulfide. In the Kaweah subbasin and the northern portion of the Tule subbasin, groundwater is of the calcium bicarbonate type with high TDS and localized areas with high nitrate concentrations (DWR 2004v, 2004w, 2013c). Portions of the Kings subbasin are characterized by high nitrate concentrations due to historical agricultural practices (CVRWQCB 2011; DWR 2006n, 2013c). High DBCP and other pesticides concentrations occur in localized areas within the Westside, Kings, Tulare Lake, Kaweah, and Tule subbasins (CVRWQCB 2011).

A recent study evaluated high nitrate concentrations in groundwater and related public health issues in four community water systems with recorded violations related to nitrates in drinking water (Pacific Institute 2011). The communities served by the water systems were evaluated to assess the quality of groundwater provided by their water distribution systems and potential costs to the communities. Overall, this significant degradation of groundwater quality throughout the area has implications on public health and economic sustainability of the region. The findings of the report indicated that improved notification procedures, new funding mechanisms, and improved regulations and incentives are needed to provide safe drinking water, as described in Chapter 18, Public Health. The four water systems included Beverly Grand Mutual Water Company (Tule subbasin), Lemon Cove Water Company (east of Tule subbasin), El Monte Village Mobile Home Park (Kings subbasin), and Soults Mutual Water Company (Kings subbasin) in Tulare County.

High groundwater salinity occurs in many locations in the Tulare Lake Area. Salts are imported into the Tulare Lake Area through irrigation with Delta water and salts added through application of fertilizers, and other salt containing materials. Except in very wet years, the Tulare Lake Area has no natural drainage, so imported salts accumulate in the groundwater unless captured and sequestered. This salt accumulation causes groundwater quality degradation for potable and agricultural uses.

To the high nitrate and salinity problems, the Central Valley Salinity Alternatives for Long-Term Sustainability (CV-Salts) was formed as a strategic initiative to address accumulation of salts and nitrates throughout the region in a comprehensive, consistent and sustainable manner (CVRWQCB 2015; SWRCB 2015). The Central Valley Regional Water Quality Control Board and the State Water Resources Control Board in cooperation with stakeholders and the Central Valley Salinity Coalition collaborate to review and update the Water Quality Control Plans for the Sacramento Valley and San Joaquin Valley groundwater basins and the Delta Plan for salinity management, as described in Chapter 6, Surface Water Quality. The goals of this program are to address groundwater nitrate legacy conditions and current loadings, direct impacts of high nitrates on drinking water supplies from diverse sources, and economic costs for water treatment or alternate supplies. A final Salinity and Nitrate Management Plan is scheduled to be completed in May 2016.

##### *Overall Groundwater Conditions*

The Westside, Kings, Tulare Lake, Kaweah, Tule, and Kern subbasins were designated by the CASGEM program as high priority. The Pleasant Valley subbasin was designated as low priority.

##### *Groundwater Use and Management*

The northern Tulare Lake Area uses groundwater for its many water needs. Groundwater is used conjunctively with surface water, where possible, when surface water supplies are not sufficient to meet the region’s demand for agricultural, industrial, and municipal uses (DWR 2003a). For example, the cities of Fresno and Visalia are almost entirely dependent on groundwater for their water supplies. Most groundwater subbasins in the Tulare Lake Area are in a state of overdraft as a consequence of groundwater pumping that exceeds the basin’s safe yield (the amount of natural and induced recharge available to replenish the basin). As a result, the aquifers in these groundwater basins contain a significant amount of potential storage space that can be filled with additional recharged water. However, cities in the northern Tulare Lake Area are considering other water sources and/or groundwater banking programs.

###### *Westside Subbasin*

The Westside subbasin is located within western Fresno County and northwestern Kings County. The majority of lands within the Westside subbasin are within the Westlands Water District which uses CVP surface water, water transferred from other agencies, and groundwater. Groundwater levels in the Westside subbasin have fluctuated over the past 46 years in response to the availability of surface water deliveries from the CVP (WWD 2013). The lowest recorded average groundwater level below the Corcoran Clay between 1950 and 1968 (prior to delivery of CVP water to the subbasin) was 156 feet below mean sea level, which occurred in 1967. Groundwater elevations increased after 1968 to 89 feet above mean sea level in 1987.

Groundwater levels are closely related to the availability of surface water. In the 1977 drought when CVP water supplies were substantially reduced, groundwater withdrawals decreased the groundwater elevation by 97 feet in 1 year (WWD 2013). In 1991 and 1992 (during the 1987 to 1992 drought), the groundwater elevation declined to 62 feet below mean sea level. In 1996, the Westlands Water District adopted a groundwater management plan to preserve and enhance reliable groundwater resources; provide long-term availability of high quality groundwater; maintain local control of groundwater in the district; and minimize the cost and impact of groundwater use (WWD 2013a). The groundwater levels recovered following the drought that ended in 1992. However, in 2010, the CVP allocation was 45 percent of the contract amount, and the average groundwater elevation was 9 feet above mean sea level (WWD 2011). In 2012, the CVP allocation was 40 percent of the contract amount, and the average groundwater elevation decreased to 1 foot above mean sea level (WWD 2013). Recent information indicates that between the spring 2013 and spring 2014, groundwater levels have declined at some wells in the Westside subbasin by up to 40 feet within the 1-year period (DWR 2014c, 2014d).

Subsidence has occurred in the Westside subbasin as a result of the high rate of historic groundwater pumping resulting in reduced groundwater levels and the compaction of fine grained soils. In some areas, the land surface elevation has decreased substantially. It is estimated that extensive groundwater pumping prior to delivery of CVP water resulted in compaction of water bearing sediments and land subsidence of 1 to 24 feet between 1926 and 1972 (WWD 2013). The Westland Water District has referenced that the Department of Water Resources estimated the amount of subsidence since 1983 to be almost 2 feet in some areas of the District with most of that subsidence occurring since 1989 (WWD 2013). The USGS monitoring between 2003 and 2010 indicated no subsidence in the Westside subbasin area during the same time period while at least 1.8 feet of subsidence occurred in the Delta-Mendota subbasin area near the southern part of the Delta-Mendota Canal (USGS 2013a).

#### *Kings Subbasin*

The Kings subbasin includes most of central and eastern Fresno County, and northern Kings and Tulare County (DWR 2006n, 2013c). Two major groundwater depressions occur near the Fresno-Clovis urban area and approximately 20 miles southwest of Fresno in the Raisin City Water District (DWR 2013c). On average, the majority of this subbasin has experienced generalized declines in groundwater levels of approximately 20 feet between 2003 and 2011 (KRCD 2012a). The Kings subbasin is in overdraft condition and overdraft continues to be a major long-term problem due to increasing water demand and reduced surface water supply reliability. Recent information indicates that between the spring 2010 and spring 2014, groundwater levels declined at some wells in the Kings subbasin by up to 20 feet (DWR 2014c, 2014d).

Groundwater is used for a portion of agricultural water demands and for most of the domestic and industrial water demands in Fresno County, including for water users in the communities of Fresno, Clovis, Sanger, Fowler, Selma, Kingsburg, Reedley, Dinuba, Orange Cove, Raisin City, and Riverdale (CVRWQCB 2011; Fresno County 2000; KRCD 2012a).

The City of Fresno, which previously used groundwater for the municipal water supplies, has developed a surface water supply program. The groundwater is recharged through direct recharge and from applied agricultural water, and groundwater inflows from the adjacent foothills (City of Fresno 2015).

Several water agencies are coordinating efforts in the Kings subbasin to mitigate the extensive historical declines in groundwater levels resulting from pumping withdrawals. Current Kings subbasin groundwater recharge efforts include a total of 4,000 acres of dedicated recharge ponds (CGRA 2012). One of the biggest groundwater recharge efforts in the Kings subbasin area is the McMullin On-farm Flood Capture and Recharge Project near Raisin City (KRCD 2013).

#### *Tulare Lake Subbasin*

The Tulare Lake subbasin includes most of Kings County (DWR 2006m, 2013c). In the Tulare Lake subbasin, water levels have declined nearly 17 feet on average from 1970 through 2000. Fluctuations in water levels have been most exaggerated in the Tulare Lakebed area of the subbasin, which has experienced both the steepest declines and the steepest rises over time. Groundwater overdraft conditions also prevail in this subbasin, similar to the Kings subbasin. Recent information indicates that between the spring 2010 and spring 2014, groundwater levels declined at some wells in the Tulare Lake subbasin by up to 20 feet (DWR 2014c, 2014d).

Groundwater is used for a portion of agricultural water demands and for most of the domestic and industrial water demands in Kings County, including the communities of Corcoran, Hanford, Lemoore, and Kettleman Hills (CVRWQCB 2011; KRCD 2012a).

#### *Kaweah Subbasin*

The Kaweah subbasin includes a portion of eastern Kings County and northwestern Tulare County. Water levels in this subbasin declined about 12 feet on average from 1970 through 2000 (DWR 2004v, 2013c). The basin is subject to large fluctuations in water levels since the 1970s to as low as 35 feet lower than the 1970 water level in 1995 to 25 feet higher in 1988. These fluctuations correspond to successive dry years (declines) and wet years (rebounds), respectively. Recent information indicates that between the spring 2010 and spring 2014, groundwater levels declined at some wells in the Kaweah subbasin by up to 20 feet (DWR 2014c, 2014d). The Kaweah Delta Water Conservation District operates recharge facilities to supplement groundwater recharge that occurs along the natural stream channels (KDWCD 2006). Water is released from the Terminus Reservoir on the Kaweah River to flow into over 40 recharge basins throughout the basin. Use of CVP water from the Friant-Kern Canal by Tulare Irrigation District and Ivanhoe Irrigation District reduces the need for groundwater withdrawals when the CVP water is available.

Groundwater is used for a portion of agricultural water demands and for most of the domestic and industrial water demands in the subbasin, including for water users in the communities of Visalia, Tulare, and Lindsay (CVRWQCB 2011; Tulare County 2010).

#### *Tule Subbasin*

The Tule subbasin includes southwestern Tulare County. Water levels in this subbasin increased by about 4 feet on average from 1970 through 2000 (DWR 2004w, 2013c). Water levels have fluctuated during dry and wet years between 16 feet below the 1970 water level in 1995 to 20 feet above the 1970 water level in 1988. Recent information indicates that between the spring 2010 and spring 2014, groundwater levels declined at some wells in the Tule subbasin by up to 20 feet (DWR 2014c, 2014d). The Deer Creek and Tule River Authority implemented a groundwater management plan in 2006 in the Tule Subbasin (DCTRA 2012). The plan participants include Lower Tule River Irrigation District, Pixley Irrigation District, Porterville Irrigation District, Terra Bella Irrigation District, Saucelito Irrigation District, Tea Pot Dome Irrigation District, Vandalia Irrigation District, Tipton Community Services District, Poplar Community Services District (primarily the City of Porterville), and Woodville Public Utility District. Many of these agencies have CVP water service contracts and some of these agencies have surface water rights. Groundwater recharge occurs in more than 25 groundwater recharge basins and along the Tule River and Deer Creek channels.

#### *Southern Tulare Lake Area: Kern County Subbasin*

The Kern County subbasin is located between the Tule and Tulare Lake groundwater subbasins on the north, the Sierra Nevada and Tehachapi Mountains granitic rock on the east, and the marine sediments of the Coast Ranges on the west. The major water suppliers within the Kern County subbasin include Kern County Water Agency and the City of Bakersfield.

##### *Hydrogeology and Groundwater Conditions*

The unconfined aquifer in the Kern County Groundwater subbasin is composed primarily of sediments that were deposited during the tertiary and quaternary age. The Tulare Formation, located in the western portion of the subbasin, includes the Corcoran Clay unit which occurs at depths of 300 to 650 feet and overlies the confined aquifer (DWR 2006o, 2013c).

Net groundwater level changes in the Kern County subbasin varied in different portions of the subbasin between 1970 and 2000 (DWR 2006o, 2013c). Since the late 1970s, the groundwater levels have ranged from an increase of over 30 feet in the southeastern portion of the subbasin to a decrease of up to 25 feet near Bakersfield and 50 feet near McFarland/Shafter. Recent information indicates that between the spring 2013 and spring 2014, groundwater levels declined at some wells in the Kern County subbasin by up to 40 feet (DWR 2014c, 2014d). The groundwater levels in some areas declined up to 10 feet between fall 2013 and fall 2014, and in some areas more than 10 feet.

Complete hydraulic disconnection between the groundwater and overlying surface water systems has occurred in the Kern County area. Kern River, a losing stream, is used as a conveyance element for irrigation purposes and to recharge groundwater.

Groundwater quality in the region is generally characterized by calcium bicarbonate in the shallow aquifers, and the groundwater quality is generally suitable for most uses. Lower aquifers have higher sodium concentrations (DWR 2006o, 2013c). Salinity is a significant groundwater quality issue in the region. Salt from imported CVP and SWP water accumulates annually in groundwater because the Tulare Lake is a closed system without any natural outlets (KCWA 2011).

Shallow groundwater with high salinity occurs in the western and southern portions of the Kern County subbasin and is related to drainage problems for irrigated agriculture (DWR 2006o, 2013c). An agricultural drainage study showed that shallow groundwater occurs between 0 and 30 feet below the ground surface in the southern portion of the Kern County subbasin (DWR 2013j). The shallow groundwater is characterized by high TDS, sodium chloride, selenium, and sulfates (DWR 2013j). Areas with high nitrate and pesticide concentrations occur in localized areas due to historic agricultural practices including irrigation and dairy wastes (CVRWQCB 2011; DWR 2006o). Elevated arsenic concentrations tend to occur in isolated areas associated with lakebed deposits. Selenium and chromium also naturally occur in portions of the subbasin (KCWA 2011).

#### *Groundwater Use and Management*

The Kern County subbasin is located in western Kern County. The majority of the lands within the Kern County subbasin are within Kern County Water Agency or the City of Bakersfield. Water supplies in the subbasin include local surface water, CVP and SWP water supplies, and groundwater. The subbasin includes a portion of the land evaluated in the Tulare Lake Basin Portion of the Kern Region IRWMP. It is estimated that over the long-term, approximately 39 percent of water supplies in this area are met by groundwater (KCWA 2011). Groundwater can provide up to 60 percent of the total water supply in drier years.

Much of the groundwater is withdrawn by individuals or farmers who do not maintain groundwater extraction records. Historically, groundwater extractions were estimated based upon electricity use, changes in groundwater storage, or changes in crop patterns and/or water requirements (DWR 2004o, 2013c; KCWA 2011).

Most of the groundwater is used by agriculture and the communities of Bakersfield, Rosedale, Shafter, Delano, Taft, and Wasco (KCWA 2011). The City of Bakersfield and surrounding unincorporated areas use surface water and groundwater. The groundwater supplies in 2010 include water provided by California Water Service Company; East Niles Community Services District;, Kern County Water Agency Improvement District No. 4 and North of the River Municipal Water District; and Vaughn Water Company (California Water Service Company 2011a; ENCSD 2011; KCWA 2011; KCWA and NORMWD 2011; Vaughn Water Company, Inc. 2011). The water entities along with adjacent water agencies manage the groundwater basin levels through ongoing recharge projects and conjunctive use projects.

##### *Conjunctive Use and Groundwater Banking*

Conjunctive use is an important component of water management in the Kern County subbasin. Many groundwater banking facilities supplement water supplies delivered to customers in dry years, when insufficient surface water supplies are available to meet demands.

More than 30,000 acres of groundwater recharge ponds are estimated to exist in the Kern County subbasin area (KCWA 2011). Infrastructure used for groundwater banking includes recharge basins, recharge canals, recovery wells, and conveyance pipelines. In addition, connections to regional conveyance infrastructure conveys water from the local water supplies, including the Kern River; Friant-Kern Canal; the Cross Valley Canal; and California Aqueduct to the recharge areas. Groundwater banking programs have developed various interties to the regional conveyance systems, such as the Semitropic Water Storage District Intake Canal and the Kern Water Bank Canal (KCWA 2011).

The major groundwater banking programs in Kern County include the Kern Water Bank operated by the Kern Water Bank Authority; the Semitropic Groundwater Bank, operated by the Semitropic Water Storage District; a groundwater bank operated by the North Kern Water Storage District; a groundwater bank operated by the City of Bakersfield; and a groundwater bank operated by Rosedale-Rio Bravo Water Storage District.

The Kern Water Bank Authority is located west of Bakersfield and covers nearly 30 square miles of the Kern County subbasin. The Kern Water Bank includes recharge ponds where water from local surface streams and the SWP infiltrates into the aquifer (KCWA n.d.; KWBA 2011). Eighty-four recovery wells are used to pump groundwater out of the aquifer in dry years when additional water is needed for irrigation since the program began operations in 1995 (KCWA 2011).

The Semitropic Water Storage District is located west of Wasco and covers more than 220,000 acres (SWSD 2011a). The Semitropic Water Storage District Stored Water Recovery Unit (a subunit of the overall Semitropic Water Storage District Water Bank) partnered with the Antelope Valley Water Bank, located close to Rosamond in the Kern County portion of the Antelope Valley, to form the Semitropic-Rosamond Water Bank Authority (SWSD 2011b). The major banking partners of Semitropic Water Storage District include (SWSD 2014):

- Metropolitan Water District of Southern California
- Santa Clara Valley Water District
- Alameda County Water District
- Zone 7 Water Agency
- Poso Creek Water Company
- Newhall Land & Farming Company
- San Diego County Water Authority
- Homer, LLC
- City of Tracy
- Harris Farms

Other banking programs include (KCWA and NORMWD 2011; KCWA 2011, n.d.):

- Arvin-Edison Water Storage District Banking

- Buena Vista Water Storage District Banking
- Cawelo Water District Banking
- City of Bakersfield 2800 Acres Recharge Facility
- Kern County Water Agency Improvement District No. 4 Pioneer Project and Allen Road Complex Well Field
- Kern Delta Water District Banking
- Kern Tulare and Rag Gulch Water Districts Banking
- Rosedale-Rio Bravo Water Storage District Banking (developed with Kern County Water Agency Improvement District No. 4)

*Western Tulare Lake Area: Pleasant Valley Subbasin*

The Pleasant Valley subbasin is located within the western portions of Fresno and Kings Counties.

*Hydrogeology and Groundwater Conditions*

Tertiary continental and marine sediments of the Coast Ranges and Kettleman Hills form the western boundary of the Pleasant Valley subbasin (DWR 2006p, 2013c). Alluvium of the San Joaquin Valley extends into the subbasin from the north, east, and south. Ephemeral streams from the Coast Ranges and Kettleman Hills flow into the subbasin. Groundwater recharge occurs primarily along these and other streams within the subbasin.

In the Pleasant Valley subbasin, groundwater levels are generally continuing a historical trend of decline. DWR measurements indicated a decline of 5 to 25 feet during the 1990s (DWR 2006p, 2013c).

Water quality in the Pleasant Valley subbasin is characterized by high TDS (CVRWQCB 2011; DWR 2006p, 2013c). Localized areas of high concentrations of boron, calcium, chlorides, magnesium, pesticides, sodium, bicarbonates, and sulfates occur in the groundwater.

The Pleasant Valley subbasin was designated by the CASGEM program as low priority.

*Groundwater Use and Management*

Groundwater is used to meet agricultural and municipal water demands in the Pleasant Valley subbasin (DWR 2006p, 2013c). Due to limited recharge capabilities in the subbasin, surface water is used either completely or conjunctively in western Fresno and Kings Counties. The communities of Avenal and Coalinga use CVP surface water due to groundwater quality, as described in Chapter 5, Surface Water Resources and Water Supplies (Reclamation 2012).

### 7.3.4 San Francisco Bay Area Region

The San Francisco Bay Area Region includes portions of Contra Costa, Alameda, Santa Clara, and San Benito counties that are within the CVP and SWP service areas. The SWP water users in Napa County do not use groundwater. Therefore, groundwater resources for Napa County are not described in this EIS.

There are several groundwater basins in the San Francisco Bay Area Region; however, only some of the basins are within the CVP and SWP service areas evaluated in this EIS. The portions of the San Francisco Bay Area Region within the CVP and/or SWP service areas include the Pittsburg Plain, Clayton Valley, Ygnacio Valley, Arroyo Del Hambre Valley, San Ramon Valley, Livermore Valley, Castro Valley, and Santa Clara Valley groundwater basins within the San Francisco Bay Hydrologic Region; and Gilroy-Hollister Valley Groundwater Basin within the Central Coast Hydrologic Region.

Groundwater represents approximately 15 percent of the agricultural, municipal, and industrial water supplies in the San Francisco Bay Area (DWR 2013i). Conjunctive use programs have been implemented by several agencies to optimize the use of groundwater and surface water sources.

Groundwater quality in the San Francisco Bay Area is generally suitable for most agricultural and municipal uses, but concerns exist about groundwater contamination from industrial and agricultural chemical spills, leaky underground and above ground storage tanks, landfill leachate, and poorer-quality surface water bodies. There were over 800 groundwater cleanup projects in the area with the majority resulting from leaky fuel tanks (DWR 2013i). Portions of the San Francisco Bay Area Region along the shorelines include aquifers that are susceptible to seawater intrusion.

In the southern San Francisco Bay Area Region, groundwater and surface water are connected through in-stream and off-stream artificial recharge projects, in which surface water is delivered to water bodies that permit the infiltration of water to recharge underlying aquifers. Surface waters recharge aquifers in other regions of the San Francisco Bay Area Region along streambeds, especially in areas with depressed groundwater levels that have resulted from extensive groundwater pumping.

This section describes groundwater in subbasins within CVP and/or SWP water service areas, including Pittsburg Plain, Clayton Valley, Arroyo Del Hambre Valley, Ygnacio Valley, and San Ramon Valley subbasins in Contra Costa County; East Bay Plain and Livermore Valley subbasins in Contra Costa and Alameda counties; Castro Valley subbasin in Alameda County; Santa Clara and Llagas Area subbasins in Santa Clara County; and Bolsa, Hollister, and San Juan Bautista Area subbasins in San Benito County, as shown in Figure 7.8.

### *7.3.4.1 San Francisco Bay Hydrologic Region*

#### 7.3.4.1.1 Hydrogeology and Groundwater Conditions

Each of these groundwater basins in the San Francisco Bay Hydrologic Region contains unique hydrogeologic characteristics. However, generally the water bearing materials consist of alluvial, unconsolidated sand, sand and gravel, and clay (DWR 2004x, 2004y, 2004z, 2004aa, 2004ab, 2004ac, 2004ad, 2004ae, 2006q, 2006r, 2013d). Aquifers in these basins are hydrologically connected to surface water bodies, such as the San Joaquin River, Suisun Bay, local streams, and San Francisco Bay.

The movement of groundwater is locally influenced by features such as faults and structural depressions and operating production wells; however, groundwater generally flows toward the nearby bays. Groundwater levels in the area exhibit seasonal variation and have been historically depressed from significant groundwater use. However, as groundwater use decreased over the last few decades following implementation of surface water projects, groundwater levels have risen significantly. Over the entire period of record, groundwater levels have shown only a slight decline and are stable in more recent years.

*Pittsburg Plain, Clayton Valley, Ygnacio Valley, and Arroyo Del Hambre Valley Groundwater Basins*

The Pittsburg Plain, Clayton Valley, Ygnacio Valley, and Arroyo Del Hambre Valley groundwater basins represent the majority of groundwater storage in northern Contra Costa County. Except for portions of the Pittsburg Plain, most of these groundwater basins are not located within the Delta.

These basins extend inland from Suisun Bay towards Mt. Diablo. The Pittsburg Plain Groundwater Basin is composed of Pleistocene deposits of consolidated and unconsolidated clay sediments; overlain by alluvial soft water-saturated muds, peat, and loose sands (DWR 2004x, 2013d). The Clayton Valley and Ygnacio Valley groundwater basins are composed of unconsolidated alluvium and semi-consolidated alluvium interbedded with clay, sand, and gravel lenses. Along Suisun Bay, the water bearing formations are composed of alluvial soft water-saturated muds, peat, and loose sands (DWR 2004y, 2004z, 2004aa, 2013d).

Groundwater levels are relatively stable because the groundwater is recharged from streams (DWR 2004x, 2004y, 2004z, 2004aa, 2013d). The streams include Kirker and Willow creeks in the Pittsburg Plain Groundwater Basin; Marsh Creek in the Clayton Valley Groundwater Basin; Walnut and Grayson creeks in the Ygnacio Valley Groundwater Basin; and Alhambra Creek in the Arroyo Del Hambre Valley Groundwater Basin. There are no recent data for these basins related to groundwater levels or storage capacities.

The groundwater in this area is characterized by moderate to high TDS (DWR 2004x, 2004y, 2004z, 2004aa, 2013d). High nitrate concentrations occur in some rural areas of these basins (Contra Costa County 2005).

The Pittsburg Plain, Clayton Valley, Ygnacio Valley, and Arroyo Del Hambre Valley groundwater basins were designated by the CASGEM program as very low priority.

*San Ramon Valley Groundwater Basin*

The San Ramon Valley Groundwater Basin is located in southern Contra Costa County and extends from the Alamo area southward under the Town of Danville and City of San Ramon to the county boundary.

The basin is a closed basin characterized by alluvial fan deposits of sand, gravel, silt, and clay sediments (DWR 2004ab, 2013d). Multiple faults within the basin affect groundwater movement.

There are no recent data for this basin related to groundwater levels, storage capacities, or quality (DWR 2004ab, 2013d).

The San Ramon Valley Groundwater Basin was designated by the CASGEM program as very low priority.

#### *Livermore Valley Groundwater Basin*

The Livermore Valley Groundwater Basin extends under northeastern Alameda County and southern Contra Costa County. The Livermore Valley Groundwater Basin contains groundwater-bearing materials originating from continental deposits from alluvial fans, outwash plains, and lakes (DWR 2006q, 2013d).

The Main Basin is the aquifer that includes the highest yielding aquifers and highest quality groundwater (Zone 7 2012). The Main Basin generally is divided into the Upper Aquifer Zone and Lower Aquifer Zone which are separated by a relatively continuous silty clay lens. Water from the Upper Aquifer Zone moves into the Lower Aquifer Zone when groundwater levels in the upper zone are high.

Well yields are mostly adequate and in some areas can produce large quantities of groundwater for all types of wells (DWR 2006q, 2013d). The movement of groundwater is locally impeded by structural features such as faults that act as barriers to groundwater flow, resulting in varying water levels in the basin. Groundwater follows a westerly flow pattern, similar to the surface water streams, along the structural central axis of the valley toward municipal pumping centers (Zone 7 2005).

Groundwater levels in the main portion of the Livermore Valley Groundwater Basin started declining in the early 1900s when groundwater pumping removed large quantities of groundwater (Zone 7 2005, 2010, 2013). This trend continued until the late 1960s when Zone 7 Water Agency began importing SWP water. Subsequently, Zone 7 Water Agency developed surface water projects to capture local runoff. Local runoff and SWP water is stored in Lake Del Valle and used to recharge groundwater within the Livermore Valley. The importation of additional surface water alleviated the pressure on the aquifer, and groundwater levels started to rise in the 1970s. However, historical lows were reached during periods of drought. During the recent dry period, groundwater levels declined 7 to 17 feet throughout the aquifers used by Zone 7 Water Agency between 2011 and 2012.

The Livermore Valley Groundwater Basin is characterized by localized areas of high boron, nitrate, and TDS (DWR 2006q, 2013; Zone 7 2012). High boron levels can be attributed to marine sediments adjacent to the basin.

Nitrate concentrations generally are within potable water criteria; however, high nitrate concentrations occur in some locations of the upper aquifer (Zone 7 2012). The source of nitrates appears to be related to agricultural activities, wastewater disposal, and natural sources from decaying vegetation.

Salinity of the aquifer depends upon the quality of the water used for recharge operations. Salinity has increased over the past 30 years (Zone 7 2012) especially in the western portion of the Main Basin. Aquifers in the central and eastern portions of the Livermore Valley Groundwater Basin are generally recharged through streambeds and are characterized by lower salinity due to the high recharge rate.

The Livermore Valley Groundwater Basin was designated by the CASGEM program as medium priority.

#### *Castro Valley Groundwater Basin*

The Castro Valley Groundwater Basin is located in the Castro Valley area of Alameda County between San Lorenzo Creek on the east and the Hayward Fault on the west (Castro Valley 2012).

The basin is composed of alluvial deposits of sand, gravel, silt, and clay sediments (DWR 2004ac, 2013d). Previous studies indicated that the maximum yield was about 140,000 gallons per day (Castro Valley 2012).

The groundwater is characterized by bicarbonates with calcium and sodium. Localized contamination has occurred in this shallow aquifer related to agricultural activities and underground storage tanks (Castro Valley 2012).

The Castro Valley Groundwater Basin was designated by the CASGEM program as very low priority.

#### *Santa Clara Valley Groundwater Basin*

The Santa Clara Valley Groundwater Basin includes three subbasins in areas that are within the CVP and/or SWP service areas. The three subbasins include the East Bay Plain subbasin in Contra Costa and Alameda counties, Niles Cone subbasin in Alameda County, and Santa Clara subbasin in Santa Clara County.

##### *East Bay Plain Subbasin*

The East Bay Plain subbasin is an alluvial plain that extends from San Pablo Bay southward to the Niles Cone subbasin, and extends under San Francisco Bay (DWR 2004ad, 2013d; EBMUD 2013). The alluvium consists of unconsolidated sediments of mud, silts, sands, and clays. Multiple faults within the subbasin affect groundwater movement. Groundwater levels declined to approximately 250 feet below the ground surface until the mid-1960s when groundwater levels began to increase. By 2000, groundwater levels were close to the ground surface. The groundwater quality is characterized as calcium and sodium bicarbonate with moderate to high TDS. Higher TDS concentrations occur near San Francisco Bay where localized sea water intrusion has occurred. High nitrate concentrations occur in localized areas due to historic agricultural activities.

The East Bay Plain subbasin was designated by the CASGEM program as medium priority.

##### *Niles Cone Subbasin*

The Niles Cone subbasin is mainly comprised of the alluvial fan along Alameda Creek. The Hayward Fault crosses the Niles Cone subbasin and further separates the subbasin into the Below Hayward Fault (west of the Hayward Fault) and Above Hayward Fault (east of the Hayward Fault) subbasins (ACWD 2012; DWR 2006r, 2013d).

The Niles Cone subbasin was in overdraft condition through the early 1960s. After 1962, groundwater levels increased as SWP water was delivered to the area and used to recharge the groundwater subbasin (DWR 2006r, 2013d).

The main groundwater quality impairment in the Niles Cone subbasin is saltwater intrusion caused by groundwater pumping (ACWD 2012; DWR 2006r, 2013d). In the 1950s the migration of saline water extended into the Above Hayward Fault subbasin, and migrated into deeper aquifers. Alameda County Water District has developed aquifer reclamation programs to help control the movement of saline water and restore the quality of groundwater in the affected aquifers, as described below.

Niles Cone subbasin was designated by the CASGEM program as medium priority.

#### *Santa Clara Subbasin*

The Santa Clara subbasin is located within Santa Clara County along a structural trough that parallels the Coast Ranges and extends from the Diablo Range and Santa Cruz Mountains. The water bearing formations of the Santa Clara subbasin include unconsolidated to semi-consolidated gravel, sand, silt and clay (DWR 2004ac, 2013d). The upper alluvial fan in the northern portion of the subbasin is characterized by coarse-grained sediments (SCVWD 2010). Towards the central portion of the subbasin, thick silty clay lenses are inter-bedded with thin sand and gravel lenses. The northern and central portions of the subbasin are locally referred to as the Santa Clara Plain (SCVWD 2011). The southern portion of the subbasin consists of extensive alluvial deposits of unconsolidated and semi-consolidated sediments and is referred to as the Coyote Valley (SCVWD 2010). The central portions and areas along the edges of the Santa Clara Plain subbasin consist of unconfined aquifers that provide recharge to the basin (SCVWD 2010, 2011). The Shallow Aquifer consists of water-bearing sediments that are less than 150 feet deep. The Principal Aquifer provides most of the groundwater supply for the Santa Clara Valley and is separated from the Shallow Aquifer by a confining lens in some areas of the Santa Clara Plain. The groundwater recharge primarily occurs due to percolation of water on the soil from precipitation or artificial recharge operations (as described below), seepage from stream beds, and subsurface inflow from surrounding hills.

In the Coyote subbasin, the groundwater aquifer is primarily unconfined with areas of perched groundwater above discontinuous clay deposits (SCVWD 2010, 2011). Groundwater recharge occurs along the streambeds. When the groundwater levels are high in the Coyote subbasin, groundwater seeps into the streams.

The movement of groundwater in the Santa Clara subbasin is locally influenced by groundwater recharge activities, proximity to streams, and operating production wells (SCVWD 2010). Regionally, groundwater in the Santa Clara Subbasin generally flows northwest toward the San Francisco Bay.

The Santa Clara subbasin has historically experienced decreasing groundwater level trends. Between 1900 and 1960, water level declines of more than 200 feet from groundwater pumping have induced unrecoverable land subsidence of nearly 13 feet (SCVWD 2011). Importation of surface water using CVP, SWP, and San Francisco Public Utilities District water supplies; and the development of an artificial recharge program have resulted in rising groundwater levels since the late 1960s. The groundwater levels in some portions of this subbasin declined up to 10 feet between fall 2013 and fall 2014, and in some areas more than 10 feet.

The groundwater quality in the Santa Clara subbasin is good to excellent and suitable for most beneficial uses. The groundwater meets all drinking water standards and can be used without additional treatment (SCVWD 2001, 2010). Some areas affected by historical saltwater intrusion exist in the northern portion of the Santa Clara subbasin in the Shallow Aquifer. Recent groundwater monitoring has indicated that seawater intrusion appears to be stabilizing (SCVWD 2012a). High nitrate concentrations occur in the Coyote Valley.

Santa Clara subbasin was designated by the CASGEM program as medium priority.

#### 7.3.4.1.2 Groundwater Use and Management

Use of groundwater in the San Francisco Bay Hydrologic Region varies extensively. In the basins within Contra Costa County (Pittsburg Plain, Clayton Valley, Ygnacio Valley, Arroyo Del Hambre Valley, and San Ramon Valley), local wells are used for small agricultural activities and landscape irrigation by individual land owners. In the Livermore Valley Groundwater Basin, groundwater is used for a major portion of the water supply.

*Pittsburg Plain, Clayton Valley, Ygnacio Valley, and Arroyo Del Hambre Valley Groundwater Basins*

Groundwater use is limited within northern Contra Costa County within the Pittsburg Plain, Clayton Valley, Ygnacio Valley, and Arroyo Del Hambre Valley groundwater basins. This area is located within the Contra Costa Water District or East Bay Municipal Utilities District service areas. These districts provide surface water to most water users in this area.

Within the Contra Costa Water District service area, groundwater use is limited (CCWD 2011). The use of existing Contra Costa Water District wells at the Mallard Well Fields is limited because of the threat of contamination from adjacent industrial areas.

The City of Pittsburg operates two municipal wells from the Pittsburg Plain Groundwater Basin (Pittsburg 2011).

The City of Martinez operates up to two wells in the Arroyo Del Hambre Valley Groundwater Basin to provide irrigation water to a municipal park (Martinez 2011).

### *San Ramon Valley Groundwater Basin*

Groundwater use is limited within the San Ramon Valley Groundwater Basin located in southern Contra Costa County. Local wells are used for small agricultural activities and landscape irrigation by individual land owners. This area is located within the East Bay Municipal Utilities District service area. The district provides surface water to most water users in this area.

### *Livermore Valley Groundwater Basin*

In the Livermore Valley Groundwater Basin, Zone 7 Water Agency administers oversight of the groundwater basins used for water supply and provides water to California Water Service Company, Dublin San Ramon Services District, City of Livermore, and City of Pleasanton. Zone 7 Water Agency only withdraws groundwater that has been recharged using surface water supplies (Zone 7 2010). The California Water Service Company, Dublin San Ramon Services District, and City of Pleasanton also withdraw groundwater (California Water Service Company 2011h; DSRSD 2011; City of Livermore 2011; City of Pleasanton 2011).

Zone 7 Water Agency manages the groundwater levels and quality in the Livermore Valley Groundwater Basin to maintain groundwater levels that would avoid subsidence and provide emergency reserves for the worst credible drought (DWR 2006q, 2013d).

Zone 7 Water Agency artificially recharges the Livermore Valley Groundwater Basin with local surface water supplies and SWP water by releasing the surface waters into the Arroyo Mocho and Arroyo Valle (Zone 7 2005, 2010). The infiltrated water is then pumped from the groundwater basin for various uses, mostly during the summer and during drought periods when local surface water supplies are diminished and the available SWP water supplies are less than the entitlement value Zone 7 Water Agency, City of Livermore, City of Pleasanton, Dublin San Ramon Services District, and California Water Service Company are permitted to withdraw groundwater from this subbasin.

In 2009, the Zone 7 Water Agency began operation of the Mocho Groundwater Demineralization Plant (Zone 7 2010). This plant is a wellhead treatment plant that produces potable water using reverse osmosis to remove TDS and hardness from the Main Basin.

### *Castro Valley Groundwater Basin*

Groundwater use is limited within the Castro Valley Groundwater Basin. Local wells are used for small agricultural activities and landscape irrigation by individual land owners (Castro Valley 2012). This area is located within the East Bay Municipal Utilities District service area. The district provides surface water to most water users in this area.

### *Santa Clara Valley Groundwater Basin*

The Santa Clara Valley Groundwater Basin includes the East Bay Plain, Niles Cone, and Santa Clara subbasins.

### *East Bay Plain Subbasin*

Groundwater use is limited within the East Bay Plains subbasin. Local wells are used for small agricultural activities and landscape irrigation by individual land owners (DWR 2004ad, 2013d; EBMUD 2013). Well fields that served the communities were initially constructed in the late 1800s and early 1900s, and were closed by 1930. This area is located within the East Bay Municipal Utilities District service area. The district provides surface water to most water users in this area. East Bay Municipal Utilities District initiated the Bayside Groundwater Project in 2009 to store surface water in wet years for use during droughts.

### *Niles Cone Subbasin*

Alameda County Water District is the primary water agency that relies upon the Niles Cone subbasin. This Alameda County Water District uses fresh groundwater from the Niles Cone subbasin and desalinated brackish groundwater in addition to local and imported surface water supplies. The Niles Cone subbasin is primarily recharged in the Alameda Creek watershed by percolation of local runoff and SWP water (ACWD 2011, 2012). In wetter years, when local water supplies are abundant, Alameda County Water District diverts some of the SWP allocation to the Semitropic Water Storage District in Kern County through a water banking agreement (as described above for the Kern County subbasin). This agreement allows Alameda County Water District to subsequently recover this water during drier years through an exchange agreement with Semitropic Water Storage District (ACWD 2012).

Alameda County Water District provides retail water supplies to the cities of Fremont, Newark, and Union City. The district has implemented treatment of brackish groundwater to allow previously unused groundwater to be used as a potable water source (ACWD 2011, 2012). In 2003, the Alameda County Water District Newark Desalination Facility began to remove salts and other constituents from the Niles Cone subbasin groundwater that is subject to seawater intrusion using a reverse-osmosis process. The aquifer reclamation program also includes withdrawing water to prevent a plume of brackish water in the Centerville-Fremont Aquifer from further migrating toward the Alameda County Water District Mowry Wellfield. Future groundwater desalination facilities are being evaluated by the district.

### *Santa Clara Subbasin*

Local water agencies and individual landowners use groundwater in the Santa Clara subbasin. The Santa Clara subbasin is primarily recharged from percolation of local runoff and water supplied by the CVP and/or SWP that is discharged to streambeds and recharge facilities (SCVWD 2011).

Treated water is provided by the Santa Clara Valley Water District to retail water agencies in order to promote conjunctive use of groundwater. The water entities in the Santa Clara subbasin that use treated surface water include the cities of Milpitas, Mountain View, Palo Alto, San Jose, Santa Clara, and Sunnyvale; California Water Service (Los Altos), Purissima Water District, and San Jose

Water Company. Several of these entities also use surface water from San Francisco Public Utilities Commission as part of their overall water supply.

In the Santa Clara subbasin, groundwater is withdrawn by local water suppliers and private well owners to meet municipal, domestic, agricultural, and industrial water needs (SCVWD 2011). Groundwater provides approximately 40 to 50 percent of total water supply in Santa Clara County in average water year conditions (SCVWD 2010). Within the Santa Clara subbasin, the users of the most groundwater include San Jose Water Company, City of Santa Clara, Great Oaks Water Company, California Water Service, and individual land owners primarily in the southern portion of the subbasin (SCVWD 2012a).

The Santa Clara Valley Water District is responsible for groundwater management in the Santa Clara subbasin, and operates a robust and flexible conjunctive use program that uses a variety of surface water sources: local supplies, imported SWP and CVP supplies, and imported transfer options. Surface water is also supplied to some water users by the San Francisco Public Utilities Commission (SCVWD 2001, 2010). The district operates an extensive system of in-stream and off-stream artificial recharge facilities to replenish the groundwater basin and provide more flexibility to manage water supplies. Eighteen major recharge systems allow local reservoir water and imported water to be released in over 30 local creeks and 71 percolation ponds that provide 393 acres for artificial recharge to the groundwater basin. Recharge in this subbasin occurs along streambeds and off-stream managed basins. Most of the recharge facilities are located in the Santa Clara subbasin. Two major recharge facilities, the Lower Llagas and Upper Llagas recharge systems, are located in the Llagas subbasin of the Gilroy-Hollister Groundwater Basin, as described below (SCVWD 2011, 2012a). The amount of water artificially recharged throughout the entire district depends upon the availability of local, CVP, and/or SWP surface water supplies.

#### *7.3.4.2 Central Coast Hydrologic Region: Gilroy-Hollister Valley Groundwater Basin*

Portions of the Gilroy-Hollister Valley Groundwater Basin within the CVP and/or SWP water service areas include the Llagas Area, Hollister Area, and San Juan Bautista Area subbasins.

##### 7.3.4.2.1 Hydrogeology and Groundwater Conditions

Each of these groundwater basins in the Gilroy-Hollister Valley Groundwater Basin contains unique hydrogeologic characteristics. However, generally the water bearing materials consist of alluvial, unconsolidated sand, sand and gravel, and clay. Within four subbasins in the study area of this EIS, groundwater flows towards the Pajaro River which flows to Monterey Bay (DWR 2004af, 2004ag, 2004ah, 2004ai, 2013d).

*Llagas Area Subbasin*

The water bearing formations of the Llagas subbasin include continental deposits of unconsolidated to semi-consolidated gravel, sand, silt and clay (DWR 2004af, 2013d; SCVWD 2010, 2011). Alluvium along the edges and the center portions of the subbasin are underlain by dense clayey soils. Younger alluvium does not have a well-defined clay subsoil.

As described above for the Santa Clara subbasin in the Santa Clara Valley Groundwater Basin, Santa Clara Valley Water District manages groundwater in the Llagas Area subbasin. Groundwater withdrawals in the Llagas subbasin have been relatively stable in recent years; and groundwater elevation has been stable since the late 1990s (SCVWD 2012a).

The groundwater quality in the Llagas subbasin is of good to excellent mineral composition and suitable for most beneficial uses (SCVWD 2010, 2012a). High nitrate concentrations occur in localized areas throughout the subbasin due to historical agricultural practices and wastewater effluent disposal. Santa Clara Valley Water District implemented a Nitrate Management Program in 1997 and nitrate concentrations are beginning to decline.

#### *Bolsa Area, Hollister Area, and San Juan Bautista Subbasins*

The Bolsa Area, Hollister Area, and San Juan Bautista Area subbasins extend over northern San Benito County. The subbasins are comprised of a sedimentary sequence that contains the principal aquifers underlying the Hollister and San Juan Valleys. The water bearing formation includes clay, silt, sand, and gravel (DWR 2004ag, 2004ah, 2004ai, 2013e).

The main water bearing formation in this area is composed of alluvium in the Bolsa Area and Hollister Area subbasins (San Benito County Water District 2012). The water bearing formations in the northern San Juan Bautista Area consist of alluvium (San Benito County Water District 2012). Groundwater movement within the aquifers is affected by the numerous faults, including the San Andreas and Calaveras Faults. Groundwater aquifers in this area include both unconfined and confined aquifer conditions with surficial clay deposits in the northern portions of these subbasins.

Groundwater in these subbasins is characterized by artesian conditions when groundwater levels are high, such as in the early 1900s (San Benito County Water District 2012). After the mid-1940s, groundwater levels declined with increased withdrawals. One of the lowest levels occurred in the late 1970s when the groundwater elevation was approximately 150 feet lower than the high water level conditions. In 2012, groundwater elevations ranged from 80 feet above mean sea level in the Bolsa Area subbasin to 700 feet above mean sea level in the San Juan Bautista Area subbasin.

The Bolsa Area, Hollister Area, and San Juan Bautista Area subbasins have localized areas with high concentrations of boron, chloride, hardness, metals, nitrate, sulfate, potassium, and TDS (San Benito County Water District 2012). The most substantial constituents include high TDS concentrations in the southeastern Bolsa Area subbasin, Hollister Area subbasin, and northern San Juan Bautista Area subbasin. High nitrate concentrations occur in the northern San Juan Bautista Area subbasin.

*Overall Groundwater Conditions*

The Llagas Area subbasin was designated by the CASGEM program as high priority. The Hollister Area and San Juan Bautista Area subbasins were designated as medium priority.

##### 7.3.4.2.2 Groundwater Use and Management

*Llagas Area Subbasin*

As described in Chapter 5, Surface Water Resources and Water Supplies, groundwater is the primary water supply for local water agencies and individual landowners in the Llagas Area subbasin. The subbasin is primarily recharged from percolation of local runoff and water supplied by the CVP that is discharged to recharge facilities managed by Santa Clara Valley Water District, as described above for the Santa Clara subbasin in the Santa Clara Valley Groundwater Basin (SCVWD 2011). The two major recharge facilities in the Llagas Area subbasin include the Lower Llagas and Upper Llagas recharge systems (SCVWD 2010).

The primary municipal water suppliers are the cities of Gilroy and Morgan Hill. Groundwater is used by these local water suppliers and private well owners to meet municipal, domestic, agricultural, and industrial water needs (SCVWD 2011).

*Bolsa Area, Hollister Area, and San Juan Bautista Subbasins*

Local water agencies and individual landowners use groundwater in the Bolsa Area, Hollister Area, and San Juan Bautista subbasins. The subbasins are primarily recharged from percolation of local runoff in streambeds, including water from Hernandez and Paicines Reservoirs that is released to Tres Pinos Creek (San Benito County Water District 2012).

San Benito County Water District provides CVP water to the cities of Hollister and San Juan Bautista, Sunnyslope County Water District, residential areas surrounding Hollister and Tres Pinos, and agricultural areas in northern San Benito County to reduce groundwater use by these areas (San Benito County Water District 2012). Most other water users in the subbasins rely upon groundwater and/or local surface water stored in Hernandez and Paicines Reservoirs.

In 2011, groundwater supplies provided 49 percent of the water used for agriculture, municipal, domestic, and industrial supply in the areas of the subbasin supplied by CVP water (San Benito County Water District 2012).

### 7.3.5 Central Coast Region

The Central Coast Region includes portions of San Luis Obispo and Santa Barbara counties served by the SWP. The Central Coast Region encompasses the southern planning area of the Central Coast Hydrologic Region (DWR 2009a).

The SWP water is provided to the Central Coast Region by the Central Coast Water Authority (CCWA 2013a). The facilities divert water from the SWP California Aqueduct at Devil's Den and convey the water to the 43 million gallon per day water treatment plant at Polonto Pass. The treated water is conveyed to municipal water users in San Luis Obispo and Santa Barbara counties to reduce groundwater overdraft in these areas.

Portions of the Central Coast Region that use SWP water are included in the Central Coast Hydrologic Region which includes 50 delineated groundwater basins, as defined by DWR (DWR 2003a). The basins vary from large extensive alluvial aquifers to small inland valleys and coastal terraces. Groundwater in the large alluvial aquifers exists in thick unconfined and confined basins.

Groundwater is generally used for urban and agricultural use in the Central Coast Region.

#### *7.3.5.1 Hydrogeology and Groundwater Conditions*

The areas within the SWP service area in the Central Coast Region include the Morro Valley and Chorro Valley groundwater basins in San Luis Obispo County; Santa Maria River Valley Groundwater Basin in San Luis Obispo and Santa Barbara counties; and San Antonio Creek Valley, Santa Ynez River Valley, Goleta, Foothill, Santa Barbara, Montecito, and Carpinteria groundwater basins in Santa Barbara County, as shown in Figure 7.9.

##### 7.3.5.1.1 Morro Valley and Chorro Valley Groundwater Basins

In the portions of San Luis Obispo County within the SWP service area near Morro Bay, groundwater is provided by Morro Valley and Chorro Valley groundwater basins. The water bearing formations are alluvium that consists of clays, silts, sands, and gravel that extend into the Pacific Ocean (DWR 2004aj, 2004ak, 2013e). The alluvium is recharged by seepage from streambeds and precipitation and irrigation water applied to the soils.

The groundwater has moderate TDS (DWR 2004aj, 2004ak, 2013e). Localized areas have high nitrate concentrations (Morro Bay 2011). Localized areas with organic contamination are also present; however, actions have been implemented to reduce the concentrations. Seawater intrusion occurs in localized areas near the Pacific Ocean.

The Morro Valley and Chorro Valley groundwater basins were designated by the CASGEM program as high priority.

##### 7.3.5.1.2 Santa Maria River Valley Groundwater Basin

The Santa Maria River Valley Groundwater Basin is located in San Luis Obispo and Santa Barbara counties. The water bearing formation is primarily unconfined alluvium with localized confined areas near the coast (DWR 2004 al, 2013e; SMVMA 2012). Recharge occurs along the streambeds. Groundwater levels in the Basin have fluctuated over the past 100 years with declining groundwater levels until the mid-1970s, recovery through the mid-1980s, and declining levels through the mid-1990s. Following importation of SWP water, groundwater levels increased to historic high levels. However, in the last decade, groundwater levels have gradually declined which could be partially due to reductions in Twitchell Reservoir releases for groundwater recharge since 2000. Groundwater levels have been maintained at levels above 15 feet above mean sea level in shallow and deep aquifers near the coast to avoid seawater intrusion. Groundwater recharge occurs along streambeds. Water released from Twitchell and Lopez reservoirs increase groundwater recharge rates (SMVMA 2012).

Groundwater quality issues in the Santa Maria Valley Groundwater Basin include hardness, nitrates, salinity, sulfate and volatile organic compounds (DWR 2004al, 2013e; San Luis Obispo County 2011; SMVMA 2012). TDS concentrations are moderate to high. There are localized areas in the basin with high sulfate concentrations. Volatile organic compound contamination was a major issue for two wells used by the City of San Luis Obispo in the late 1980s. High nitrate concentrations occur in the shallow aquifer due to historic agricultural practices. Higher salinity levels occur in the shallow aquifer near the coast than within the inland areas or in the deep aquifer.

The Santa Maria River Valley Groundwater Basin was designated by the CASGEM program as high priority.

#### 7.3.5.1.3 San Antonio Creek Valley Groundwater Basins

San Antonio Creek Valley Groundwater Basin is located along the Pacific Ocean within San Luis Obispo and Santa Barbara counties. The water bearing formations are characterized by unconsolidated alluvial and terrace deposits of sand, clay, silt, and gravel (DWR 2004dq, 2013e). Groundwater flows towards the Pacific Ocean. A groundwater barrier to the east of the Pacific Ocean creates the Barka Slough. Groundwater has declined in some areas of the basin over the past 60 years. Groundwater quality issues include areas with high salinity near the Pacific Ocean.

The San Antonio Creek Valley Groundwater Basin was designated by the CASGEM program as medium priority.

#### 7.3.5.1.4 Santa Ynez River Valley Groundwater Basins

Several groundwater basins in Santa Barbara County are in a state of overdraft, including the Santa Ynez River Valley Groundwater Basin. The Santa Ynez Groundwater Basin is located along the Pacific Ocean in southwestern Santa Barbara County. The water bearing formations are characterized by unconsolidated alluvial and terrace deposits of gravel, sand, silt, and clay (DWR 2004an, 2013e). Groundwater flows towards the Santa Ynez River, and then towards the Pacific Ocean. Groundwater recharge occurs along the stream beds.

Groundwater quality is generally good for municipal and agricultural uses. There are localized areas with high TDS near the Pacific Ocean due to seawater intrusion (DWR 2004an, 2013e).

The Santa Ynez River Valley Groundwater Basin was designated by the CASGEM program as medium priority.

#### 7.3.5.1.5 Goleta, Foothill, Santa Barbara, Montecito, and Carpinteria Groundwater Basins

The Goleta, Foothill, Santa Barbara, Montecito, and Carpinteria groundwater basins are located in southwestern Santa Barbara County along the Pacific Ocean and near the boundary with Ventura County. The water bearing formations in the Goleta, Foothill, Santa Barbara, and Montecito groundwater basins are unconsolidated alluvium of clay, silt, sand, and/or gravel that overlays the generally confined Santa Barbara Formation of marine sand, silt, and clay (DWR 2004an, 2004ao, 2004ap, 2004aq, 2013e).

In the Carpinteria Groundwater Basin, the alluvium extends under the agricultural plain (DWR 2004ar, 2013e). A confined aquifer occurs under a thick clay bed in the lower part of the alluvium. This basin includes the Santa Barbara Formation; as well as the Carpinteria Formation, of unconsolidated to poorly consolidated sand with gravel and cobble; and the Casitas Formation, of poorly to moderately consolidated clay, silt, sand, and gravel.

Several faults restrict groundwater flow throughout these basins. Recharge occurs along streambeds and from subsurface inflow into the basin from upland areas. Water released from Lake Cachuma increases groundwater recharge rates.

The groundwater levels in portions of these groundwater basins declined up to 10 feet between fall 2013 and fall 2014, and in some areas more than 10 feet (DWR 2014d).

Groundwater quality is generally good for municipal and agricultural uses. There are localized areas with high TDS near the Pacific Ocean due to seawater intrusion (DWR 2004an, 2004ao, 2004ap, 2004aq, 2004ar, 2013e; GWD and LCMWC 2010). High concentrations of nitrate, iron, and manganese occur in localized areas in the Goleta Groundwater Basin. Localized areas of high nitrate and sulfate concentrations occur within the Foothill Groundwater Basin. High concentrations of calcium, magnesium, bicarbonate, and sulfate occur in localized areas of the Santa Barbara Groundwater Basin. High concentrations of iron and manganese occur in localized areas of the Montecito Groundwater Basin. Localized areas with high nitrates occur within the Carpinteria Groundwater Basin. Other basins are in equilibrium due to management of the basin through conjunctive use by local water districts (Santa Barbara County 2007). The Goleta Groundwater Basin generally is near or above historical groundwater conditions (Goleta Groundwater Basin and La Cumbre Mutual Water Company 2010), with the northern and western portions of the basin having groundwater levels near the ground surface. High groundwater levels may result in degradation to building foundations and agricultural crops (water levels within the crop root zone).

The Goleta Groundwater Basin was designated by the CASGEM program as medium priority. Goleta, Foothill, Santa Barbara, Montecito, and Carpinteria groundwater basins were designated as very low priority.

#### *7.3.5.2 Groundwater Use and Management*

Groundwater is an important source of water supply for the population of the Central Coast; it is the region's primary water source.

##### 7.3.5.2.1 Morro Valley and Chorro Valley Groundwater Basins

As described in Chapter 5, Surface Water Resources and Water Supplies, the City of Morro Bay uses groundwater from Morro Valley and Chorro Valley groundwater basins. These basins have been designated by the State Water Resources Control Board as riparian underflow basins. The City of Morro Bay and other users of these basins have received water rights permits which limits the rate and volume of groundwater withdrawals (Morro Bay 2011).

##### 7.3.5.2.2 Santa Maria River Valley Groundwater Basin

The Santa Maria River Valley Groundwater Basin is the primary water supply for irrigation in southwestern San Luis Obispo County and northwestern Santa Barbara County. Groundwater also is a major portion of the water supplies for the communities of Pismo Beach, Grover Beach, Arroyo Grande, Oceano, Nipomo, and several smaller communities in San Luis Obispo County; and Guadalupe, Santa Maria, and Orcutt in Santa Barbara County (City of Grover Beach 2011). In many cases, groundwater is the total water supply for these communities including Nipomo Community Services District (NCSD 2011).

The groundwater basin was adjudicated as defined by a settlement agreement, or stipulation, in 2005 that was filed in 2008. The stipulation defined the safe yield of the basin and measures to protect groundwater supplies (Pismo Beach 2011, Arroyo Grande 2012, NCSD 2011, Santa Maria 2011). The stipulation provided for the Northern Cities Management Area, Nipomo Mesa Management Area, and Santa Maria Valley Management Area. The groundwater adjudication considers groundwater recharge from precipitation and applied irrigation water; and water released from Reclamation's Twitchell Reservoir and San Luis Obispo Flood Control and Water Conservation District's Lopez Reservoir that recharge the basin from the downstream stream beds.

The cities of Pismo Beach, Grover Beach, Arroyo Grande; Oceano Community Services District; San Luis Obispo County; and San Luis Obispo Flood Control and Water Conservation District have formed the Northern Cities Management Area to manage and protect groundwater supplies in accordance with the adjudication stipulation (Pismo Beach 2011, Arroyo Grande 2012, NCSD 2011). Historical monitoring reporting indicates that the groundwater levels have varied from 20 feet above to 20 feet below mean sea level. When groundwater levels are below mean sea level, there is a potential for sea water intrusion. In 2008, groundwater levels in this area were approximately 10 feet below mean sea level. In 2010, groundwater levels had recovered and ranged from 0 to 20 feet above mean sea level. Overdraft conditions occurred more frequently prior to the groundwater adjudication and completion of the Central Coast Water Authority project that provides SWP water supplies to the area. There is a deep aquifer under the City of Arroyo Grande (Pismo Formation) that provides groundwater not addressed in the adjudicated Santa Maria Groundwater Basin.

Agricultural water users and the communities of Guadalupe, Orcutt, and Santa Maria use groundwater in the Santa Maria Valley Management Area of the Santa Maria Groundwater Basin (SMVMA 2012). Historically, groundwater was used to provide almost 50 percent of the water supply to the City of Santa Maria. Recently, groundwater supplies have become 10 to 20 percent of the total water supply to the city (Santa Maria 2011). Groundwater provides most of the water supplies in Orcutt (Golden State Water Company 2011a).

#### 7.3.5.2.3 San Antonio Creek Valley Groundwater Basin

Groundwater is used for agricultural and domestic water supplies in the San Antonio Creek Valley Groundwater Basin, including the Los Alamos area (DWR 2004dq, 2013e).

#### 7.3.5.2.4 Santa Ynez River Valley Groundwater Basin

Groundwater is used for agricultural and domestic water supplies in the Santa Ynez River Valley Groundwater Basin. As described in Chapter 5, Surface Water Resources and Water Supplies, groundwater is used by all agricultural water users and the communities of Buellton, Lompoc, Solvang, Mission Hills, Vandenberg Village, and Santa Ynez (DWR 2004am, 2013e; Santa Barbara County 2007).

#### 7.3.5.2.5 Goleta, Foothill, Santa Barbara, Montecito, and Carpinteria Groundwater Basins

Groundwater is used agricultural and domestic water supplies in the Goleta, Foothill, Santa Barbara, Montecito, and Carpinteria groundwater basins within Santa Barbara County. Goleta Water District and La Cumbre Mutual Water Company are the major communities that use groundwater in the Goleta Groundwater Basin (DWR 2004an; GWD 2011; GWD and LCMWC 2010). This basin is operated under an adjudication settlement in 1989 and a voter-passed groundwater management plan. Historically, Goleta Water District provided up to 14 percent of the water supply by groundwater. As described in Chapter 5, Surface Water Resources and Water Supplies, Goleta Water District has increased use of surface water from Lake Cachuma and the SWP; and decreased long-term average use of groundwater to about 5 percent of the total water supply.

Portions of the La Cumbre Mutual Water Company and City of Santa Barbara use groundwater from the Foothill Groundwater Basin. The City of Santa Barbara also relies upon groundwater from the Santa Barbara Groundwater Basin. The City of Santa Barbara manages groundwater in accordance with the Pueblo Water Rights (Santa Barbara 2011).

Montecito Water District uses groundwater from the Montecito Groundwater Basin. Carpinteria Valley Water District uses groundwater from the Carpinteria Groundwater Basin (Carpinteria Valley WD 2011). Total groundwater pumping averages approximately 3,700 acre-feet per year.

### 7.3.6 Southern California Region

The Southern California Region includes portions of Ventura, Los Angeles, Orange, San Diego, Riverside, and San Bernardino counties served by the SWP. The Southern California Region groundwater basins are as varied as the geology that occurs in different geographic portions of the region. Therefore, the following discussions are organized in the following subregions.

- Ventura County and northwestern Los Angeles County
- Central and southern Los Angeles County and Orange County
- Western San Diego County
- Western and central Riverside County and southern San Bernardino County
- Antelope Valley and Mojave Valley

#### *7.3.6.1 Western Ventura County and Northwestern Los Angeles County*

The areas within the SWP service area in Ventura County and northwestern Los Angeles County in the Southern California Region include the Acton Valley Groundwater Basin in Los Angeles County; Santa Clara River Valley, Thousand Oaks Area, and Russell Valley groundwater basins in Ventura and Los Angeles counties; and Simi Valley, Las Posas Valley, Pleasant Valley, Arroyo Santa Rosa Valley, Tierre Rejada, and Conejo Valley groundwater basins in Ventura County, as shown in Figure 7.10.

##### 7.3.6.1.1 Hydrogeology and Groundwater Conditions

*Acton Valley Groundwater Basin*

The Acton Valley Groundwater Basin is located upgradient of the Santa Clara River Valley Groundwater Basin and drains towards the Santa Clara River. Water bearing formations include unconsolidated alluvium of sand, gravel, silt, and clay with cobbles and boulders; and poorly consolidated terraced deposits (DWR 2004as; 2013f). Recharge occurs along the streambed, water applied to the soils, and subsurface inflow. Groundwater is characterized by calcium, magnesium, and sulfate bicarbonate with localized areas of high concentrations of TDS, sulfate, nitrate, and chlorides.

Acton Valley Groundwater Basin was designated by the CASGEM program as very low priority.

*Santa Clara River Valley Groundwater Basin*

The Santa Clara River Valley Groundwater Basin is the source of local groundwater along the Santa Clara River watershed from the Santa Clarita Valley in northwestern Los Angeles County to the Pacific Ocean near the City of Oxnard in Ventura County. The Santa Clara River Valley Groundwater Basin includes the Piru, Fillmore, Santa Paula, Mound, and Oxnard subbasins in Ventura county; and Santa Clara River Valley East Subbasin in Los Angeles County. Groundwater movement is effected by the occurrence of several fault zones (DWR 2004at, 2004au, 2006s, 2006t, 2006u, 2013f). Groundwater recharge occurs along the Santa Clara River and its tributaries, and by percolation of precipitation and applied irrigation water.

The Santa Clara River Valley East Subbasin is characterized by unconsolidated alluvium of sand, gravel, silt, and clay; poorly consolidated terrace deposits of gravel, sand, and silt; and the Saugus Formation of poorly consolidated sandstone, siltstone, and conglomerate (DWR 2006s, 2013f).

The Piru, Fillmore, Santa Paula, Mound, and Oxnard subbasins are characterized by alluvium of silts and clays interbedded with sand and gravel lenses; and the San Pedro Formation of fine sands and gravels over the alluvium (DWR 2004at, 2004au, 2006t, 2006u, 2006v, 2013f).

Groundwater quality in the Santa Clara River Valley Groundwater Basin is suitable for a variety of beneficial uses. However, some areas have been impaired by elevated TDS, nitrate, and boron concentrations (DWR 2004at, 2004au, 2006t, 2006u, 2006v, 2013f; CLWA et al. 2012). Groundwater quality is characterized by fluctuating salinity that increases during dry periods. Localized areas of high nitrates and organic compounds occur due to historic agricultural activities and wastewater disposal.

The Piru, Oxnard, and Santa Clara River Valley East subbasins were designated by the CASGEM program as high priority. The Fillmore, Santa Paula, and Mound subbasins were designated as medium priority.

#### *Simi Valley Groundwater Basin*

The Simi Valley Groundwater Basin is located in Ventura County (DWR 2004av, 2013f). Water bearing formations in this basin are characterized by generally unconfined alluvium of gravel, clays, and sands; with local clay lenses that provide confined aquifers. The Simi Fault confines the basin on the northern boundary. Groundwater recharge occurs along stream beds. Groundwater quality is characterized as calcium sulfate with localized areas of high TDS and organic contaminants.

Simi Valley Groundwater Basin was designated by the CASGEM program as low priority.

#### *Las Posas Valley and Pleasant Valley Groundwater Basins*

The Las Posas Valley and Pleasant Valley groundwater basins are located in western Ventura County. Groundwater is found within these basins in thick alluvium that is dominated by sand and gravel in the eastern part of the Las Posas Valley Groundwater Basin; and by silts and clays with lenses of sands and gravels in the western part of the Las Posas Valley Groundwater Basin and the Pleasant Valley Groundwater Basin (DWR 2006w, 2006x, 2013f). Underlying the alluvium are the San Pedro and Santa Barbara formations of gravels, sands, silts and clays with a discontinuous aquitard located within the Santa Barbara Formation. The movement of groundwater is locally influenced by features such as faults, structural depressions and constrictions and operating production wells; however, groundwater generally flows west-southwest toward the Oxnard Subbasin. Hydrographs from the Las Posas Valley and Pleasant Valley

Groundwater Basins have exhibited a variety of groundwater-level histories over the past couple decades. Most hydrographs in the eastern part of the Las Posas Valley Groundwater Basin indicate relatively unchanged groundwater levels or a slight rise since 1994. Most hydrographs in the western Las Posas Valley and Pleasant Valley groundwater basins indicate that groundwater levels have risen to and been maintained at moderate levels since 1992.

Groundwater quality in the Las Posas Valley and Pleasant Valley groundwater basins is suitable for a variety of beneficial uses. Moderate to high TDS concentrations occur in the Las Posas Valley Groundwater Basin and the Pleasant Valley Groundwater Basin (DWR 2006w, 2006x, 2013f).

The Las Posas Valley and Pleasant Valley groundwater basins were designated by the CASGEM program as high priority.

#### *Arroyo Santa Rosa Valley Groundwater Basin*

The Arroyo Santa Rosa Valley Groundwater Basin is located within Ventura County. The water bearing formations include alluvium of gravel, sand, and clay; and the alluvial San Pedro Formation of sand and gravel (DWR 2006y, 2013f). Groundwater recharge occurs along the Santa Clara River and the tributaries, and by percolation of precipitation and applied irrigation water. Fault zones affect groundwater movement within the basin. Groundwater quality is adequate for community and agricultural water uses. Localized areas of high sulfate and nitrate concentrations occur within the basin.

Arroyo Santa Rosa Valley Groundwater Basin was designated by the CASGEM program as medium priority.

#### *Tierra Rejada Valley, Conejo Valley, and Thousand Oaks Area Groundwater Basins*

The Tierra Rejada Valley, Conejo Valley, and Thousand Oaks groundwater basins in southern Ventura County are characterized by shallow alluvium that overlays marine sandstone and shale of the Modelo and Topanga formations (DWR 2004aw, 2004ax, 2004ay, 2013f). In some portions of the basin, the Topanga Formation of volcanic tuff, debris flow, and basaltic flow occurs. Groundwater recharge occurs along the streambeds and by percolation of precipitation and applied irrigation water. Fault zones affect groundwater movement within the basins. Groundwater quality is adequate for community and agricultural water uses. Localized areas of high alkalinity and nitrate concentrations occur within the basins. High iron and TDS occur in the Thousand Oaks Area Groundwater Basin (Thousand Oaks 2011).

Conejo Valley Groundwater Basin was designated by the CASGEM program as low priority. The Tierra Rejada Valley and Thousand Oaks Area groundwater basin were designated as very low priority.

#### *Russell Valley Groundwater Basin*

The Russell Valley Groundwater Basin is located along the boundaries of Ventura and Los Angeles counties (DWR 2004az, 2013f). This small groundwater basin is characterized by unconsolidated, poorly bedded, sand, gravel, silt, and clay with cobbles and boulders. The groundwater is recharged by precipitation within the basin. Groundwater quality is characterized by sodium bicarbonate and calcium bicarbonate with high sulfates and TDS in some localized areas.

Russell Valley Groundwater Basin was designated by the CASGEM program as very low priority.

###### 7.3.6.1.2 Groundwater Use and Management

Groundwater is an important water supply throughout the Southern California Region. Many of the basins have been adjudicated and groundwater management agencies have been established to manage, preserve, and regulate groundwater withdrawals and recharge actions. In Ventura County, the Fox Canyon Groundwater Management Agency was established in 1982 to implement a groundwater plan that identifies withdrawal allocations and groundwater elevation and quality criteria (MWDSC 2007).

*Acton Valley Groundwater Basin*

As described in Chapter 5, Surface Water Resources and Water Supplies, the Acton community primarily uses groundwater supplemented by SWP water treated at the Antelope Valley East Kern Acton Water Treatment Plant (Los Angeles County 2014b).

*Santa Clara River Valley Groundwater Basin*

Communities and agricultural water users in the Santa Clara River Valley Groundwater Basin use a combination of surface water and groundwater to meet water demands. Agricultural use of groundwater is greater than community use of groundwater in this basin (UCWD 2012).

Four retail water purveyors provide water service to most residents of the Santa Clara River Valley East Subbasin. These water purveyors include the Castaic Lake Water Agency; Santa Clarita Water Division, Los Angeles County Waterworks District Number 36; Newhall County Water District; and Valencia Water Company. Groundwater is used by the communities of Santa Clarita, Saugus, Canyon Country, Newhall, Val Verde, Hasley Canyon, Valencia, Castaic, Stevenson Ranch (CLWA et al. 2012).

Water purveyors in the Piru, Fillmore, Santa Paula, Mound, and Oxnard subbasins include United Water Conservation District and Ventura County. United Water Conservation District operates surface water facilities to encourage groundwater protection through conjunctive use (UWCD 2012). Groundwater issues within the United Water Conservation District service area (which includes all of the basin) include overdraft conditions, sea water intrusion, and high nitrate concentrations.

*Simi Valley Groundwater Basin*

The Simi Valley area primarily relies upon surface water supplies, including SWP water supplies. Groundwater is used to supplement these supplies and by users that cannot be easily served with surface water. Groundwater is provided by Golden State Water Company service area and Ventura County Waterworks

District No. 8. The Golden State Water Company provides less 10 percent of the total water supply to the area (Golden State Water Company 2011b). Ventura County Waterworks District No. 8 provides groundwater to a golf course, nursery, and industrial user in the Simi Valley area (VCWD8 2011).

*Las Posas Valley and Pleasant Valley Groundwater Basins*

Communities and agricultural water users in the Las Posas Valley and Pleasant Valley groundwater basins use a combination of surface water and groundwater to meet water demands. Agricultural use of groundwater is greater than community use of groundwater in this basin (UCWD 2012). United Water Conservation District and Ventura County manage water service to many residents of the Las Posas Valley and Pleasant Valley groundwater basins.

As described above, United Water Conservation District operates surface water facilities to encourage groundwater protection through conjunctive use (UWCD 2012). Groundwater is used within the United Water Conservation District service area, which includes western Las Posas Valley and Pleasant Valley groundwater basins. The Oxnard Subbasin of the Santa Clara River Valley Groundwater Basin and Las Posas Valley and Pleasant Valley groundwater basins are within the groundwater management plan established by the Fox Canyon Groundwater Management Agency (Fox Canyon GMA 2013). The groundwater management agency manages and monitors groundwater in areas with groundwater overdraft and seawater intrusion which includes the communities of Port Hueneme, Oxnard, Camarillo, and Moorpark. The long-term average groundwater use within Fox Canyon Groundwater Management Agency includes a portion of the withdrawals reported by United Water Conservation District.

The Calleguas Municipal Water District, in partnership with Metropolitan Water District of Southern California (Metropolitan), operates the Las Posas Basin Aquifer Recharge and Recovery project. Calleguas Municipal Water District stores SWP surplus water in the Las Posas Valley Groundwater Basin, near the City of Moorpark. The current Aquifer Recharge and Recovery system includes 18 wells (Calleguas MWD 2011).

*Arroyo Santa Rosa Valley Groundwater Basin*

Communities and agricultural water users in the Arroyo Santa Rosa Valley Groundwater Basin use a combination of surface water and groundwater to meet water demands. Camarosa Water District and Fox Canyon Groundwater Management Agency manage groundwater supplies within the basin (Camarosa WD 2013).

*Tierra Rejada Valley, Conejo Valley, and Thousand Oaks Area Groundwater Basins*

Groundwater in the Tierra Rejada Valley, Conejo Valley, and Thousand Oaks Area groundwater basins is primarily used by agricultural and individual residential water users. Portions of the Tierra Rejada Valley Groundwater Basin is within the Camarosa Water District; however, this area is primarily open space and agricultural land uses with individual wells (Camarosa WD 2013). The City of Thousand Oaks does operate two wells; however, the city primarily relies upon SWP water supplies because of the high iron concentrations and salinity in the groundwater (Thousand Oaks 2011).

*Russell Valley Groundwater Basin*

Most groundwater users in the Russell Valley Groundwater Basin are agricultural and individual residential water users. Portions of the basin are located within the Calleguas Municipal Water District. However, the district does not use water from this basin (Calleguas MWD 2011). The Las Virgenes Municipal Water District withdraws groundwater from the Russell Basin to augment recycled water supplies (GLCIRWMR 2014).

#### *7.3.6.2 Western Los Angeles County and Orange County*

The areas within the SWP service area in Central and Southern Los Angeles County and Orange County in the Southern California Region include the San Fernando Valley, Raymond, San Gabriel Valley, Coastal Plain of Los Angeles, and Malibu Valley groundwater basins in Los Angeles County; Coastal Plain of Orange County and San Juan Valley groundwater basins in Orange County, as shown in Figure 7.10.

##### 7.3.6.2.1 Hydrogeology and Groundwater Conditions

*San Fernando Valley Groundwater Basin*

The San Fernando Valley Groundwater Basin extends under the Los Angeles River watershed. Groundwater flows toward the middle of the basin, beneath the Los Angeles River Narrows, to the Central Subbasin of the Coastal Plain of Los Angeles Basin. The water bearing formation is mainly unconfined gravel and sand with clay lenses that provide some confinement in the western part of the basin (DWR 2004ba).

Groundwater movement is affected by the occurrence of several fault zones (DWR 2004ba). Groundwater is recharged naturally from precipitation and stream flow and from imported water and reclaimed wastewater that percolates into the groundwater from stormwater spreading grounds.

In the San Fernando Valley Groundwater Basin, the groundwater is characterized by calcium, magnesium, radioactive material, and sulfate bicarbonate with localized areas of high TDS, volatile organic compounds, petroleum compounds, chloroform, pesticides, nitrate, and sulfate (DWR 2004ba, ULARAW 2013). There are several ongoing groundwater remediation programs within the groundwater basin to reduce volatile organic compounds and one program to reduce hexavalent chromium.

San Fernando Valley Groundwater Basin was designated by the CASGEM program as medium priority.

*Raymond Groundwater Basin*

The Raymond Groundwater Basin is located to the north of the San Gabriel Valley Groundwater Basin. Groundwater flow is affected by the occurrence of several fault zones; and causes the groundwater to flow into the San Gabriel

Valley Groundwater Basin. The water bearing formations are mainly unconsolidated gravel, sand, and silt with local areas of confinement (DWR 2004bb). Groundwater is recharged naturally from precipitation and stream flow and from water that percolates into the groundwater from spreading grounds and local dams.

In the Raymond Groundwater Basin, the groundwater is characterized by calcium, magnesium, and sulfate bicarbonate with localized areas of high volatile organic compounds, nitrate, radioactive material, and perchlorate (DWR 2004bb). There is an ongoing groundwater remediation program within the groundwater basin to reduce volatile organic compounds and perchlorate.

Raymond Groundwater Basin was designated by the CASGEM program as medium priority.

#### *San Gabriel Valley Groundwater Basin*

Groundwater in the San Gabriel Valley Groundwater Basin flows from the San Gabriel Mountains towards the west under the San Gabriel Valley to the Whittier Narrows where it discharges into the Coastal Plain of the Los Angeles Groundwater Basin (DWR 2004bc). Groundwater in the San Gabriel Valley Groundwater Basin also is interconnected to groundwater in the Chino subbasin of the Upper Santa Ana Valley Groundwater Basin in Riverside County. The northeastern portion of the San Gabriel Valley Groundwater Basin adjacent to the Chino subbasin includes six subbasins and is known as “Six Basins.” The water-bearing formations include unconsolidated to semi-consolidated alluvium deposits of gravel, sands, and silts.

Groundwater recharge occurs from direct percolation of precipitation and stream flow, including treated wastewater effluent conveyed in the San Gabriel River (DWR 2004bc). In the San Gabriel Valley Groundwater Basin, the groundwater is characterized by calcium bicarbonate with localized areas of high TDS, carbon tetrachloride nitrate, and volatile organic compounds (DWR 2004bc).

San Gabriel Valley Groundwater Basin was designated by the CASGEM program as high priority.

#### *Coastal Plain of Los Angeles Groundwater Basin*

The Coastal Plain of Los Angeles Groundwater Basin includes the Hollywood, Santa Monica, Central, and West Coast subbasins.

##### *Hollywood Subbasin*

The Hollywood subbasin is located to the north of the Central subbasin and upgradient of the Santa Monica subbasin. Groundwater flows towards the Pacific Ocean (DWR 2004bd). The water bearing formations are mainly alluvial gravel. Groundwater is recharged naturally from precipitation and stream flow.

The Hollywood subbasin was designated by the CASGEM program as very low priority.

#### *Santa Monica Subbasin*

The Santa Monica subbasin is located to the north of the West Coast subbasin and to the west of the Hollywood subbasin. Groundwater flows towards the west and the Hollywood subbasin (DWR 2004be). The water bearing formations are mainly alluvial gravel and sand with semi-perched areas over silt and clay deposits. Unconfined shallow aquifers occur in the northern and eastern portions of the subbasin. Confined deeper aquifers occur in the remaining portion of the subbasin. Groundwater is recharged naturally from precipitation and stream flow.

The Santa Monica subbasin was designated by the CASGEM program as high priority.

#### *Central Subbasin*

The Central subbasin is located to the east of the West Coast subbasin. The Central subbasin is characterized by shallow sediments and extends from the Los Angeles River Narrows with groundwater flows from the San Gabriel Valley (DWR 2004bf).

The non-pressurized, or forebay, portions of the subbasin are located in the northern portion of the subbasin in unconfined aquifers underlying the Los Angeles and San Gabriel rivers (DWR 2004bf). These areas provide the major recharge areas for the subbasin. The “pressure” areas are confined aquifers composed of permeable sands and gravel separated by less permeable sandy clay and clay, and constitute the main water-bearing formations. Several faults and uplifts create some restrictions to groundwater flow in the subbasin while others run parallel to the groundwater flow and do not restrict flow.

In the Central subbasin, the groundwater is characterized by localized areas of high inorganics and volatile organic compounds (DWR 2004bf).

The Central subbasin was designated by the CASGEM program as high priority.

#### *West Coast Subbasin*

The West Coast subbasin is located on the southern coast of Los Angeles County to the west of the Central subbasin. The water bearing formations are composed of unconfined and semi-confined aquifers composed of sands, silts, clays, and gravels (DWR 2004bg). Several fault zones paralleling the coast act as partial barriers to groundwater flow in certain areas. The general regional groundwater flow pattern is southward and westward toward the Pacific Ocean. Recharge occurs through groundwater flow from the Central subbasin, and from infiltration along the Los Angeles and San Gabriel rivers. Seawater intrusion occurs along the Pacific Ocean coast.

In the West Coast subbasin, the most critical issue is high TDS along the Pacific Ocean coast due to seawater intrusion. As described below, several agencies have implemented sea water barrier projects to protect the groundwater quality.

The West Coast subbasin was designated by the CASGEM program as high priority.

### *Malibu Valley Groundwater Basin*

The Malibu Valley Groundwater Basin is an isolated alluvial basin in northern Los Angeles County along the Pacific Ocean Coast under the Malibu Creek watershed (DWR 2004bh). Groundwater flows towards the Pacific Ocean. The water bearing formations are mainly gravel, sand, clays, and silt (DWR 2004bb). Groundwater is recharged naturally from precipitation and stream flow.

In the Malibu Valley Groundwater Basin, the groundwater is characterized by localized areas of high TDS due to sea water intrusion along the Pacific Ocean coast (DWR 2004bh).

The Malibu Valley Groundwater Basin was designated by the CASGEM program as very low priority.

### *Coastal Plain of Orange County Groundwater Basin*

The Coastal Plain of Orange County Groundwater Basin is located under a coastal alluvial plain in northern Orange County (DWR 2004 bi). Groundwater is recharged naturally from precipitation and injection wells to reduce seawater intrusion. The water bearing formations are mainly interbedded marine and continental sand, silt, and clay deposits (DWR 2004bi). The Newport-Inglewood fault zone parallels the coast and generally forms a barrier to groundwater flow. Groundwater recharge occurs along the Santa Ana River. Water levels are characterized by seasonal fluctuations (DWR 2013f; Orange County 2009). Groundwater flowed towards the Pacific Ocean prior to recent development. However, due to extensive groundwater withdrawals, there are groundwater depressions that result in potential sea water intrusion. Groundwater levels have increased since the 1990s following implementation of several recharge programs.

In the Coastal Plain of Orange County Groundwater Basin, the groundwater is characterized as sodium-calcium bicarbonate with localized areas of high TDS due to sea water intrusion along the Pacific Ocean coast, as well as nitrate, and volatile organic compounds (DWR 2004bi).

The Coastal Plain of Orange County Groundwater Basin was designated by the CASGEM program as medium priority.

### *San Juan Valley Groundwater Basin*

The San Juan Valley Groundwater Basin is located in southern Orange County (DWR 2004bj). Groundwater flows towards the Pacific Ocean. The water bearing formations are mainly sand, clays, and silt. Groundwater is recharged naturally from precipitation and stream flows from San Juan and Oso creeks and Arroyo Trabuca.

In the San Juan Valley Groundwater Basin, the groundwater is characterized as calcium bicarbonate, bicarbonate-sulfate, calcium-sodium sulfate, and sulfate-chloride with localized areas of high TDS due to sea water intrusion along the Pacific Ocean coast and high fluoride near hot springs near Thermal Canyon (DWR 2004bj).

The San Juan Valley Groundwater Basin was designated by the CASGEM program as low priority.

#### 7.3.6.2.2 Groundwater Use and Management

Groundwater is an important water supply throughout the Southern California Region. Many of the groundwater basins in Los Angeles and Orange counties have been adjudicated, as summarized in Table 7.1, and groundwater management agencies have been established to manage, preserve, and regulate groundwater withdrawals and recharge actions.

*San Fernando Valley Groundwater Basin*

The communities and agricultural users in the San Fernando Valley Groundwater Basin use a combination of surface water and groundwater to meet water demands (GLCIRWMR 2014; ULARAW 2013). The Metropolitan Water District of Southern California provides wholesale surface water supplies to several communities. The cities of Los Angeles, Glendale, Burbank, San Fernando, Crescenta Valley, Bell Canyon, and Hidden Hills provide retail water supplies, including groundwater, to the communities. The groundwater basin has been adjudicated and is managed by the Upper Los Angeles River Area Watermaster.

Groundwater is recharged in the San Fernando Valley Groundwater Basin through seepage of precipitation within the groundwater basin, including the recharge of stormwater at spreading grounds between 1968 and 2012; and storage of imported water (ULARAW 2013). The spreading basins for stormwater flows are operated by Los Angeles County and the cities of Los Angeles and Burbank. A portion of the extracted groundwater is exported to areas that overly other groundwater basins.

The operations of the San Fernando Valley Groundwater Basin are defined by the Upper Los Angeles River Area January 26, 1979 Final Judgment; the Sylmar Basin Stipulations of August 26, 1983; and subsequent agreements. These agreements, as managed by the Upper Los Angeles River Area Watermaster, provide for the right to extract a percent of surface water, including applied recycled water, that enters within specified subbasins of the San Fernando Valley Groundwater Basin with specific calculations to identify maximum withdrawals for the cities of Burbank, Glendale, Los Angeles, and San Fernando and Crescenta Valley Water District; the right to store and withdraw water within specified subbasins by the cities of Burbank, Glendale, Los Angeles, and San Fernando; and the acknowledgment that the City of Los Angeles has an exclusive Pueblo Water Right for the native safe yield of the San Fernando subbasin within the larger San Fernando Valley Groundwater Basin.

*Raymond Groundwater Basin*

The communities in the Raymond Groundwater Basin use a combination of surface water and groundwater to meet water demands (GLCIRWMR 2014). The Metropolitan Water District of Southern California and Foothills Municipal Water District provide wholesale surface water supplies to several communities. The cities of Alhambra, Arcadia, Pasadena, San Marino, and Sierra Madre; Upper San

Gabriel Municipal Water District; and Valley Water Company and several other private water companies, provide retail water supplies, including groundwater, to the communities to Altadena, Las Crescenta-Montrose, La Cañada Flintridge, Rubio Canyon, and South Pasadena. The City of Alhambra and San Gabriel Valley Municipal Water District; can withdraw groundwater from the Raymond Basin, but currently are not operating wells within this groundwater basin (City of Alhambra 2011).

The groundwater basin was the first adjudicated groundwater basin in California and is managed by the Raymond Basin Management Board as the Watermaster (RBMB 2014). The Raymond Basin Management Board limits the amount of groundwater withdrawals in different areas of the basin, and allows for short-term and long-term storage of water in the groundwater basin.

Groundwater is recharged in the Raymond Groundwater Basin through seepage of precipitation within the groundwater basin, injection wells, and spreading basins operated by Los Angeles County and the cities of Pasadena and Sierra Madre (MWDSC 2007). Water from Metropolitan Water District of Southern California, which is generally a combination of SWP water and Colorado River water, cannot be used for direct recharge if the TDS is greater than 450 milligrams/liter (RBMB 2014). A portion of the extracted groundwater is exported to areas that overly other groundwater basins.

*San Gabriel Valley Groundwater Basin*

The communities in the San Gabriel Valley Groundwater Basin use a combination of surface water and groundwater to meet water demands (GLCIRWMR 2014; MWDSC 2007). The Metropolitan Water District of Southern California, San Gabriel Valley Municipal Water District, Upper San Gabriel Municipal Water District; Three Valleys Municipal Water District, and Covina Irrigating Company provide wholesale surface water and/or groundwater supplies to several communities. The cities of Alhambra, Arcadia, Azusa, Covina, El Monte, Glendora, La Verne, Monrovia, Pomona, San Marino, and Upland; San Gabriel County Water District and Valley County Water District; Golden State Water Company, San Antonio Water Company, San Gabriel Valley Water Company, Suburban Water Systems, Valencia Heights Water Company, and several other private water companies, provide retail water supplies, including groundwater, to users within their communities and to the communities of Baldwin Park, Bradbury, Claremont, Duarte, Hacienda Heights, Irwindale, La Puente, Montebello, Monterey Park, Pico Rivera, Rosemead, San Dimas, San Gabriel, Santa Fe Springs, Sierra Madre, South El Monte, South San Gabriel, Temple City, Valinda, and Whittier (City of Alhambra 2011; City of Arcadia 2011; City of La Verne 2011; City of Pomona 2011; City of Upland 2011; Golden State Water Company 2011c; SGCWD 2011; SGVWC 2011; Suburban Water Systems 2011; SAWCO 2011; TVMWD 2011; USGVMWD 2011).

The San Gabriel Valley Groundwater Basin includes several adjudicated basins. A portion of the groundwater basin is managed by the San Gabriel River Watermaster and the Main San Gabriel Basin Watermaster (MWDSC 2007; SGVWC 2011). The Watermasters coordinate groundwater elevation and water quality monitoring, coordinate imported water supplies, coordinate recharge operations with imported water and recycled water, manage the amount of groundwater withdrawals in different areas of the basin by balancing the amount of groundwater recharge, and allow for short-term and long-term storage of water in the groundwater basin. Groundwater is recharged through seepage of precipitation within the groundwater basin, injection wells, and spreading basins operated by Los Angeles County and a private water company (MWDSC 2007). Water recharged into the spreading basins from Metropolitan Water District of Southern California and San Gabriel Valley Municipal Water District.

The Six Basins portion of the groundwater basin also is adjudicated and managed by the Six Basins Watermaster Board (MWDSC 2007). The Watermaster manages withdrawals and requires replenishment obligation of equal amounts for withdrawals over the operating safe yield of the basin. The Pomona Valley Protective Agency conveys flows from San Antonio Creek and SWP water to the San Antonio Spreading Grounds; and from local waters to the Thompson Creek Spreading Grounds. The City of Pomona conveys flows from local surface waters to the Pomona Spreading Grounds. Los Angeles County Department of Public Works conveys flows from local surface water and SWP water to the Live Oak Spreading Grounds.

The cities of Alhambra, Arcadia, La Verne, Monterey Park, San Gabriel Valley Water Company, and other water entities operate groundwater treatment facilities to remove dichloroethane, chloroform, other volatile organic compounds, and/or nitrates (City of Alhambra 2011; City of Arcadia 2011; City of Monterey Park 2012; MWDSC 2007; SGVWC 2011).

#### *Coastal Plain of Los Angeles Groundwater Basin*

The Coastal Plain of Los Angeles Groundwater Basin includes four subbasins: Hollywood, Santa Monica, Central and West Coast.

##### *Hollywood Subbasin*

The primary user of groundwater in the Hollywood subbasin is the City of Beverly Hills (MWDSC 2007). The basin is not adjudicated. The city manages the groundwater subbasin through limits on withdrawals and discharges to the groundwater. Groundwater is recharged through seepage of precipitation within the groundwater subbasin (City of Beverly Hills 2011). All groundwater withdrawn by the city is treated to reduce salinity.

##### *Santa Monica Subbasin*

The primary user of groundwater in the Santa Monica subbasin is the City of Santa Monica (MWDSC 2007). The basin is not adjudicated. Groundwater is recharged through seepage of precipitation within the groundwater subbasin (City of Santa Monica 2011; MWDSC 2007). Groundwater treatment is provided to a portion of the subbasin withdrawals to reduce volatile organic compounds, and methyl tertiary butyl ether.

### *Central Subbasin*

The communities in the Central subbasin use a combination of surface water and groundwater to meet water demands (GLCIRWMR 2014; MWDSC 2007). The Metropolitan Water District of Southern California and Central Basin Municipal Water District provide wholesale surface water supplies to several communities. The cities of Bell, Bell Gardens, Cerritos, Compton, Cudahy, Downey, Huntington Park, Lakewood, Long Beach, Los Angeles, Lynwood, Monterey Park, Norwalk, Paramount, Pico Rivera, Santa Fe Springs, Signal Hill, South Gate, Vernon, and Whittier; Los Angeles County Water District, La Habra Heights County Water District, Orchard Dale Water District, and Paramount Water District; Golden State Water Company, Suburban Water Systems, Bellflower-Somerset Mutual Water Company, Montebello Land & Water Company; Park Water Company, Dominguez Water Corp, California Water Service Company, San Gabriel Valley Water Company, Walnut Park Mutual Water Company, and several other private water companies, provide retail water supplies, including groundwater, to users within their communities and to the communities of Artesia, Commerce, Dominguez, East La Mirada, East Los Angeles, East Rancho, Florence-Graham, Hawaiian Gardens, La Mirada, Los Nieto, Maywood, Montebello, South Whittier, Walnut Park, Westmount, West Whittier, and Willow Brook (CBMWD 2011; BSMWC 2011; City of Compton 2011; City of Downey 2012; City of Huntington Park 2011; City of Lakewood 2011; City of Long Beach 2011; City of Los Angeles 2011; City of Monterey Park 2012; City of Norwalk 2011; City of Paramount 2011; City of Pico Rivera 2011; City of Santa Fe Springs 2011; City of South Gate; City of Vernon 2011; City of Whittier 2011; LHHCWD 2012; Golden State Water Company 2011d, 2011e, 2011f, 2011g; Suburban Water Systems 2011).

The Central subbasin was adjudicated, and is managed by DWR. The adjudication specifies a total amount of allowed annual withdrawals (or Allowable Pumping Allocation) in the Central subbasin (MWDSC 2007; WRD 2013a). Approximately 25 percent of the water users of groundwater from the Central subbasin are not located on the land that overlies the subbasin (CBMWD 2011). Groundwater from the San Gabriel Valley Groundwater Basin also is used by water users that overlie the Central subbasin.

The Water Replenishment District of Southern California has the statutory authority to replenish the groundwater in the Central and West Coast subbasins of the Coastal Plain of Los Angeles Groundwater Basin. The Water Replenishment District of Southern California purchases water for water replenishment facilities operated by Los Angeles County Department of Public Works at the Montebello Forebay near the Rio Hondo and San Gabriel Rivers near the boundaries of the Central and West Coast subbasins (CBMWD 2011; Los Angeles County 2015; WRD 2013a). The Montebello Forebay includes the Rio Hondo Coastal Basin Spreading Grounds along the Rio Hondo Channel; the San Gabriel River Coastal Basin Spreading Grounds; and the unlined reach of the lower San Gabriel River from Whittier Narrows Dam to Florence Avenue (LACDPW 2014, WRD 2013a).

The replenishment water is purchased water from two different sources: recycled water from various regional treatment facilities, and imported water (WRD 2013a). The recycled water is used for groundwater recharge at the spreading grounds and at the seawater barrier wells. Water Replenishment District of Southern California must blend recycled water with other water sources to meet the groundwater recharge water quality and volumetric requirements established by the State Water Resources Control Board. This blended water is either imported water from the SWP and/or the Colorado River, or untreated surface water flows from the San Gabriel River, Rio Hondo River, and waterways in the San Gabriel Valley (CBMWD 2011). Up to 35 percent of the replenishment water can be provided from recycled water supplies. Several recent projects have been implemented to store stormwater flows for increased replenishment water volumes.

In the Central subbasin, the Water Replenishment District of Southern California also purchases imported and recycled water for injection by the Los Angeles County Department of Public Works into the portion of the Alamitos Barrier Project located in Los Angeles County to reduce seawater intrusion (MWDSC 2007; WRD 2007). Initially, imported SWP water was used to prevent seawater intrusion. However, over the past 20 years, recycled water has been used for a substantial amount of the groundwater injection program. The Water Replenishment District of Southern California is planning to fully use recycled water at the Alamitos Gap Barrier Project by 2014 (WRD 2013b).

The cities of Long Beach, Monterey Park, South Gate, and Whittier operate groundwater treatment facilities in the Central subbasin (City of Long Beach 2012; City of Monterey Park 2012; City of South Gate; City of Whittier 2011).

#### *West Coast Subbasin*

The communities in the Central subbasin use a combination of surface water and groundwater to meet water demands (GLCIRWMR 2014; MWDSC 2007). The Metropolitan Water District of Southern California and West Basin Municipal Water District provide wholesale surface water supplies to several communities. The cities of Inglewood, Lomita, Manhattan Beach, and Torrance; Golden State Water Company, California Water Service Company, and several other private water companies, provide retail water supplies, including groundwater, to users within their communities and to the communities of Athens, Carson, Compton, Del Aire, Gardena, Hawthorne, Hermosa Beach, Inglewood, Lawndale, Lennox, Redondo Beach, Torrance (WBMWD 2011a; City of Inglewood 2011; City of Lomita 2011; City of Manhattan Beach 2011; City of Torrance 2011; Golden State Water 2011h; California Water Service Company 2011b, 2011c, 2011d, 2011e). The communities of El Segundo, Long Beach, and Los Angeles overlie the West Coast subbasin; however, no groundwater from this subbasin is used in these communities due to water quality issues and facilities locations. Groundwater use is primarily for emergency uses, including firefighting, in the communities of Hawthorne, Lomita, and Torrance due to high concentrations of minerals (e.g., iron and manganese), sulfides, and/or volatile organic compounds.

The West Coast subbasin was adjudicated, and is managed by DWR. The adjudication specifies a total amount of allowed annual withdrawals (or Allowable Pumping Allocation) in the West Coast subbasin (MWDSC 2007; WBMWD 2011a; WRD 2013a). Groundwater from the Central subbasin is used by some water users that overlie the West Coast subbasin.

The Water Replenishment District of Southern California has the statutory authority to replenish the groundwater in the Central and West Coast subbasins of the Coastal Plain of Los Angeles Groundwater Basin. In the West Coast subbasin, the Water Replenishment District of Southern California purchases imported and recycled water for injection by the Los Angeles County Department of Public Works into the West Coast Barrier Project and the Dominguez Barrier Project (MWDSC 2007; WRD 2007; WRD 2013). Water is purchased by the Water Replenishment District of Southern California for injection at the barrier projects (WRD 2013). Initially, imported SWP water was used to prevent seawater intrusion. However, over the past 20 years, recycled water has been used for a substantial amount of the groundwater injection program. The Water Replenishment District of Southern California is planning to fully use recycled water at the West Coast Barrier Project and the Dominguez Barrier Project by 2014 and 2017, respectively (WRD 2013b).

California Water Service Company operates groundwater treatment facilities within the community of Hawthorne (California Water Service Company 2011b). The Water Replenishment District of Southern California operates the Robert W. Goldsworthy Desalter near Torrance to reduce salinity for up to 18,000 acre-feet/year of groundwater that is located inland of the West Coast Basin Barrier (WRD 2013a).

The West Basin Municipal Water District treats brackish groundwater at the C. Marvin Brewer Desalter Facility for two wells near Torrance that are affected by a saltwater plume in the West Coast subbasin (WBMWD 2011a).

#### *Malibu Valley Groundwater Basin*

No groundwater is used by the communities in this groundwater basin, including the Malibu area (Los Angeles County 2011; MWDSC 2007).

#### *Coastal Plain of Orange County Groundwater Basin*

The communities in the Coastal Plain of Orange County Groundwater Basin use a combination of surface water and groundwater to meet water demands (MWDSC 2007). The Municipal Water District of Orange County, Orange County Water District, and East Orange County Water District provide wholesale surface water supplies to several communities. The cities of Anaheim, Buena Park, Fountain Valley, Fullerton, Garden Grove, Huntington Beach, La Habra, La Palma, Newport Beach, Orange, Santa Ana, Seal Beach, Tustin, and Westminister; East Orange County Water District, Irvine Ranch Water District, Mesa Consolidated Water District, Rowland Water District, Serrano Water District, Walnut Valley Water District, and Yorba Linda Water District; Golden State Water Company, California Water Service Company, California Domestic Water Company, and several other private water companies, provide retail water supplies, including groundwater, to users within their communities and to the communities of Brea, Costa Mesa, Cypress, Diamond Bar, Garden Grove, Hacienda Heights, Industry, Irvine, La Palma, La Puente, Los Alamitos, Midway City, Newport Beach, Orange, Panorama Heights, Placentia, Pomona, Rowland Heights, Rossmoor, Seal Beach, Stanton, Villa Park, Walnut, West Covina, West Orange, and Yorba Linda (City of Anaheim 2011; City of Brea 2011; City of Buena Park 2011; City of Fountain Valley 2011; City of Fullerton 2011; City of Garden Grove 2011; City of Huntington Beach 2011; City of La Habra 2011; City of La Palma 2011; City of Newport Beach 2011; City of Orange 2011; City of Santa Ana 2011; City of Seal Beach 2011; City of Tustin 2011; City of Westminster 2011; IRWD 2011; MCWD 2011; RWD 2011; SWD 2011; WVWD 2011; YLWD 2011; Golden State Water Company 2011i, 2011j). Groundwater use is primarily for non-potable water uses in West Covina and for supplemental supplies for users of recycled water in Rowland Heights.

The Coastal Plain of Orange County Groundwater Basin is managed by Orange County Water District in accordance with special State legislation to increase supply and provide uniform costs for groundwater (MWDSC 2007). The basin is managed to maintain a water balance over several years using two step pricing levels to incentivize users to obtain alternative water supplies after withdrawing a basin production target. The groundwater basin is managed to provide approximately a three-year drought supply.

Orange County Water District manages an extensive groundwater recharge program in the Coastal Plain of Orange County Basin (Orange County Water District 2014). The Orange County Water District manages spreading basins along the Santa Ana River and Santiago Creek for groundwater recharge (MWDSC 2007). Water is supplied to these basins with flows diverted from the Santa Ana River into the recharge basins at inflatable rubber dams, SWP water, and recycled water from the Orange County Water District/Orange County Sanitation District Groundwater Replenishment System Advanced Water Purification Facility (OCWD n.d.).

The Orange County Water District also injects water into the Talbert Barrier and the portion of the Alamitos Barrier Project within Orange County. Water supplies for the seawater barriers include water from the Groundwater Replenishment System and SWP water (GWRS n.d.; MWDSC 2007).

The Irvine Desalter Project was initiated in 2007 by Orange County Water District, Irvine Ranch Water District, Metropolitan Water District of Orange County, Metropolitan Water District of Southern California, and the U.S. Navy to reduce TDS and salts (IRWD 2011; MWDSC 2007). Several other treatment facilities remove volatile organic compounds. The city of Tustin operates the Tustin Seventeenth Street Desalter to reduce TDS within the Tustin community (MWDSC 2007). The City of Garden Grove and Mesa County Water District operate treatment facilities to reduce nitrates and compounds that change the color of the water, respectively (City of Garden Grove 2011; MCWD 2011).

*San Juan Valley Groundwater Basin*

The communities in the San Juan Groundwater Basin use a combination of surface water and groundwater to meet water demands (MWDSC 2007). The Municipal Water District of Orange County provides wholesale surface water supplies to several communities. The City of San Juan Capistrano; Moulton Niguel Water District, Santa Margarita Water District, and South Coast Water District provide retail water supplies to users within their communities and to the communities of Coto de Caza, Dana Point, Laguna Forest, Laguna Woods, Las Flores, Ladera Ranch, Mission Viejo, Rancho Santa Margarita, South Laguna, Talega, (City of San Juan Capistrano 2011; MNWD 2011; SCWD 2011; SMWD 2011). Most of the groundwater use occurs within or near the City of San Juan Capistrano. Groundwater use is small or does not occur within the Santa Margarita Water District, South Coast Water District, and Moulton Niguel Water District service areas.

The San Juan Basin Authority manages water resources development in the San Juan Valley Groundwater Basin and in the surrounding San Juan watershed to protect water quality and water resources (MWDSC 2007; SJBA 2013). In addition to community uses, groundwater also is used for agricultural and industrial purposes and golf course irrigation. Overall, groundwater provides less than 10 percent of the total water supply within the groundwater basin.

The City of San Juan Capistrano Groundwater Recovery Plant reduces iron, manganese, and TDS concentrations. This city is modifying the treatment plant to reduce recently observed high concentrations of methyl tertiary butyl ether (MTBE) (City of San Juan Capistrano 2011; MWDSC 2007). The South Coast Water District operates the Capistrano Beach Groundwater Recovery Facility in Dana Point to reduce iron and manganese concentrations (SCWD 2011; MWDSC 2007).

### 7.3.6.3 Western San Diego County

The areas within the SWP service area in western San Diego County in the Southern California Region include the San Mateo Valley Groundwater Basin in Orange and San Diego counties; and the San Onofre Valley, Santa Margarita Valley, San Luis Rey Valley, Escondido Valley, San Marcos Area, Batiquitos Lagoon Valley, San Elijo Valley, San Dieguito Creek, Poway Valley, San Diego River Valley, El Cajon Valley, Mission Valley, Sweetwater Valley, Otay Valley, Tijuana Basin groundwater basins in San Diego County, as shown in Figure 7.11.

#### 7.3.6.3.1 Hydrogeology and Groundwater Conditions

In San Diego County, several smaller groundwater basins exist, in the western portion of the county. The most productive groundwater basins are characterized by narrow river valleys filled with shallow sand and gravel deposits. Groundwater occurs farther inland in fractured bedrock and semi consolidated sedimentary deposits with limited yield and storage (SDCWA et al. 2013).

### *San Mateo Valley, San Onofre Valley, and Santa Margarita Valley Groundwater Basins*

The San Mateo Valley Groundwater Basin is located in southern Orange County and northern San Diego County (DWR 2004bk). The San Onofre Valley and Santa Margarita Valley groundwater basins are located in northwestern San Diego County (DWR 2004bl, 2004bm). Groundwater flows towards the Pacific Ocean. The water bearing formations are mainly gravel, sand, clays, and silt. Groundwater is recharged naturally from precipitation and stream flows. In the San Mateo Valley and San Onofre Valley groundwater basins, treated wastewater effluent discharged from the Marine Corps Base Camp Pendleton wastewater treatment plants into local streams also recharges the groundwater. In the San Mateo Valley and Santa Margarita Valley groundwater basins, the groundwater is characterized as calcium-sulfate-chloride. In the San Onofre Valley Groundwater Basin, the groundwater is characterized as calcium-sodium bicarbonate-sulfate. Localized areas with high boron, chloride, magnesium, nitrate, sulfate, and TDS occur in the Santa Margarita Valley Groundwater Basin.

Santa Margarita Valley Groundwater Basin was designated by the CASGEM program as medium priority. San Mateo Valley and San Onofre Valley groundwater basins were designated as very low priority.

### *San Luis Rey Valley Groundwater Basin*

The San Luis Rey Valley Groundwater Basin is located in northwestern San Diego County (DWR 2004bn). Groundwater flows towards the Pacific Ocean. The water bearing formations are mainly gravel and sand. Under some portions of the alluvial aquifer, partially consolidated marine terrace deposits of partly consolidated sandstone, mudstone, siltstone, and shale occur. Groundwater is recharged naturally from precipitation and stream flows, and from runoff that flows into the streams from lands irrigated with SWP water. The groundwater is characterized as calcium-sodium bicarbonate-sulfate with localized areas of high magnesium, nitrate, and TDS (MWDSC 2007).

San Luis Rey Valley Groundwater Basin was designated by the CASGEM program as medium priority.

### *San Marcos Valley, Escondido Valley, San Pasqual Valley, Pamo Valley, Santa Maria Valley, and Poway Valley Groundwater Basins*

The San Marcos Valley, Escondido Valley, San Pasqual Valley, Pamo Valley, Santa Maria Valley, and Poway Valley groundwater basins are located in the foothills within central, western San Diego County. The water bearing formations are mainly alluvium of sand, gravel, clay, and silt; consolidated sandstone; or weathered crystalline basement rock (DWR 2004bo, 2004bp, 2004bq, 2004br, 2004bs, 2004bt). The basins area bounded by semi-permeable marine and non-marine deposits and impermeable granitic and metamorphic rocks. Groundwater is recharged naturally from precipitation and stream flows, and from runoff that flows into the streams from irrigated lands. The groundwater is characterized with moderate to high concentrations of salinity. There are localized areas with high sulfate and nitrate concentrations in the Santa Maria Valley Groundwater Basin.

San Pasqual Valley Groundwater Basin was designated by the CASGEM program as medium priority. San Marcos Valley, Escondido Valley, Pamo Valley, Santa Maria, and Poway Valley groundwater basins were designated as very low priority.

*Batiquitos Lagoon Valley, San Elijo Valley, and San Dieguito Valley Groundwater Basins*

The Batiquitos Lagoon Valley, San Elijo Valley, and San Dieguito Valley groundwater basins are located along the central San Diego County coast of the Pacific Ocean. The water bearing formations are mainly alluvium of sand, gravel, clay, and silt with areas of consolidated sandstone (DWR 2004bu, 2004bv, 2004bw). Some areas of the Batiquitos Lagoon Valley Groundwater Basin are bounded by impermeable crystalline rock. Groundwater is recharged naturally from precipitation and stream flows, and from runoff that flows into the streams from irrigated lands. The groundwater is characterized with moderate to high concentrations of salinity.

Batiquitos Valley, San Elijo Valley, and San Dieguito Valley groundwater basins were designated by the CASGEM program as very low priority.

*San Diego River Valley, El Cajon, Mission Valley, Sweetwater Valley, Otay Valley, and Tijuana Groundwater Basins*

The San Diego River Valley, El Cajon, Mission Valley, Sweetwater Valley, Otay Valley, and Tijuana groundwater basins are located in the southwestern portion of San Diego County. The water bearing formations are mainly alluvium of sand, gravel, cobble, clay, and silt; or siltstone and sandstone (DWR 2004bx, 2004by, 2004bz, 2004ca, 2004cb, 2004cc). Groundwater is recharged naturally from precipitation and stream flows, and from runoff that flows into the streams from irrigated lands. The groundwater is characterized with moderate to high levels of salinity. A recent study by USGS evaluated the sources and movement of saline groundwater in these groundwater basins (USGS 2013b). The chloride concentrations ranged from 57 to 39,400 mg/L. The sources of salinity were natural geologic sources and sea water intrusion. There are localized areas with high sulfate and magnesium concentrations.

San Diego River Valley Groundwater Basin was designated by the CASGEM program as medium priority. El Cajon, Mission Valley, Sweetwater Valley, Otay Valley, and Tijuana groundwater basins were designated as very low priority.

#### 7.3.6.3.2 Groundwater Use and Management

Groundwater production and use in the San Diego region is currently limited due to a lack of aquifer storage capacity, available recharge, and degraded water quality due to high salinity. Groundwater currently represents about 3 percent of the water supply portfolio within the areas of San Diego County that could be served by SWP water (SDCWA et al. 2013).

*San Mateo Valley, San Onofre Valley, and Santa Margarita Valley Groundwater Basins*

The primary user of groundwater in the San Mateo Valley, San Onofre Valley, and Santa Margarita Valley groundwater basins is the Marine Corps Base Camp Pendleton (FPUD 2011; MWDSC 2007; SCWD 2011; SDCWA et al. 2013). The Marine Corps Base Camp Pendleton withdraws approximately 8,500 acre-feet/year from the three groundwater basins and operates spreading basins to recharge the groundwater in the Santa Margarita Valley Groundwater Basin. Portions of the South Coast Water District overlie the northern portions of the San Mateo Valley Groundwater Basin; however, the district does not withdraw water from that basin. Fallbrook Public Utility District overlies northern portions of the Santa Margarita Valley Groundwater Basin; however, the district currently uses a small amount of groundwater to meet their water demand (FPUD 2011).

The Santa Margarita Valley Groundwater Basin is within an adjudicated watershed (SMRW 2011). The Santa Margarita River Watermaster manages both surface water and groundwater that contributes direct or indirect flows into the Santa Margarita River in accordance with the Modified Final Judgment and Decrees of 1966 by the U.S. District Court in the *United States v. Fallbrook Public Utility et al*. The watershed includes the Santa Margarita Valley Groundwater Basin near the Pacific Ocean and the Temecula Valley groundwater basins in the upper Santa Margarita River Watershed within Riverside County, as discussed in the following subsection. Within San Diego County, the only groundwater user in the Santa Margarita Valley Groundwater Basin is the Marine Corps Base Camp Pendleton.

*San Luis Rey Valley Groundwater Basin*

The communities in the San Luis Rey Valley Groundwater Basin use a combination of surface water and groundwater to meet water demands (City of Oceanside 2011; MWDSC 2007; RMWD 2011; VCMWD 2011; YMWD 2014a, 2014b). The San Diego County Water Authority provides wholesale surface water supplies to several communities. The City of Oceanside; Rainbow Municipal Water District, Valley Center Municipal Water District, and Yuima Municipal Water District; and Rancho Pauma Mutual Water Company and several other private water companies provide retail water supplies to users within their communities. Groundwater use is small or does not occur within the Rainbow Municipal Water District or Valley Center Municipal Water District. Groundwater also is used on agricultural lands, especially for orchards in the Pauma area (San Diego County 2010). The Tribal lands also depend upon groundwater including lands within the La Jolla Reservation, Los Coyotes Reservation, Pala Reservation, Pauma & Yuima Reservation, Rincon Reservation, and Santa Ysabel Reservation (SDCWA et al. 2013).

There are three municipal water districts that overlie the San Luis Rey Valley Groundwater Basin that manage water rights protection efforts. Groundwater is the only water supply within the Pauma Municipal Water District and the primary water supplies within the Mootamai Municipal Water District and the San Luis Rey Municipal Water District (SDLAFCO 2011; SDCWA et al. 2013). The districts protect groundwater, surface water rights, and water storage; and to coordinate planning studies and legal activities within the San Luis Rey River watershed. Vista Irrigation District withdraws and stores groundwater in Lake Henshaw and withdraws groundwater in a subbasin located upgradient the San Luis Rey Valley Groundwater Basin.

#### *San Marcos, Escondido Valley, San Pasqual Valley, Pamo Valley, Santa Maria Valley, and Poway Valley Groundwater Basins*

The communities in the San Marcos, Escondido Valley, San Pasqual Valley, Pamo Valley, Santa Maria Valley, and Poway Valley groundwater basins use a combination of surface water and groundwater to meet water demands (City of Escondido 2011; City of Poway 2011; Ramona MWD 2011; RDDMWD 2011; VWD 2011). The San Diego County Water Authority provides wholesale surface water supplies to several communities. The cities of Escondido and Poway; Ramona Municipal Water District, Rincon del Diablo Municipal Water District, Vallecitos Water District, and Vista Irrigation District; and private water companies provide retail water supplies to users within their communities. Groundwater use is small or does not occur within the cities of Escondido and Poway, Ramona Municipal Water District, Rincon del Diablo Municipal Water District, and Vallecitos Water District. Ramona Municipal Water District used to use groundwater until high nitrate concentrations required the district to abandon the wells.

#### *Batiquitos Lagoon Valley, San Elijo Valley, and San Dieguito Valley Groundwater Basins*

The communities in the Batiquitos Lagoon Valley, San Elijo Valley, and San Dieguito Valley groundwater basins primarily use surface water to meet water demands (CMWD 2011; OMWD 2011; SDLAFCO 2011; SDWD 2011; SFID 2011). The San Diego County Water Authority provides wholesale surface water supplies to several communities. Groundwater use is limited to private wells within the Carlsbad Municipal Water District, including the City of Carlsbad; Olivenhain Municipal Water District, including the cities of Encinitas, Carlsbad, San Diego, Solano Beach, and San Marcos, and the communities of Olivenhain, Leucadia, Elfin Forest, Rancho Santa Fe, Fairbanks Ranch, Santa Fe Valley, and 4S Ranch; San Dieguito Water District, including the communities of Encinitas, Cardiff-by-the-Sea, New Encinitas, and Old Encinitas; and Santa Fe Irrigation District, including the City of Solana Beach and the communities of Rancho Santa Fe and Fairbanks Ranch. Groundwater was used within the Carlsbad Municipal Water District area until high salinity caused the area to abandon the wells. Questhaven Municipal Water District manages groundwater for a recreation community located to the west of Escondido.

#### *San Diego River Valley, El Cajon, Mission Valley, Sweetwater Valley, Otay Valley, and Tijuana Groundwater Basins*

The communities in the San Diego River Valley, El Cajon, Mission Valley, Sweetwater Valley, Otay Valley, and Tijuana groundwater basins use a combination of surface water and groundwater to meet water demands (California American Water Company 2012; City of San Diego 2011; HWD 2011; OWD

2011; PDMWD 2011; SDCWA et al. 2013; Sweetwater Authority 2011). The San Diego County Water Authority provides wholesale surface water supplies to several communities. The City of San Diego, Helix Water District, and Sweetwater Authority provide retail surface water and/or groundwater supplies to users within cities of La Mesa, Lemon Grove, National City, and San Diego; portions of Chula Vista and El Cajon; and all or portions of the communities of Bonita, Lakeside, and Spring Valley. The County of San Diego–Campo Water and Sewer Maintenance District, Cuyamaca Water District, Decanso Community Services District, Julian Community Services District, Majestic Pines Community Services District, Wynola Water District, Lake Morena Oak Shores Mutual Water Company, Pine Hills Mutual Water Company, and Pine Valley Mutual Water Company rely upon groundwater to meet their water demands. Groundwater is not used for water supplies within Padre Dam Municipal Water District which serves the City of Santee and portions of the City of El Cajon; Otay Water District which serves portions of the cities of Chula Vista, El Cajon, and La Mesa, and several unincorporated communities; and California American Water which serves the City of Imperial Beach and portions of the cities of Chula Vista, Coronado, and San Diego. Sweetwater Authority operates the Desalination Facility to treat brackish groundwater (San Diego County LAFCO 2011).

#### *7.3.6.4 Western Riverside County and Southwestern San Bernardino County*

The areas within the SWP service area in western and central Riverside County and southern San Bernardino County in the Southern California Region include the Upper Santa Ana Valley Groundwater Basin in Riverside and San Bernardino counties; the Elsinore, San Jacinto Groundwater Basin in Riverside County; and the Temecula Valley Groundwater Basin in Riverside and San Diego counties, as shown in Figure 7.12.

##### 7.3.6.4.1 Hydrogeology and Groundwater Conditions

*Upper Santa Ana Valley Groundwater Basin*

The Upper Santa Ana Valley Groundwater Basin consists of the Cucamonga, Chino, Riverside-Arlington, Temescal, Rialto-Colton, Cajon, Bunker Hill, Yucaipa, and San Timoteo groundwater subbasins.

*Cucamonga Subbasin*

The Cucamonga subbasin is located within San Bernardino County in the upper Santa Ana River watershed (DWR 2004 cd; MWDSC 2007). Groundwater is contained within the basin by the Red Hill fault. The water bearing formations are mainly alluvium of gravel, sand, and silt with beds of compacted clay. Groundwater is recharged naturally from precipitation and stream flows, water discharged to spreading basins, and runoff that flows into the streams from irrigated lands, including lands irrigated with SWP water. The groundwater is characterized as calcium-sodium bicarbonate with moderate to high TDS and nitrates, and localized areas with high volatile organic compounds, perchlorate, and dibromochloropropane (DBCP) (MWDSC 2007).

The Cucamonga subbasin was designated by the CASGEM program as medium priority.

*Chino Subbasin*

The Chino subbasin is located in San Bernardino County. The Chino subbasin is composed of alluvial material. The Rialto-Colton, San Jose, and the Cucamonga faults act as groundwater flow barriers (DWR 2006z). Along the southern boundary of the subbasin, groundwater can rise to the elevation of the Santa Ana River and be discharged into the stream. Groundwater is recharged naturally from precipitation and stream flows along the Santa Ana River and its tributaries, water discharged to spreading basins, and runoff that flows into the streams from irrigated lands, including lands irrigated with SWP water.

The Chino subbasin is characterized with high TDS and nitrate concentrations and localized areas of high volatile organic compounds, and perchlorate (MWDSC 2007).

The Chino subbasin was designated by the CASGEM program as high priority.

*Riverside-Arlington Subbasin*

The Riverside-Arlington subbasin is located within the Santa Ana River Valley in southwestern San Bernardino County and northwestern Riverside County (DWR 2004ce). Water bearing formations include alluvial deposits of sand, gravel, silt, and clay. The Rialto-Colton Fault separates this subbasin from the Rialto-Colton subbasin. The Riverside and Arlington portions of the subbasin are also separated. Groundwater flows to the northwest and to the Arlington Gap in the southwest area of the subbasin; and continues into the Temescal subbasin. Groundwater is recharged naturally from precipitation and stream flows in the Santa Ana River, and flow from adjacent subbasins. The groundwater is characterized as calcium-sodium bicarbonate with moderate to high TDS and nitrates, and localized areas with high volatile organic compounds, perchlorate, and DBCP (MWDSC 2007).

The Riverside-Arlington subbasin was designated by the CASGEM program as high priority.

*Temescal Subbasin*

The Temescal subbasin is located within the Santa Ana River Valley in Riverside County. Water bearing formations consist of alluvium bounded by the Elsinore fault zone on the west and the Chino fault zone on the northwest (DWR 2006aa). Groundwater is recharged naturally from precipitation and stream flows in the tributaries of the Santa Ana River. The groundwater is characterized as calcium-sodium bicarbonate with moderate to high TDS and nitrates, and localized areas with high volatile organic compounds, perchlorate, iron, and manganese (MWDSC 2007).

The Temescal subbasin was designated by the CASGEM program as medium priority.

### *Cajon Subbasin*

The Cajon subbasin is located within the upper Santa Ana River Valley in San Bernardino County. Water bearing formations consist of alluvium bounded by the San Andreas Fault zone on the south and impermeable rock formations on the east and west (DWR 2004cf). Groundwater is recharged naturally from precipitation, stream flows in the tributaries of the Santa Ana River, and runoff that flows into the streams from irrigated lands, including lands irrigated with SWP water. The groundwater quality is good for the beneficial uses.

The Cajon subbasin was designated by the CASGEM program as very low priority.

### *Rialto-Colton Subbasin*

The Rialto-Colton subbasin is located within the upper Santa Ana River Valley in southwestern San Bernardino County and northwestern Riverside County. Water bearing formations consist of alluvium bounded by the Rialto-Colton and San Jacinto fault zones (DWR 2004cg). Groundwater is recharged naturally from precipitation and stream flows. The groundwater quality is good for the beneficial uses with localized areas of high volatile organic compounds.

The Rialto-Colton subbasin was designated by the CASGEM program as medium priority.

### *Bunker Hill Subbasin*

The Bunker Hill subbasin is located in San Bernardino County. The water bearing formations include alluvium of sand, gravel, and boulders with deposits of silt and clay bounded by the Rialto-Colton and San Jacinto fault zones (DWR 2004ch). Groundwater is recharged naturally from precipitation, stream flows in the Santa Ana River and its tributaries, water discharged to spreading basins, and runoff that flows into the streams from irrigated lands, including lands irrigated with SWP water. The groundwater quality is good for the beneficial uses. The groundwater is characterized as calcium- bicarbonate with localized areas of high volatile organic compounds and perchlorate within several contamination plumes (*Lockheed Martin Corporation v. United States, Civil Action No. 2008-1160*).

The Bunker Hill subbasin was designated by the CASGEM program as high priority.

### *Yucaipa Subbasin*

The Yucaipa subbasin is located within the upper Santa Ana River Valley in San Bernardino County. Water bearing formations include alluvial deposits of sand, gravel, boulders, silt, and clay (DWR 2004ci). Several fault zones restrict groundwater movement. The San Timoteo formation along the western boundary of the basin causes the water to rise to the elevation of the San Timoteo Wash, a tributary of the Santa Ana River. Groundwater is recharged naturally from precipitation and stream flows, and water discharged to recharge basins. The groundwater is characterized as calcium-sodium bicarbonate with moderate TDS and high nitrate concentrations, and localized areas with high volatile organic compounds.

The Yucaipa subbasin was designated by the CASGEM program as medium priority.

#### *San Timoteo Subbasin*

The San Timoteo subbasin is located within the upper Santa Ana River Valley in Riverside County. Water bearing formations include alluvial deposits of gravel, silt, and clay (DWR 2004cj). Several fault zones restrict groundwater movement. Groundwater is recharged naturally from precipitation and stream flows, and water discharged to recharge basins. The groundwater is characterized as calcium-sodium bicarbonate and good quality for the beneficial uses.

The San Timoteo subbasin was designated by the CASGEM program as medium priority.

### *San Jacinto Groundwater Basin*

The San Jacinto Groundwater Basin is located in upper Santa Ana River Valley in Riverside County, and underlies the San Jacinto, Perris, Moreno and Menifee valleys and Lake Perris. The water bearing formations are alluvium over crystalline basement rock (DWR 2006ab). Several fault zones restrict groundwater movement. Groundwater is recharged naturally from precipitation and stream flows along the San Jacinto River and its tributaries, percolation from Lake Perris, and water discharged to recharge basins. The groundwater is characterized as calcium-sodium bicarbonate with high TDS and nitrate concentrations and localized areas with high iron, manganese, sulfides, volatile organic compounds, and perchlorate (DWR 2006ac; MWDSC 2007).

The San Jacinto Groundwater Basin was designated by the CASGEM program as high priority.

### *Elsinore Groundwater Basin*

The Elsinore Groundwater Basin is located in upper Santa Ana River Valley in Riverside County. The water bearing formations are alluvial fan, floodplain, and lacustrine deposits underlain by alluvium of gravel, sand, silt, and clay (DWR 2006ac). Several fault zones restrict groundwater movement. Groundwater is recharged naturally from precipitation and stream flows along the San Jacinto River, and water discharged to recharge basins. The groundwater is characterized as calcium-sodium bicarbonate with moderate salinity and localized areas with high fluoride, arsenic, nitrate, iron, manganese, volatile organic compounds, and perchlorate (DWR 2006ac; MWDSC 2007).

The Elsinore Groundwater Basin was designated by the CASGEM program as high priority.

### *Temecula Valley Groundwater Basin*

The Temecula Valley Groundwater Basin is located in the upper Santa Margarita River watershed within Riverside and San Diego counties. The water bearing formations are alluvium of sand, tuff, and silt underlain by fractured bedrock

(DWR 2004ck). Several fault zones restrict groundwater movement. Groundwater is recharged naturally from precipitation and stream flows. The groundwater is characterized as calcium-sodium bicarbonate with high TDS, fluoride, nitrate, volatile organic compounds, and perchlorate (DWR 2006ac; MWDSC 2007).

The Temecula Valley Groundwater Basin was designated by the CASGEM program as high priority.

#### 7.3.6.4.2 Groundwater Use and Management

*Upper Santa Ana Valley Groundwater Basin*

The Upper Santa Ana Valley Groundwater Basin consists of the Cucamonga, Chino, Riverside-Arlington, Temescal, Rialto-Colton, Cajon, Bunker Hill, Yucaipa, and San Timoteo groundwater subbasins.

*Cucamonga and Chino Subbasins*

The communities in the Cucamonga and Chino subbasins use a combination of surface water and groundwater to meet water demands (City of Chino 2011; City of Ontario 2011; City of Pomona 2011; City of Upland 2011; Cucamonga Valley WD 2011; FWC 2011; JCSD 2011; MWDSC 2007; MVWD 2011; SAWC 2011; WMWD 2011). The cities of Chino, Ontario, Pomona, and Upland; Cucamonga Valley Water District, Jurupa Community Services District, Monte Vista Water District, and Western Municipal Water District; San Antonio Water Company, Fontana Water Company, Santa Ana River Water Company, and Marygold Mutual Water Company, and Golden State Water Company provide wholesale and/or retail water supplies, including groundwater, to users within their communities and to portions of the City of Rialto, Montclair, Rancho Cucamonga, and San Antonio Heights.

The Cucamonga subbasin was adjudicated in 1958 to allocate groundwater rights in the basin and surface water rights to Cucamonga Creek (City of Chino 2011; Cucamonga Valley WD 2011; MWDSC 2007). The water supplies are allocated to the Cucamonga Valley Water District, San Antonio Water Company, and the West End Consolidated Water Company. The City of Upland has agreements with San Antonio Water Company and the West End Consolidated Water Company to divert from the subbasin.

The Chino subbasin was adjudicated in 1978 through the Chino Basin Judgment which established the Chino Basin Watermaster to manage the subbasin and enforce the provisions of the judgment (City of Chino 2011; Cucamonga Valley WD 2011; MWDSC 2007). The judgment and subsequent agreements allocated the available safe yield to three categories, or pools: Overlying Agricultural Pool, including dairies, farms, and the State of California; Overlying Non-Agricultural Pool for industrial users; and the Appropriative Pool Committee, including local cities, public water agencies, and private water companies. The judgment and subsequent agreements included provisions for reallocation of water rights, groundwater replenishment if the subbasin is operated in a controlled overdraft condition, and development of a groundwater management plan. Through "Peace

Agreements" adopted in 2000 and amended in 2004, included provisions to allow: members of the Overlying Non-Agricultural Pool to transfer their water within their pool or to the Watermaster, appropriators to provide water service to overlying lands, and the Watermaster to allocate unallocated safe yield. The Peace Agreement also addressed use of local storage facilities, management of the subbasin under the Dry Year Yield program when imported water, including SWP water, is not fully available. Groundwater replenishment is allowed through spreading basins, percolation, groundwater injection, and in-lieu use of other water supplies, including SWP water. The Chino Basin Watermaster also was required to develop an Optimum Basin Management Plan, adopted in 1998, to address approaches that would enhance basin water supplies, protect and enhance water quality, enhance management of the basin, and equitably finance implementation of programs identified in the plan. The Peace II Agreement was adopted in 2007 addressed procedures related to basin reoperation under controlled overdraft conditions using the Chino Desalters to meet the replenishment obligation and to maintain hydraulic control in the subbasin, and transfers. The Groundwater Recharge Master Plan update was prepared by the Watermaster in 2010.

The Santa Ana Regional Water Quality Control Board adopted a Water Quality Control Plan in 2004 for the entire Santa Ana River Basin which included a Maximum Benefit Basin Plan, recommended by the Chino Basin Watermaster and the Inland Empire Utilities Agency. The plan established water quality objectives in groundwater quality objectives for TDS and Total Inorganic Nitrogen and wasteload allocations to allow use of recycled water for groundwater recharge. The Maximum Benefit Basin Plan includes commitments for surface water and groundwater monitoring programs; implementation of up to 40 million gallons/day of treated groundwater at desalters; implementation of recharge facilities, conjunctive use programs, and recycled water quality management programs; and groundwater management to provide hydraulic controls to protect the Santa Ana River water quality.

Operations of the Chino Basin portion of the upper Santa Ana River are also affected by surface water right judgments administered by the Santa Ana River Watermaster.

A large portion of the natural runoff in the upper Santa Ana River watershed is captured and used to recharge the groundwater aquifers. Flood control channels and percolation basins are operated by San Bernardino County Flood Control District to allow for flood control and groundwater recharge (MWDSC 2007). Groundwater recharge also occurs in spreading basins operated by the City of Upland, San Antonio Water Company, and San Antonio Water Company. The Chino Basin Water Conservation District operates percolation ponds and spreading basins to facilitate groundwater recharge (IEUA 2011).

The Inland Empire Utilities Agency manages production and treatment of recycled water supplies that are used in groundwater recharge operations and as part of conjunctive use programs in the cities of Chino, Chino Hills, Ontario, and Upland; and in the service areas of the Cucamonga Valley Water District, Monte

Vista Water District, Fontana Water Company, and San Antonio Water Company (IEUA 2011). The district is a member of the Chino Basin Watermaster Board of Directors. The Inland Empire Utilities Agency operates several recharge facilities in the Chino subbasin. Recharge water comes from three sources: recycled water, stormwater, and imported SWP water. The Inland Empire Utilities Agency operates the Chino Desalter Authority's Chino I and Chino II Desalters that treat water from 22 wells. The Chino Desalter Authority is a joint powers authority that includes the cities of Chino, Chino Hills, Norco, and Ontario; and the Jurupa Community Services District, Santa Ana River Water Company, Western Municipal Water District, and Inland Empire Utilities Agency. The treated water from the desalters is used for potable water supplies, groundwater recharge with water with reduced salts and nitrates, and improved water quality of the Santa Ana River.

#### *Riverside-Arlington and Temescal Subbasins*

The communities in the Riverside-Arlington and Temescal subbasins use a combination of surface water and groundwater to meet water demands (City of Corona 2011; City of Norco 2014; City of Rialto 2011; City of Riverside 2011; JCSD 2011; MWDSC 2007; RCWD 2011; SBVMWD 2011; WMWD 2011). The San Bernardino Valley Municipal Water District and Western Municipal Water District provide wholesale and retail water supplies, including groundwater, in the areas that overlay the Riverside-Arlington and Temescal subbasins. The cities of Colton, Corona, Norco, Rialto, and Riverside; Elsinore Valley Municipal Water District; Jurupa Community Services District, Lee Lake Water District; Rubidoux Community Services District, San Bernardino Valley Municipal Water District, Western Municipal Water District, and West Valley Water District; and Box Springs Mutual Water Company, Riverside Highland Mutual Water Company, and Terrace Water Company provide retail water supplies, including groundwater, to users within their communities. The Jurupa Community Services District uses wells within the Riverside-Arlington subbasin for non-potable uses (JCSD 2011).

The Riverside portion of the Riverside-Arlington subbasin was adjudicated in 1969 through the stipulated judgment for the *Western Municipal Water District of Riverside County et al. versus East San Bernardino County Water District, et al.* The judgment provided average annual extraction volumes and replenishment schedules for the separate sections of the subbasin as defined by the San Bernardino County and Riverside County boundary (Riverside North and Riverside South portions of the subbasin) (City of Riverside 2011; MWDSC 2007). Within the Riverside North portion, the judgment affects only withdrawals that are to be used in Riverside County because withdrawals for use of water in San Bernardino County are not limited. The Western-San Bernardino Watermaster manages the monitoring and reporting of groundwater conditions of the Riverside portion of the subbasin.

The northern portion of the Riverside portion of the subbasin also was part of the 1969 judgment in the *Orange County Water District v. City of Chino et al.* This judgment primarily includes the Bunker Hill subbasin and small portions of the northern Riverside, Rialto-Colton, and Yucaipa subbasins; and requires minimum downstream flows into the lower Santa Ana River (SBVMWD 2011). To meet the flow obligations, the San Bernardino Valley Municipal Water District is responsible to manage groundwater and surface waters within the San Bernardino Basin Area, as defined in the judgment. The district manages the groundwater by allocation of groundwater withdrawal amounts and requiring replenishment when additional groundwater is withdrawn.

The Arlington portion of the Riverside-Arlington subbasin and the Temescal subbasins are not adjudicated (City of Corona 2011; MWDSC 2007). In 2008, an agreement was adopted between Elsinore Valley Municipal Water District and the City of Corona for use of water from the southern portion of the Temescal subbasin.

The City of Riverside operates two water treatment plants as part of the North Riverside Water Project to remove volatile organic compounds. The City of Corona operates the Temescal Basin Desalter Treatment Plant/Facility and the Western Municipal Water District operates the Arlington Desalter (City of Corona 2011; WMWD 2011) to reduce TDS. The City of Norco operates a groundwater treatment plant to reduce iron, manganese, and hydrogen sulfide (City of Norco 2014).

#### *Cajon, Rialto-Colton, Bunker Hill, Yucaipa, and San Timoteo Subbasins*

The communities in the Cajon, Rialto-Colton, Bunker Hill, Yucaipa, and San Timoteo subbasins use a combination of surface water and groundwater to meet water demands (City of Rialto 2011; City of Riverside 2011; MWDSC 2007; SBVMWD 2011; YVWD 2011; WMWD 2011; West Valley WD 2014a). The San Bernardino Valley Municipal Water District and Western Municipal Water District provide wholesale and retail water supplies, including groundwater, in the areas that overlay the Cajon, Rialto-Colton, Bunker Hill, Yucaipa, and San Timoteo subbasins. The cities of Colton, Loma Linda, Redlands, Rialto, Riverside, and San Bernardino; Beaumont-Cherry Valley Water District, East Valley Water District, South Mesa Water District, West Valley Water District, Western Municipal Water District, West Valley Water District, and Yucaipa Valley Water District; and several private water companies provide retail water supplies, including groundwater, to users within their communities and to portions of the cities of Beaumont, Calimesa, and Yucaipa; the communities of Cherry Valley, Mission Grove, Orange Crest, and Woodcrest; and numerous private water companies.

Groundwater adjudication in these subbasins have occurred over the past 90 years. A portion of the Bunker Hill subbasin underlays the Lytle Creek watershed (City of Rialto 2011). The remaining portion of the Lytle Creek watershed overlays the Lytle Creek groundwater basin that is not included in the DWR Bulletin 118. The entire Lytle Creek groundwater basin, including the portion in the Bunker Hill subbasin, is a major groundwater recharge source to the Bunker Hill and Rialto-Colton subbasins; and was adjudicated in 1924. The stipulation of the judgment allocated groundwater withdrawal right to the City of Rialto, Citizens Land and Water Company, Lytle Creek Water and Improvement Company, Rancheria Water Company, and Mutual Water Company.

The Rialto-Colton subbasin was adjudicated in 1961 under the *Lytle Creek Water & Improvement Company vs. Fontana Ranchos Water Company et al* (City of Rialto 2011). The adjudication allocated groundwater withdrawals between the cities of Rialto and Colton, West Valley Water District, and Fontana Union Water Company based upon spring groundwater levels at three index wells between March and May of each water year. The groundwater subbasin is managed by the Rialto Basin Management Association. The stipulation of the judgment allocated groundwater withdrawal right to the City of Rialto, Citizens Land and Water Company, Lytle Creek Water and Improvement Company, and private well users. Use of this aquifer has been limited due to contamination with volatile organic compounds which are currently being treated. The City of Rialto also has agreements with San Bernardino Municipal Water District to store SWP water in the Rialto subbasin. The city can withdraw the stored water without affecting the water allowed to be withdrawn under the 1961 decree.

As described above under the Riverside-Arlington and Temescal Subbasins section, in 1969 the stipulated judgment for the *Western Municipal Water District of Riverside County et al. versus East San Bernardino County Water District, et al.* to preserve the safe yield of the San Bernardino Basin Area through entitlements to groundwater withdrawals to protect the safe yield and establishment of replenishment schedules when the safe yield is exceeded (City of Rialto 2011; SBVMWD 2011). The San Bernardino Basin Area includes the Bunker Hill subbasin and portions of the Rialto-Colton and Yucaipa subbasins; and portions of the Mill Creek, Lytle Creek, and upper Santa Ana River watersheds. The Western-San Bernardino Watermaster, which includes Western Municipal Water District and San Bernardino Municipal Water District, manages the monitoring and reporting of groundwater conditions. The primary users of the groundwater under this decree include the cities of Colton, Loma Linda, Redlands, and Rialto; East Valley Water District, San Bernardino Municipal Water District, West Valley Water District, and Yucaipa Valley Water District; Riverside-Highland Water Company and 13 private water companies.

In 2002, the City of Beaumont, Beaumont-Cherry Valley Water District, South Mesa Water Company, and Yucaipa Valley Water District formed the San Timoteo Watershed Management Authority to enhance water supplies and water quality, manage groundwater in the Beaumont Basin (part of the San Timoteo subbasin), protect riparian habitat in San Timoteo Creek, and allocate benefits and costs of these programs (Beaumont Basin Watermaster 2013; SBVMWD 2011). One of the issues that the authority initiated was negotiations related to groundwater withdrawals by the City of Banning. A Stipulated Agreement was adopted in 2004 in accordance with the judgment for the *San Timoteo Watershed Management Authority, vs. City of Banning et al.* The judgment established a Watermaster committee of the cities of Banning and Beaumont, Beaumont-Cherry Valley Water District, South Mesa Water Company, and Yucaipa Valley Water

District. The judgment allocated groundwater supplies in a manner that allows for storage of groundwater recharge from spreading basins or in-lieu programs.

The Seven Oaks Accord, a settlement agreement, was signed by the City of Redlands; East Valley Water District, San Bernardino Valley Municipal Water District, and Western Municipal Water District; and Bear Valley Mutual Water Company, Lugonia Water Company, North Fork Water Company, and Redlands Water Company to recognize prior rights of water users of a portion of the natural flow of the Santa Ana River (SBVMWD 2011). The Seven Oaks Accord requires that San Bernardino Valley Municipal Water District, and Western Municipal Water District develop a groundwater spreading program to recharge the groundwater in cooperation with other parties to the accord to maintain relatively constant groundwater levels.

In 2005, the San Bernardino Valley Municipal Water District entered into an agreement with the San Bernardino Valley Water Conservation District to work cooperatively to develop and implement a groundwater management plan which includes groundwater banking programs (SBVMWD 2011).

The City of Rialto, San Bernardino Valley Municipal Water District, West Valley Water District, and Riverside Highland Water District have jointly constructed the Baseline Feeder to convey groundwater from the Bunker Hill subbasin to the Rialto area and West Valley Water District to be used in an in-lieu program that would reduce reliance on SWP water supplies (City of Rialto 2011; West Valley WD 2014c, 2014d).

West Valley Water District implemented a bioremediation wellhead treatment system (West Valley Water District 2014b).

#### *San Jacinto Groundwater Basin*

The communities in the San Jacinto Groundwater Basin use a combination of surface water and groundwater to meet water demands (City of Hemet 2011; City of San Jacinto 2011; EMWD 2011; LHMWD 2011; MWDSC 2007; RCWD 2011). The Eastern Municipal Water District provides wholesale and retail water supplies, including groundwater, in the areas that overlay the San Jacinto Groundwater Basin. The cities of Hemet and San Jacinto; and Eastern Municipal Water District and Rancho California provide retail water supplies, including groundwater, to users within their communities and to portions of the cities of Menifee, Moreno Valley, Murrieta, and Temecula; Lake Hemet Municipal Water District; Nuevo Water Company and numerous private water companies; and the communities of Edgemont, Homeland, Juniper Flats, Lakeview, Mead Valley, North Perris Water System, Romoland, Sunnymead, Valle Vista, and Winchester. The City of Perris overlays a portion of the San Jacinto Groundwater Basin; however, the city does not use groundwater. A substantial portion of the groundwater supplies within the San Jacinto Groundwater Basin are used by agricultural water users.

The 1954 Fruitvale Judgment allows for Eastern Municipal Water District to withdraw water from the San Jacinto Groundwater Basin if the groundwater elevation is greater than a specified elevation (EMWD 2009, 2011, 2014). The judgment includes a maximum withdrawal volume for use outside of the groundwater basin. There are further restrictions within the Canyon Basin subbasin of the San Jacinto Groundwater Basin. DWR worked with the cities of Hemet and San Jacinto, Lake Hemet Municipal Water District, Eastern Municipal Water District, and private groundwater companies to file a stipulated judgment in 2007 to form a Watermaster to develop and implement the Hemet/San Jacinto Water Management Plan, including the Hemet/San Jacinto Integrated Recharge and Recovery Program, Recycled Water In-Lieu Project, and Hemet Filtration Plant. The stipulated judgment also limited groundwater withdrawals to protect the groundwater basin, provide for recharge programs, expand water production, and protect water quality. The program uses SWP water and San Jacinto River runoff to recharge the San Jacinto-Upper Pressure Groundwater Management Zone. In 2013, the judgment was filed with the court to adopt the Hemet/San Jacinto Water Management Plan and create the Watermaster Board.

The stipulated judgment also addressed methods to fulfil the Soboaba Band of Luiseño Indians water rights in accordance with the findings of the Court for the *Soboba Band of Luiseño Indians Water Settlement Agreement* in 2006. In 2008, the Soboba Settlement Act was signed by the President of the United States to provide an annual water supply and provide funds for economic development. The legislation also provides funds to construct recharge facilities and provisions for the Soboba Tribe to participate in restoration efforts.

The Eastern Municipal Water District adopted the West San Jacinto Groundwater Basin Management Plan in 1995. The management plan includes the Nuevo Water Company, City of Moreno Valley, City of Perris, and McCanna Ranch Water Company (MWDSC 2007).

Eastern Municipal Water District operates two desalination plants to treat brackish water within the San Jacinto Groundwater Basin as part of the Groundwater Salinity Management Program (EMWD 2011). Other wells within the Eastern Municipal Water District also include treatment facilities to reduce hydrogen sulfide, iron, and/or manganese.

#### *Elsinore Groundwater Basin*

The communities in the Elsinore Groundwater Basin use a combination of surface water and groundwater to meet water demands (EVMWD 2011; MWDSC 2007). The Elsinore Valley Municipal Water District provides wholesale and retail water supplies, including groundwater, in the areas that overlay the Elsinore Groundwater Basin. The cities of Lake Elsinore, Canyon Lake, and Wildomar; Elsinore Valley Municipal Water District and Elsinore Water District; and Farm Mutual Water Company provide retail water supplies, including groundwater, to users within their communities and to portions of Cleveland Ranch, Farm, Horsethief Canyon, Lakeland Village, Meadowbrook, Rancho Capistrano – El Cariso Village, and Temescal Canyon.

The Elsinore Groundwater Basin is not adjudicated. The Elsinore Valley Municipal Water District was responsible for over 90 percent of the groundwater withdrawals in mid-2000s (EVMWD 2011). The Elsinore Basin Groundwater

Management Plan, adopted by Elsinore Valley Municipal Water District in 2005, identifies conjunctive use projects, including direct recharge projects. The direct recharge projects use imported water, including SWP water.

*Temecula Valley Groundwater Basin*

The communities in the Temecula Valley Groundwater Basin use a combination of surface water and groundwater to meet water demands (MWDSC 2007; RCSD 2011; WMWD 2011). The Rancho California Water District and Western Municipal Water District (including Murrieta County Water District) provide wholesale and retail water supplies, including groundwater, in the areas that overlay the Temecula Valley Groundwater Basin, including the cities of Murrieta and Temecula. The Pechanga Indian Reservation operates groundwater wells within the Temecula Valley Groundwater Basin (MWDSC 2007).

The Temecula Valley Groundwater Basin is located within the Santa Margarita River watershed. As described above for the San Mateo Valley, San Onofre Valley, and Santa Margarita Valley Groundwater Basins, the groundwater basins that contribute direct or indirect flows into the Santa Margarita River have been adjudicated and are managed by the Santa Margarita River Watermaster in accordance with the 1940 Stipulated Judgment, the 1966 Modified Final Judgment and Decree, and subsequent court orders (MWDSC 2007; RCWD 2011; SMRW 2011; WMWD 2011). The court-appointed steering committee for the Watermaster includes Eastern Municipal Water District, Fallbrook Public Utility District, Metropolitan Water District of Southern California, Pechanga Band of Luiseno Mission Indians of the Pechanga Reservation, Rancho California Water District, Western Municipal Water District, and Marine Corps Base Camp Pendleton. In accordance with the judgment, the Rancho California Water District prepares the annual Groundwater Audit and Recommended Groundwater Production Report that allocates groundwater withdrawals based upon rainfall, recharge area, and pumping capacity. The subsequent orders adopted following 1966 included the Cooperative Water Resource Management Agreement between Rancho California Water District and the Marine Corps Base Camp Pendleton to manage groundwater levels and surface water flows; water rights to Vail Lake on Temecula Creek; and an agreement between the Rancho California Water District and the Pechanga Band of Luiseno Mission Indians of the Pechanga Reservation.

Rancho California Water District provides imported water, including SWP water, and natural runoff released from Vail Lake to the Valle de Los Caballos Recharge Basins (RCWD 2011). The district also has implemented the Vail Lake Stabilization and Conjunctive Use Project to store imported water in Vail Lake for subsequent groundwater recharge (RCWD et al. 2014).

#### 7.3.6.5 Central Riverside County

The areas within the SWP service area which receive Colorado River water in-lieu of SWP water deliveries are located within the Coachella Valley Groundwater Basin. The Coachella Valley Groundwater Basin includes the

Desert Hot Springs, Indio, Mission Creek, and San Gorgonio Pass subbasins, as shown in Figure 7.12.

#### 7.3.6.5.1 Hydrogeology and Groundwater Conditions

The Coachella Valley Groundwater Basin underlies the entire floor of the Coachella Valley. Primary water-bearing materials in the Coachella Valley Groundwater Basin are unconsolidated alluvial deposits along the valley floor which consist of older alluvium and a thick sequence of poorly bedded coarse sand and gravel; terrace deposits under the surrounding foothills in the Mission Creek subbasin; and partly consolidated fine to coarse sandstone in the surrounding mountains in the San Gorgonio Pass subbasin (DWR 2004cm, 2004cn, 2004co, 2004cp). The movement of groundwater is locally influenced by features such as faults, structural depressions, and constrictions; however, groundwater generally flows to the southeast towards the Salton Sea. Groundwater recharge occurs along stream beds and from groundwater inflows from adjacent subbasins. Within the Indio subbasin, groundwater also is recharged from spreading basins and injection wells.

The groundwater quality is characterized as calcium-sodium bicarbonate. Groundwater quality is adequate for community and agricultural water uses within the San Gorgonio Pass, Mission Creek, and Indio subbasins. There are localized areas with high fluoride near the Banning and San Andreas fault zones. Groundwater quality in the Desert Hot Springs subbasin is poor due to the geothermal activity which results in high sodium sulfate, TDS, and chlorides. The hot springs water is only used by a resort for bathing.

Desert Hot Springs Groundwater Basin was designated by the CASGEM program as low priority. Indio, Mission Creek, and San Gorgonio Pass groundwater basins were designated as medium priority.

#### 7.3.6.5.2 Groundwater Use and Management

*Coachella Valley Groundwater Basin*

The Coachella Valley Groundwater Basin includes the San Gorgonio Pass, Mission Creek, Desert Hot Springs, and Indio subbasins.

*San Gorgonio Pass Subbasin*

The communities in the San Gorgonio Pass subbasin use a combination of surface water and groundwater to meet water demands (BCVWD 2013; City of Banning 2011; SGPWA 2010). The City of Banning, Beaumont-Cherry Valley Water District, Cabazon Water District, and High Valley Water District provide retail water supplies, including groundwater, in the areas that overlay the San Gorgonio Pass subbasin, including the City of Banning and the eastern portion of the City of Beaumont; Banning Heights Mutual Water Company; and the community of Cabazon. The Morongo Band of Mission Indians operates groundwater wells within the San Gorgonio Pass subbasin.

The western portion of the San Gorgonio Pass subbasin is located within the Beaumont Basin (USGS 1974). As described above, the City of Beaumont,

Beaumont-Cherry Valley Water District, South Mesa Water Company, and Yucaipa Valley Water District formed the San Timoteo Watershed Management Authority to enhance water supplies and water quality, manage groundwater, protect riparian habitat in San Timoteo Creek, and allocate benefits and costs of these programs (Beaumont Basin Watermaster 2013). One of the issues that the authority initiated was negotiations related to groundwater withdrawals by the City of Banning. A Stipulated Agreement was adopted in 2004 in accordance with the judgment for the *San Timoteo Watershed Management Authority, vs. City of Banning et al.* The judgment established a Watermaster committee of the cities of Banning and Beaumont, Beaumont-Cherry Valley Water District, South Mesa Water Company, and Yucaipa Valley Water District. The judgment allocated groundwater supplies in a manner that allows for storage of groundwater recharge from spreading basins or in-lieu programs.

#### *Mission Creek, Desert Hot Springs, and Indio Subbasins*

The communities in the Mission Creek, Desert Hot Springs, and Indio subbasins use a combination of surface water and groundwater to meet water demands (City of Coachella 2011; CVWD 2011, 2012; DWA 2011; IWA 2010; MSWD 2011). The City of Coachella, Coachella Valley Water District, Desert Water Agency, Indio Water Authority, and Mission Springs Water District provide retail water supplies, including groundwater, in the areas that overlay the Mission Creek, Desert Hot Springs, and Indio subbasins, including the cities of Cathedral City, Coachella, Desert Hot Springs, Indian Wells, Indio, La Quinta, Palm Desert, Palm Springs, and Rancho Mirage; and the communities of Barton Canyon, Bermuda Dunes, Bombay Beach, Desert Crest, Desert Edge, Indio Hills, Mecca, Mecca Hills, Palm Springs Crest, Salton City, Thermal, and West Palm Springs Village. The Cabazon Band of Mission Indians and the Torres-Martinez Desert Cahuilla Indians operate groundwater wells within the subbasins.

The Coachella Valley Water District, Desert Water Agency, and Mission Springs Water District all participate in groundwater management programs within the subbasins (CVWD 2011, 2012; DWA 2011; MSWD 2011). These programs include purchasing imported Colorado River water for groundwater recharge and in-lieu programs, conjunctive use programs, and conservation programs. Coachella Valley Water District and Desert Water Agency are SWP water contractors. However, because no conveyance facilities exist to deliver the SWP water, these districts have agreements with the Metropolitan Water District of Southern California to exchange SWP water for Colorado River water (CVWD 2012). Since 1973, these agencies have recharged more than 2.6 million acre-feet of water in the groundwater basin with delivery of Colorado River water to the Whitewater River Recharge Facility. The Metropolitan Water District of Southern California also has an agreement with Coachella Valley Water District and Desert Water Agency to store water in the Coachella Valley Groundwater Basin. The Coachella Valley Water District also operates the Thomas E. Levy Groundwater Replenishment Facility and the Martinez Canyon Pilot Recharge Facility. Coachella Valley Water District and Desert Water Agency also provide recycled water for in-lieu programs. The Coachella Valley Water District has agreed to operate groundwater recharge facilities to store Colorado River water for Imperial Irrigation District (CVWD 2011).

These groundwater recharge programs and broader groundwater management programs for the Indio subbasin have been developed in accordance with the Whitewater Basin Water Management Plan developed by Coachella Valley Water District and Desert Water Agency, and the Coachella Valley Water Management Plan developed by Coachella Valley Water District (CVWD 2011, 2012; DWA 2011).

The Coachella Valley Water District, Desert Water Agency, and Mission Springs Water District jointly manage the Mission Creek subbasin in accordance with the 2004 Mission Creek Settlement Agreement (DWA 2011; MSWD 2011). The Coachella Valley Water District and Desert Water Agency also manage portions of the subbasin in accordance with the 2003 Mission Creek Groundwater Replenishment Agreement. These agreements provide for the allocation of available Colorado River water under the SWP water exchange agreement with the Metropolitan Water District of Southern California between the Mission Creek and Indio (also known as the Whitewater) subbasins.

#### *7.3.6.6 Antelope Valley and Mojave Valley*

The areas within the SWP service area in the Antelope Valley and Mojave Valley include Salt Wells Valley, Cuddeback Valley, Pilot Knob Valley, Grass Valley, Superior Valley, El Mirage Valley, Upper Mojave River Valley, Middle Mojave River Valley, Lower Mojave River Valley, Caves Canyon Valley, Langford Valley, Cronise Valley, Coyote Lake Valley, Kane Wash Area, Iron Ridge Area, Bessemer Valley, Lucerne Valley, Johnson Valley, Means Valley, Deadman Valley, Twentynine Palms Valley, Joshua Tree, Ames Valley, Copper Mountain Valley, Warren Valley, and Morongo Valley groundwater basins in San Bernardino County; Harper Valley and Fremont Valley groundwater basins in San Bernardino Kern counties; Lost Horse Valley in Riverside and San Bernardino counties; Antelope Valley Groundwater Basin in San Bernardino, Kern, and Los Angeles counties; and Indian Wells and Searles Valley groundwater basin in San Bernardino, Inyo, and Kern counties, as shown in Figure 7.13.

##### 7.3.6.6.1 Hydrogeology and Groundwater Conditions

*Indian Wells Valley Groundwater Basin*

Indian Wells Valley Groundwater Basin is located in Inyo, Kern, and San Bernardino Counties. Water bearing formations consist of unconsolidated lakebed, stream, and alluvial fan deposits with upper and lower aquifers (DWR 2004cn). The lower aquifer is more productive and has a saturated thickness of approximately 1000 feet. The upper aquifer provides low yield and has low quality. The lower aquifer is considered unconfined in most of the valley. There is indication that some faults within the valley could obstruct groundwater flow. Groundwater is recharged from runoff on the southwest to northeast sides of the valley. Groundwater levels have been declining since 1945. Groundwater quality varies throughout the groundwater basin from appropriate for beneficial uses to areas with poor water quality due to wastewater disposal practices. Areas near geothermal activity are characterized by high chloride, boron, and arsenic concentrations.

Indian Wells Valley Groundwater Basin was designated by the CASGEM program as medium priority.

#### *Salt Wells Valley Groundwater Basin*

Salt Wells Valley Groundwater Basin is located in San Bernardino County. Water bearing formations consist of unconsolidated to poorly consolidated alluvium (DWR 2004co). Groundwater is recharged from the Indian Wells Groundwater Basin and percolation of rainfall on the valley floor. The regional groundwater flow direction is towards the east into the Searles Valley Groundwater Basin. The groundwater has extremely high salinity, TDS, and boron.

Salt Wells Valley Groundwater Basin was designated by the CASGEM program as very low priority.

#### *Searles Valley Groundwater Basin*

Searles Valley Groundwater Basin is located in San Bernardino, Inyo, and Kern Counties. Water bearing formations consist of alluvium with unconsolidated to semi-consolidated deposits (DWR 2004cp). The Garlock fault may be a barrier to groundwater flow in the southern part of the basin. Groundwater is recharged from percolation of mountain runoff through the alluvial fan deposits and subsurface inflow from Salt Wells Valley and Pilot Knob Valley groundwater basins. Groundwater flows towards Searles Lake except in the northern portion of the basin where pumping by industrial water users has altered the groundwater flow. Groundwater levels near Searles Lake are close to the lake bed elevations. Groundwater quality is generally appropriate for beneficial uses with localized areas with high levels of fluoride and nitrate. In the vicinity of Searles Lake, the groundwater quality is poor with high levels of fluoride, boron, sodium, chloride, sulfate, and TDS.

Searles Valley Groundwater Basin was designated by the CASGEM program as very low priority.

#### *Cuddeback Valley, Pilot Knob Valley, Grass Valley, and Superior Valley, Groundwater Basins*

Cuddeback Valley, Pilot Knob Valley, Grass Valley, and Superior Valley Groundwater basins are located in northern San Bernardino County. Water bearing formations consist of unconsolidated to poorly consolidated alluvium (DWR 2004cq, 2004cr, 2004cs, 2004ct). Several fault zones restrict groundwater movement. Groundwater is recharged in the Cuddeback Valley, Pilot Knob Valley, Grass Valley, and Superior Valley groundwater basins primarily through groundwater inflow into the basins and percolation of precipitation at the valley margins. Groundwater within Cuddeback Valley, Grass Valley, and Superior Valley groundwater basins flows towards the Harper Valley Groundwater Basin.

Groundwater in the Cuddeback Valley Groundwater Basin also flows towards Cuddeback Lake. Groundwater in Pilot Knob Valley Groundwater Basin flows towards the Searles Valley and Brown Mountain Valley groundwater basins. Groundwater quality is characterized as sodium chloride-bicarbonate with high salinity and TDS in the Cuddeback Valley Groundwater Basin and high concentrations of sodium and fluoride in the Superior Valley Groundwater Basin.

Cuddeback Valley, Pilot Knob Valley, Grass Valley, and Superior Valley groundwater basins were designated by the CASGEM program as very low priority.

#### *Harper Valley Groundwater Basin*

Harper Valley Groundwater Basin is located in western San Bernardino County and eastern Kern County. Water bearing formations consist of lacustrine deposits and unconsolidated to semi-consolidated alluvial deposits (DWR 2004cu). The alluvial deposits at the center of the basin are generally more interbedded with lacustrine silty clay. Faults in the Harper Valley Groundwater Basin cause at least partial barriers to groundwater flow. Groundwater is recharged from percolation of rainfall and runoff through alluvial fan material at the valley edges and underflow from Cuddeback Valley, Grass Valley, Superior Valley, and Middle Mojave River Valley groundwater basins. Regional groundwater flows toward the south and Harper Lake. Groundwater quality is characterized as sodium chloride-bicarbonate with high concentrations of boron, fluoride, and sodium.

Harper Valley Groundwater Basin was designated by the CASGEM program as low priority.

#### *Fremont Valley Groundwater Basin*

The Fremont Valley Groundwater Basin is located in eastern Kern County and in northwestern San Bernardino County. Water bearing formations consist of alluvial and lacustrine deposits (DWR 2004cv). The alluvial deposits are generally unconfined and the lacustrine deposits may exhibit locally confined conditions. Fault zones, including the Garlock and El Paso fault zones, are barriers to groundwater flow. Groundwater is recharged along streambeds in the Sierra Nevada Mountains. Groundwater flow is generally toward the center of the valley and Koehn Lake. Groundwater is characterized as sodium bicarbonate with high concentrations of calcium, chloride, fluoride, and sodium.

Fremont Valley Groundwater Basin was designated by the CASGEM program as low priority.

#### *Antelope Valley Groundwater Basin*

The Antelope Valley Groundwater Basin is located in Kern, Los Angeles, and San Bernardino counties. Water bearing formations consist of unconsolidated alluvial and lacustrine deposits consisting of compact gravels, sand, silt, and clay (DWR 2004cw). Several fault zones restrict groundwater movement. Groundwater is recharged along streams from the surrounding mountains, including Big Rock Creek and Little Rock Creek. The regional groundwater flow direction historically was towards the dry lakebeds of Rosamond, Rogers, and Buckhorn

Lakes. However, extensive groundwater pumping has caused subsidence and reduced the groundwater storage and flow direction. The groundwater is characterized as sodium bicarbonate with localized areas of high nitrate and boron.

Antelope Valley Groundwater Basin was designated by the CASGEM program as high priority.

### *El Mirage Valley Groundwater Basin*

The El Mirage Valley Groundwater Basin is located in San Bernardino County. Water bearing formations consist of unconsolidated to semi-consolidated alluvium (DWR 2003c). Several fault zones restrict groundwater movement. Groundwater is recharged in alluvial deposits at the mouth of Sheep Creek. The regional groundwater flow direction is generally north toward El Mirage Lake. The groundwater is characterized as sodium bicarbonate with localized areas of high levels of fluoride, sulfate, sodium, and TDS.

El Mirage Valley Groundwater Basin was designated by the CASGEM program as medium priority.

### *Upper Mojave River Valley, Middle Mojave River Valley, Lower Mojave River Valley, and Caves Canyon Valley Groundwater Basins*

The Upper Mojave River Valley, Middle Mojave River Valley, Lower Mojave River Valley, and Caves Canyon Valley groundwater basins are located along the Mojave River in southwestern and central San Bernardino County. The water bearing formations consist of alluvial fan deposits overlain by river channel, floodplain, or lake deposits (DWR 2004cx, 2004cy, 2003d, 2003e). The general groundwater flow direction follows the Mojave River north through the Upper Mojave River Valley Groundwater Basin, and east through the Middle Mojave River Valley, Lower Mojave River Valley, and Caves Canyon Valley groundwater basins. Several fault zones restrict groundwater movement. Groundwater is recharged from precipitation on the valley floor, underflow from the Mojave River, streamflow, and flow between the basins. Treated wastewater and irrigation return flows also provide a source of groundwater recharge in these basins. Groundwater quality in the Upper Mojave River Valley, Middle Mojave River Valley, Lower Mojave River Valley, and Caves Canyon Valley groundwater basins varies throughout the basins due to geological formations and includes areas dominated by calcium bicarbonate, calcium-sodium bicarbonate, calcium-sodium sulfate, sodium-calcium sulfate, and sodium sulfate-chloride. There are localized areas of high nitrate, iron, and manganese in the Upper Mojave River Valley Groundwater Basin; and areas with high nitrates, fluoride, and boron in the Middle Mojave River Valley and Lower Mojave River Valley groundwater basins. Localized areas with high volatile organic compounds occur in the Upper Mojave River Valley and Lower Mojave River Valley groundwater basins.

Upper Mojave River Valley Groundwater Basin was designated by the CASGEM program as high priority. Lower Mojave River Valley Groundwater Basin was designated as medium priority. Middle Mojave River Valley Groundwater Basin was designated as low priority. Caves Canyon Valley Groundwater Basin was designated as very low priority.

#### *Langford Valley Groundwater–Langford Well Lake Subbasin, and Cronise Valley and Coyote Lake Valley Groundwater Basins*

The Langford Well Lake subbasin and the Cronise Valley and Coyote Lake Valley groundwater basins are located in central San Bernardino County. Water bearing formations consist of unconsolidated to semi-consolidated alluvium (DWR 2004cz, 2004da, 2004db). Groundwater is recharged from precipitation, stream flows into alluvial deposits along the mountains at the basin boundaries, and subsurface inflow from other groundwater basins including the Superior Valley Groundwater Basin. Groundwater quality is poor due to high concentrations of fluoride, boron, and TDS, and localized areas with high iron in the Langford Well Lake subbasin.

Langford Well Lake subbasin and the Cronise Valley and Coyote Lake Valley groundwater basins were designated by the CASGEM program as very low priority.

#### *Kane Wash Area Groundwater Basin*

The Kane Wash Area Groundwater Basin is located in San Bernardino County. Water bearing formations consist of unconsolidated to semi-consolidated alluvium with undissected coarse gravel to sand in the younger deposits and dissected gravel sand and silt in the older deposits (DWR 2004dc). Groundwater is recharged from precipitation and stream flows. The groundwater is characterized as sodium sulfate-bicarbonate with moderate TDS concentrations.

Kane Wash Area Groundwater Basin was designated by the CASGEM program as very low priority.

#### *Iron Ridge Area Groundwater Basin*

The Iron Ridge Area Groundwater Basin is located in southern San Bernardino County. Water bearing formations consist of unconsolidated to semi-consolidated alluvium (DWR 2004dd). Several fault zones restrict groundwater movement. Groundwater is recharged from precipitation and stream flows from the nearby mountains.

Iron Ridge Area Groundwater Basin was designated by the CASGEM program as very low priority.

#### *Bessemer Valley Groundwater Basin*

The Bessemer Valley Groundwater Basin is located in eastern San Bernardino County. Water bearing formations consist of unconsolidated to semi-consolidated alluvial deposits, fanglomerate, and playa lake deposits (DWR 2004de). More recent deposits consist of unconsolidated, undissected coarse gravel to sand. Older deposits consist of gravel, sand, and silt from dissected alluvial fans. Several fault zones restrict groundwater movement. Groundwater is recharged from precipitation and stream flows at the valley margins.

Bessemer Valley Groundwater Basin was designated by the CASGEM program as very low priority.

*Lucerne Valley Groundwater Basin*

The Lucerne Valley Groundwater basin is located in San Bernardino County. Water bearing formations consist of unconsolidated or semi-consolidated alluvial deposits and dune sand deposits composed of gravel, sand, silt, clay, and occasional boulders (DWR 2004df). Several fault zones restrict groundwater movement. Groundwater is recharged from precipitation and stream flows. Groundwater levels have declined throughout the basin and caused subsidence. The groundwater is characterized as calcium-magnesium bicarbonate or magnesium-sodium sulfate with TDS and nitrates.

Lucerne Valley Groundwater Basin was designated by the CASGEM program low priority.

*Johnson Valley Groundwater Basin*

The Johnson Valley Groundwater Basin is located in San Bernardino County and includes the Soggy Lake and Upper Johnson Valley subbasins. Water bearing formations in both subbasins consist of alluvial deposits with mainly sand and gravel in the Soggy Lake subbasin and silt, clay, sand, and gravel in the Upper Johnson Valley subbasin (DWR 2004dg, 2004dh). Springs occur throughout the Soggy Lake subbasin. Groundwater flows from Soggy Lake subbasin into the Upper Johnson Valley subbasin. Several fault zones restrict groundwater movement. The groundwater is characterized with moderate to high TDS and localized areas with high fluoride.

Johnson Valley Groundwater Basin was designated by the CASGEM program as very low priority.

*Means Valley Groundwater Basin*

The Means Valley Groundwater Basin is located in south central part of San Bernardino County. Water bearing formations consist of alluvial and lacustrine deposits with unconsolidated fine to coarse grained sand, pebbles, and boulders; and varying silt and clay deposits throughout the basin (DWR 2004di). Several fault zones restrict groundwater movement. Groundwater is recharged from precipitation and subsurface inflow from the Johnson Valley Groundwater Basin. The groundwater is characterized as sodium-chloride bicarbonate with high TDS, fluoride, and nitrates.

Means Valley Groundwater Basin was designated by the CASGEM program as very low priority.

*Deadman Valley Groundwater Basin*

The Deadman Valley Groundwater Basin is located in San Bernardino County. The Deadman Valley Groundwater Basin includes the Deadman Lake and Surprise Spring subbasins. Water bearing formations consist of unconsolidated to partly consolidated continental deposits including interbedded gravels, conglomerates, clays, and silts in alluvial fan units (DWR 2004dj, 2004dk). Several fault zones restrict groundwater movement. Groundwater is recharged from precipitation and stream flows. Groundwater flows from the Surprise Spring subbasin into the Deadman Lake subbasin, and from Deadman Lake subbasin to the dry Mesquite Lake. Groundwater also flows from the Ames Valley Groundwater Basin into the Surprise Spring subbasin. The groundwater is characterized as sodium bicarbonate with moderate to high TDS and localized areas of high fluoride.

Deadman Valley Groundwater Basin was designated by the CASGEM program as very low priority.

*Twentynine Palms Valley, Joshua Tree, Ames Valley, Copper Mountain Valley, and Warren Valley Groundwater Basins*

The Twentynine Palms Valley, Ames Valley, and Copper Mountain Valley groundwater basins are located in southern San Bernardino County. The Joshua Tree and Warren Valley groundwater basins are located in southern San Bernardino County and northern Riverside County. Water bearing formations consist of unconfined, unconsolidated to partly consolidated continental deposits with interbedded gravels, conglomerates, lake playa, silts, clays, and sandy-clay deposits (DWR 2004di, 2004dj, 2004dk, 2004dl, 2004dm). Several fault zones restrict groundwater movement. Groundwater is recharged from precipitation, stream flows, and wastewater effluent disposal. Groundwater flows from the Joshua Tree Groundwater Basin into the Copper Mountain Valley Groundwater Basin. Groundwater recharge in the Warren Valley Groundwater Basin also occurs at spreading grounds. The groundwater is characterized as calcium-sodium bicarbonate or sodium sulfate with moderate to high TDS in all of the basins except the Copper Mountain Valley Groundwater Basin; and localized areas with high fluoride, nitrate, sulfate, and chloride.

Warren Valley Groundwater Basin was designated by the CASGEM program as medium priority. Twentynine Palms Valley was designated as low priority. Joshua Tree, Ames, and Copper Mountain Valley groundwater basins were designated as very low priority.

*Morongo Valley Groundwater Basin*

The Morongo Valley Groundwater basin is located in southern San Bernardino County. Water bearing formations consist of alluvial deposits composed of sand, gravel, silt, and clay (DWR 2003f). Several fault zones restrict groundwater movement. Groundwater is recharged from precipitation and stream flows in the Big Morongo and Little Morongo creeks. The groundwater is characterized as calcium-sodium bicarbonate with moderate TDS.

Morongo Valley Groundwater Basin was designated by the CASGEM program as very low priority.

*Lost Horse Valley Groundwater Basin*

The Lost Horse Valley Groundwater Basin is located on the border between southeastern San Bernardino County and northeastern Riverside County. Water bearing formations consist of unconsolidated to semi-consolidated alluvial deposits (DWR 2004dn). Groundwater is recharged from precipitation and stream flows.

Lost Horse Valley Groundwater Basin was designated by the CASGEM program as very low priority.

##### 7.3.6.6.2 Groundwater Use and Management

Within the Antelope Valley and Mojave Valley, groundwater management is facilitated by the Antelope Valley-East Kern Water Agency and Mojave Water Agency. These agencies purchase SWP water and other water supplies to be used for groundwater recharge or in-lieu uses to protect groundwater within the Antelope and Mojave valleys.

*Antelope Valley*

The Antelope Valley-East Kern Water Agency (AVEK) provides SWP water to areas that overlay portions of the Antelope Valley, Fremont Valley, and Indian Wells Valley groundwater basins. To maintain groundwater aquifers in the area, the AVEK provides treated SWP water to users through the Domestic-Agricultural Water Network and untreated SWP water to some agricultural users (AVEK 2011a). The AVEK participates in groundwater banking programs. Communities within the AVEK service area also use groundwater, including the cities of California City, Lancaster, and Palmdale; Edwards Air Force Base; County of Los Angeles Waterworks District No. 40; Boron Community Services District, Desert Lake Community Services District, Indian Wells Water District (including the City of Ridgecrest), Mojave Public Utilities District, Palmdale Water District, Palm Ranch Irrigation District, Quartz Hill Water District, and Rosamond Community Services District; and California Water Service Company (Antelope Valley, Lake Hughes, areas outside of the City of Lancaster, and Leona Valley), Edgemont Crest Municipal Water Company, El Dorado Mutual Water Company, Lake Elizabeth Mutual Water Company, Shadow Acres Mutual Water Company, Sunnyside Farm Mutual Water Company, Westside Park Mutual Water Company, and White Fence Farms Mutual Water Company provide retail groundwater supplies (AVEK 2011a; AVRWC 2011; California Water Service Company 2011f; City of California City 2013; IWVWD 2011; Los Angeles County et al. 2011; PWD 2011; Rosamond CSD 2011).

In 2004, the County of Los Angeles Waterworks District No. 40 and Palmdale Water District filed for the adjudication of the Antelope Valley Groundwater Basin (DWR 2014a; Los Angeles County et al. 2011; PWD 2011). The request of the filing is to allocate groundwater rights within the basin to these districts, other municipal and industrial water users, and Overlying Landowners and provide for a program to replace groundwater withdrawals in excess of a specified yield in order to stabilize or reverse groundwater declines.

*Mojave Valley*

Within the Mojave Water Agency service area, most of the water supply is from groundwater (AVRWC 2011; City of Adelanto 2011; Golden State Water Company 2011k; HDWD 2011; Hesperia Water District 2011; JBWD 2011;

MWA 2011; PPHCSD 2011; San Bernardino County 2012; TPWD 2014; Victorville Water District 2011). The Mojave Water Agency uses natural surface water flows, recycled water imported from outside of the agency's service area, SWP water, and return flows from water users of groundwater within the service area to recharge groundwater. These water supplies are provided as wholesale water supplies to retail groundwater users to maintain groundwater levels in the area. The Mojave Water Agency overlays all or portions of all of the groundwater basins described in this subsection. The City of Adelanto; Hesperia Water District, Hi-Desert Water District, Joshua Water District, Twentynine Palms Water District, Victorville Water District, Apple Foothill County Water District, Apple Heights County Water District, Juniper Riviera County Water District, Thunderbird County Water District, Daggett Community Services District, Helendale Community Services District, Phelan Piñon Hills Community Services District, Yermo Community Services District, Bighorn-Desert View Water Agency, and San Bernardino County Service Areas numbers 64 and 70; and Golden State Water Company, Apple Valley Ranchos Water Company, Jubilee Water Company, and Rancheritos Mutual Water Company provide retail groundwater supplies. These entities provide water to the cities of Adelanto, Barstow, Hesperia, Twentynine Palms, Victorville; towns of Apple Valley and Yucca; Joshua Tree National Park; Twentynine Palms Marine Corps Base; and the communities of Apple Heights, Apple Valley, Daggett, Flamingo Heights, Helendale, Johnson Valley, Landers, Lucerne Valley, Newberry Springs, Oak Hills, Spring Valley Lake, Yermo, and users between these communities. The Morongo Band of Mission Indians also rely upon groundwater from this area.

The Mojave Water Agency has implemented 13 groundwater recharge facilities (MWA 2011). The SWP water is delivered to the recharge facilities throughout the Mojave Water Agency service area.

The area known as the Mojave Basin Area has been adjudicated. This area includes all or portions of Cuddeback Valley, Superior Valley, Harper Valley, Antelope Valley, El Mirage Valley, Upper Mojave River Valley, Middle Mojave River Valley, Lower Mojave River Valley, Caves Canyon Valley, Langford Valley, Cronise Valley, Coyote Lake Valley, Kane Wash Area, Iron Ridge Area, Lucerne Valley, and Johnson Valley groundwater basins (Golden State Water Company 2011k; MWA 2011). The Mojave Basin Judgment allocated groundwater withdrawals in the area and required groundwater users that withdraw more than the allocated amount to purchase replenishment SWP water from the Watermaster or from another entity within the judgment. The judgment considers local surface water sources, including groundwater recharge near Hesperia with treated wastewater effluent from Lake Arrowhead Community Services District (LACSD 2011). The judgment also provides for carry over storage between water years. The Mojave Water Agency has been appointed as the Watermaster.

The Warren Valley Groundwater Basin was adjudicated in 1977 (MWA 2011). The Hi-Desert Water District was appointed as the Watermaster to manage groundwater withdrawals and groundwater quality; to provide SWP water, captured stormwater, and recycled water; and to encourage conservation.

In 1991, the Bighorn-Desert Water Agency and the Hi-Desert Water District agreed to the court approved Ames Valley Basin Water Management Agreement. In accordance with this agreement, the Hi-Desert Water District implemented the Mainstream Wells and expansion to conveyance and monitoring approaches.

## 7.4 Impact Analysis

This section describes the potential mechanisms and analytical methods for change in groundwater resources, results of the impact analysis, potential mitigation measures, and cumulative effects.

### 7.4.1 Potential Mechanisms for Change and Analytical Methods

As described in Chapter 4, Approach to Environmental Analysis, the impact analysis considers changes in groundwater conditions related to changes in CVP and SWP operations under the alternatives as compared to the No Action Alternative and Second Basis of Comparison.

#### *7.4.1.1 Changes in Groundwater Use and Groundwater Levels*

Changes in availability of CVP and SWP water supplies could result in changes in groundwater use. For example, if CVP and SWP water supplies are decreased, water users may increase the amount of groundwater withdrawals in response.

Historically, groundwater resources were the only source of water supply in the Central Valley. The heavy use of groundwater has caused groundwater quality issues, drainage issues, groundwater overdraft, and land subsidence (as discussed in Section 7.3). Throughout many areas of the San Joaquin Valley, shallow groundwater is characterized by high salinity. Use of this groundwater for irrigation deposited salts along with agricultural chemicals (nutrients and fertilizers) in the upper soil layer. These constituents leached into the underlying shallow groundwater aquifers and caused them to be unsuitable for irrigation. Surface water was provided though the CVP and SWP to provide irrigation water of higher quality than was available in local groundwater. The expanded use of surface water for irrigation has resulted in a reduction in the degree of groundwater overdraft of local groundwater basins.

Generally, when available, agricultural water users in the San Joaquin Valley prefer to use surface water for irrigation because the water quality is better than for groundwater. When adequate surface water is not available, they will use groundwater (USGS 2009).

As previously described in Section 7.2.3, Sustainable Groundwater Management Act, most groundwater users in California must develop Groundwater Sustainability Plans (GSPs) by 2020 or 2022, and meet the sustainable goal within 20 years after adoption of the plan. The timeframe of this EIS analysis is 2030. Therefore, the EIS analysis assumes that groundwater users have developed the

GSPs before that timeframe (by 2020 or 2022), and have begun to plan, design, and possibly construct alternative water supply facilities or implement water conservation measures to achieve full compliance by 2040 or 2042. However, this EIS analysis assumes that the new facilities or conservation measures are not fully implemented by 2030. Therefore, reductions in groundwater use in accordance with the SGMA are not anticipated until after 2030 and are discussed under Section 7.4.39, Cumulative Effects Analysis.

Changes in groundwater use by users of or providers to CVP and SWP water supplies could result in changes in groundwater storage and groundwater levels. For example, if CVP and SWP water supplies are decreased and water users increase the amount of groundwater withdrawals, groundwater levels could decline. Changes in groundwater levels resulting in levels declining could result in a decrease in well yields. Changes in groundwater levels also could result in different groundwater pumping costs, as analyzed in Chapter 12, Agricultural Resources, and Chapter 14, Socioeconomics, for agricultural and municipal water users of CVP and SWP water supplies, respectively.

#### 7.4.1.1.1 Use of Central Valley Hydrologic Model

There are many groundwater models that have been developed for portions of the Central Valley. However, most of these models were not developed in a manner that would allow for analysis of groundwater changes throughout the Central Valley which includes the majority of CVP and SWP agricultural water users. As described in Appendix 7A, Groundwater Model Documentation, changes in groundwater use, and levels in the Central Valley have been evaluated using the Central Valley Hydrologic Model (CVHM) because this model is readily available and covers the entire Central Valley. CVHM is a regional-scale calibrated historical finite-difference, block-centered saturated groundwater flow model application developed by the USGS and uses the MODFLOW-2000 computer code (USGS 2000b). The CVHM model spans a 42-year simulation period between water years 1962 and 2003.

CVHM is used to estimate the changes in groundwater levels and groundwater withdrawals under the alternatives as compared to the No Action Alternative and Second Basis of Comparison. CVHM model output is also used as input files of the State Wide Agricultural Production (SWAP) model to simulate agricultural production changes based on groundwater pumping costs, as described in Chapter 12, Agricultural Resources.

The CVHM domain is subdivided into 21 WBSs, as summarized in Figure 7.14 (USGS 2009). Applied water requirements for each WBS are computed based on crop type and available water from precipitation, shallow groundwater uptake, and surface water, as limited by surface water rights and CVP and SWP water supply deliveries.

CVHM simulates primarily subsurface and limited surface hydrologic processes over the entire Central Valley at a uniform grid-cell spacing of 1 mile. Boundary conditions were modified to reflect anticipated changes in surface water availability, including the effects of climate change.

Surface water inflows from the CalSim II model were used to define boundary conditions for CVHM for each alternative and the Second Basis of Comparison. The CalSim II model simulates the operation of the major SWP and CVP facilities in the Central Valley by calculating river flows; and CVP and SWP reservoir storage, exports, and deliveries (see Appendix 5A for more details on CalSim II). The CalSim II outputs are included in the CVHM input files.

The CVHM uses the FMP process (described in Appendix 7A) to estimate agricultural water supply needs and assumes that when surface water deliveries are available, they are used first, before groundwater is pumped for additional water supplies.

Changes in agricultural groundwater pumping under the alternatives are compared to groundwater pumping under the No Action Alternative and Second Basis of Comparison. The data for these results were processed from the FMP output files, which include the amount of water used from each available source by the farm, based on the computed crop water demand for each WBS.

For the analyses presented in this chapter, changes in groundwater use, elevation, and pumping volumes between the alternatives, No Action Alternative, and Second Basis of Comparison are described for agricultural water users only in the Central Valley Region.

###### 7.4.1.1.2 Analysis of Changes in Municipal and Industrial Groundwater Use

Due to the regional scale of the CVHM model, municipal and industrial groundwater use is a very small portion of total groundwater use due to the predominance of agricultural groundwater use. Therefore, in the CVHM model, municipal and industrial groundwater use in the Central Valley was assumed to continue at the 2003 calibrated volume throughout the predictive simulations.

For municipal and industrial groundwater use in the Central Valley, the CWEST model is a more appropriate model than CVHM. The CWEST model evaluates total water use by municipal and industrial water users in the Central Valley, San Francisco Bay Area, Central Coast, and Southern California regions based upon economic decisions.

It is recognized that municipal and industrial pumping in urban areas in the Central Valley could cause localized impacts to groundwater levels from increased drawdown. The increased withdrawals could also impact groundwater quality due to the migration of existing plumes, as described in the Affected Environment section.

###### 7.4.1.1.3 Analysis of Changes in Agricultural Groundwater Use Outside of the Central Valley Region

Agricultural groundwater use by CVP and SWP water users located outside of the Central Valley primarily occurs in Santa Clara and San Benito counties in the San Francisco Bay Area Region; San Luis Obispo and Santa Barbara counties in the Central Coast Region; and Ventura, Orange, San Bernardino, and Riverside counties in the Southern California Region. Basin adjudication programs in many portions of these counties will minimize changes in groundwater use and levels as a result of changes in CVP and SWP water supplies. There are no regional groundwater flow models available that uniformly help analyze groundwater use and elevation in these areas linked to CVP and SWP water supply deliveries, in a similar manner as CVHM simulates in the Central Valley, however in some areas local models have been developed to support groundwater management activities. Therefore, changes in groundwater use and related changes in groundwater levels are assumed to be correlated to availability of CVP and SWP water supplies. It is generally assumed that an increase in CVP and SWP water supplies would result in a decrease in groundwater use in these areas. Similarly, a decrease in CVP and SWP water supplies could result in a short-term increase in groundwater use and associated groundwater level decrease. In adjudicated basins, groundwater use restrictions limit the amount of groundwater that can be pumped, even when surface water availability is reduced. In those basins, long-term groundwater use is assumed to not increase, and agricultural production could decrease if CVP and SWP water supplies decrease.

#### *7.4.1.2 Changes in Land Subsidence*

Extensive groundwater withdrawals from confined and unconfined aquifers increases the potential for land subsidence. In aquifers with clay and silt lenses, decreased groundwater levels can result in compaction of fine-grained deposits which could lead to irreversible land subsidence. Subsidence could result in structural damage to roads, railroad tracks, pipelines and associated structures, drainage, buildings, and wells. Subsidence can also result in the permanent loss of groundwater storage potential within an aquifer system.

Subsidence is related to changes in groundwater levels; and a review of simulated changes in groundwater elevation output from the CVHM model as compared between alternatives is used to provide an indication of the potential occurrence of subsidence.

CVHM includes a module known as the SUB package that computes the cumulative compaction of each model layer during the model simulation. The cumulative layer compactions at the end of the simulation are summed into a total subsidence. However, this version of the SUB package does not consider the potential reduction in the rate of subsidence that would occur as the magnitude of compaction approaches the physical thickness of the affected fine-grained interbeds. Thus, subsidence forecasts from the predictive versions of CVHM were not used as they may not accurately depict long-term changes in subsidence using the current version of the SUB package. Therefore, a qualitative approach was used for the estimation of the potential for increased land subsidence in areas of the Central Valley that have historically experienced inelastic subsidence due to the compaction of fine-grained interbeds.

Potential changes in subsidence due to changes in municipal and industrial groundwater use were qualitatively analyzed for regions with historic or existing subsidence issues, such as in Santa Clara County in the San Francisco Bay Area Region.

#### *7.4.1.3 Changes in Groundwater Quality*

Changes in groundwater quality could occur in several ways under implementation of the alternatives as compared to the No Action Alternative and Second Basis of Comparison. Reductions in groundwater levels could change groundwater flow directions, potentially causing poorer quality groundwater to migrate into areas with higher quality groundwater, or cause intrusion of poor water quality (e.g. from aquitards) as water levels decline.

Groundwater quality also could change due to changes in availability of CVP and/or SWP water supplies used by agricultural water users. For example, if reductions in CVP and/or SWP water supplies result in increased use of groundwater with higher salinity than CVP and/or SWP supplies, shallow groundwater could become more saline and soil salinity could increase, as described in Chapter 11, Geology and Soils. In addition, the reduced availability of higher quality surface water for use in recharge facilities may decrease the overall groundwater quality in those localized areas.

Changes in groundwater quality due to changes in CVP and SWP water supply availability could occur under the following mechanisms:

- Migration of reduced quality groundwater towards areas of groundwater withdrawals, including seawater intrusion and migration of contaminant plumes
- Depletion of the freshwater aquifer that overlays poorer quality groundwater, and the upwelling of the poorer quality groundwater into the upper aquifers
- Percolation of applied water with poorer water quality than underlying groundwater

Within the Central Valley, changes in groundwater use and groundwater flow direction are analyzed using the CVHM. The model does not directly simulate changes in groundwater quality. However, in regions with existing poorer quality groundwater, changes in groundwater levels or flow directions can be used to evaluate potential impacts to groundwater quality. For example, declines in groundwater levels that result in seawater intrusion, or the migration of good quality groundwater into areas with poor quality can result in groundwater quality degradation. Further, reduction in groundwater quality could also occur due to migration or upwelling of poorer quality groundwater into areas with good quality groundwater.

Long-term use of poorer quality groundwater due to changes in CVP and SWP water supplies could also result in a reduction in shallow aquifer groundwater quality. Application of poorer quality groundwater also could increase soil salinity, as described in Chapter 11, Geology and Soils Resources.

#### *7.4.1.4 Effects Related to Water Transfers*

Historically water transfer programs have been developed on an annual basis.

The demand for water transfers is dependent upon the availability of water supplies to meet water demands. Water transfer transactions have increased over time as CVP and SWP water supply availability has decreased, especially during drier water years.

Parties seeking water transfers generally acquire water from sellers who have available surface water who can make the water available through releasing previously stored water, pump groundwater instead of using surface water (groundwater substitution); idle crops; or substitute crops that uses less water in order to reduce normal consumptive use of surface water.

Water transfers using CVP and SWP Delta pumping plants and south of Delta canals generally occur when there is unused capacity in these facilities. These conditions generally occur during drier water year types when the flows from upstream reservoirs plus unregulated flows are adequate to meet the Sacramento Valley water demands and the CVP and SWP export allocations. In non-wet years, the CVP and SWP water allocations would be less than full contract amounts; therefore, capacity may be available in the CVP and SWP conveyance facilities to move water from other sources.

Projecting future groundwater conditions related to water transfer activities is difficult because specific water transfer actions required to make the water available, convey the water, and/or use the water would change each year due to changing hydrological conditions, CVP and SWP water availability, specific local agency operations, and local cropping patterns. Reclamation recently prepared a long-term regional water transfer environmental document which evaluated potential changes in groundwater conditions related to water transfer actions (Reclamation 2014c). Results from this analysis were used to inform the impact assessment of potential effects of water transfers under the alternatives as compared to the No Action Alternative and the Second Basis of Comparison.

### 7.4.2 Conditions in Year 2030 without implementation of Alternatives 1 through 5

The impact analysis in this EIS is based upon the comparison of the alternatives to the No Action Alternative and the Second Basis of Comparison in the Year 2030. Changes that would occur over the next 15 years without implementation of the alternatives are not analyzed in this EIS. However, the changes that are assumed to occur by 2030 under the No Action Alternative and the Second Basis of Comparison are summarized in this section. Many of the changed conditions would occur in the same manner under both the No Action Alternative and the Second Basis of Comparison.

This section of Chapter 7 provides qualitative projections of the No Action Alternative as compared to existing conditions described under the Affected Environment; and qualitative projections of the Second Basis of Comparison as compared to “recent historical conditions.” Recent historical conditions are not the same as existing conditions which include implementation of the 2008 U.S. Fish and Wildlife Service (USFWS) biological opinion (BO) and 2009 National Marine Fisheries Service (NMFS) BO; and consider changes that would have occurred without implementation of the 2008 USFWS BO and the 2009 NMFS BO.

### *7.4.2.1 Common Changes in Conditions under the No Action Alternative and Second Basis of Comparison*

Conditions in 2030 would be different than existing conditions due to:

- Climate change and sea-level rise
- General plan development throughout California, including increased water demands in portions of Sacramento Valley
- Implementation of reasonable and foreseeable water resources management projects to provide water supplies

These changes would result in a decline of the long-term average CVP and SWP water supply deliveries by 2030 as compared to recent historical long-term average deliveries, as described in Chapter 5, Surface Water Resources and Water Supplies.

#### 7.4.2.1.1 Changes in Conditions due to Climate Change and Sea-Level Rise

It is anticipated that climate change would result in more short-duration high-rainfall events and less snowpack in the winter and early spring months. The reservoirs would be full more frequently by the end of April or May by 2030 than in recent historical conditions. However, as the water is released in the spring, there would be less snowpack to refill the reservoirs. This condition would reduce reservoir storage and available water supplies to downstream uses in the summer. The reduced end of September storage also would reduce the ability to release stored water to downstream regional reservoirs. These conditions would occur for all reservoirs in the California foothills and mountains, including non-CVP and SWP reservoirs.

Climate change also would reduce groundwater supplies due to reduced groundwater recharge potential and increased groundwater overdraft potential as surface water supplies decline. However, in some locations, sustainable groundwater supplies could remain similar to recent historical conditions or rise due to implementation of groundwater management plans to reduce groundwater overdraft, including the completion of ongoing groundwater recharge and recovery programs.

#### 7.4.2.1.2 General Plan Development in California

Counties and cities throughout California have adopted general plans which identify land use classifications including those for municipal and industrial uses and those for agricultural uses. Preparation of general plans includes an environmental evaluation under the California Environmental Quality Act to identify adverse impacts to the physical environment and to provide mitigation measures to reduce those impacts to a level of less than significance. Most of the counties where CVP and SWP water supplies are delivered have adopted general plans following the environmental review of the plans and appropriate alternatives. Population projections from those general plan evaluations are provided to the State Department of Finance and are used to project future water needs and the potential for conversion of existing undeveloped lands and agricultural lands. Many of the existing general plans for counties with municipal areas recently have been modified to include land use and population projections through 2030. The No Action Alternative and the Second Basis of Comparison assume that land uses will develop through 2030 in accordance with existing general plans.

The assumptions related to 2030 municipal water demands are based upon a review of the 2010 Urban Water Management Plans (UWMPs) prepared by CVP and SWP water users. The No Action Alternative and the Second Basis of Comparison assumptions related to future water supplies presented in the UWMPs were evaluated to determine if the projects were reasonable and certain to occur by 2030. Projects that had undergone environmental review, were under design, or under construction were included in the future water supply assumptions for 2030 in the No Action Alternative and the Second Basis of Comparison. Projects described in the UWMPs that currently were under evaluation were included in the Cumulative Effects analysis for future water supplies.

Under the No Action Alternative and Second Basis of Comparison, it is assumed that water demands would be met on a long-term basis and in dry and critical dry years using a combination of conservation, CVP and SWP water supplies, other imported water supplies, groundwater, recycled water, infrastructure improvements, desalination water treatment, and water transfers and exchanges. It is anticipated that individual communities or users could be in a situation that would not allow for affordable water supply options, and that water demands could not be fully met. However, on a regional scale, it is anticipated that water demands would be met.

##### 7.4.2.1.3 Reasonable and Foreseeable Water Resources Management Projects

The No Action Alternative and the Second Basis of Comparison assumes completion of water resources management and environmental restoration projects that would have occurred without implementation of the 2008 USFWS BO and 2009 NMFS BO by 2030, as described in Chapter 3, Description of Alternatives. Many of these future actions could affect groundwater conditions and use of groundwater.

The No Action Alternative and the Second Basis of Comparison assume that groundwater would continue to be used even if groundwater overdraft conditions continue or become worse. It is recognized that SGMA was enacted in September 2014. The SGMA requires the formation of GSPs in groundwater basins or subbasins that DWR designates as medium or high priority based upon groundwater conditions identified using the CASGEM results by 2022. Sustainable groundwater operations must be achieved within 20 years following completion of the GSPs. In some areas with adjudicated groundwater basins, sustainable groundwater management could be achieved and/or maintained by 2030. However, to achieve sustainable conditions in many areas, measures could require several years to design and construct water supply facilities to replace groundwater, such as seawater desalination. Therefore, it does not appear to be reasonable and foreseeable that sustainable groundwater management would be achieved by 2030; and it is assumed that groundwater pumping will continue to be used to meet water demands not fulfilled with surface water supplies or other alternative water supplies in 2030.

##### 7.4.2.1.4 Potential Future Groundwater Conditions in 2030 due to Common Changes

*Groundwater Conditions*

In the Central Valley Region, the combination of increased groundwater withdrawals due to reductions in CVP and SWP water deliveries as compared to recent historical long-term deliveries and reduced groundwater recharge due to climate change could result in continued reductions in groundwater levels in the same manner as recent declines of up to 10 feet in the Sacramento Valley and more than 20 feet in the San Joaquin Valley, as described in Section 7.3.4, Central Valley Region. It is also assumed that full implementation of SGMA GSPs would not occur by 2030; and therefore, groundwater pumping will continue to be used to meet water demands not fulfilled with surface water supplies or other alternative water supplies in 2030, as described above.

Under the No Action Alternative and Second Basis of Comparison, groundwater banks and other management programs would continue to be implemented, and possibly expanded, including ongoing groundwater recharge efforts in the Eastern San Joaquin, Kings, Kaweah, and Kern subbasins in the San Joaquin Valley Groundwater Basin. These programs could result in groundwater levels that are similar or higher as compared to recent groundwater conditions. If local agencies fully implement GSPs in accordance with the state SGMA prior to the regulatory deadline, groundwater levels could remain similar to recent conditions or rise.

Localized groundwater levels in portions of the Central Valley Region could increase due to seepage in lands adjacent to the ecosystem restoration areas in the Yolo Bypass, Cache Slough, and Suisun Marsh areas depending upon local geological and soil conditions.

In the Southern California Region, several SWP water users have purchased transferred water, expanded groundwater storage within their service areas, implemented wastewater recycling and stormwater recycling programs to provide water supplies for groundwater recharge, and participated in groundwater banks outside of their service areas as part of ongoing sustainable groundwater management programs. Under the No Action Alternative and the Second Basis of Comparison, groundwater banks and other management programs would continue to be implemented, and possibly expanded. Several of the programs include expansion of groundwater storage by Kern County and Antelope Valley-East Kern Water Agency; groundwater recharge programs using recycled stormwater by the Los Angeles Department of Water and Power; groundwater recharge programs using recycled wastewater by the Water Replenishment District; and groundwater treatment by City of Oxnard and Western Municipal Water District (AVEK 2011b; City of Los Angeles 2011; City of Oxnard 2013; Reclamation 2010b; WMWD 2012; WRD 2015). Expansion of these programs could result in maintenance of groundwater levels in accordance with objectives in the current groundwater management plans even with reduced SWP water supplies under the No Action Alternative and Second Basis of Comparison.

#### *Potential Land Subsidence*

Land subsidence due to groundwater withdrawals historically occurred in the Yolo subbasin of the Sacramento Valley Groundwater Basin and Delta-Mendota and Westside subbasins of the San Joaquin Valley Groundwater Basin in the Central Valley Region; Santa Clara Valley Groundwater Basin in the San Francisco Bay Area Region; and the Antelope Valley and Lucerne Valley groundwater basins in the Southern California Region. Under the No Action Alternative, it is anticipated that increased groundwater withdrawals due to reductions in CVP and SWP water supplies and reduced groundwater recharge due to climate change could result in increased irreversible land subsidence in these areas.

#### *Groundwater Quality*

##### *Central Valley Region*

As described in Section 7.3, Affected Environment, in the Central Valley, there are localized areas of high salinity related to natural geologic formations and/or historic land uses; high naturally occurring arsenic, calcium, iron, and/or manganese; and high levels of boron, and/or phosphates related to historic land use practices. High concentrations of nitrates due to current anthropogenic sources and legacy sources occur in many locations in the San Joaquin Valley Groundwater Basin, especially in the Eastern San Joaquin, Modesto, Merced, Kings, Kaweah, Tule, and Tulare Lake subbasins. Under the No Action Alternative, it is anticipated that these conditions would continue to occur; and that groundwater quality could be further degraded due to reduction of groundwater elevation that can cause adjacent poorer quality water to flow towards the groundwater withdrawals.

Groundwater quality in the Grasslands Drainage Area and near Mud Slough and the San Joaquin River is anticipated to improve as compared with historic conditions due to the implementation of the Grasslands Bypass project. This program would reduce seepage from unlined canals and capture, treat, and/or reuse drainage flows (Reclamation 2009).

In the Tulare Lake Area of the San Joaquin Valley Groundwater Basin (in the Westside, Tulare Lake, Kings, Kaweah, and Tule subbasins within Fresno, Kern, Kings, and Tulare counties) high salinity groundwater occurs in the shallow aquifers due to agricultural drainage issues and naturally occurring high saline soils. Salts are imported into the Tulare Lake Area through the use of CVP and SWP irrigation water supplies and introduced into groundwater from dissolution of salts in the local soil from agricultural land use. Groundwater salinity increases because the Tulare Lake Area is a closed basin.

The CV-SALTS program is preparing a Salinity and Nitrate Management Plan for publication in 2016 (CVRWQCB 2015). The plan will include sustainable salt management alternatives, including treatment and salt recovery technologies, such as, reverse osmosis; and related brine disposal/storage options that could range from deep well injection to dedicated disposal locations to conveyance of brine to locations outside of the San Joaquin Valley. This plan also will address current and legacy sources of nitrates; assimilative capacity of the groundwater subbasins and aquifers; drinking water protection measures, including waste discharge requirements from irrigated lands and dairies; and measurable and enforceable milestones that do not disproportionately impact disadvantaged communities; and measures that minimize costs and maximize benefits to the community and water users. The 2015 CV-SALTS work plan projects completion of Central Valley Basin Plan amendments and Water Quality Control Plans for the Sacramento Valley and San Joaquin Valley updates to incorporate recommendations of CV-SALTS by 2018, including source control strategies and real time management strategies (CVRWQCB 2015; SWRCB 2015). The *2015 CV-SALTS Annual Report* indicated that structural best management practices would not be fully selected until 2018 and may not be implemented until after 2030 (SWRCB 2015). Under the No Action Alternative and Second Basis of Comparison it is assumed that non-structural measures would be implemented by 2030 to reduce salinity and nitrate loadings; however, structural improvements that would reduce total groundwater salinity and nitrate concentrations generally would not be implemented. Therefore, water quality under the No Action Alternative and the Second Basis of Comparison is anticipated to be poorer in some portions of the Central Valley than under recent groundwater quality conditions.

Poor groundwater quality occurs near urban areas in the Central Valley due to contamination from municipal and industrial land use practices. In many of these areas, groundwater quality improvement programs have been implemented, as described above. However, in many areas, groundwater quality is managed by reducing groundwater drawdown near contaminant plumes to avoid transporting the contaminants into other portions of the aquifer. Under the No Action Alternative and the Second Basis of Comparison, it is assumed that these programs would continue. However, as CVP and SWP water supplies become less available in 2030 as compared to recent conditions, increased reliance on groundwater could cause groundwater contamination of portions of the aquifers near existing wells.

#### *San Francisco Bay Area Region*

In the San Francisco Bay Area Region, there are localized areas of moderate to high salinity due to natural geologic formations and/or seawater intrusion near San Francisco Bay. High levels of boron due to natural geologic formations and nitrates related to historic land use practices occur in the Livermore Valley and the Gilroy-Hollister- Valley groundwater basins. Under the No Action

Alternative and the Second Basis of Comparison, it is anticipated that these conditions would continue to occur; and that groundwater quality could be further degraded due to reduction of groundwater elevation that can cause adjacent poorer quality water to flow towards the groundwater withdrawals, especially in locations with seawater intrusion near the coast.

*Central Coast Region*

In the Central Coast Region, there are localized areas of moderate to high salinity due to seawater intrusion near the coast. High levels of iron and manganese due to natural geologic formations and nitrates related to historic land use practices occur in local areas of the Central Coast Region. Under the No Action Alternative and Second Basis of Comparison, it is anticipated that these conditions would continue to occur. Seawater intrusion could increase and further degrade groundwater quality in groundwater adjacent to the coast if groundwater levels decline in the future.

*Southern California Region*

In the Southern California Region, there are localized areas of moderate to high salinity due to natural geologic formations, percolation of high salinity applied water supplies, and/or seawater intrusion near the coast. High levels of calcium, sulfate, magnesium, iron, manganese, and fluoride due to natural geologic formations, and nitrates and organic compounds related to historic land use practices. Under the No Action Alternative and the Second Basis of Comparison, it is anticipated that these conditions would continue to occur; and that groundwater quality could be further degraded due to reduction of groundwater elevation that can cause adjacent poorer quality water or seawater to flow towards the groundwater withdrawals.

#### 7.4.2.2 Changes in Conditions under the No Action Alternative

Due to the climate change and sea-level rise and increased water demands in the Sacramento Valley, CVP and SWP water deliveries would be less in 2030 than under recent historical conditions. It is anticipated that these reductions in CVP and SWP water availability would result in a greater reliance on groundwater, especially during dry and critical dry year.

#### 7.4.2.3 Changes in Conditions under the Second Basis of Comparison

Due to the climate change and sea-level rise and increased water demands in the Sacramento Valley, CVP and SWP water deliveries would be less in 2030 than under recent historical conditions. It is anticipated that these reductions in CVP and SWP water availability would result in a greater reliance on groundwater, especially during dry and critical dry year. However, as described in Chapter 5, Surface Water Resources and Water Supplies, the availability of CVP and SWP water supplies would be greater under the Second Basis of Comparison as compared to the No Action Alternative because CVP and SWP water operations would not include requirements of the 2008 USFWS BO and 2009 NMFS BO. However, reliance on groundwater in 2030 under the Second Basis of Comparison is anticipated to increase as compared to recent historical conditions due to the climate change and sea-level rise and increased water demands in the Sacramento Valley.

### 7.4.3 Evaluation of Alternatives

As described in Chapter 4, Approach to Environmental Analysis, Alternatives 1 through 5 have been compared to the No Action Alternative; and the No Action Alternative and Alternatives 1 through 5 have been compared to the Second Basis of Comparison.

During review of the numerical modeling analyses used in this EIS, an error was determined in the CalSim II model assumptions related to the Stanislaus River operations for the Second Basis of Comparison, Alternative 1, and Alternative 4 model runs. Appendix 5C includes a comparison of the CalSim II model run results presented in this chapter and CalSim II model run results with the error corrected. Appendix 5C also includes a discussion of changes in the comparison of groundwater conditions for the following alternative analyses.

- No Action Alternative compared to the Second Basis of Comparison
- Alternative 1 compared to the No Action Alternative
- Alternative 3 compared to the Second Basis of Comparison
- Alternative 5 compared to the Second Basis of Comparison.

#### *7.4.3.1 No Action Alternative*

The No Action Alternative is compared to the Second Basis of Comparison.

##### 7.4.3.1.1 Trinity River Region

Groundwater conditions in the Trinity River Region are not directly related to CVP and SWP water supplies or operations. Therefore, groundwater use, related groundwater levels, potential for land subsidence, and groundwater quality under the No Action Alternative would be the same as under the Second Basis of Comparison.

##### 7.4.3.1.2 Central Valley Region

*Groundwater Use and Elevation*

In areas of the Central Valley Region that do not use CVP and SWP water supplies, areas that use CVP water under Sacramento River Exchange Settlement Contracts, and areas that use San Joaquin River Exchange Contracts water, under the No Action Alternative water supplies would be the same as under the Second Basis of Comparison. Therefore, in these areas of the Central Valley Region, groundwater use and groundwater levels under the No Action Alternative would be the same as under the Second Basis of Comparison.

In areas of the Central Valley Region that use CVP water service contract and SWP entitlement contract water supplies, the CVP and SWP water supplies would be less under the No Action Alternative as compared to the Second Basis of Comparison. The differences would result in increased groundwater use and decreased groundwater levels in the San Joaquin Valley Groundwater Basin under the No Action Alternative as compared to the Second Basis of Comparison. Results of CVHM simulations indicate that groundwater levels would be similar in the Redding and Sacramento Valley Groundwater Basins and the northern portion of the San Joaquin Valley Groundwater Basin, as shown in Figures 7.15 through 7.19. The CVHM simulation primarily focuses on changes in agricultural groundwater use in response to changes in the availability of CVP and SWP water. However, it is recognized that in the vicinity of some communities, such as in the area in the American River watershed served with CVP water supplies, groundwater use also would increase with the reduction in surface water availability. However, these changes are not considered to be substantial under the No Action Alternative as compared to the Second Basis of Comparison because the long-term reductions in CVP municipal water supplies are anticipated to be up to 7,000 acre-feet per year (or 6 percent) over the long-term condition, up to 8,000 acre-feet per year (or 8 percent) in dry years, and similar (or 5 percent or less) in critical dry years. The water demands are consistent between the No Action Alternative and Second Basis of Comparison; therefore, it is anticipated that reduced surface water supplies would result in increased groundwater use.

Groundwater levels decline under the No Action Alternative in the central and southern San Joaquin Valley Groundwater Basin as compared to the Second Basis of Comparison with greater reductions occurring in wet years than in critical dry years. Figures 7.20 and 7.21 present the simulated changes in groundwater levels over the 42-year CVHM study period. Simulated average July agricultural groundwater pumping under the No Action Alternative as compared to the Second Basis of Comparison is presented in Figures 7.22 and 7.23.

Overall, under the No Action Alternative as compared to the Second Basis of Comparison, July average groundwater levels decrease approximately 2 to 10 feet in most of the central and southern San Joaquin Valley Groundwater Basin in all water year types. July average groundwater levels decline 10 to 50 feet in the Delta-Mendota, Tulare Lake, and Kern County subbasins; and 50 to 200 feet in the Westside subbasin in all water year types. In critical dry years, groundwater levels decline by up to 100 feet on average in the Westside subbasin. Groundwater level changes in the Sacramento Valley are forecast to be less than 2 feet. The groundwater level change hydrographs show that in the central and southern San Joaquin Valley, groundwater levels can fluctuate up to 200 feet in some areas due to climatic variations under the No Action Alternative compared to the Second Basis of Comparison.

The change in groundwater pumping in the Sacramento Valley would result in similar conditions (less than 5 percent change). Therefore, groundwater pumping in the Sacramento Valley is similar under the No Action Alternative compared to the Second Basis of Comparison.

Groundwater pumping in the San Joaquin and Tulare Basins would increase by approximately 8 percent under the No Action Alternative as compared to the Second Basis of Comparison. Figure 7.23 shows that the biggest change in groundwater pumping under the No Action Alternative as compared to the

Second Basis of Comparison occurs in the Westside subbasin, with an average July increase close to 40 thousand acre-feet (TAF).

*Land Subsidence*

Land subsidence due to groundwater withdrawals historically occurred in the Yolo subbasin of the Sacramento Valley Groundwater Basin. CVP and SWP water supplies are not used extensively in this area. The conditions under the No Action Alternative would be similar as conditions under the Second Basis of Comparison.

Under the No Action Alternative, potential for land subsidence due to groundwater withdrawals in the Delta-Mendota and Westside subbasins of the San Joaquin Valley Groundwater Basin would increase as compared to the Second Basis of Comparison due to the increased groundwater withdrawals.

Groundwater level-induced land subsidence has the highest potential to occur in the San Joaquin Groundwater Basin, based on historical data, if groundwater pumping substantially increases. Under the No Action Alternative, CVP and SWP water supplies are expected to decrease in the San Joaquin Valley as compared to the Second Basis of Comparison. Decreased surface water deliveries could result in an increase in groundwater pumping. The increased groundwater pumping would result in lower groundwater levels, and therefore, the potential for groundwater level-induced land subsidence is increased under the No Action Alternative as compared to the Second Basis of Comparison.

*Groundwater Quality*

Under the No Action Alternative, groundwater conditions, including groundwater quality, in areas that do not use CVP and SWP water supplies would be the same as under the Second Basis of Comparison.

In areas that use CVP and SWP water supplies, groundwater quality under the No Action Alternative could be reduced as compared to the Second Basis of Comparison in the central and southern San Joaquin Valley Groundwater Basin due to increased groundwater withdrawals and resulting potential changes in groundwater flow patterns. For example, potential impacts to groundwater quality may arise from deeper pumping close to the base of freshwater, where higher TDS water exists. Large areas in the San Joaquin Valley also experience impairments due to nitrate and other fertilizers used in agriculture, which could migrate to areas with better quality water due to increased pumping and potential changes in groundwater flow directions.

As described above, it is assumed that measures implemented in accordance with the CV-SALTS program or future sustainable groundwater management plans implemented in accordance with SGMA would not be fully implemented by 2030. Therefore, groundwater quality could decline under the No Action Alternative as compared to the Second Basis of Comparison.

*Effects Related to Cross Delta Water Transfers*

Potential effects to groundwater resources could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c). Potential effects to groundwater were identified as reduced groundwater levels and potentially subsidence in areas that sold water using groundwater substitution practices. Because all water transfers would be required to avoid adverse impacts to other water users and biological resources (see Section 3.A.6.3, Transfers), including impacts to other groundwater users, the analysis indicated that water transfers would not result in substantial changes in groundwater because mitigation and monitoring plans would be required. The mitigation measures would require reductions in providing water from groundwater substitutions if the monitoring results indicated substantial declines in groundwater levels. For the purposes of this EIS, it is anticipated that similar conditions would occur during implementation of cross Delta water transfers under the No Action Alternative and the Second Basis of Comparison.

Groundwater use in areas that purchase the transferred water could be reduced if additional surface water is provided. However, if the transferred water is used to meet water demands that would not have been met (e.g., crops that had been idled), groundwater conditions would be similar with or without water transfers.

Under the No Action Alternative, the timing of cross Delta water transfers would be limited to July through September and include annual volumetric limits, in accordance with the 2008 USFWS BO and 2009 NMFS BO. Under the Second Basis of Comparison, water could be transferred throughout the year without an annual volumetric limit. Overall, the potential for cross Delta water transfers would be less under the No Action Alternative than under the Second Basis of Comparison.

#### 7.4.3.1.3 San Francisco Bay Area, Central Coast, and Southern California Regions

*Groundwater Use and Elevation*

Under the No Action Alternative, it is anticipated that CVP and SWP water supplies in the San Francisco Bay Area, Central Coast, and Southern California regions would be reduced as compared to CVP and SWP water supplies under the Second Basis of Comparison, as discussed in Chapter 5, Surface Water Resources and Water Supplies. The reduction in surface water supplies could result in increased groundwater withdrawals, decreased groundwater recharge, and decreased groundwater levels in areas with CVP and SWP water users. It may be legally impossible to extract additional groundwater in adjudicated basins without gaining the permission of watermasters and accounting for groundwater pumping entitlements and various parties under their adjudicated rights.

*Land Subsidence*

Increased use of groundwater and reductions in groundwater levels would result in an increased potential for additional land subsidence under the No Action Alternative as compared to the Second Basis of Comparison in the Santa Clara Valley Groundwater Basin in the San Francisco Bay Area Region, and the Antelope Valley and Lucerne Valley groundwater basins in the Southern California Region.

*Groundwater Quality*

As described in Section 7.3, Affected Environment, there are localized areas of moderate to high salinity due to natural geologic formations and/or seawater intrusion in the San Francisco Bay Area, Central Coast, and Southern California regions. Under the No Action Alternative as compared to the Second Basis of Comparison, it is anticipated that the increased groundwater withdrawals would cause poorer quality groundwater to flow towards the groundwater withdrawals, especially near the coast. This would result in poorer quality groundwater in some areas under the No Action Alternative as compared to the Second Basis of Comparison.

### *7.4.3.2 Alternative 1*

Alternative 1 is identical to the Second Basis of Comparison. As described in Chapter 4, Approach to Environmental Analysis, Alternative 1 is compared to the No Action Alternative and the Second Basis of Comparison. However, because groundwater conditions under Alternative 1 are identical to groundwater conditions under the Second Basis of Comparison; Alternative 1 is only compared to the No Action Alternative.

#### 7.4.3.2.1 Alternative 1 Compared to the No Action Alternative

*Trinity River Region*

Groundwater conditions in the Trinity River Region are not directly related to CVP and SWP water supplies or operations. Therefore, groundwater use, related groundwater levels, potential for land use subsidence, and groundwater quality degradation under Alternative 1 would be the same as under the No Action Alternative.

*Central Valley Region*

*Groundwater Use and Elevation*

In areas of the Central Valley Region that do not use CVP and SWP water supplies, areas that use CVP water under Sacramento River Exchange Settlement Contracts, and areas that use San Joaquin River Exchange Contracts under Alternative 1 water supplies would be the same as under the No Action Alternative. Therefore, in these areas of the Central Valley Region, groundwater use and groundwater levels under Alternative 1 would be the same as under the No Action Alternative.

In areas of the Central Valley Region that use CVP water service contract and SWP entitlement contract water supplies, the CVP and SWP water supplies would be greater under Alternative 1 as compared to the No Action Alternative. The differences would result in decreased groundwater use and increased groundwater levels in the San Joaquin Valley Groundwater Basin under Alternative 1 as compared to the No Action Alternative. Results of CVHM simulation indicate that groundwater levels would be similar in the Redding and Sacramento Valley groundwater basins and the northern portion of the San Joaquin Valley Groundwater Basin, as shown in Figures 7.24 through 7.28. The CVHM simulation primarily focuses on changes in agricultural groundwater use in response to changes in the availability of CVP and SWP water. However, it is recognized that in the vicinity of some communities, such as in the area in the American River watershed served with CVP water supplies, groundwater use also would increase with the reduction in surface water availability. However, these changes are not considered to be substantial under Alternative 1 as compared to the No Action Alternative because the long-term increases in CVP municipal water supplies are anticipated to be up to 7,000 acre-feet per year (or up to 6 percent) over the long-term condition, up to 8,000 acre-feet per year (or up to 8 percent) in dry years, and up to 5,000 acre-feet per year (or up to 7 percent) in critical dry years. The water demands are consistent between Alternative 1 and the No Action Alternative; therefore, it is anticipated that increased surface water supplies would result in reduced groundwater use.

Groundwater levels increase under Alternative 1 in the central and southern San Joaquin Valley Groundwater Basin as compared to the No Action Alternative with greater increases occurring in wet years than in critical dry years (up to 100 feet). Figures 7.29 and 7.30 present the simulated changes in groundwater levels over the 42-year CVHM study period. Simulated average July agricultural groundwater pumping under Alternative 1 as compared to the No Action Alternative is presented in Figures 7.31 and 7.32.

Overall, under Alternative 1 as compared to the No Action Alternative, July average groundwater levels increase approximately 2 to 10 feet in most of the central and southern San Joaquin Valley Groundwater Basin in all water year types. July average groundwater levels rise 10 to 50 feet in the Delta-Mendota, Tulare Lake, and Kern County subbasins; and 50 to 200 feet in the Westside subbasin in most water year types. In critical dry years, groundwater levels increase by up to 100 feet on average in the Westside subbasin. The groundwater level change hydrographs show that in the central and southern San Joaquin Valley subbasins, groundwater levels can fluctuate up to 200 feet in some areas due to climatic variations under Alternative 1 compared to the No Action Alternative.

The change in groundwater pumping in the Sacramento Valley is less than 5 percent. Therefore, groundwater pumping in the Sacramento Valley is similar under Alternative 1 as compared to the No Action Alternative.

Groundwater pumping in the San Joaquin and Tulare Basins would decrease by approximately 8 percent under Alternative 1 as compared to the No Action Alternative. Figure 7.32 shows that the biggest change in groundwater pumping under the Alternative 1 compared to the No Action Alternative occurs in the Westside subbasin with an average July decrease close to 40 TAF.

#### *Land Subsidence*

Land subsidence due to groundwater withdrawals historically occurred in the Yolo subbasin of the Sacramento Valley Groundwater Basin. CVP and SWP water supplies are not used extensively in this area. The conditions under Alternative 1 would be similar as conditions under the No Action Alternative.

Under Alternative 1, potential for land subsidence due to groundwater withdrawals in the Delta-Mendota and Westside subbasins of the San Joaquin Valley Groundwater Basin would decrease under Alternative 1 as compared to the No Action Alternative due to the decreased groundwater withdrawals.

Groundwater level-induced land subsidence has the highest potential to occur in the San Joaquin Valley Groundwater Basin, based on historical data, if groundwater pumping substantially increases. Under Alternative 1 CVP and SWP water supplies are expected to increase in the San Joaquin Valley as compared to the No Action Alternative. Increased surface water deliveries could result in a decrease in groundwater pumping. The decreased groundwater pumping would result in higher groundwater levels, and therefore, the potential for groundwater level-induced land subsidence is reduced under Alternative 1 as compared to the No Action Alternative.

#### *Groundwater Quality*

Under Alternative 1, groundwater conditions, including groundwater quality, in areas that do not use CVP and SWP water supplies would be the same as under the No Action Alternative.

In areas that use CVP and SWP water supplies, groundwater quality under Alternative 1 could be improved as compared to the No Action Alternative in the central and southern San Joaquin Valley Groundwater Basin due to decreased groundwater withdrawals. As described above, it is assumed that measures implemented in accordance with the CV-SALTS program or future sustainable groundwater management plans implemented in accordance with SGMA would not be fully implemented by 2030. However, due to the increased availability of CVP and SWP water supplies and related reduction in groundwater use, the groundwater quality would be improved under Alternative 1 as compared to the No Action Alternative.

#### *Effects Related to Water Transfers*

Potential effects to groundwater resources could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c), as described above under the No Action Alternative compared to the Second Basis of Comparison. For the purposes of this EIS, it is anticipated that similar conditions would occur during implementation of cross Delta water transfers under Alternative 1 and the No Action Alternative, and that groundwater impacts would not be substantial in the seller's service area due implementation requirements of the transfer programs.

Groundwater use in areas that purchase the transferred water could be reduced if additional surface water is provided. However, if the transferred water is used to meet water demands that would not have been met (e.g., crops that had been idled), groundwater conditions would be similar with or without water transfers.

Under Alternative 1, water could be transferred throughout the year without an annual volumetric limit. Under the No Action Alternative, the timing of cross

Delta water transfers would be limited to July through September and include annual volumetric limits, in accordance with the 2008 USFWS BO and 2009 NMFS BO. Overall, the potential for cross Delta water transfers would be greater under Alternative 1 as compared to the No Action Alternative.

*San Francisco Bay Area, Central Coast, and Southern California Regions*

*Groundwater Use and Elevation*

Under Alternative 1, it is anticipated that CVP and SWP water supplies in the San Francisco Bay Area, Central Coast, and Southern California regions would be increased as compared to CVP and SWP water supplies under the No Action Alternative, as discussed in Chapter 5, Surface Water Resources and Water Supplies. The increase in surface water supplies could result in decreased groundwater withdrawals by CVP and SWP water users, resulting in increased groundwater recharge, and increased groundwater levels in areas with CVP and SWP water users.

*Land Subsidence*

Decreased use of groundwater and higher groundwater levels would result in a decreased potential for additional land subsidence under Alternative 1 as compared to the No Action Alternative in the Santa Clara Valley Groundwater Basin in the San Francisco Bay Area Region, and the Antelope Valley and Lucerne Valley groundwater basins in the Southern California Region.

*Groundwater Quality*

As described in Section 7.3, Affected Environment, there are localized areas of moderate to high salinity due to natural geologic formations and/or seawater intrusion in the San Francisco Bay Area, Central Coast, and Southern California regions. Under Alternative 1 as compared to the No Action Alternative, it is anticipated that the decreased groundwater withdrawals would cause improved groundwater quality, especially near the coast.

#### 7.4.3.2.2 Alternative 1 Compared to the Second Basis of Comparison

Alternative 1 is identical to the Second Basis of Comparison.

### *7.4.3.3 Alternative 2*

The CVP and SWP operations under Alternative 2 are identical to the CVP and SWP operations under the No Action Alternative; therefore, the groundwater conditions under Alternative 2 is only compared to the Second Basis of Comparison.

#### 7.4.3.3.1 Alternative 2 Compared to the Second Basis of Comparison

Changes to groundwater resources under Alternatives 2 as compared to the Second Basis of Comparison would be the same as the impacts described in Section 7.4.3.1, No Action Alternative.

### *7.4.3.4 Alternative 3*

As described in Chapter 3, Description of Alternatives, CVP and SWP operations under Alternative 3 are similar to the Second Basis of Comparison and

Alternative 1 with modified Old and Middle River flow criteria. Alternative 3 is compared to the No Action Alternative and the Second Basis of Comparison.

#### 7.4.3.4.1 Alternative 3 Compared to the No Action Alternative

*Trinity River Region*

Groundwater conditions in the Trinity River Region are not directly related to CVP and SWP water supplies or operations. Therefore, groundwater use, related groundwater levels, potential for land use subsidence, and groundwater quality under Alternative 3 would be the same as under the No Action Alternative.

*Central Valley Region*

*Groundwater Use and Elevation*

In areas of the Central Valley Region that do not use CVP and SWP water supplies, areas that use CVP water under Sacramento River Exchange Settlement Contracts, and areas that use San Joaquin River Exchange Contracts under Alternative 3 water supplies would be the same as under the No Action Alternative. Therefore, in these areas of the Central Valley Region, groundwater use and groundwater levels under Alternative 3 would be the same as under the No Action Alternative. The CVHM simulation primarily focuses on changes in agricultural groundwater use in response to changes in the availability of CVP and SWP water. However, it is recognized that in the vicinity of some communities, such as in the area in the American River watershed served with CVP water supplies, groundwater use also would increase with the reduction in surface water availability. However, these changes are not considered to be substantial under Alternative 3 as compared to the No Action Alternative because the long-term increases in CVP municipal water supplies are anticipated to be up to 7,000 acre-feet (up to 7 percent) in dry years, and similar (or 5 percent or less) in long-term conditions and critical dry years. The water demands are consistent between Alternative 3 and the No Action Alternative; therefore, it is anticipated that increased surface water supplies would result in reduced groundwater use.

In areas of the Central Valley Region that use CVP water service contract and SWP entitlement contract water supplies, the CVP and SWP water supplies would be greater under Alternative 3 as compared to the No Action Alternative. The differences would result in decreased groundwater use and increased groundwater levels in the San Joaquin Valley Groundwater Basin under Alternative 3 as compared to the No Action Alternative. Results of CVHM simulation indicate that groundwater levels would be similar in the Redding and Sacramento Valley groundwater basins and the northern portion of the San Joaquin Valley Groundwater Basin (changes would be plus/minus 2 feet), as shown in Figures 7.33 through 7.37.

Groundwater levels increase under Alternative 3 in the central and southern San Joaquin Valley Groundwater Basin as compared to the No Action Alternative with greater increases occurring in wet years than in critical dry years. Figures 7.38 and 7.39 present the simulated changes in groundwater levels over the 42-year CVHM model study period. Simulated average July agricultural groundwater pumping under Alternative 3 as compared to the No Action Alternative is presented in Figures 7.31 and 7.32.

Overall, under Alternative 3 as compared to the No Action Alternative, July average groundwater levels increase approximately 2 to 10 feet in most of the central and southern San Joaquin Valley Groundwater Basin in all water year types. July average groundwater levels increase 10 to 50 feet in the Delta-Mendota, Tulare Lake, and Kern County subbasins; and 50 to 200 feet in the Westside subbasin in most water year types. In critical dry years, groundwater levels increase by up to 50 feet on average in the Westside subbasin. The groundwater level change hydrographs show that in the central and southern San Joaquin Valley, groundwater levels can fluctuate up to 200 feet in some areas due to climatic variations under Alternative 3 compared to the No Action Alternative.

The change in groundwater pumping in the Sacramento Valley is less than 5 percent. Therefore, groundwater pumping in the Sacramento Valley is similar under Alternative 3 compared to the No Action Alternative.

Groundwater pumping in the San Joaquin and Tulare Basins decreases by approximately 6 percent under Alternative 3 as compared to the No Action Alternative. Figure 7.32 shows that the largest change in groundwater pumping under Alternative 3 as compared to the No Action Alternative occurs in the Westside subbasin with an average July decrease of approximately 35 TAF.

#### *Land Subsidence*

Land subsidence due to groundwater withdrawals historically occurred in the Yolo subbasin of the Sacramento Valley Groundwater Basin. CVP and SWP water supplies are not used extensively in this area. The conditions under Alternative 3 would be similar as conditions under the No Action Alternative.

Under Alternative 3, potential for land subsidence due to groundwater withdrawals in the Delta-Mendota and Westside subbasins of the San Joaquin Valley Groundwater Basin would decrease under Alternative 3 as compared to the No Action Alternative due to the decreased groundwater withdrawals.

Groundwater level-induced land subsidence has the highest potential to occur in the San Joaquin Valley Groundwater Basin, based on historical data, if groundwater pumping substantially increases. Under Alternative 3 CVP and SWP water supplies are expected to increase in the San Joaquin Valley as compared to the No Action Alternative. Increased surface water deliveries could result in a decrease in groundwater pumping. The decreased groundwater pumping would result in higher groundwater levels, and therefore, the potential for groundwater level-induced land subsidence is reduced under Alternative 3 as compared to the No Action Alternative.

#### *Groundwater Quality*

Under Alternative 3, groundwater conditions, including groundwater quality, in areas that do not use CVP and SWP water supplies would be the same as under the No Action Alternative.

In areas that use CVP and SWP water supplies, groundwater quality under Alternative 3 could be improved as compared to the No Action Alternative in the central and southern San Joaquin Valley Groundwater Basin due to decreased groundwater withdrawals. As described above, it is assumed that measures implemented in accordance with the CV-SALTS program or future sustainable groundwater management plans implemented in accordance with SGMA would not be fully implemented by 2030. However, due to the increased availability of CVP and SWP water supplies and related reduction in groundwater use, the groundwater quality would be improved under Alternative 3 as compared to the No Action Alternative.

#### *Effects Related to Water Transfers*

Potential effects to groundwater resources could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c), as described above under the No Action Alternative compared to the Second Basis of Comparison. For the purposes of this EIS, it is anticipated that similar conditions would occur during implementation of cross Delta water transfers under Alternative 3 and the No Action Alternative, and that groundwater impacts would not be substantial in the seller's service area due implementation requirements of the transfer programs.

Groundwater use in areas that purchase the transferred water could be reduced if additional surface water is provided. However, if the transferred water is used to meet water demands that would not have been met (e.g., crops that had been idled), groundwater conditions would be similar with or without water transfers.

Under Alternative 3, water could be transferred throughout the year without an annual volumetric limit. Under the No Action Alternative, the timing of cross Delta water transfers would be limited to July through September and include annual volumetric limits, in accordance with the 2008 USFWS BO and 2009 NMFS BO. Overall, the potential for cross Delta water transfers would be greater under Alternative 3 as compared to the No Action Alternative.

### *San Francisco Bay Area, Central Coast, and Southern California Regions*

#### *Groundwater Use and Elevation*

Under Alternative 3, it is anticipated that CVP and SWP water supplies in the San Francisco Bay Area, Central Coast, and Southern California regions would be increased as compared to CVP and SWP water supplies under the No Action Alternative, as discussed in Chapter 5, Surface Water Resources and Water Supplies. The increase in surface water supplies could result in decreased groundwater withdrawals by CVP and SWP water users, resulting in increased groundwater recharge, and increased groundwater levels. It may be legally impossible to extract additional groundwater in adjudicated basins without gaining the permission of watermasters and accounting for groundwater pumping entitlements and various parties under their adjudicated rights.

*Land Subsidence*

Decreased use of groundwater and higher groundwater levels would result in a decreased potential for additional land subsidence under Alternative 3 as compared to the No Action Alternative in the Santa Clara Valley Groundwater Basin in the San Francisco Bay Area Region, and the Antelope Valley and Lucerne Valley groundwater basins in the Southern California Region.

*Groundwater Quality*

As described in Section 7.3, Affected Environment, there are localized areas of moderate to high salinity due to natural geologic formations and/or seawater intrusion in the San Francisco Bay Area, Central Coast, and Southern California regions. Under Alternative 3 as compared to the No Action Alternative, it is anticipated that the decreased groundwater withdrawals would cause improved groundwater quality, especially near the coast.

#### 7.4.3.4.2 Alternative 3 Compared to the Second Basis of Comparison

*Trinity River Region*

Groundwater conditions in the Trinity River Region are not directly related to CVP and SWP water supplies or operations. Therefore, groundwater use, related groundwater levels, potential for land use subsidence, and groundwater quality under Alternative 3 would be the same as under the Second Basis of Comparison.

*Central Valley Region*

*Groundwater Use and Elevation*

In areas of the Central Valley Region that do not use CVP and SWP water supplies, areas that use CVP water under Sacramento River Exchange Settlement Contracts, and areas that use San Joaquin River Exchange Contracts under Alternative 3 water supplies would be the same as under the Second Basis of Comparison. Therefore, in these areas of the Central Valley Region, groundwater use and groundwater levels under Alternative 3 would be the same as under the Second Basis of Comparison. The CVHM simulation primarily focuses on changes in agricultural groundwater use in response to changes in the availability of CVP and SWP water. However, it is recognized that in the vicinity of some communities, such as in the area in the American River watershed served with CVP water supplies, groundwater use also would increase with the reduction in surface water availability. However, these changes are considered to be similar under Alternative 3 as compared to the Second Basis of Comparison because the CVP municipal water supplies are similar (or 5 percent or less) in long-term conditions, dry years, and critical dry years. The water demands are consistent between Alternative 3 and the Second Basis of Comparison; therefore, it is anticipated that similar surface water supplies would result in similar groundwater use.

In areas of the Central Valley Region that use CVP water service contract and SWP entitlement contract water supplies, the CVP and SWP water supplies would be less under Alternative 3 as compared to the Second Basis of Comparison. The differences would result in increased groundwater use and decreased groundwater levels in the San Joaquin Valley Groundwater Basin under Alternative 3 as compared to the Second Basis of Comparison. Results of CVHM simulation indicate that groundwater levels would be similar in the Redding and Sacramento Valley groundwater basins and the northern portion of the San Joaquin Valley Groundwater Basin, as shown in Figures 7.40 through 7.44.

Groundwater levels generally decrease under Alternative 3 in the central and southern San Joaquin Valley Groundwater Basin as compared to the Second Basis of Comparison. Figures 7.45 and 7.46 present the simulated change in groundwater levels over the 42-year CVHM study period. Simulated average July agricultural groundwater pumping under Alternative 3 as compared to the Second Basis of Comparison is presented in Figures 7.22 and 7.23.

Overall, under Alternative 3 as compared to the Second Basis of Comparison, July average groundwater levels decrease approximately 2 to 10 feet areas of the western and southern San Joaquin Valley Groundwater Basin in all water year types. July average groundwater levels decline up to 25 feet in the Delta-Mendota, Tulare Lake, and Kern County subbasins; and decline up to 25 feet in Westside subbasin, in most water year types. However, groundwater levels in the Westside subbasin increase by up to 10 feet on average in wet years, due to increased CVP water deliveries to this region in wet years. Groundwater level changes in the Sacramento Valley are forecast to be less than 2 feet. The groundwater level change hydrographs show that in the central and southern San Joaquin Valley, groundwater levels can fluctuate up to 200 feet in some areas due to climatic variations under Alternative 3 compared to the Second Basis of Comparison.

The change in groundwater pumping in the Sacramento Valley is less than 5 percent. Therefore, groundwater pumping in the Sacramento Valley is similar under Alternative 3 compared to the Second Basis of Comparison.

Groundwater pumping in the San Joaquin and Tulare Basins changes by less than 5 percent under Alternative 3 as compared to the Second Basis of Comparison, and is therefore considered similar. Figure 7.23 shows that the biggest change in groundwater pumping under Alternative 3 compared to the Second Basis of Comparison occurs in WBS 18, with an average July increase close to 10 TAF.

#### *Land Subsidence*

Groundwater pumping would be similar in the Sacramento and San Joaquin valleys, therefore, the potential for groundwater level-induced land subsidence would be similar under Alternative 3 as compared to the Second Basis of Comparison.

#### *Groundwater Quality*

Groundwater pumping would be similar in the Sacramento and San Joaquin valleys, therefore, groundwater quality would be similar under Alternative 3 as compared to the Second Basis of Comparison.

*Effects Related to Water Transfers*

Potential effects to groundwater resources could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c), as described above under the No Action Alternative compared to the Second Basis of Comparison. For the purposes of this EIS, it is anticipated that similar conditions would occur during implementation of cross Delta water transfers under Alternative 3 and the Second Basis of Comparison, and that groundwater impacts would not be substantial in the seller's service area due implementation requirements of the transfer programs.

Groundwater use in areas that purchase the transferred water could be reduced if additional surface water is provided. However, if the transferred water is used to meet water demands that would not have been met (e.g., crops that had been idled), groundwater conditions would be similar with or without water transfers.

Under Alternative 3 and the Second Basis of Comparison, water could be transferred throughout the year without an annual volumetric limit. Therefore, the potential for cross Delta water transfers would be similar under Alternative 3 and the Second Basis of Comparison.

*San Francisco Bay Area, Central Coast, and Southern California Regions*

*Groundwater Use and Elevation*

Under Alternative 3, it is anticipated that CVP and SWP water supplies in the San Francisco Bay Area, Central Coast, and Southern California regions would be decreased as compared to CVP and SWP water supplies under the Second Basis of Comparison, as discussed in Chapter 5, Surface Water Resources and Water Supplies. The decrease in surface water supplies could result in increased groundwater withdrawals by CVP and SWP water users, resulting in decreased groundwater recharge, and decreased groundwater levels in areas with CVP and SWP water users.

*Land Subsidence*

Increased use of groundwater and lower groundwater levels would result in an increased potential for additional land subsidence under Alternative 3 as compared to the Second Basis of Comparison in the Santa Clara Valley Groundwater Basin in the San Francisco Bay Area Region, and the Antelope Valley and Lucerne Valley groundwater basins in the Southern California Region.

*Groundwater Quality*

As described in Section 7.3, Affected Environment, there are localized areas of moderate to high salinity due to natural geologic formations and/or seawater intrusion in the San Francisco Bay Area, Central Coast, and Southern California regions. Under Alternative 3 as compared to the Second Basis of Comparison, it is anticipated that the increased groundwater withdrawals would cause poorer groundwater quality, especially near the coast.

#### *7.4.3.5 Alternative 4*

Groundwater conditions under Alternative 4 would be identical to groundwater conditions under the Second Basis of Comparison; therefore, Alternative 4 is only compared to the No Action Alternative.

##### 7.4.3.5.1 Alternative 4 Compared to the No Action Alternative

Changes in groundwater conditions under Alternative 4 as compared to the No Action Alternative would be the same as the impacts described in Section 7.4.3.2.1, Alternative 1 Compared to the No Action Alternative.

#### *7.4.3.6 Alternative 5*

CVP and SWP operations under Alternative 5 are similar to the No Action Alternative with modified Old and Middle River flow criteria and New Melones Reservoir operations. As described in Chapter 4, Approach to Environmental Analysis, Alternative 5 is compared to the No Action Alternative and the Second Basis of Comparison.

##### 7.4.3.6.1 Alternative 5 Compared to the No Action Alternative

*Trinity River Region*

Groundwater conditions in the Trinity River Region are not directly related to CVP and SWP water supplies or operations. Therefore, groundwater use, related groundwater levels, potential for land use subsidence, and groundwater quality under Alternative 5 would be the same as under the No Action Alternative.

*Central Valley Region*

*Groundwater Use and Elevation*

In areas of the Central Valley Region that do not use CVP and SWP water supplies, areas that use CVP water under Sacramento River Exchange Settlement Contracts, and areas that use San Joaquin River Exchange Contracts under Alternative 5 water supplies would be the same as under the No Action Alternative. Therefore, in these areas of the Central Valley Region, groundwater use and groundwater levels under Alternative 5 would be the same as under the No Action Alternative. The CVHM simulation primarily focuses on changes in agricultural groundwater use in response to changes in the availability of CVP and SWP water. However, it is recognized that in the vicinity of some communities, such as in the area in the American River watershed served with CVP water supplies, groundwater use also would increase with the reduction in surface water availability. However, these changes are not considered to be substantial under Alternative 5 as compared to the No Action Alternative because the CVP municipal water supplies are anticipated to be similar in long-term conditions, dry years, and critical dry years. The water demands are consistent between Alternative 5 and the No Action Alternative; therefore, it is anticipated that similar surface water supplies would result in similar groundwater use.

In areas of the Central Valley Region that use CVP water service contract and SWP entitlement contract water supplies, the CVP and SWP water supplies would be slightly lower under Alternative 5 as compared to the No Action Alternative.

The differences would result in increased groundwater use and decreased groundwater levels in the San Joaquin Valley Groundwater Basin under Alternative 5 as compared to the No Action Alternative. Results of CVHM simulations indicate that groundwater levels would be similar in the Redding and Sacramento Valley groundwater basins and the northern portion of the San Joaquin Valley Groundwater Basin, as shown in Figures 7.47 through 7.51.

Groundwater levels decrease under Alternative 5 in the central and southern San Joaquin Valley Groundwater Basin as compared to the No Action Alternative with the greatest decreases occurring in above normal years. Figures 7.52 and 7.53 present the simulated change in groundwater levels over the 42-year CVHM study period. Simulated average July agricultural groundwater pumping under Alternative 5 as compared to the No Action Alternative is presented in Figures 7.31 and 7.32.

Overall, under Alternative 5 as compared to the No Action Alternative, July average groundwater levels decrease approximately 2 to 10 feet on average in some of the Westside subbasin and the northern portion of the Kern County subbasin in most water year types, and decrease approximately by up to 25 feet in dry and above normal water years in the Westside subbasin. The groundwater level change hydrographs show that in the central and southern San Joaquin Valley, groundwater levels usually fluctuate by no more than 50 feet in some areas due to seasonal and climatic variations under Alternative 5 compared to the No Action Alternative.

The change in groundwater pumping in the Sacramento Valley is less than 5 percent. Therefore, groundwater pumping in the Sacramento Valley is similar under Alternative 5 compared to the No Action Alternative.

Groundwater pumping in the San Joaquin and Tulare Basins changes by less than 5 percent under Alternative 5 as compared to the No Action Alternative, and is therefore considered similar. Figure 7.32 shows that the biggest change in groundwater pumping under Alternative 5 compared to the No Action Alternative occurs in the Western San Joaquin Valley.

#### *Land Subsidence*

Groundwater pumping would be similar in the Sacramento and San Joaquin valleys, therefore, the potential for groundwater level-induced land subsidence would be similar under Alternative 5 as compared to the No Action Alternative.

#### *Groundwater Quality*

Groundwater pumping would be similar in the Sacramento and San Joaquin valleys, therefore, groundwater quality would be similar under Alternative 5 as compared to the No Action Alternative.

#### *Effects Related to Water Transfers*

Potential effects to groundwater resources could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c), as described above under the No Action Alternative compared to the Second Basis of Comparison. For the purposes of this EIS, it is anticipated that similar conditions would occur during implementation of cross Delta water transfers under Alternative 5 and the No Action Alternative, and that groundwater impacts would not be substantial in the seller's service area due implementation requirements of the transfer programs.

Groundwater use in areas that purchase the transferred water could be reduced if additional surface water is provided. However, if the transferred water is used to meet water demands that would not have been met (e.g., crops that had been idled), groundwater conditions would be similar with or without water transfers.

Under Alternative 5 and the No Action Alternative, the timing of cross Delta water transfers would be limited to July through September and include annual volumetric limits, in accordance with the 2008 USFWS BO and 2009 NMFS BO. Overall, the potential for cross Delta water transfers would be similar under Alternative 5 as compared to the No Action Alternative.

*San Francisco Bay Area, Central Coast, and Southern California Regions Groundwater Use and Elevation*

Under Alternative 5, it is anticipated that CVP and SWP water supplies in the San Francisco Bay Area, Central Coast, and Southern California regions would be similar to CVP and SWP water supplies under the No Action Alternative, as discussed in Chapter 5, Surface Water Resources and Water Supplies. Therefore, groundwater pumping would be similar.

*Land Subsidence*

Because the groundwater pumping would be similar under Alternative 5 as compared to the No Action Alternative; therefore, the potential for additional land subsidence would be similar.

*Groundwater Quality*

Because the groundwater pumping would be similar under Alternative 5 as compared to the No Action Alternative; therefore, groundwater quality would be similar.

#### 7.4.3.6.2 Alternative 5 Compared to the Second Basis of Comparison

*Trinity River Region*

Groundwater conditions in the Trinity River Region are not directly related to CVP and SWP water supplies or operations. Therefore, groundwater use, related groundwater levels, potential for land use subsidence, and groundwater quality under Alternative 5 would be the same as under the Second Basis of Comparison.

*Central Valley Region*

*Groundwater Use and Elevation*

In areas of the Central Valley Region that do not use CVP and SWP water supplies, areas that use CVP water under Sacramento River Exchange Settlement Contracts, and areas that use San Joaquin River Exchange Contracts under Alternative 5 water supplies would be the same as under the Second Basis of

Comparison. Therefore, in these areas of the Central Valley Region, groundwater use and groundwater levels under Alternative 5 would be the same as under the Second Basis of Comparison. The CVHM simulation primarily focuses on changes in agricultural groundwater use in response to changes in the availability of CVP and SWP water. However, it is recognized that in the vicinity of some communities, such as in the area in the American River watershed served with CVP water supplies, groundwater use also would increase with the reduction in surface water availability. However, these changes are not considered to be substantial under Alternative 5 as compared to the Second Basis of Comparison because the long-term reductions in CVP municipal water supplies are anticipated to be up to 7,000 acre-feet per year (up to 6 percent) over the long-term condition, up to 9,000 acre-feet per year (up to 9 percent) in dry years, and up to 6,000 acre-feet per year (up to 8 percent) in critical dry years. The water demands are consistent between Alternative 5 and the Second Basis of Comparison; therefore, it is anticipated that reduced surface water supplies would result in increased groundwater use.

In areas of the Central Valley Region that use CVP water service contract and SWP entitlement contract water supplies, the CVP and SWP water supplies would be lower under Alternative 5 as compared to the Second Basis of Comparison. The differences would result in increased groundwater use and decreased groundwater levels in the San Joaquin Valley Groundwater Basin under Alternative 5 as compared to the Second Basis of Comparison. Results of CVHM simulations indicate that groundwater levels would be similar in the Redding and Sacramento Valley groundwater basins and the northern portion of the San Joaquin Valley Groundwater Basin, as shown in Figures 7.54 through 7.58.

Groundwater levels generally decrease under Alternative 5 in the central and southern San Joaquin Valley Groundwater Basin as compared to the Second Basis of Comparison. Figures 7.59 and 7.60 present the simulated change in groundwater levels over the 42-year CVHM study period. Simulated average July agricultural groundwater pumping under Alternative 5 as compared to the Second Basis of Comparison is presented in Figures 7.22 and 7.23.

Overall, under Alternative 5 as compared to the Second Basis of Comparison, July average groundwater levels decrease approximately 2 to 10 feet in most of the central and southern San Joaquin Valley Groundwater Basin in all water year types. July average groundwater levels decline 10 to 50 feet in the Delta-Mendota, Tulare Lake, and Kern County subbasins; and can decline up to 200 feet in the Westside subbasin, in below normal, above normal and dry water year types. Groundwater level changes in the Sacramento Valley are forecast to be less than 2 feet. The groundwater level change hydrographs show that in the central and southern San Joaquin Valley, groundwater levels can fluctuate up to 200 feet in some areas due to seasonal and climatic variations under Alternative 5 compared to the Second Basis of Comparison.

The change in groundwater pumping in the Sacramento Valley is less than 5 percent. Therefore, groundwater pumping in the Sacramento Valley is similar under Alternative 5 compared to the Second Basis of Comparison.

Groundwater pumping in the San Joaquin and Tulare Basins increases by approximately 8 percent under the Alternative 5 as compared to the Second Basis of Comparison. Figure 7.23 shows that the biggest change in groundwater pumping under Alternative 5 compared to the Second Basis of Comparison occurs in WBS 14, with an average July increase of almost 40 TAF.

#### *Land Subsidence*

Land subsidence due to groundwater withdrawals historically occurred in the Yolo subbasin of the Sacramento Valley Groundwater Basin. CVP and SWP water supplies are not used extensively in this area. The conditions under Alternative 5 would be similar as conditions under the Second Basis of Comparison.

Under Alternative 5, potential for land subsidence due to groundwater withdrawals in the Delta-Mendota and Westside subbasins of the San Joaquin Valley Groundwater Basin would increase under Alternative 5 as compared to the Second Basis of Comparison due to the increased groundwater withdrawals.

Groundwater level-induced land subsidence has the highest potential to occur in the San Joaquin Groundwater Basin, based on historical data, if groundwater pumping substantially increases. Under Alternative 5, CVP and SWP water supplies are expected to decrease in the San Joaquin Valley as compared to the Second Basis of Comparison. Decreased surface water deliveries could result in an increase in groundwater pumping. The increased groundwater pumping would result in lower groundwater levels, and therefore, the potential for groundwater level-induced land subsidence is increased under Alternative 5 as compared to the Second Basis of Comparison.

#### *Groundwater Quality*

Under Alternative 5, groundwater conditions, including groundwater quality, in areas that do not use CVP and SWP water supplies would be the same as under the Second Basis of Comparison.

In areas that use CVP and SWP water supplies, groundwater quality under Alternative 5 could be reduced as compared to the Second Basis of Comparison in the central and southern San Joaquin Valley Groundwater Basin due to increased groundwater withdrawals and resulting potential changes in groundwater flow patterns. As described above, it is assumed that measures implemented in accordance with the CV-SALTS program or future sustainable groundwater management plans implemented in accordance with SGMA would not be fully implemented by 2030. Therefore, groundwater quality may be affected under Alternative 5 as compared to the Second Basis of Comparison.

#### *Effects Related to Water Transfers*

Potential effects to groundwater resources could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c), as described above under the No Action Alternative compared to the Second Basis of Comparison. For the purposes of this EIS, it is anticipated that similar conditions would occur during implementation of cross Delta water transfers under Alternative 5 and the Second Basis of Comparison, and that groundwater impacts would not be substantial in the seller's service area due implementation requirements of the transfer programs.

Groundwater use in areas that purchase the transferred water could be reduced if additional surface water is provided. However, if the transferred water is used to meet water demands that would not have been met (e.g., crops that had been idled), groundwater conditions would be similar with or without water transfers.

Under Alternative 5 and the Second Basis of Comparison, water could be transferred throughout the year without an annual volumetric limit. Therefore, the potential for cross Delta water transfers would be similar under Alternative 5 and the Second Basis of Comparison.

*San Francisco Bay Area, Central Coast, and Southern California Regions Groundwater Use and Elevation*

Under Alternative 5, it is anticipated that CVP and SWP water supplies in the San Francisco Bay Area, Central Coast, and Southern California regions would be decreased as compared to CVP and SWP water supplies under the Second Basis of Comparison, as discussed in Chapter 5, Surface Water Resources and Water Supplies. The decrease in surface water supplies could result in increased groundwater withdrawals by CVP and SWP water users, resulting in decreased groundwater recharge, and decreased groundwater levels in areas with CVP and SWP water users. It may be legally impossible to extract additional groundwater in adjudicated basins without gaining the permission of watermasters and accounting for groundwater pumping entitlements and various parties under their adjudicated rights.

*Land Subsidence*

Increased use of groundwater and lower groundwater levels would result in a decreased potential for additional land subsidence would increase under Alternative 5 as compared to the Second Basis of Comparison in the Santa Clara Valley Groundwater Basin in the San Francisco Bay Area Region, and the Antelope Valley and Lucerne Valley groundwater basins in the Southern California Region.

*Groundwater Quality*

As described in Section 7.3, Affected Environment, there are localized areas of moderate to high salinity due to natural geologic formations and/or seawater intrusion in the San Francisco Bay Area, Central Coast, and Southern California regions. Under Alternative 5 as compared to the Second Basis of Comparison, it is anticipated that the increased groundwater withdrawals would cause poorer groundwater quality, especially near the coast.

#### 7.4.3.7 Summary of Impact Analysis

The results of the impact analysis of implementation of Alternatives 1 through 5 as compared to the No Action Alternative and the Second Basis of Comparison are presented in Tables 7.3 and 7.4.

**Table 7.3 Comparison of Alternatives 1 through 5 to No Action Alternative**

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| Alternative 1 | **Trinity River Region**<br>Groundwater conditions would be similar.<br>**Central Valley Region**<br>Groundwater pumping and levels in the Sacramento Valley would be similar.<br>Groundwater pumping in the San Joaquin Valley would decrease by approximately 8 percent. July groundwater levels in all water year types would be higher by approximately 2 to 10 feet in most of the central and southern San Joaquin Valley; 10 to 50 feet in the Delta-Mendota, Tulare Lake, and Kern County subbasins; and 50 to 200 feet in the Westside subbasin. The higher groundwater levels would reduce the potential for land subsidence.<br>Groundwater quality in the San Joaquin Valley Groundwater Basin could decline.<br>**San Francisco Bay Area, Central Coast, and Southern California Regions**<br>Increases in CVP and SWP water supplies, could decrease groundwater pumping and decrease the potential for land subsidence. | None needed |
| Alternative 2 | No effects on groundwater resources or water supplies. | None needed |
| Alternative 3 | **Trinity River Region**<br>Groundwater conditions would be similar.<br>**Central Valley Region**<br>Groundwater pumping and levels in the Sacramento Valley would be similar.<br>Groundwater pumping in the San Joaquin Valley would decrease by approximately 6 percent. July groundwater levels in all water year types would be higher by approximately 2 to 10 feet in most of the central and southern San Joaquin Valley; 10 to 50 feet in the Delta-Mendota, Tulare Lake, and Kern County subbasins; and 50 to 200 feet in the Westside subbasin. The higher groundwater levels would reduce the potential for land subsidence.<br>Groundwater quality in the San Joaquin Valley Groundwater Basin could decline.<br>**San Francisco Bay Area, Central Coast, and Southern California Regions**<br>Increases in CVP and SWP water supplies, could decrease groundwater pumping and decrease the potential for land subsidence. | None needed |

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| Alternative 4 | Same effects as described for Alternative 1 compared to the No Action Alternative. | None needed |
| Alternative 5 | **Trinity River Region**<br>Groundwater conditions would be similar.<br>**Central Valley Regions**<br>Groundwater pumping and levels in the Sacramento Valley would be similar.<br>Groundwater pumping, levels, and quality in the San Joaquin Valley would be similar.  July groundwater levels in all water year types would decline approximately 2 to 10 feet in most of the central and southern San Joaquin Valley; and up to 25 feet in the Westside subbasin.<br>**San Francisco Bay Area, Central Coast, and Southern California Regions**<br>Because the CVP and SWP water deliveries would be similar; groundwater pumping would be similar the potential for land subsidence would be similar. | None needed |

Note:
*Due to the limitations and uncertainty in the CalSim II monthly model and other analytical tools, incremental differences of 5 percent or less between alternatives and the Second Basis of Comparison are considered to be “similar.”

**Table 7.4 Comparison of No Action Alternative and Alternatives 1 through 5 to Second Basis of Comparison**

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| No Action Alternative | **Trinity River Region**<br>Groundwater conditions would be similar.<br>**Central Valley Regions**<br>Groundwater pumping and levels in the Sacramento Valley would be similar.<br>Groundwater pumping in the San Joaquin Valley would increase by approximately 8 percent. July groundwater levels in all water year types would decline approximately 2 to 10 feet in most of the central and southern San Joaquin Valley; 10 to 50 feet in the Delta-Mendota, Tulare Lake, and Kern County subbasins; and 100 to 200 feet in the Westside subbasin. The reduction in groundwater levels could cause additional land subsidence.<br>Groundwater quality in the San Joaquin Valley Groundwater Basin could decline.<br>**San Francisco Bay Area, Central Coast, and Southern California Regions**<br>Reductions in CVP and SWP water supplies, could increase groundwater pumping and increase the potential for land subsidence. | Not considered for this comparison. |
| Alternative 1 | No effects on groundwater resources or water supplies. | None needed. |
| Alternative 2 | Same effects as described for No Action Alternative as compared to the Second Basis of Comparison. | Not considered for this comparison. |
| Alternative 3 | **Trinity River Region**<br>Groundwater conditions would be similar.<br>**Central Valley Regions**<br>Groundwater pumping and levels in the Sacramento Valley would be similar.<br>Groundwater pumping, levels, and quality in the San Joaquin Valley would be similar. July groundwater levels in all water year types would decline approximately 2 to 10 feet in the areas of the western and southern San Joaquin Valley; up to 25 feet in the Delta-Mendota, Tulare Lake, Kern County and in Westside subbasins.<br>**San Francisco Bay Area, Central Coast, and Southern California Regions**<br>Reductions in CVP and SWP water supplies, could increase groundwater pumping and increase the potential for land subsidence. | Not considered for this comparison. |

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| Alternative 4 | No effects on groundwater resources or water supplies. | None needed |
| Alternative 5 | **Trinity River Region**<br>Groundwater conditions would be similar.<br>**Central Valley Regions**<br>Groundwater pumping and levels in the Sacramento Valley would be similar.<br>Groundwater pumping in the San Joaquin Valley would increase by approximately 8 percent. July groundwater levels in all water year types would decline approximately 2 to 10 feet in most of the central and southern San Joaquin Valley; 10 to 50 feet in the Delta-Mendota, Tulare Lake and Kern County subbasins; and up to 200 feet in the Westside subbasin. The reduction in groundwater levels could cause additional land subsidence.<br>Groundwater quality in the San Joaquin Valley Groundwater Basin could decline.<br>**San Francisco Bay Area, Central Coast, and Southern California Regions**<br>Reductions in CVP and SWP water supplies, could increase groundwater pumping and increase the potential for land subsidence. | Not considered for this comparison. |

Note:
*Due to the limitations and uncertainty in the CalSim II monthly model and other analytical tools, incremental differences of 5 percent or less between alternatives and the Second Basis of Comparison are considered to be “similar.”

#### *7.4.3.8 Potential Mitigation Measures*

Mitigation measures are presented in this section to avoid, minimize, rectify, reduce, eliminate, or compensate for adverse environmental effects of Alternatives 1 through 5 as compared to the No Action Alternative. Mitigation measures were not included to address adverse impacts under the alternatives as compared to the Second Basis of Comparison because this analysis was included in this EIS for information purposes only.

As described above and summarized in Table 7.3, implementation of Alternatives 1 through 5 as compared to the No Action Alternative would result in either similar or less groundwater pumping and potential for land subsidence; and similar groundwater quality conditions. Therefore, there would be no adverse impacts to groundwater; and no mitigation measures are needed.

#### *7.4.3.9 Cumulative Effects Analysis*

As described in Chapter 3, the cumulative effects analysis considers projects, programs, and policies that are not speculative; and are based upon known or reasonably foreseeable long-range plans, regulations, operating agreements, or other information that establishes them as reasonably foreseeable.

The cumulative effects analysis for Alternatives 1 through 5 for Groundwater Resources are summarized in Table 7.5.

**Table 7.5 Summary of Cumulative Effects on Groundwater Resources of Alternatives 1 through 5 as Compared to the No Action Alternative**

| Scenarios | Actions | Cumulative Effects of Actions |
|---|---|---|
| Past & Present, and Future Actions included in the No Action Alternative in All Alternatives in Year 2030 | Consistent with Affected Environment conditions plus:<br>Actions in the 2008 USFWS BO and 2009 NMFS BO that would have occurred without implementation of the BOs, as described in Section 3.3.1.2 (of Chapter 3, Descriptions of Alternatives), including climate change and sea level rise<br>Actions not included in the 2008 USFWS BO and 2009 NMFS BO that would have occurred without implementation of the BOs, as described in Section 3.3.1.3 (of Chapter 3, Descriptions of Alternatives):<br>- Implementation of Federal and state policies and programs, including Clean Water Act (e.g.,Total Maximum Daily Loads); Safe Drinking Water Act; Clean Air Act; and flood management programs<br>- General plans for 2030.<br>- Trinity River Restoration Program.<br>- Central Valley Project Improvement Act programs<br>- Iron Mountain Mine Superfund Site<br>- Nimbus Fish Hatchery Fish Passage Project<br>- Folsom Dam Water Control Manual Update | These effects would be the same in all alternatives.<br>Climate change and sea level rise, development under the general plans, FERC relicensing projects, and some future projects to improve water quality and/or habitat are anticipated to reduce availability of CVP and SWP water supplies; and therefore, increase groundwater use, reduce groundwater elevations, and increase potential subsidence.<br>Future water supply projects are anticipated to both increase surface water supply reliability due to increased surface water supplies and to accommodate planned growth in the general plans. Most of these programs were initiated prior to implementation of the 2008 USFWS BO and 2009 NMFS BO which reduced CVP and SWP water supply reliability.<br>Developments under the general plans and future water supply, water quality improvement, and restoration projects are anticipated to potentially affect future groundwater resources. |

| Scenarios | Actions | Cumulative Effects of Actions |
|---|---|---|
| | - FERC Relicensing for the Middle Fork of the American River Project<br>- Lower Mokelumne River Spawning Habitat Improvement Project<br>- Dutch Slough Tidal Marsh Restoration | However, development of these future programs would include preparation of environmental documentation that would identify methods to minimize adverse impacts to groundwater resources. |
| | - Suisun Marsh Habitat Management, Preservation, and Restoration Plan Implementation<br>- Tidal Wetland Restoration: Yolo Ranch, Northern Liberty Island Fish Restoration Project, Prospect Island Restoration Project, and Calhoun Cut/Lindsey Slough Tidal Habitat Restoration Project<br>- San Joaquin River Restoration Program<br>- Stockton Deep Water Ship Channel Dissolved Oxygen Project<br>- Grasslands Bypass Project<br>- Central Valley Salinity Alternatives for Long-Term Sustainability (CV-SALTS)<br>- Future water supply projects, including water recycling, desalination, groundwater banks and wellfields, and conveyance facilities (projects with completed environmental documents) | Some of the future actions would reduce the effects of agricultural drainage and/or reduce salinity in the San Joaquin River and the Delta. These programs would result in a beneficial impact to groundwater quality. |

| Scenarios | Actions | Cumulative Effects of Actions |
|---|---|---|
| Future Actions considered as Cumulative Effects Actions in All Alternatives in Year 2030 | Actions as described in Section 3.5 (of Chapter 3, Descriptions of Alternatives):<br>- Bay-Delta Water Quality Control Plan Update<br>- FERC Relicensing Projects<br>- Bay Delta Conservation Plan (including California WaterFix alternative)<br>- Shasta Lake Water Resources, North-of-the-Delta Offstream Storage, Los Vaqueros Reservoir Expansion Phase 2, and Upper San Joaquin River Basin Storage Investigations<br>- El Dorado Water and Power Authority Supplemental Water Rights Project<br>- Sacramento River Water Reliability Project | These effects would be the same in all alternatives.<br>Most of the future reasonably foreseeable actions are anticipated to reduce water supply impacts due to climate change, sea level rise, increased water allocated to improve habitat conditions, and future growth.<br>Some of the future reasonably foreseeable actions related to improved water quality and habitat conditions (e.g., Water Quality Control Plan Update and FERC Relicensing Projects), could in further reductions in CVP and SWP water deliveries. |
| | - Semitropic Water Storage District Delta Wetlands<br>- North Bay Aqueduct Alternative Intake<br>- Irrigated Lands Regulatory Program<br>- San Luis Reservoir Low Point Improvement Project<br>- Westlands Water District v. United States Settlement<br>- Future water supply projects, including water recycling, desalination, groundwater banks and wellfields, and conveyance facilities (projects that did not have completed environmental documents during preparation of the EIS) | Developments under the future projects are anticipated to potentially affect groundwater resources. However, development of these future programs would include preparation of environmental documentation that would identify methods to minimize adverse impacts to groundwater resources.<br>Some of the future reasonably foreseeable actions would reduce the effects of agricultural drainage and/or reduce salinity in the San Joaquin River and the Delta. These programs would result in a beneficial impact to groundwater quality. |

| Scenarios | Actions | Cumulative Effects of Actions |
|---|---|---|
| No Action Alternative with Associated Cumulative Effects Actions in Year 2030 | Full implementation of the 2008 USFWS BO and 2009 NMFS | Climate change and sea level rise, development under the general plans, FERC relicensing projects, and some future projects to improve water quality and/or habitat are anticipated to reduce availability of CVP and SWP water supplies, and increase groundwater use as compared to past conditions.<br>Future water supply projects are anticipated to both increase water supply reliability due to increased surface water supplies and to accommodate planned growth in the general plans.<br>Some of the future actions would reduce the effects of agricultural drainage and/or reduce salinity in the San Joaquin River and the Delta, and improve groundwater quality. |
| | | Groundwater substitution water transfers could result in reduced groundwater levels and potential subsidence in areas that sell water using groundwater substitution practices. Because all water transfers would be required to avoid adverse impacts to other water users and biological resources, including impacts to other groundwater users, it is anticipated that water transfers would not result in substantial changes in groundwater conditions |
| Alternative 1 with Associated Cumulative Effects Actions in Year 2030 | No implementation of the 2008 USFWS BO and 2009 NMFS BO actions unless the actions would have been implemented without the BO (e.g., Red Bluff Pumping Plant) | Implementation of Alternative 1 with future reasonably foreseeable would result in increased surface water availability and reduced groundwater use as compared to the No Action Alternative with the added actions. |

| Scenarios | Actions | Cumulative Effects of Actions |
|---|---|---|
| Alternative 2 with Associated Cumulative Effects in Year 2030 | Full implementation of the 2008 USFWS BO and 2009 NMFS BO CVP and SWP operational actions<br>No implementation of structural improvements or other actions that require further study to develop a more detailed action description. | Implementation of Alternative 2 with future reasonably foreseeable would result in similar surface water availability and similar groundwater use as compared to the No Action Alternative with the added actions. |
| Alternative 3 with Associated Cumulative Effects in Year 2030 | No implementation of the 2008 USFWS BO and 2009 NMFS BO actions unless the actions would have been implemented without the BO (e.g., Red Bluff Pumping Plant)<br>Slight increase in positive Old and Middle River flows in the winter and spring months | Implementation of Alternative 3 with future reasonably foreseeable would result in increased surface water availability and reduced groundwater use as compared to the No Action Alternative with the added actions. |
| Alternative 4 with Associated Cumulative Effects in Year 2030 | No implementation of the 2008 USFWS BO and 2009 NMFS BO actions unless the actions would have been implemented without the BO (e.g., Red Bluff Pumping Plant) | Implementation of Alternative 4 with future reasonably foreseeable would result in increased surface water availability and reduced groundwater use as compared to the No Action Alternative with the added actions. |
| Alternative 5 with Associated Cumulative Effects in Year 20530 | Full implementation of the 2008 USFWS BO and 2009 NMFS BO<br>Positive Old and Middle River flows and increased Delta outflow in spring months | Implementation of Alternative 5 with future reasonably foreseeable would result in similar surface water availability and similar groundwater use as compared to the No Action Alternative with the added actions. |

There would be no adverse impacts associated with implementation of the alternatives as compared to the No Action Alternative. Therefore, Alternatives 1 through 5 would not contribute cumulative impacts to groundwater as compared to the No Action Alternative. However, implementation of No Action Alternative and Alternative 5 (in the Central Valley, San Francisco Bay Area, Central Coast, and Southern California regions) and Alternative 3 (in the San Francisco Bay Area, Central Coast, and Southern California regions) as compared to the Second Basis of Comparison would result in increased groundwater pumping and associated potential for land subsidence and poorer groundwater quality; and could contribute to cumulative impacts related to groundwater conditions as compared to the Second Basis of Comparison conditions.

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